Application Note RAN502012R0
Tested Version : RWC5020x_NST SW V1.000
RWC5020x FW V1.320

Manufacturing test solution for LoRa products using RWC5020x and example application program

Background

RedwoodComm is proposing 3 kinds of manufacturing test solutions for faster testing LoRa products using the non-signaling function of RWC5020x. The first is TX only test, the second is RX only test, and the third is MFG(manufacturing) test for both TX and RX test. The all three tests will be done in non-signaling test mode. Basically a manufacturing test of LoRa products should be performed in non-signaling mode because of two reasons; test time and a type of DUT. Testing in signaling mode requires much longer test time caused by the limitation of LoRa communication technology. Testing in non-signaling mode does not concern a type of DUT, in other words, either End-devices or Gateways can be tested under the same test concept.

Test Environment

We tested and verified the proposed manufacturing tests with the RWC5020B and a B-L072Z LRWAN end device of ST microelectronics. In this document, all test procedures and test conditions are described with an end-device(Fig 1). The example application program is available on RedwoodComm's website.

Tester : RWC5020A/B/M Tester for LoRaWAN
DUT(Device Under Test, End device) : B-L072Z LRWAN end device of ST microelectronics
Application : Manufacturing test application for LoRa devices using RWC5020x (including C# source code)

Fig 1. Connection for test

NST-MFG(Manufacturing)

In this solution, measuring TX power and RX sensitivity of DUT can be performed at once without controlling the DUT. But the DUT is required to operate in the special test mode, which is described as 'DUT Requirement' in the following sections. There is a way to get PER information and to measure POWER of the DUT in the special and simple test protocol.

Test Procedure

Although the test is performed in non-signaling mode, simple protocol should be defined for test automation in production lines as communication between the tester and DUT. Fig 1 shows the test procedure for MFG test using RWC5020x and DUT can be an End-device or a Gateway. The procedure consists of 3 steps as follows.

Step 1

Upon starting the test, the tester waits for the first packet from DUT, which indicates DUT is ready to be tested. The first 2 bytes of payload in this packet shall be 0xFFFF which means it's the control packet to initiate the test (START_FLAG) and the rest of payload may contain user-defined data for application purpose, e.g., serial number of DUT. The maximum length of the user-defined data shall be 128 bytes. Then DUT should be ready to receive test packets from the tester and count them.

Step 2

Once the tester receives the first packet (START_FLAG) from DUT, it starts transmitting the test packets. The test packet is described in the Parameter Configuration section. The time interval between consecutive packets can be configured by users, which may depend on the receivability of DUT and may affect the resultant total test time. Test packets should be transmitted at the defined power level of the tester to evaluate the receiver performance of DUT, while DUT counts the number of successfully received packets, denoted as *K*. After packets are transmitted *N* times, the number of packets defined by users, the tester sends the control packet to inform the transmission ends (END_FLAG) and to force DUT to be ready to report the *K* value to the tester. The control packet should be transmitted at 20dB higher power than the power of test packets for reliability of control.

Step 3

The tester waits for the report packet from DUT within the report timeout defined by users. DUT should wait at least 500ms after receiving END_FLAG, transmit the report packet containing K value of 2byte-long, and retransmit the same packet twice with a time interval (Δt) for reliability of test and power measurements. Then the tester calculates Packet Error Rate (PER) by K / N and measures the power to check whether the results meet the user criteria.

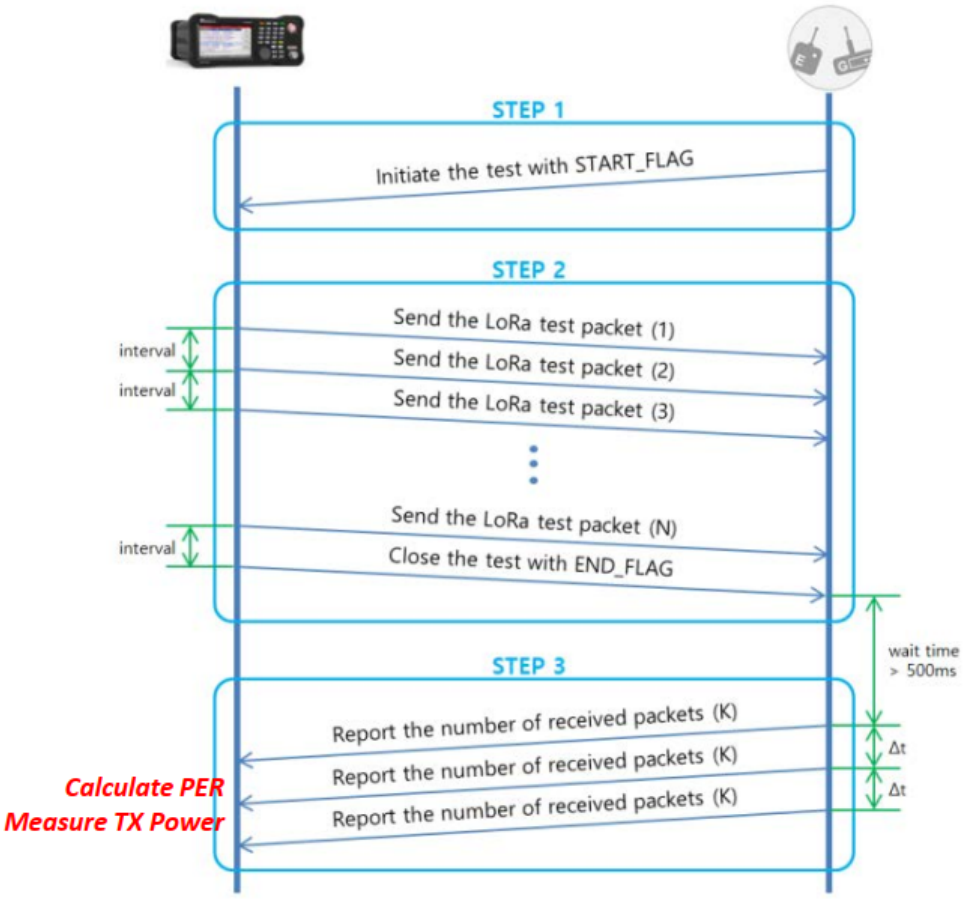

Fig 2. Test procedure between the tester and the DUT for the NST-MFG test

DUT processing procedure

DUT processing for Step 1

After power-on, DUT shall transmit START_FLAG (the first 2 bytes should be 0xFFFF). Users can load any useful data into payload such as the serial number of DUT with the maximum length of 128 bytes. After transmission, DUT should be ready to receive test packets from the tester and count them. If there is no test packet from the tester within its own timeout, DUT shall retransmit the same START_FLAG.

DUT processing for Step 2

DUT shall count the number of packets (*K*), received successfully. Upon receiving END_FLAG, DUT shall prepare to send the report packet containing the *K* value of 2byte-long.

DUT processing for Step 3

DUT shall wait at least 500ms and transmit the report packet including *K* value in payload 3 times. Each transmission must be done every time interval (Δt) within the report timeout defined by the

user. Then DUT may switch to normal firmware or the final firmware may be downloaded to DUT at the next stage in the production line.

DUT's State Transition Diagram

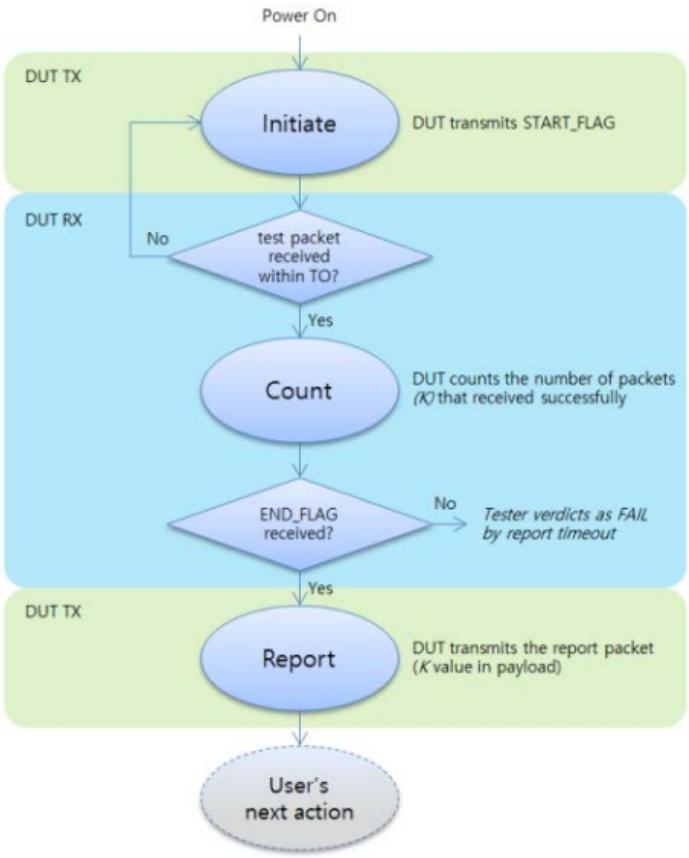

Fig 3. The operation of DUT for the NST-MFG test.

Packet Format

START_FLAG packet(2B~128B)

It is issued by DUT

Maximum length of packet is 128B

The very first 2BYTEs must be 'FFFF'.

Users can transmit START_FLAG with its own data, i.e. the Serial number of DUT.

EX) FFFF534E3A5257313233343531(="SN:RW123451")

END_FLAG packet(2B)

It is issued by Tester

Payload length is 2B.

The Very first 2 BYTEs are always 'FFFF'.

REPORT packet(2B)

It is issued by DUT

Payload length is 2 Bytes which is the number of received packets.

DUT should wait at least 500ms after received EDN_FLAG

DUT should transmit the REPORT packet three times.

EX)
// End Device's Report packet (K=19)
13 00
// Add the time interval (Δt)
13 00
// Add the time interval (Δt)
13 00

MFG test of the example application

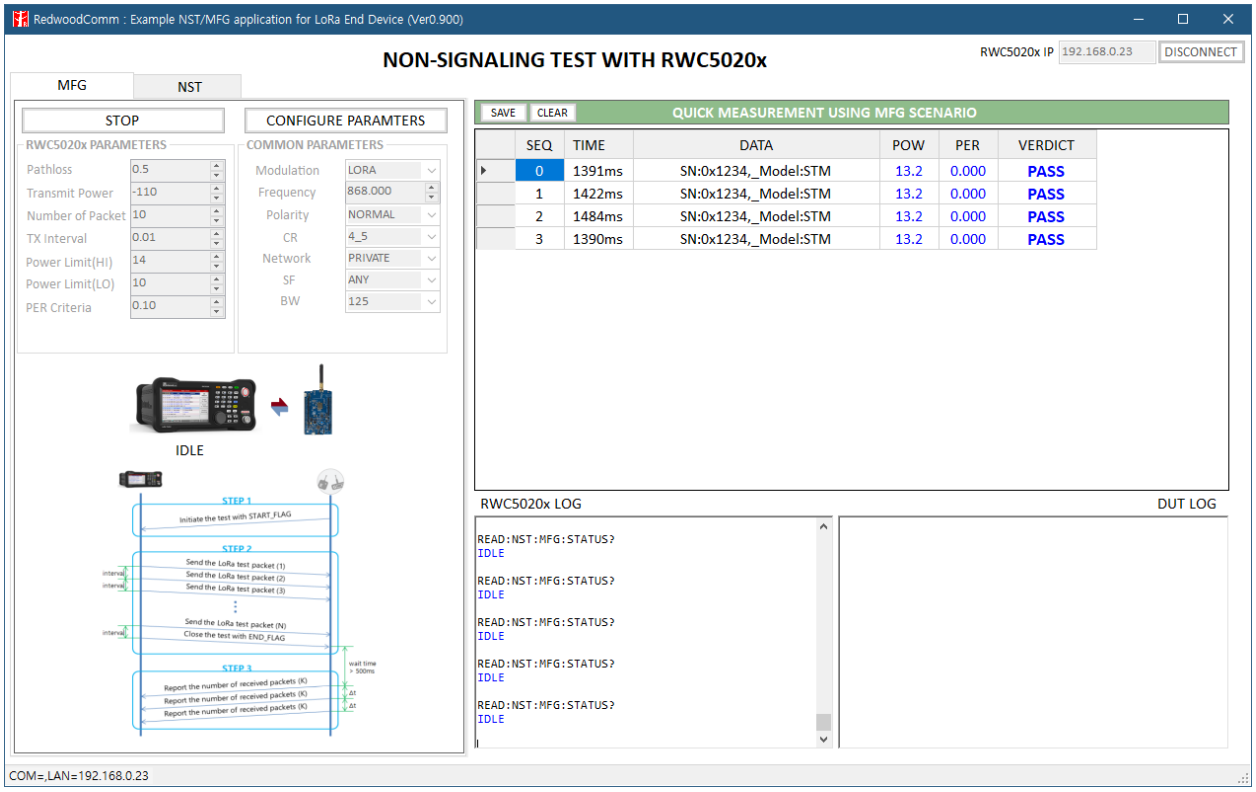

Fig 4. Screenshot of Application during NST-MFG test

Parameters

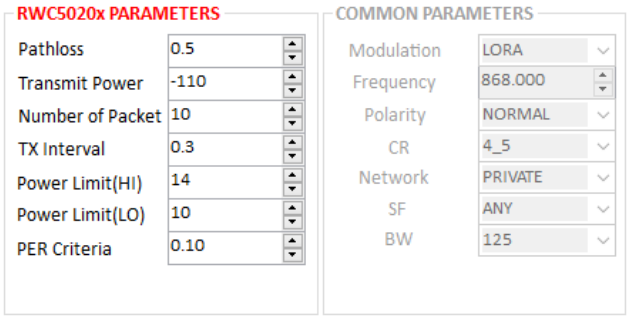

Fig 5. NST-MFG Parameters

RWC5020x PARAMETERS

Path loss

RF path loss between antennas of the tester and DUT

Transmit Power

TX power of the tester to evaluate the receiver performance of DUT

Number of Packets

the number of test packets to be transmitted

TX Interval

the time interval between consecutive test packets

Power Criteria (HI)

the upper limit of measured TX power to determine the verdict

Power Criteria (LO)

the lower limit of measured TX power to determine the verdict

PER Criteria

the limit of PER to determine the verdict

TEST PARAMETERS

Modulation

LORA only

Frequency

RF frequency to be tested

Polarity

NORMAL only

CR(Coding Rate)

4/5, 4/6, 4/7, 4/8

Network

PRIVATE, PUBLIC

Bandwidth (BW)

125kHz, 250kHz, or 500kHz

Spreading Factor (SF)

SF7 ~ SF 12

Result Information

SEQ

Sequential number of test

TIME

Elapsed test time in millisecond unit

DATA

Data in the START_FLAG packet from the DUT

POWER

Power value of the DUT measured by the RWC5020x

PER

PER value of the DUT measured by the RWC5020x

VERDICT

Verdicted by the RWC5020x

TIMEOUT, PASS, or FAIL

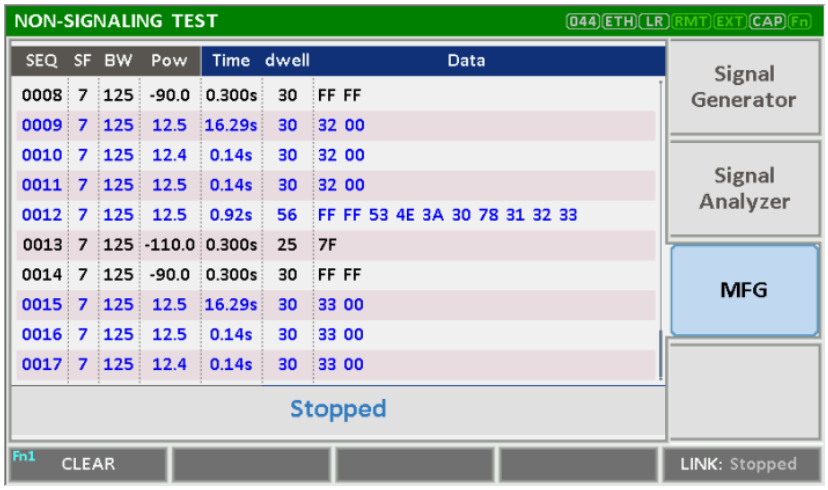

Fig 6. Screenshot of MFG test of RWC5020x

NST-TX Test

This test is to measure the transmitted power and frequency of DUT. The tester RWC5020x is in RX mode to measure the power and frequency from DUT. In RX mode, RWC5020x is always ready to measure the power and frequency from DUT. Frequency measurement is only available in CW mode test and with RWC5020B and RWC5020M.

Users need to connect the application program with the DUT with RS232 to set DUT parameters if necessary.

Test Procedure

Step 1

Set the tester RWC5020x as RX mode. In RX mode, the tester waits for any signal.

Step 2

Make the DUT transmit LORA or CW signal. In CW modulation mode, the tester measures power and frequency periodically according to the 'test interval' parameters. In LORA modulation mode, the tester measures only the power of the DUT whenever it receives a LORA packet.

Step 3

Read the measured power and frequency values from RWC5020x.

The TX-Test of the example application

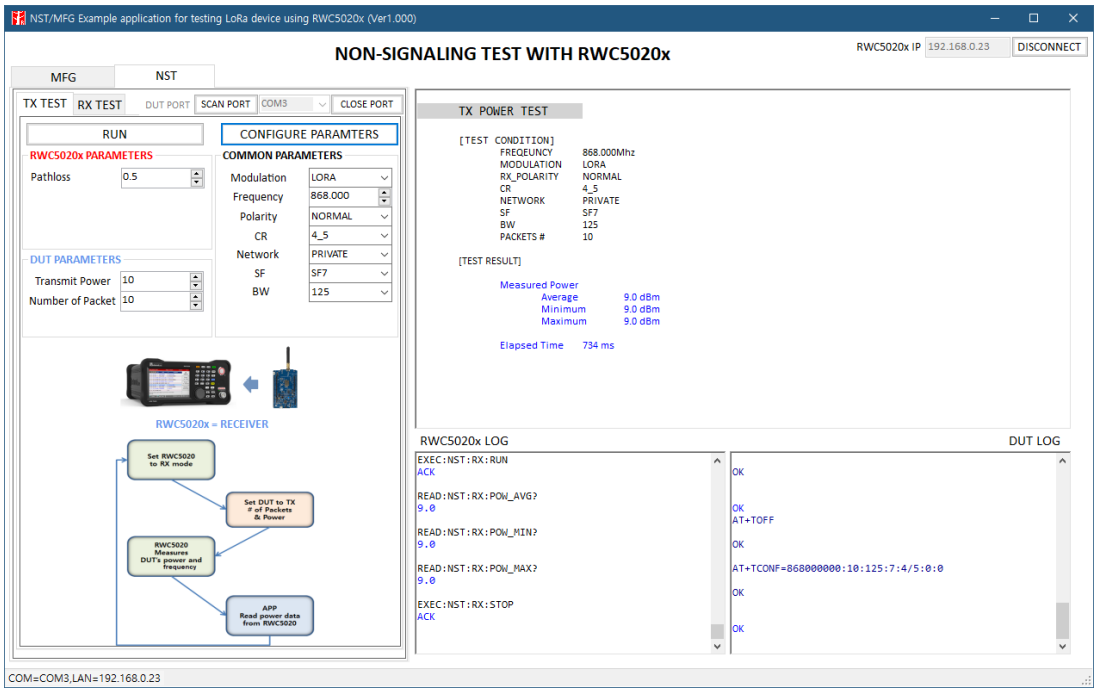

Fig 7. Screenshot of Application during NST-TX test(LORA Modulation)

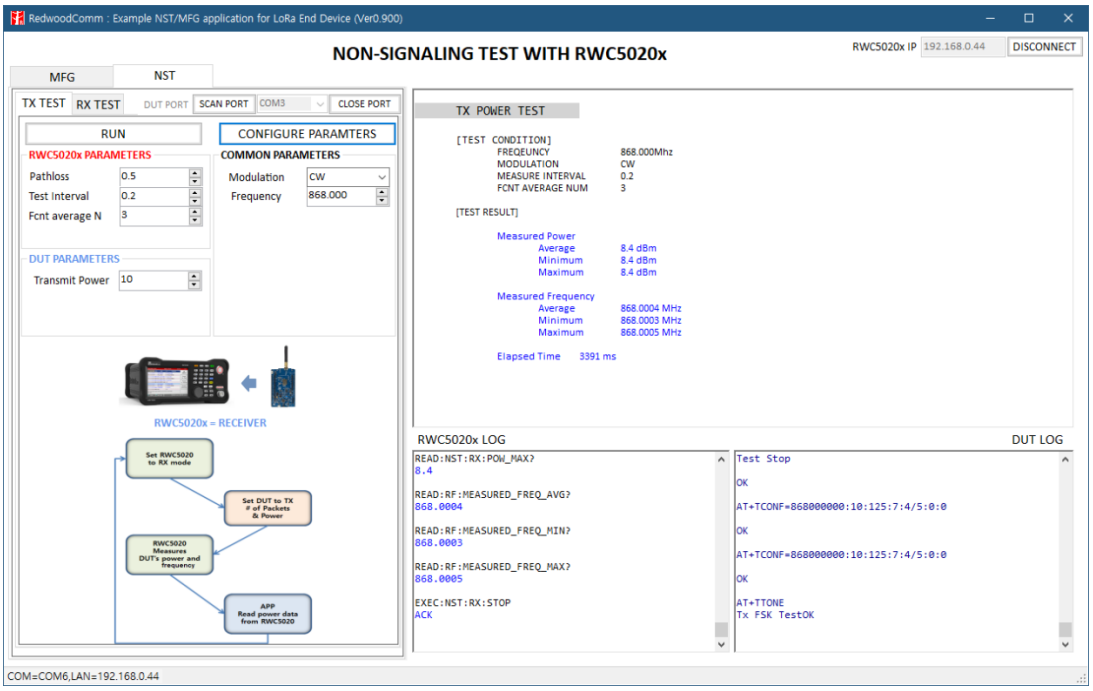

Fig 8. Screenshot of Application during NST-TX test(CW modulation)

Parameters

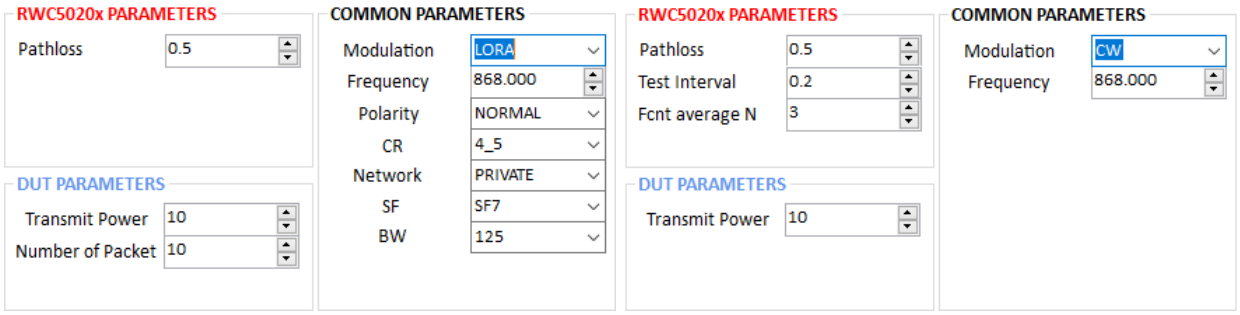

Fig 9. NST-TX Parameters

RWC5020x PARAMETERS

Path loss

RF path loss between antennas of the tester and DUT

CW PARAMETER

Test Interval

The time interval between consecutive measurement the CW signal from DUT

Fcnt Average N

The average number to measure the frequency of CW signal from DUT

DUT PARAMETERS

Transmit Power

TX power of the DUT

Number of Packets

The number of test packets to be transmitted

TEST PARAMETERS

Modulation

LORA , CW

Frequency

RF frequency to be tested

LORA PARAMETER

Polarity

NORMAL only

CR(Coding Rate)

4/5, 4/6, 4/7, 4/8

Network

PRIVATE only

Spreading Factor (SF)

SF7 ~ SF 12, ANY

Bandwidth (BW)

125kHz, 250kHz, or 500kHz

Result information

Measured Power

Average : Averaged power value

Minimum : The minimum power value among measured power values

Maximum : The maximum power value among measured power values

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Measured frequency

Available only in CW modulation test

Average : Averaged frequency value

Minimum : The minimum frequency value among measured frequency values

Maximum : The maximum frequency value among measured frequency values

Elapsed Time

Elapsed test value in millisecond unit.

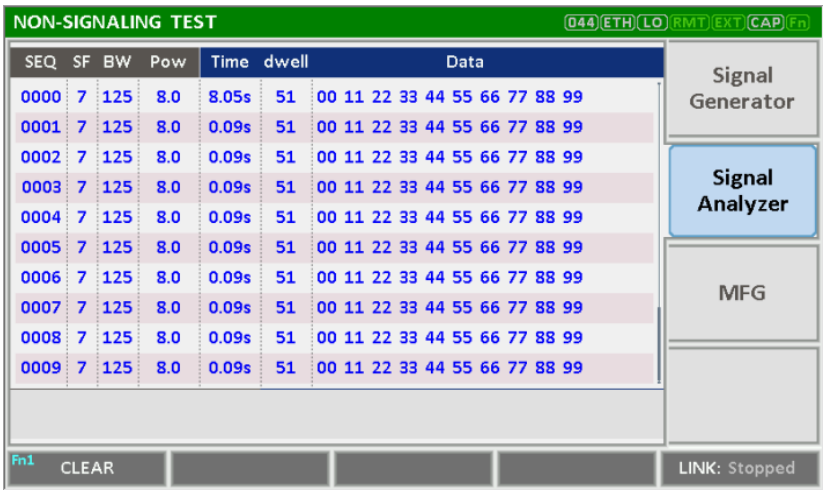

Fig 10. Screenshot of NST-TX test of RWC5020x

NST-RX Test

This test is to measure the sensitivity of DUT using PER(Packet Error Rate). The tester RWC5020x should be in TX mode to transmit LORA packets consecutively. Users need to set the DUT as RX mode. There is no protocol in this test but DUT is supposed to be able to count the number of received packets from RWC5020x. In order to report PER, the DUT should be able to report the number of received packets to the application as a response to the command asking the number of received packets. Users need to connect the application program with the DUT with RS232 for this purpose.

Test Procedure

Step 1

Set the DUT as RX mode.

Step 2

Make the tester RWC5020x as TX mode and execute transmission.

Step 3

Read the received packet number from the DUT. Make sure the last packet is finished transmitting before reading the received packet number. You can use “READ:NST:TX:STATUS?” to ensure if the last packet transmitting is finished. Response “BUSY” indicates it is still transmitting. Response “IDLE” indicates it is finished transmitting.

The RX-Test of the example application

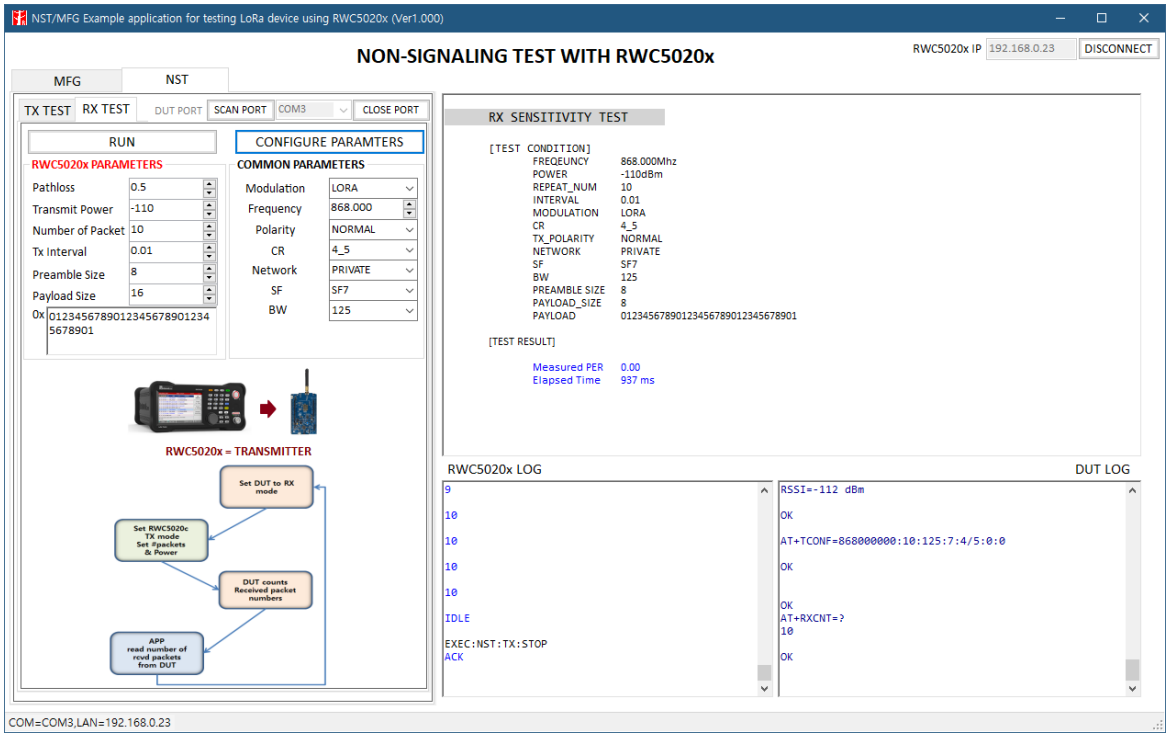

Fig 11. Screenshot of Application during NST-RX test

Parameters

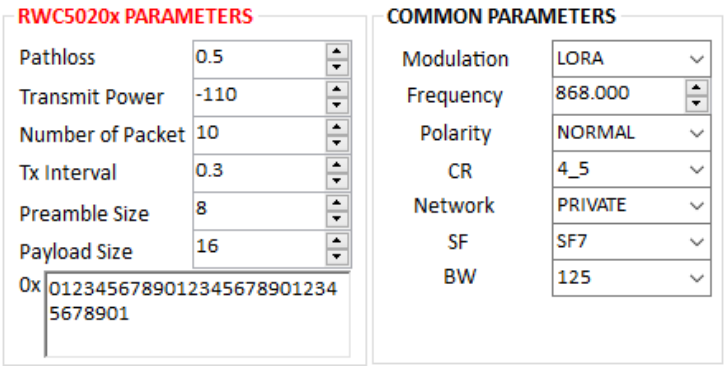

Fig 12. NST-RX Parameters

RWC5020x PARAMETERS

Path loss

RF path loss between antennas of the tester and DUT

Transmit Power

TX power of the tester to evaluate the receiver performance of DUT

Number of Packets

the number of test packets to be transmitted

TX Interval

the time interval between consecutive test packets

Preamble Size

the length of preamble in LoRa frame

Payload Size

the length of payload

Payload

User payload

TEST PARAMETERS

Modulation

LORA only

Frequency

RF frequency to be tested

Polarity

INVERSE, NORMAL

CR(Coding Rate)

4/5, 4/6, 4/7, 4/8

Network

PUBLIC, PRIVATE

Spreading Factor (SF)

SF7 ~ SF 12

Bandwidth (BW)

125kHz, 250kHz, or 500kHz

Test Result information

Measured PER

Measured packet error rate

Elapsed Time

Elapsed Test time in millisecond unit.

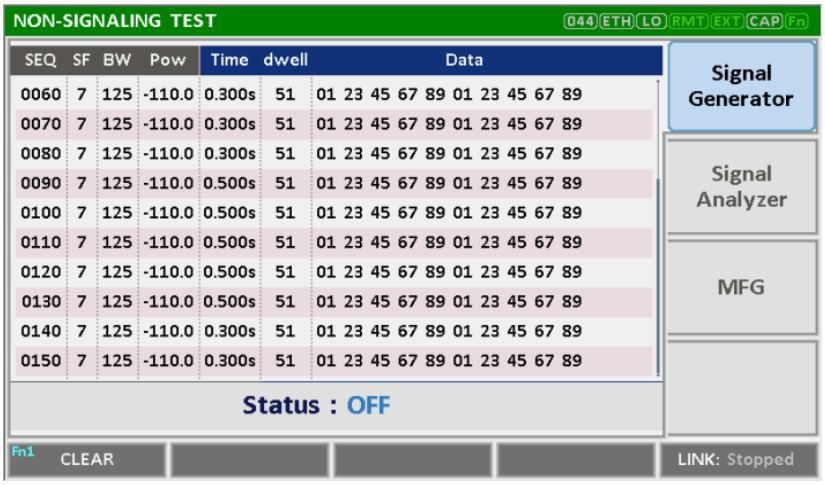

Fig 13. Screenshot of NST-RX test of RWC5020x

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