

Testing of LoRa[®] in Development & Manufacturing



RedwoodComm

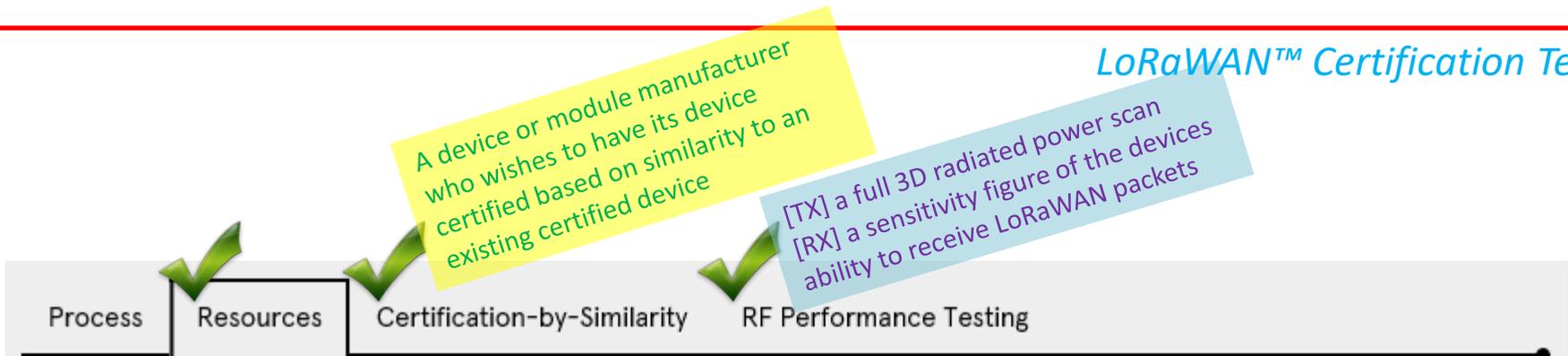
Contents

LoRaWAN™ Certification Tests

- **LoRaWAN™ Certification Tests**
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 - RF Performance
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 - Necessity of Pre-Certification
 - Requirement of Pre-Certification Tester
 - Pre-Certification & RF Performance Tests
- **Semtech's Gateway Tests**
- **LBT Test**
- **Manufacturing Tests**

LoRa Alliance Certification Standards

LoRaWAN™ Certification Tests



The documents below are available to all LoRa Alliance Members and can be found in the All Members/Certification folder within the Member Portal:

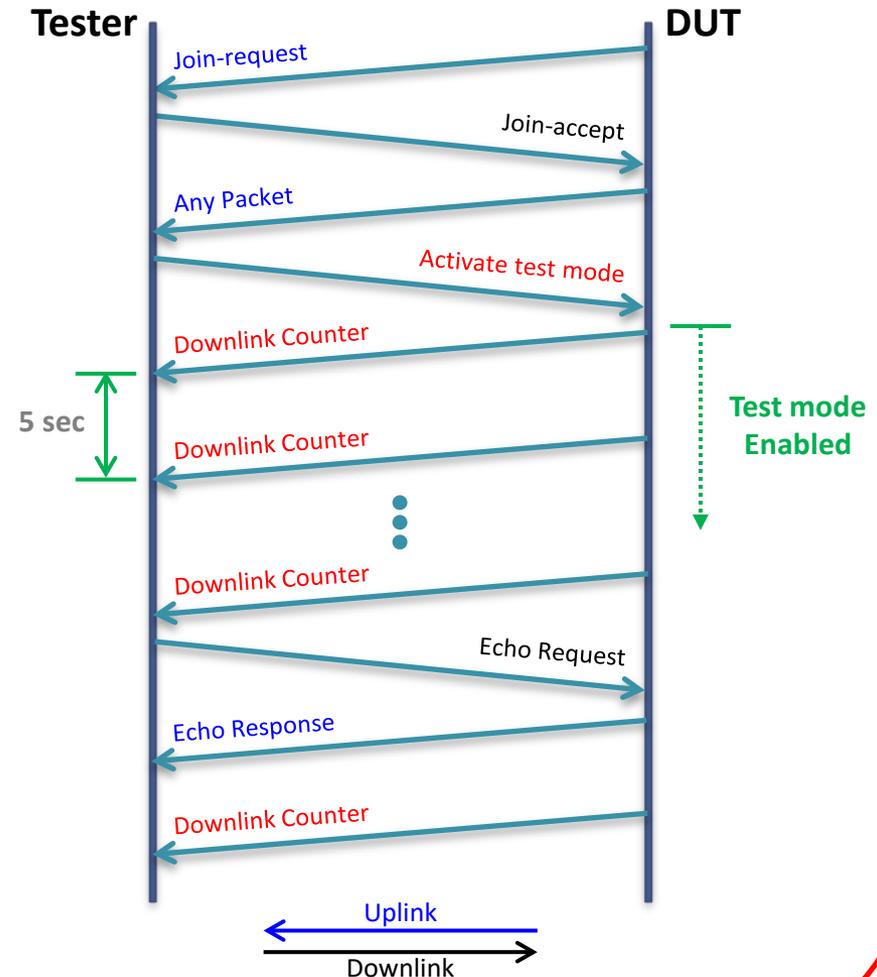
- [LoRa Alliance Certification Policies and Procedures](#) document*
- [LoRa Alliance European EU 863–870MHz Region End Device Certification Requirements](#) document V1.5*
- [LoRa Alliance US902–928MHz Region End Device Certification Requirements](#) document V1.3*
- [LoRa Alliance Asia AS 923MHz Region End Device Certification Requirements](#) document V1.1*
- [LoRa Alliance South Korea 920–923MHz Region End Device Certification Requirements](#) document V1.2*
- [LoRa Alliance India IN865–867MHz Region End Device Certification Requirements](#) document 1.0*
- [LoRa Alliance Customer Questionnaire V2.0](#) document*
- GitHub link to reference code <https://github.com/Lora-net>

*Documents are exclusively available to LoRa Alliance Members via the Member Portal

Overview of LoRa[®] Certification Test

LoRaWAN[™] Certification Tests

- Purpose
 - To confirm the End Device meets the Functional Requirements of the LoRaWAN[™] protocol specification
- Test Mode Activation
 - End Device should support test mode
 - Should periodically report the number of DL packets using Downlink_Counter packet
 - Should support Echo commands; EchoRequest & EchoResponse



Protocol Certification Test (e.g. EU)

LoRaWAN™ Certification Tests

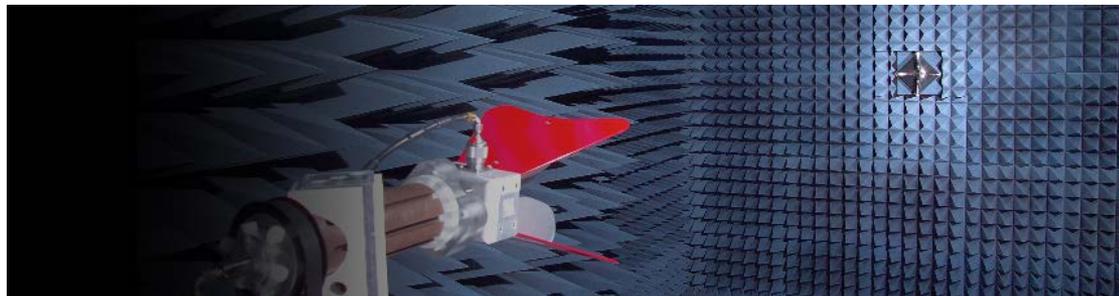
- Test Application Functionality
 - Periodic downlink_counter, Echo command
- Over The Air Activation
- Cryptography
 - AEC encryption, MIC
- Downlink window timing
 - Timing offset tolerance
- Frame sequence number
 - FCntUp, FCntDown
- MAC commands
 - DevStatusReq, Invalid Command, NewChannelReq, RXParamSetupReq, LinkADDRReq
- Confirmed Packets
 - Acknowledgement, UL/DL retransmission
- Packet Error Rates
 - SF12~SF7 for RX1 and RX2 windows, at least 60 DL packets, 95% reception

RF Performance Tests

Optional

LoRaWAN™ Certification Tests

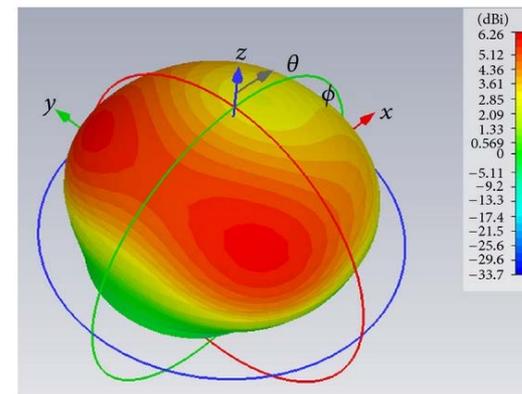
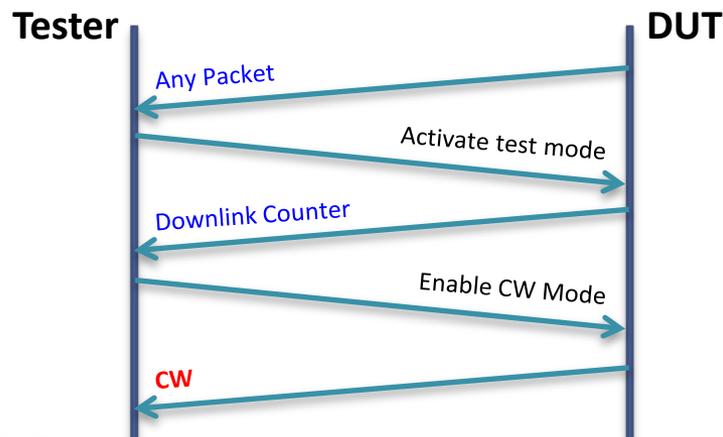
- Main Requirement
 - For the 868 MHz ISM band, the device should not radiate in excess of 14 dBm (or 25 mW) ERP for any orientation
 - Receiver performance is important as Transmitter
- The pass/fail criteria is deliberately not defined by the LoRa Alliance™ (but requested by LoRaWAN™ operators)
- End-device Requirements for Testing
 - Should fulfil the LoRaWAN™ specification version 1.0.2 or newer
 - Should implement CW transmit mode via OTA commands
 - Should integrate the antenna or at least provide one



Transmitter Performance

LoRaWAN™ Certification Tests

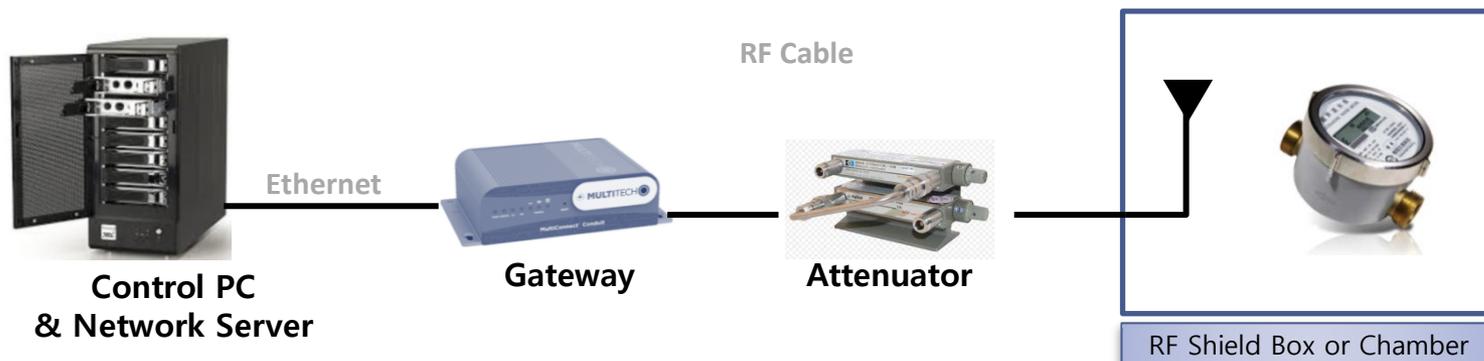
- Channels
 - 863.1 MHz (low), 868.3 MHz (default, RX1 window), 869.525MHz (high, RX2 window)
- DUT should transmit CW signal (max output power)
- RMS detector is used (RBW: 100kHz)
- The result of the measurement shall be a full 3D radiation power pattern
 - $ERP(\varphi, \vartheta) = EIRP(\varphi, \vartheta) - G_{\text{dipole}}$
 - G_{dipole} : the gain of an ideal dipole antenna (2.15dBi)



Receiver Performance (1/2)

LoRaWAN™ Certification Tests

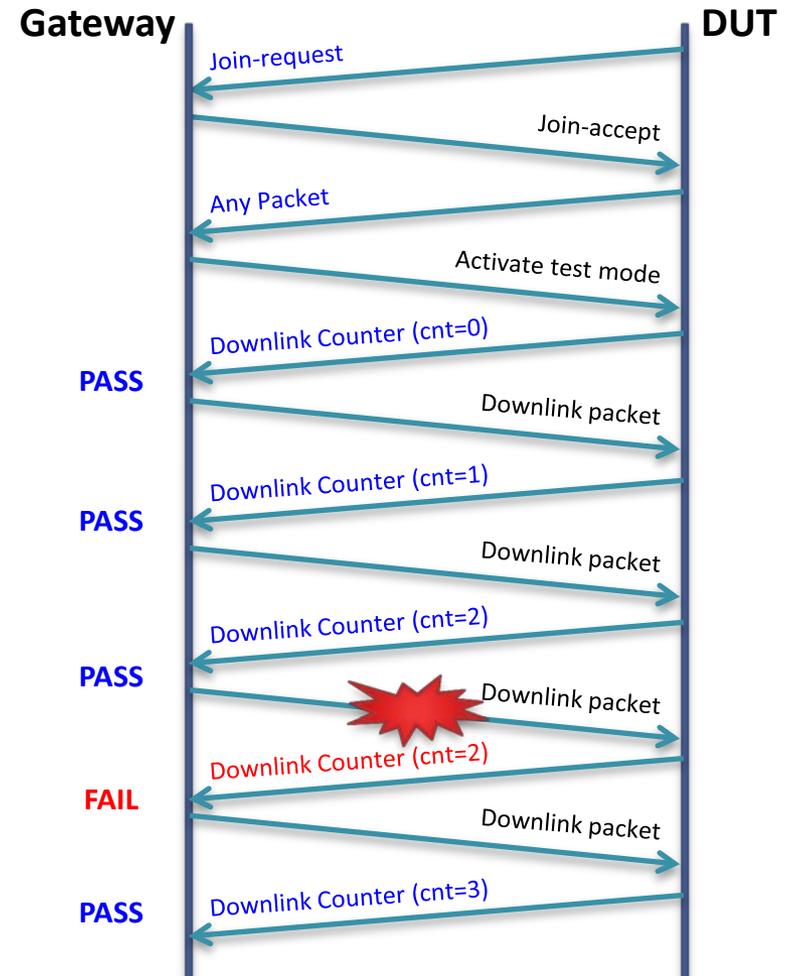
- RX performance is described with the effective isotropic sensitivity EIS (φ, ϑ)
- RF Parameters
 - Channel: 868.3 MHz (RX1), 869.525 MHz (RX2)
 - BW: 125kHz
 - SF7(DR5) and SF12(DR0)
- The angle is chosen from a region where the antenna gain is stable



Receiver performance (2/2)

LoRaWAN™ Certification Tests

- Test at least 60 packets
- Sensitivity threshold
 - Attenuate the gateway TX power level with a precise RF step attenuators to achieve 90% reception of packets in the respective position of DUT
 - The power value is recorded along with the direction it has been measured



Contents

Pre-Certification Tests

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- **LBT Test**
- **Manufacturing Tests**

Development without Pre-Certification

Pre-Certification Tests

Development



Apply Certi



Testing



Certified



PASS

FAIL

Increase Cost & Time for Development



Development with Pre-Certification

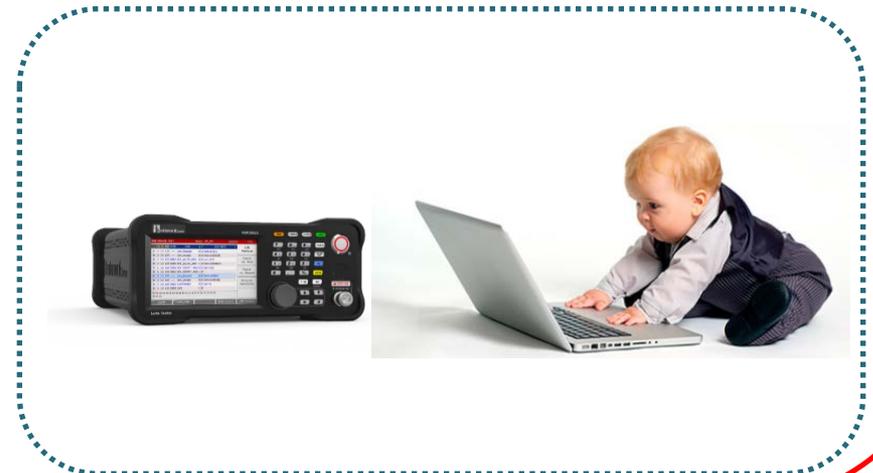
Pre-Certification Tests



Requirement of Pre-Certification Tester

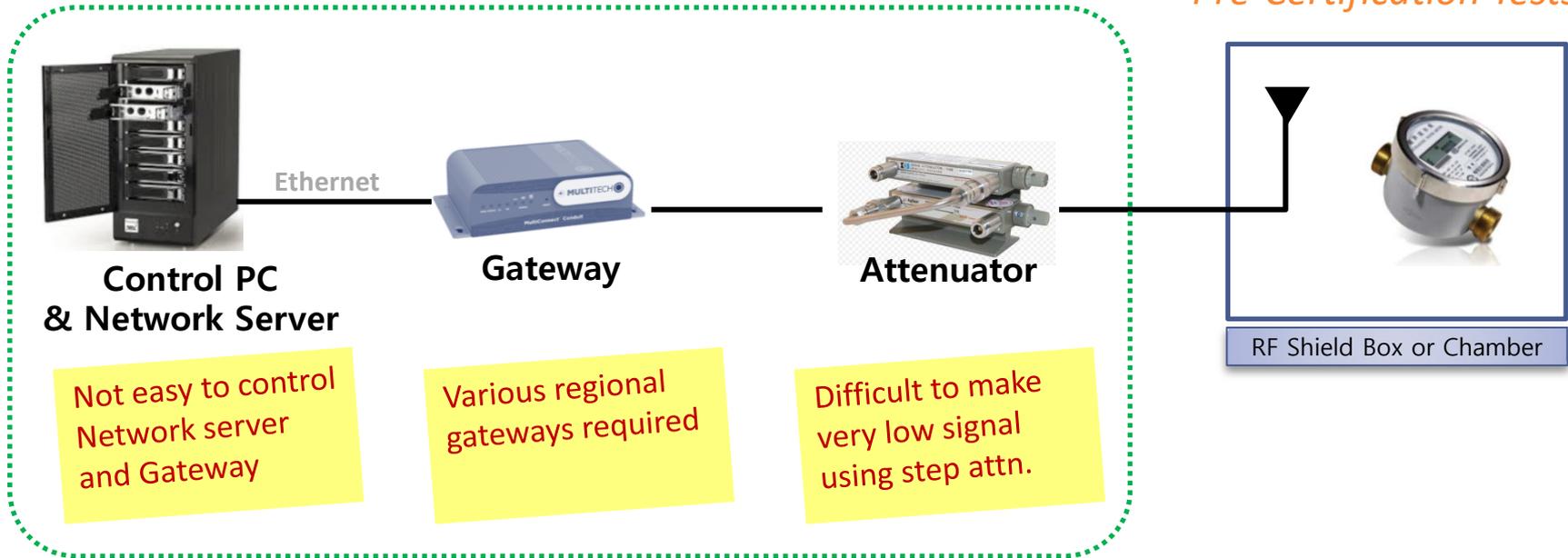
Pre-Certification Tests

- Fulfil LoRaWAN™ specification V1.0.2 or newer
 - Flexible configuration of protocol and test parameters
- Support various regions
- Accurate TX power control down to -150dBm
- Accurate RX power measurement
- Same Test Result as Certification Test system
- Easy to use, compact to move

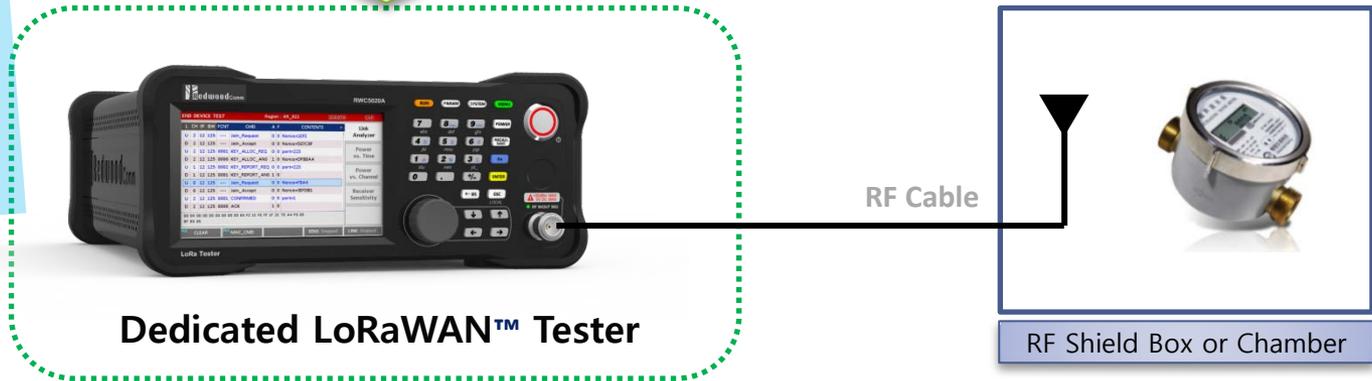


Why Need a Dedicated LoRaWAN™ Tester

Pre-Certification Tests



- ✓ Simple & compact
- ✓ Multiple regions
- ✓ -150dBm



LoRaWAN™ Pre-Certification Tests

Pre-Certification Tests

The screenshot displays the RedwoodComm LoRaWAN Autotest (Version: 1.151) interface. The main window title is "PRE-CERTIFICATION - EU_868 V1.5". The interface is divided into several sections:

- Header:** PROJECT: lora_demo_v1150, PATH: D:\RWC5020A\Software\lora_demo_v1150, DUT NAME: demo, REPORT PATH: D:\RWC5020A\Software\lora_demo_v1150\demo, FILE NAME: [blank].
- Navigation:** LoRa CERTIFICATION, PERFORMANCE, LINK ANALYZER, UTILITIES.
- Buttons:** CREATE REPORT, OPEN REPORT.
- Time Table:**

TIME	Estimated	Elapsed
Total	00:00:00	02:26:09
Curr-Item	00:00:00	00:00:00
- CERTIFICATION Panel:**
 - EU 868 (Selected)
 - US 915
 - AS 923
 - KR 920
 - IN 865
- START TEST EU Certification Test:**
 - Add raw data when testing
 - Stop link after test
 - Selected:0
 - Skip
 - LoRa Alliance Conformance Test (EU)
 - 1 Test Mode Activation
 - 2 Test Application Functionality
 - 3 Over The Air Activation
 - 4 Packet Error Rate RX2 default DR
 - 5 Cryptography
 - 6 Downlink Window Timing
 - 7 Frame Sequence Number
 - 8 DevStatusReq MAC Command
 - 9 MAC Commands
 - 10 NewChannelReq MAC command
 - 11 DChannelReq MAC command
 - 12 Confirmed packets
 - 13 RXParameterSetupReq MAC command
 - 14 RXTimingSetupReq MAC command
 - 15 LinkADRReq MAC command
 - 16 Packet error rate RX1 Window
 - 17 Packet error rate RX2 Window
 - Test Parameters: [1 Test Mode Activation] Default
 - Test Opt DR
 - Test ADR
- LORA CERTIFICATION TEST SUMMARY(EU V1.5):**

ITEMS	VERDICT	SUB VERDICT
1 Test Mode Activation	PASS	
1.1 Test Mode Activation		PASS
2 Test Application Functionality	PASS	
2.1 Test Echo Service		PASS
2.2 Test Downlink Counter		PASS
3 Over The Air Activation	PASS	
3.1 Over The Air Activation		PASS
4 Packet Error Rate RX2 default DR	PASS	
4.1 Packet Error Rate		PASS
5 Cryptography	PASS	
5.1 AES Encryption		PASS
5.2 Invalid Message Integrity Code		PASS
6 Downlink Window Timing	PASS	
6.1 Test RX1 Downlink at +20us		PASS
6.2 Test RX2 Downlink at +20us		PASS
6.3 Test RX1 Downlink at -20us		PASS
6.4 Test RX2 Downlink at -20us		PASS
7 Frame Sequence Number	PASS	
7.1 Uplink Sequence Number is Incrementing		PASS
7.2 End node Rejects a Frame with Decreasing Sequence Counter		PASS
8 DevStatusReq MAC Command	PASS	
8.1 DevStatusReq MAC Command		PASS
9 MAC Commands	PASS	
9.1 MAC Commands		PASS
10 NewChannelReq MAC command	PASS	
10.1 Test to modify read only default channel, try to remove CH 0		PASS
- Footer:** DUT Monitor, DUT PORT, [TEST TIME] Begin: [blank], Finish: [blank], View Remote Message

RF Performance Tests

Pre-Certification Tests

RedwoodComm : LoRaWAN Autotest (Version : 1.151)

PROJECT SETUP ABOUT PERFORMANCE 1.0.2 192.168.0.163:Not Connected

PROJECT lora_demo_v1150 DUT NAME demo NEW

REPORT PATH D:\RWC5020A\Software\lora_demo_v1150\demo FILE NAME

LoRa CERTIFICATION PERFORMANCE LINK ANALYZER UTILITIES

START TEST Show Result Graph CONFIG TEST

TEST MODE END DEVICE TEST REGION EU_868 CLASS Class A LoRaWAN 1.0.2 MODE OTAA SCENARIO NORMAL_UL Selected : 24

TEST CONDITIONS Default

Test Parameters (RX1)

DR	START	STOP	CRITERIA
DR0	-132.0	-141.0	-136.0
DR1	-129.0	-138.0	-133.0
DR2	-128.0	-137.0	-132.0
DR3	-125.0	-134.0	-129.0
DR4	-122.0	-131.0	-126.0
DR5	-119.0	-128.0	-123.0
DR6	-115.0	-124.0	-118.0
DR7	-100.0	-109.0	-103.0

STEP # POW # PKT PATHLOSS
1 10 60 0.0
TARGET PER 0.10
TARGET CHMSK 7 6 5 4 3 2 1 0
SCENARIO NORMAL_UL
PAYLOAD SIZE 16

Report Option
 Show Link message during test
 Paste tested Image after test

Receiver Sensitivity Test

PER using RX1 Window : PASS

DR	Start	Step	Stop	Target	#Pkt	Criteria	Result	Verdict
DR_0	-132.0	1.0	-141.0	0.1	60.0	-136	-137.0/0.016	PASS
DR_1	-129.0	1.0	-138.0	0.1	60.0	-133	-135.0/0.050	PASS
DR_2	-128.0	1.0	-137.0	0.1	60.0	-132	-132.0/0.050	PASS
DR_3	-125.0	1.0	-134.0	0.1	60.0	-129	-130.0/0.050	PASS
DR_4	-122.0	1.0	-131.0	0.1	60.0	-126	-127.0/0.050	PASS
DR_5	-119.0	1.0	-128.0	0.1	60.0	-123	-124.0/0.016	PASS
DR_6	-115.0	1.0	-124.0	0.1	60.0	-118	-121.0/0.100	PASS
DR_7	-100.0	1.0	-109.0	0.1	60.0	-103	-106.0/0.033	PASS

PER using RX2 Window : PASS

DR	Start	Step	Stop	Target	#Pkt	Criteria	Result	Verdict
DR_0	-132.0	1.0	-141.0	0.1	60.0	-136	-135.0/0.033	PASS
DR_1	-129.0	1.0	-138.0	0.1	60.0	-133	-133.0/0.033	PASS
DR_2	-128.0	1.0	-137.0	0.1	60.0	-132	-129.0/0.016	PASS
DR_3	-125.0	1.0	-134.0	0.1	60.0	-129	-127.0/0.000	PASS
DR_4	-122.0	1.0	-131.0	0.1	60.0	-126	-124.0/0.033	PASS

View Remote Message [TEST TIME] Begin : Finish :

DUT Monitor DUT PORT

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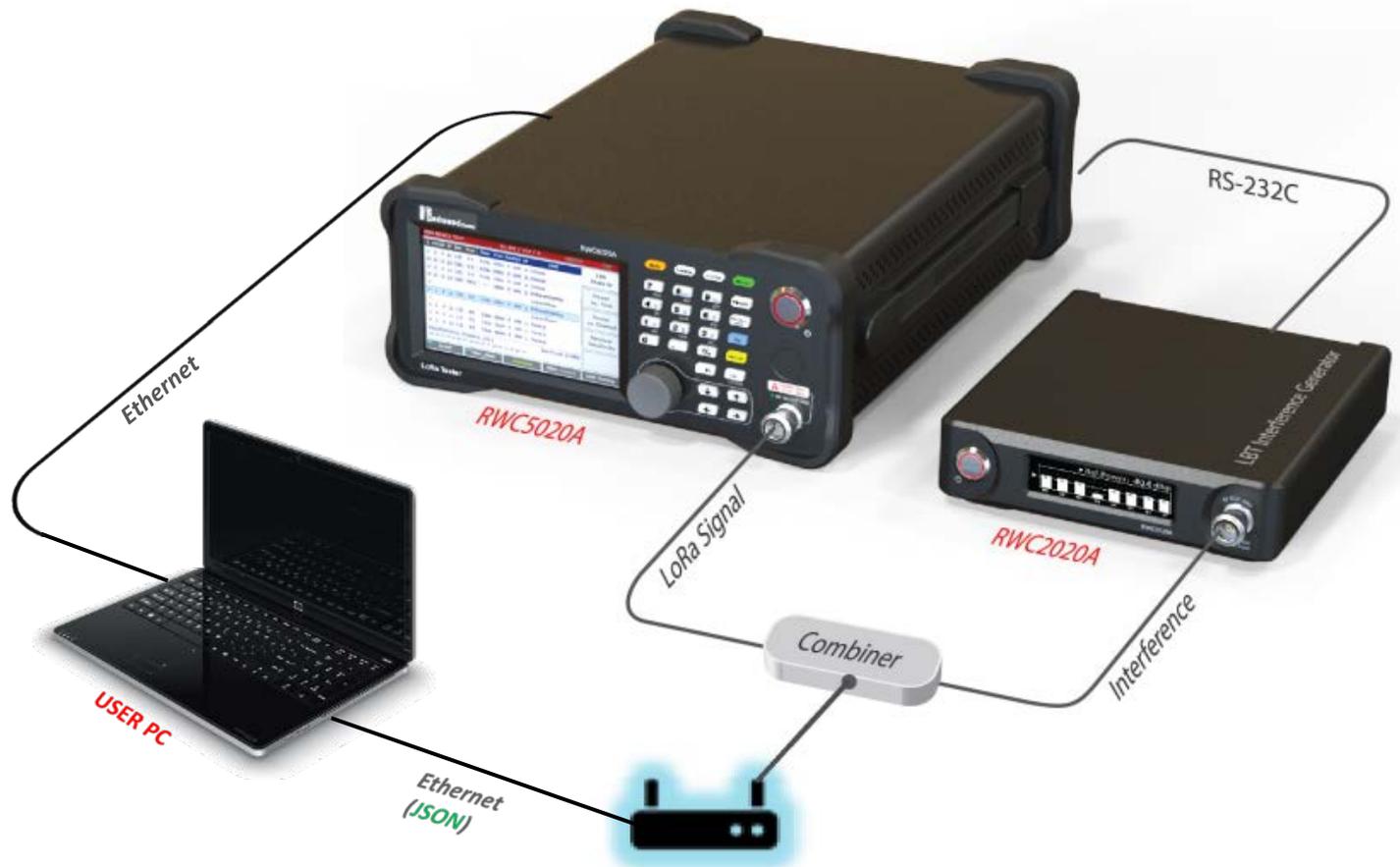
Test List

Semtech's Gateway Tests

- **GW V2 Non-regression Tests – EU 868**
 - TX output Power Calibration
 - Sensitivity
 - PER/RSSI/SNR
 - Frequency Error Tolerance
 - CW Interferer/Blocker Immunity

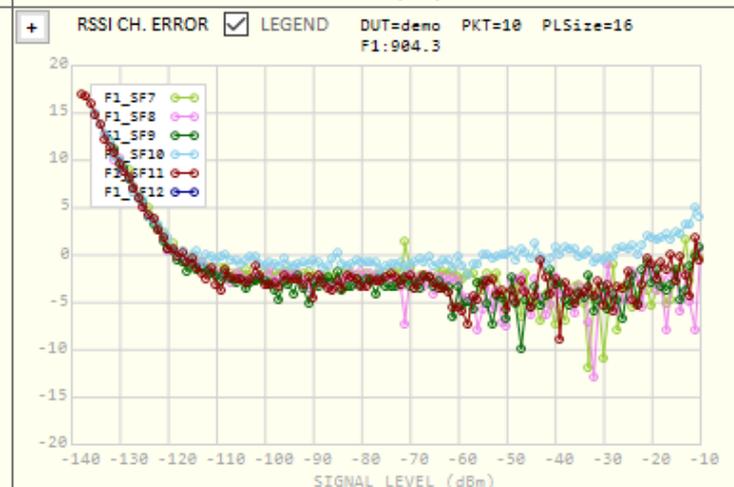
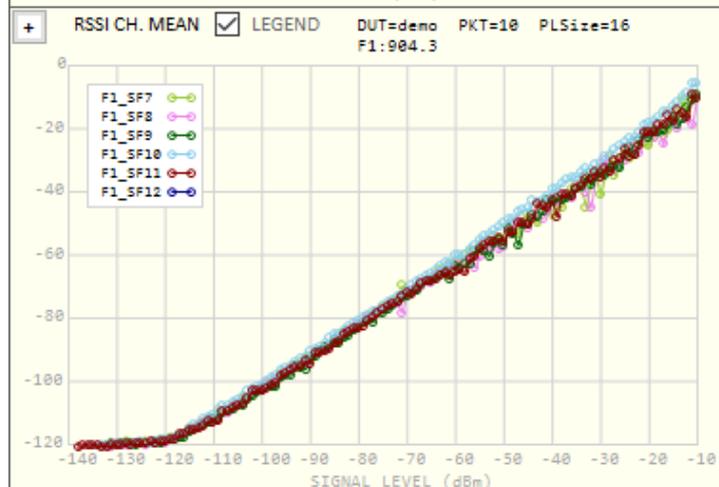
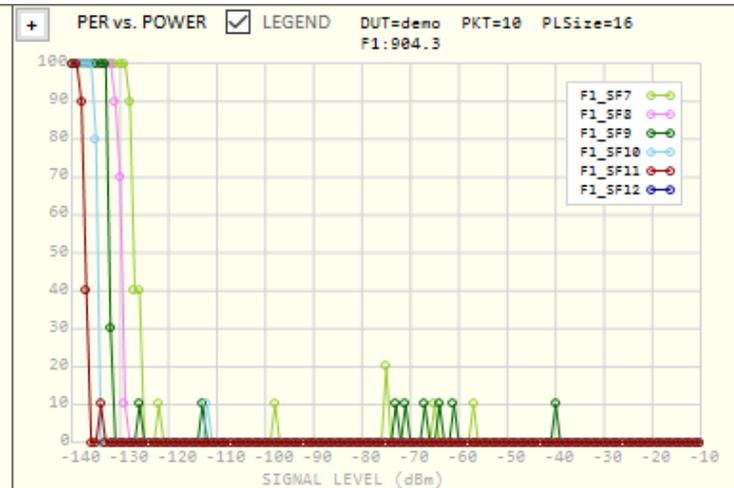
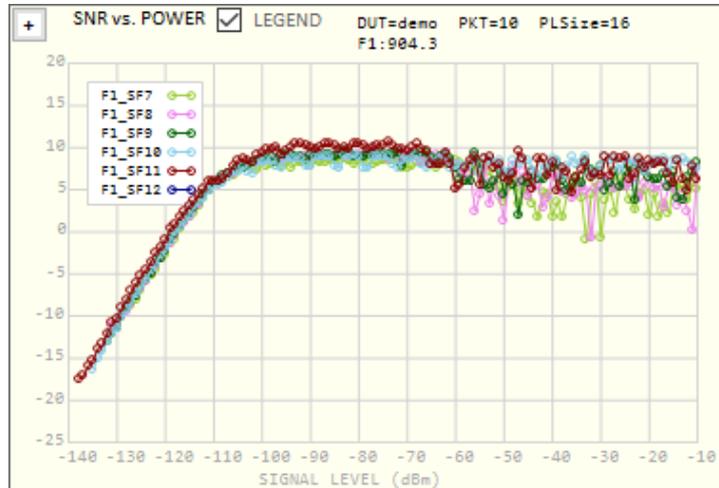
Test Setup

Semtech's Gateway Tests



Example. PER/RSSI/SNR

Semtech's Gateway Tests



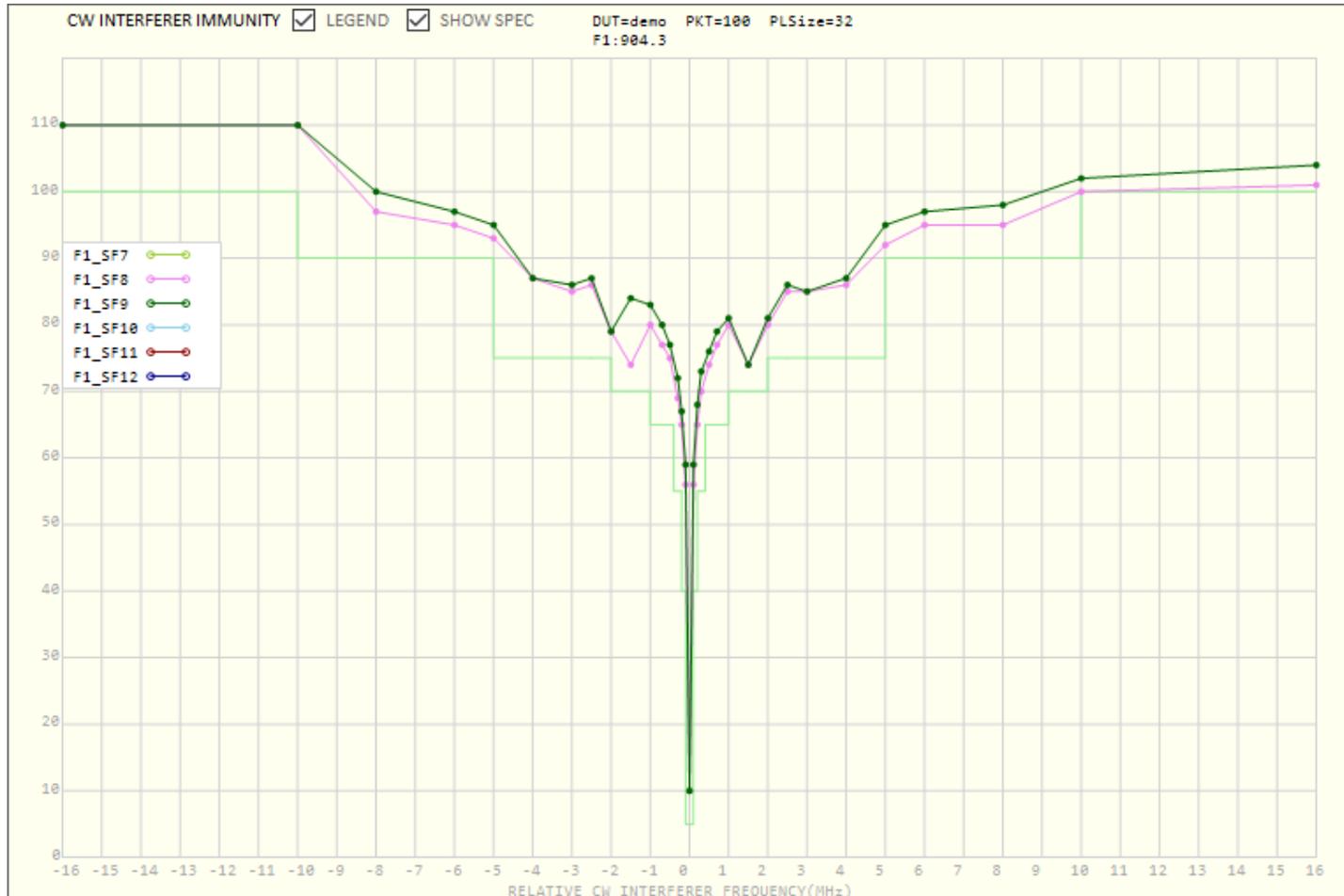
Example. Sensitivity

Semtech's Gateway Tests



Example. CW Interferer Immunity

Semtech's Gateway Tests



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LBT Test

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LBT

LBT Test

- Listen Before Talk
 - to prevent interference or collision between devices on common frequency channels
- How To Test LBT
 - Use RWC2020A Interference Generator as an interferer
 - For details, refer to the Local Regulations of Japan and Korea

LBT Test Setup

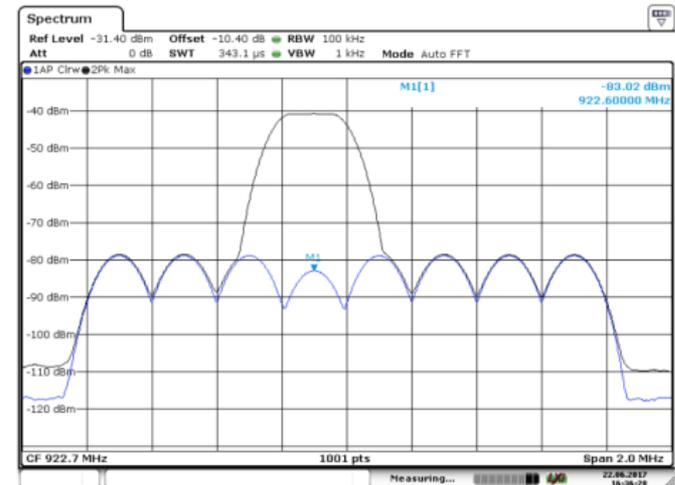
LBT Test



DUT should follow LBT AFA (Listen Before Talk Adaptive Frequency Agility) transmissions management



DUT(End-Device or Gateway)



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Manufacturing Tests

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Considerations on Manufacturing

Manufacturing Tests

- What needs to be tested in Production lines
 - Transmit Power
 - Receiver Sensitivity (PER)
- Selection of test mode
 - Test Time
 - Non-signaling mode is preferred than Signaling mode
 - Target Device Type
 - Non-signaling mode is applicable to both End-device and Gateway
 - Wired Control of DUT
 - It may increase test time and complexity
- Our Proposals for Automation
 - Separate T/RX Tests
 - Simultaneous T/RX Tests (called MFC Test)

Manufacturing Solution 1

Manufacturing Tests

- Separate T/RX Test with SG/SA



DUT
End-device or Gateway

SF, BW, length, ...
Frequency,
Low TX Power

Number of
packets

- Configure the test packet
 - Repeat sending packets
 - Stop
- Signal Generator**



- Enter **RX** Test Mode
- Count # of packets rcvd
- Calculate PER

Any form of LoRa test packets can be generated
with various flexible protocol parameters

SF, BW, ...
Frequency

- Configure the receiver
 - Measure TX Power
- Signal Analyzer**



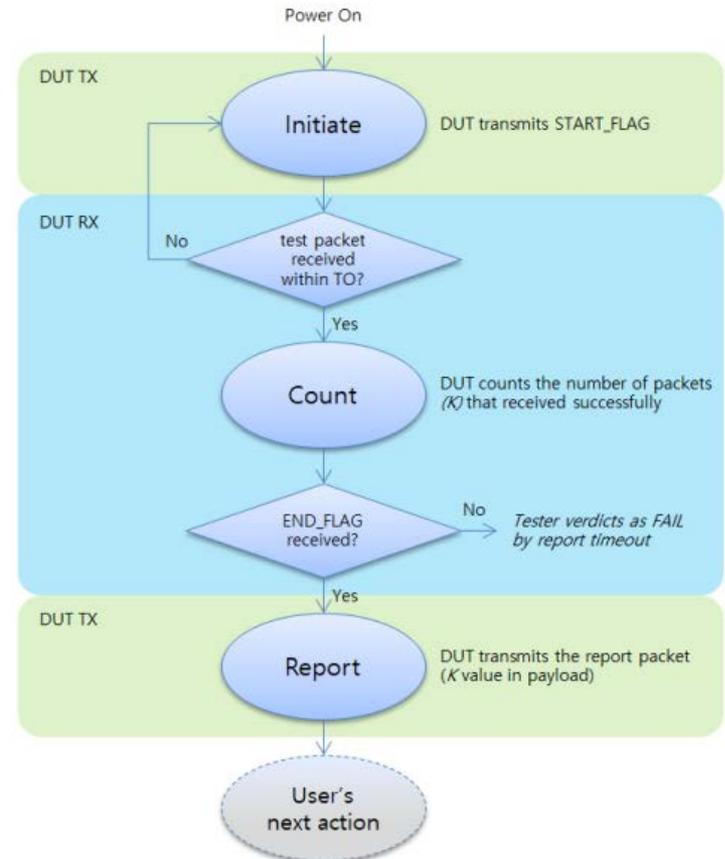
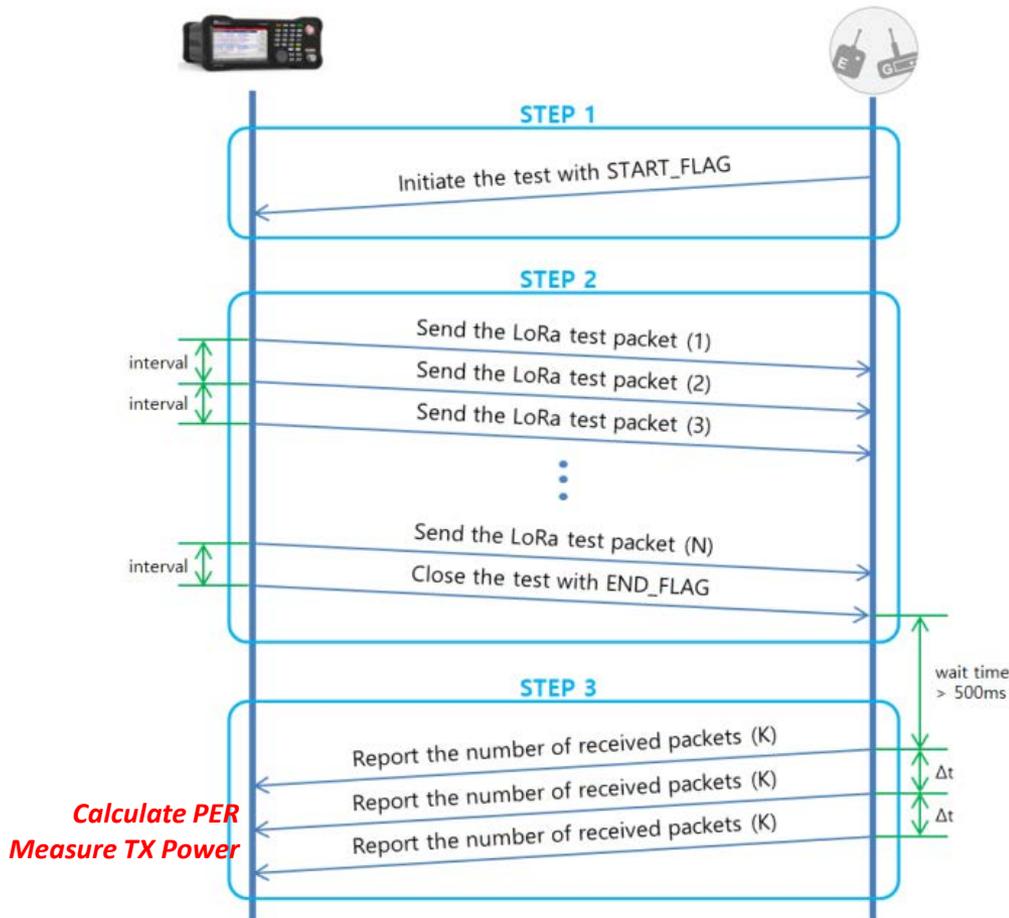
- Enter **TX** Test Mode
- Repeat sending packets
- Stop

Manufacturing Solution 2

Manufacturing Tests

- **Simultaneous T/RX Test with MFG**

Applicable to all LoRa products (end-devices & gateways)



Verified with customers' firmware!

Example of MFG Test Time

Manufacturing Tests

- Test time may depend on
 - SF
 - Payload length
 - Number of packets
 - Frame interval

Elapsed Test Time in sec

Number of packets	50	100	200
SF7	11	21	38
SF8	12	23	44
SF9	16	29	56
SF10	24	47	91
SF11	41	80	156
SF12	76	148	292

Determine the best test condition for your manufacturing tests!

Feedback

Thank you
&
Questions?

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