

Testing of LoRa in Development & Manufacturing



RedwoodComm

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Darby CHO

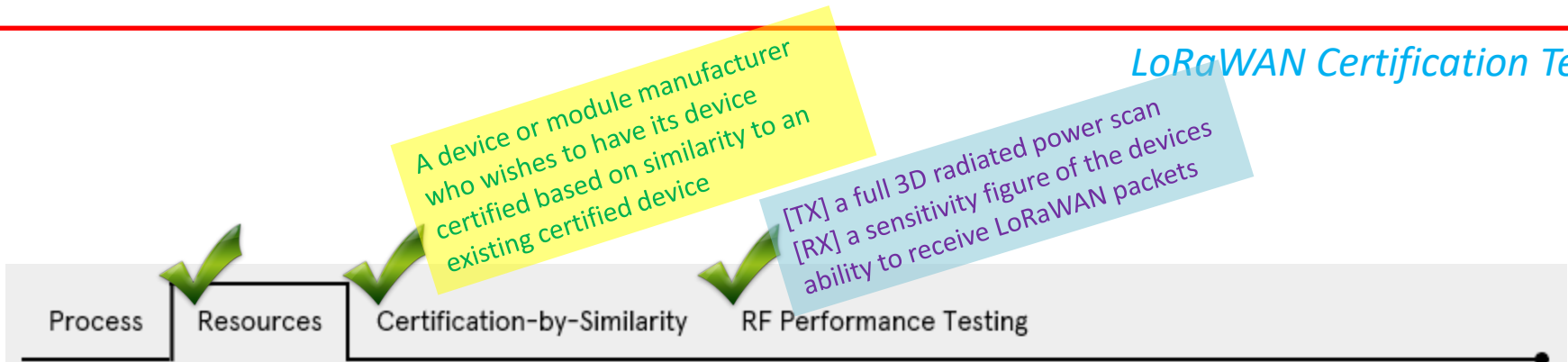
Contents

LoRaWAN Certification Tests

- **LoRaWAN Certification Tests**
 - Protocol Certification
 - RF Performance
- **Pre-Certification Tests**
 - Necessity of Pre-Certification
 - Requirement of Pre-Certification Tester
 - Pre-Certification & RF Performance Tests
- **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:

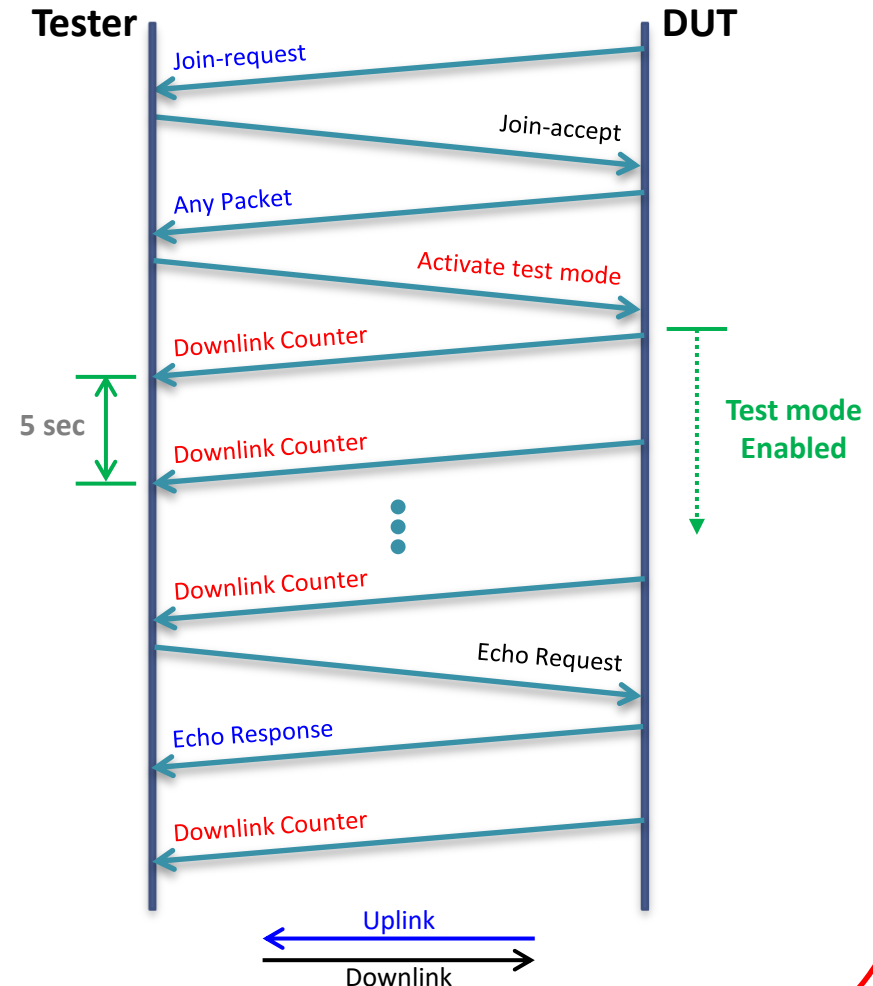
- [LoRa Alliance Certification Policies and Procedures](#) document*
- [LoRa Alliance European EU 863–870MHz Region End Device Certification Requirements](#) document V1.5*
- [LoRa Alliance US902–928MHz Region End Device Certification Requirements](#) document V1.3*
- [LoRa Alliance Asia AS 923MHz Region 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

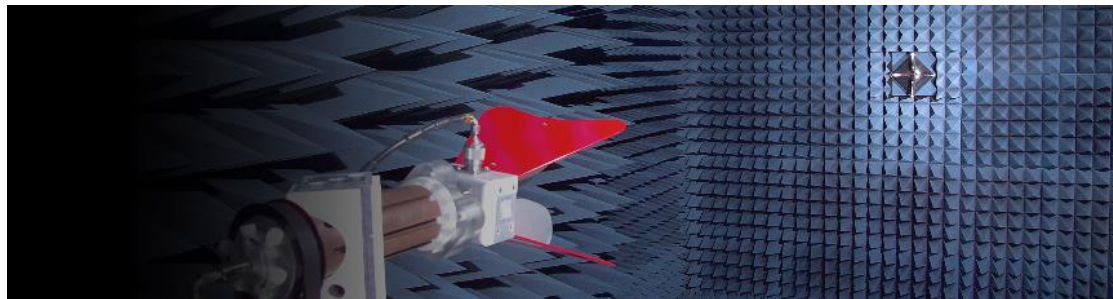
- Test Application Functionality
 - Periodic downlink_counter, Echo command
- Over The Air Activation
- Cryptography
 - AEC encryption, MIC
- Downlink window timing
 - Timing offset tolerance
- Frame sequence number
 - FCntUp, FCntDown
- MAC commands
 - DevStatusReq, Invalid Command, NewChannelReq, RXParamSetupReq, 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

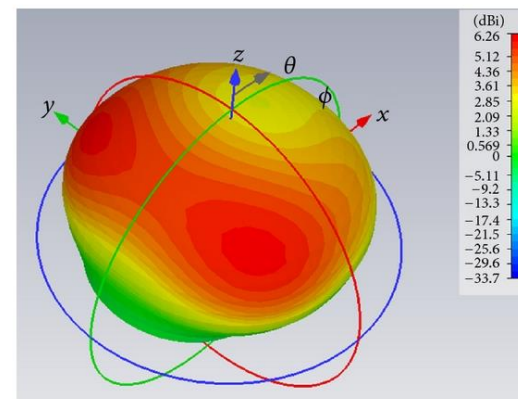
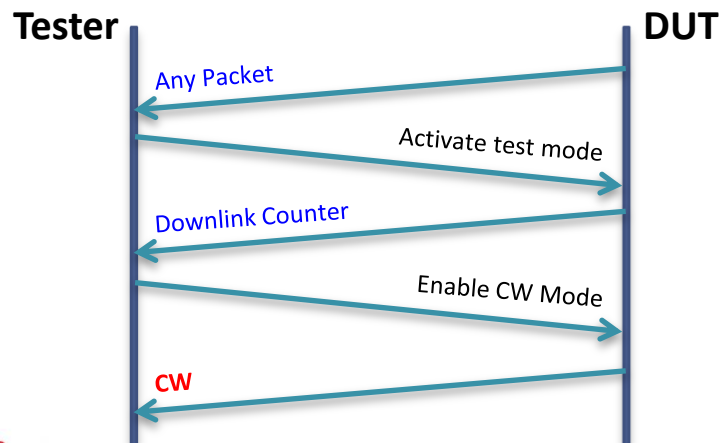
- Main Requirement
 - For the 868 MHz ISM band, the device should not radiate in excess of 14 dBm (or 25 mW) ERP for any orientation
 - Receiver performance is important as Transmitter
- The pass/fail criteria is deliberately not defined by the LoRa Alliance (but requested by LoRaWAN operators)
- End-device 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

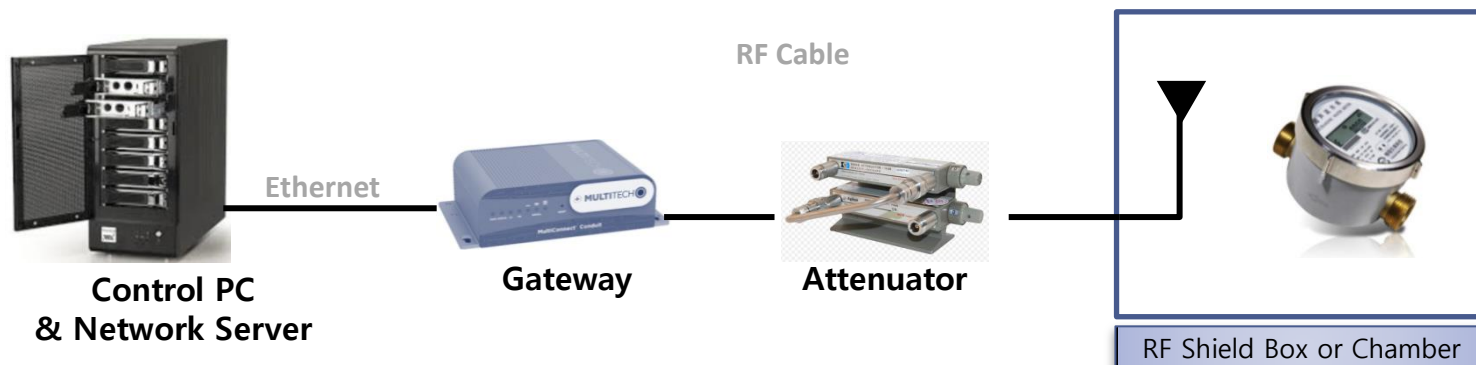
- Channels
 - 863.1 MHz (low), 868.3 MHz (default, RX1 window), 869.525MHz (high, RX2 window)
- DUT should transmit CW signal (max output power)
- RMS detector is used (RBW: 100kHz)
- The result of the measurement shall be a full 3D radiation power pattern
 - $ERP(\varphi, \vartheta) = EIRP(\varphi,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



Receiver Performance (1/2)

LoRaWAN Certification Tests

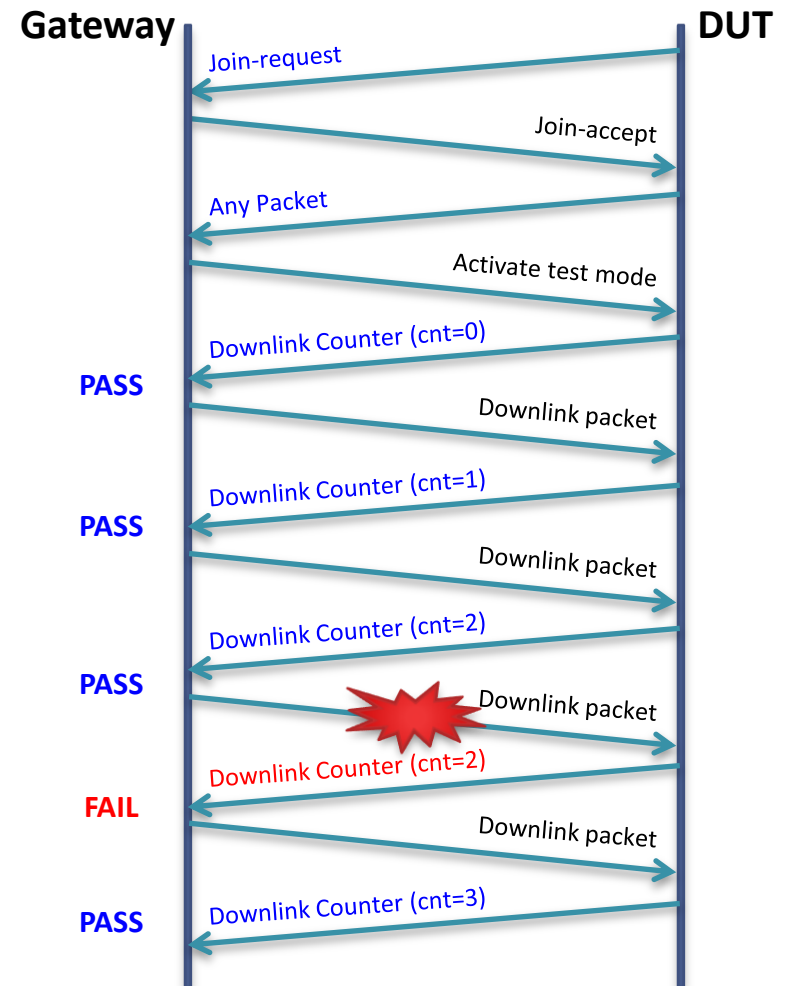
- RX performance is described with the effective isotropic sensitivity EIS (φ, ϑ)
- RF Parameters
 - Channel: 868.3 MHz (RX1), 869.525 MHz (RX2)
 - BW: 125kHz
 - SF7(DR5) and SF12(DR0)
- The angle is chosen from a region where the antenna gain is stable



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



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Pre-Certification Tests

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Development without Pre-Certification

Pre-Certification Tests

Development



Apply Certi



Testing



Certified



PASS

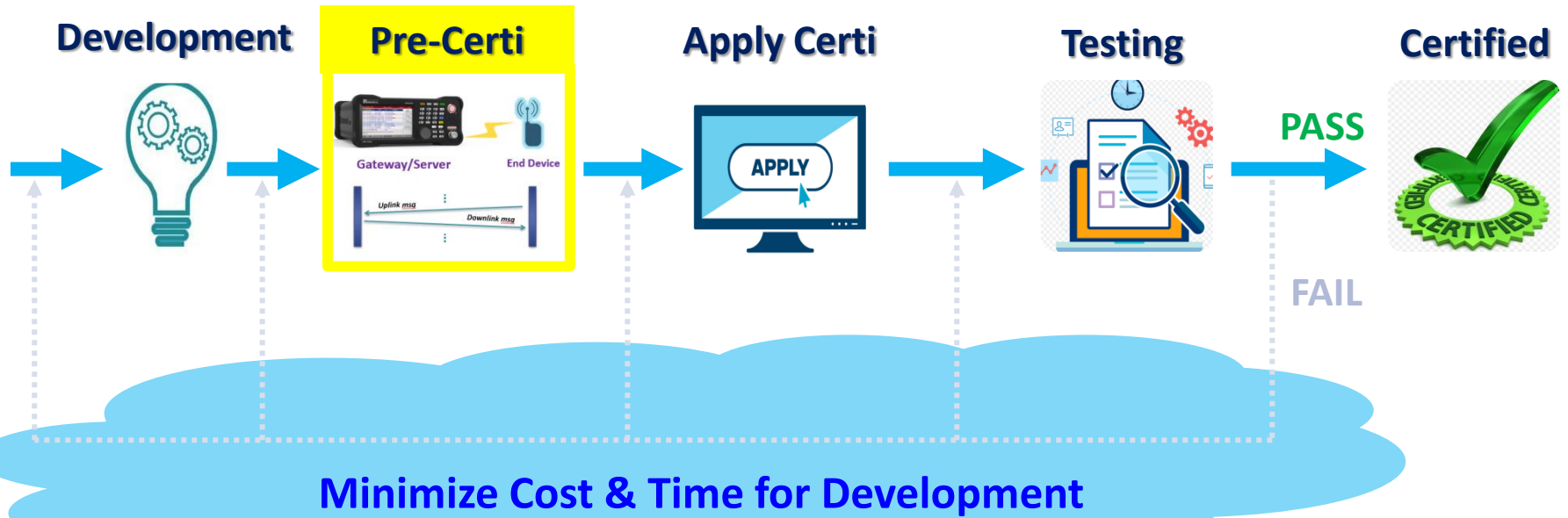
FAIL

Increase Cost & Time for Development



Development with Pre-Certification

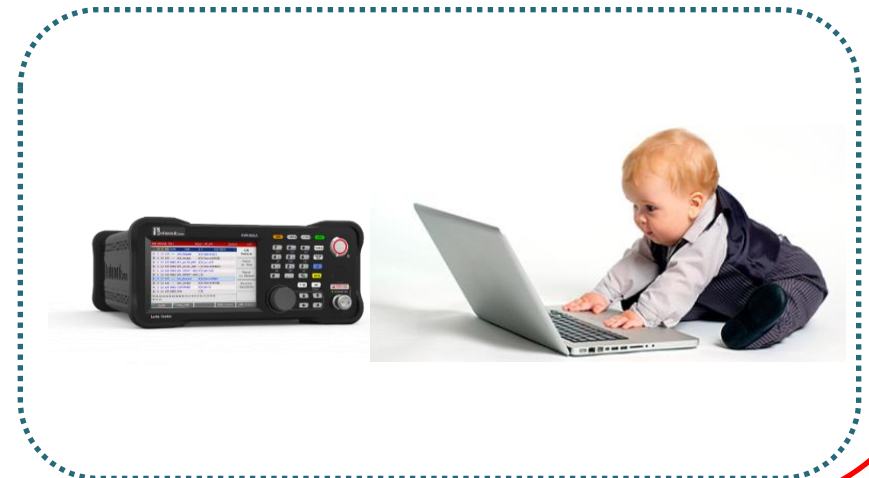
Pre-Certification Tests



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 LoRa Tester

Pre-Certification Tests



Control PC & Network Server

Not easy to control Network server and Gateway

Ethernet



Gateway

Various regional gateways required



Attenuator

Difficult to make very low signal using step attn.



RF Shield Box or Chamber



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



Dedicated LoRa Tester

RF Cable



RF Shield Box or Chamber

LoRa Pre-Certification Tests

Pre-Certification Tests

RedwoodComm : LoRa Autotest (Version : 1.10a)

PROJECT SETUP ABOUT CERTIFICATION - EU_868 V1.5 192.168.0.217-RWC5020A LoRa Tester, Ver=1.065,SN=RWC50201780011

PROJECT lora_demo DUT NAME DUT_00 NEW REPORT PATH D:\RWC5020A\Software\lora_demo\DUT_00 FILE NAME

LoRa CERTIFICATION PERFORMANCE LINK ANALYZER UTILITIES CREATE REPORT OPEN REPORT

CERTIFICATION EU Certification Test V1.5 START TEST Control DUT

Expand All Collapse All Selected:53 SKIP

- LoRa Alliance Conformance Test (EU)
 - 1 Test Mode Activation
 - 1.1 Test Mode Activation
 - 2 Test application functionality
 - 2.1 Test echo servcie
 - 2.2 Test downlink counter
 - 3 Over The Air Activation
 - 3.1 Over The Air Activation
 - 4 Packet Error Rate RX2 SF12
 - 4.1 Packet Error Rate
 - 5 Cryptography
 - 5.1 AES Encryption
 - 5.2 Invalid Message Integrity Code
 - 6 Downlink Window Timing
 - 6.1 Test RX1 downlink at +20 microseconds
 - 6.2 Test RX2 downlink at +20 microseconds
 - 6.3 Test RX1 downlink at -20 microseconds
 - 6.4 Test RX2 downlink at -20 microseconds
 - 7 Frame Sequence Number
 - 7.1 Uplink sequence number is incrementing
 - 7.2 End node rejects a frame with decreasing sequence counter
 - 8 Device Status Request
 - 8.1 DevStatusReq MAC Command
 - 9 MAC Commands

Test Parameters [1 Test Mode Activation] PathLoss 0.0 Default

Test Information
 REGION EU_868
 PLOSS 0
 OTA/ABP OTAA
 DUT CMD UnLoaded
 DUT VENDOR

CONFIG

DUT Monitor DUT PORT

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 servcie		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 SF12	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 +20 microseconds		PASS
6.2 Test RX2 downlink at +20 microseconds		PASS
6.3 Test RX1 downlink at -20 microseconds		PASS
6.4 Test RX2 downlink at -20 microseconds		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 Device Status Request	PASS	

CLEAR MON MSG
 CLEAR SPY MSG
 SAVE SPY MSG

View Remote Message [TEST TIME] Begin :
 Finish :

RF Performance Tests

Pre-Certification Tests

RedwoodComm : LoRa Autotest (Version : 1.10a)

PROJECT SETUP ABOUT **PERFORMANCE V1.0.2** 192.168.0.217-RWC5020A LoRa Tester, Ver=1.065,SN=RWC50201780011

PROJECT lora_demo DUT NAME DUT_00 NEW REPORT PATH D:\RWC5020A\Software\lora_demo\DUT_00 FILE NAME

LoRa CERTIFICATION PERFORMANCE LINK ANALYZER UTILITIES CREATE REPORT OPEN REPORT

START TEST CONFIG TEST Control DUT Show Result Graph

REGION EU_868 DUT TYPE END DEVICE CLASS Class A LoRaWAN V1.0.2 MODE OTAA SCENARIO CERTI_ECHO DUT CMD UnLoaded

TEST CONDITIONS Default

Test Parameters (RX1)

Change SF during test

	START	STOP	CRITERIA
SF12	-132.0	-141.0	-136.0
SF11	-129.0	-138.0	-133.0
SF10	-128.0	-137.0	-132.0
SF9	-125.0	-134.0	-129.0
SF8	-122.0	-131.0	-126.0
SF7	-119.0	-128.0	-123.0

STEP # POW # PKT PATHLOSS
1 10 60 0.0

RX2 Frequency 869.525

Target PER 0.10

Report Option

Show Link message during test
 Paste tested Image after test

Selected : 0

Receiver Sensitivity Test

PERFORMANCE TEST SUMMARY (DUT_00)

DUT NAME DUT_00
REGION EU_868
SCENARIO CERTI_ECHO

PER using RX1 Window : **PASS**

SF	Start	Step	Stop	Target	#Pkt	Criteria	Result	Verdict
SF12	-132.0	1.0	-141.0	0.1	60	-136.0	-139/0.050	PASS
SF11	-129.0	1.0	-138.0	0.1	60	-133.0	-136/0.000	PASS
SF10	-128.0	1.0	-137.0	0.1	60	-132.0	-133/0.100	PASS
SF9	-125.0	1.0	-134.0	0.1	60	-129.0	-130/0.000	PASS
SF8	-122.0	1.0	-131.0	0.1	60	-126.0	-128/0.083	PASS

CLEAR MON MSG
CLEAR SPY MSG
SAVE SPY MSG

View Remote Message [TEST TIME] Begin : Finish :

DUT Monitor DUT PORT

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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
 - Non-signaling mode is applicable to both End-device and Gateway
- Automation
 - A wired control of DUT should be excluded
 - Simple protocol is required between DUT and the tester
 - Hence the firmware of DUT needs to be modified

MFG Test Solution of RWC5020A

RedwoodComm : LoRa Autotest (Version : 1.120a)

PROJECT SETUP ABOUT UTILITIES - MFG 192.168.0.180-RWC5020A LoRa Tester, Ver=1.120,SN=RWC50200000118

PROJECT lora_demo DUT NAME DUT_RWC
 PATH D:\RWC5020A\Software\lora_demo

LoRa CERTIFICATION PERFORMANCE LINK ANALYZER UTILITIES

CREATE REPORT OPEN REPORT

TIME	Estimated	Elapsed
Total	00:00:00	00:01:28
Curr-Item	00:00:00	00:00:22

UTILITIES

STOP CLEAR SAVE CONFIG

SEQ	TIME	DATA	POW	PER	VERDICT
0	00:00:22	Serial:000	8.9	0.000	PASS
1	00:00:22	Serial:001	8.9	0.000	PASS
2	00:00:22	Serial:002	8.9	0.000	PASS

SCR. CAPTURE
 TESTER CTRL
 DUT CTRL
 MFG

Quick measurement using MFG scenario

MFG Measurement Manufacturing Mode

PL:0xFFFF|USERDATA (MEAS_START_FLAG)

Interval PL:0
 Interval PL:1
 Interval PL:2
 ...
 PL:N-1
 PL:0xFFFF (MEAS_END_FLAG)

Wait Timer PL:K
 PL:K
 PL:K

CLEAR MON MSG 0.000
 READ:NST:MFG:POW?
 8.9

CLEAR SPY MSG
 READ:NST:MFG:PER?
 0.000

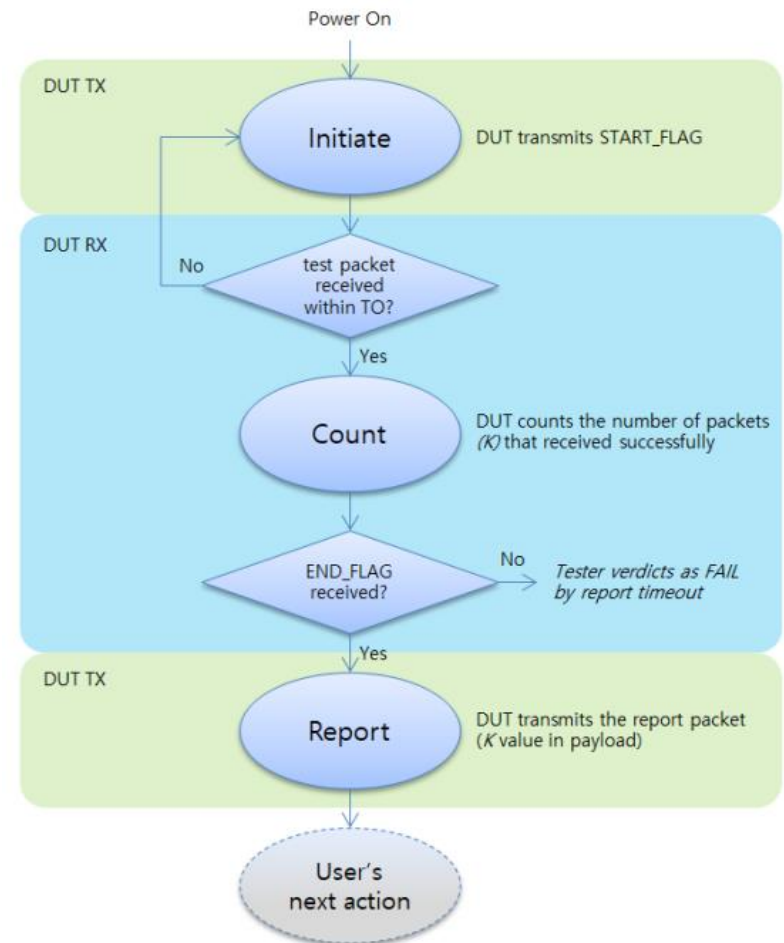
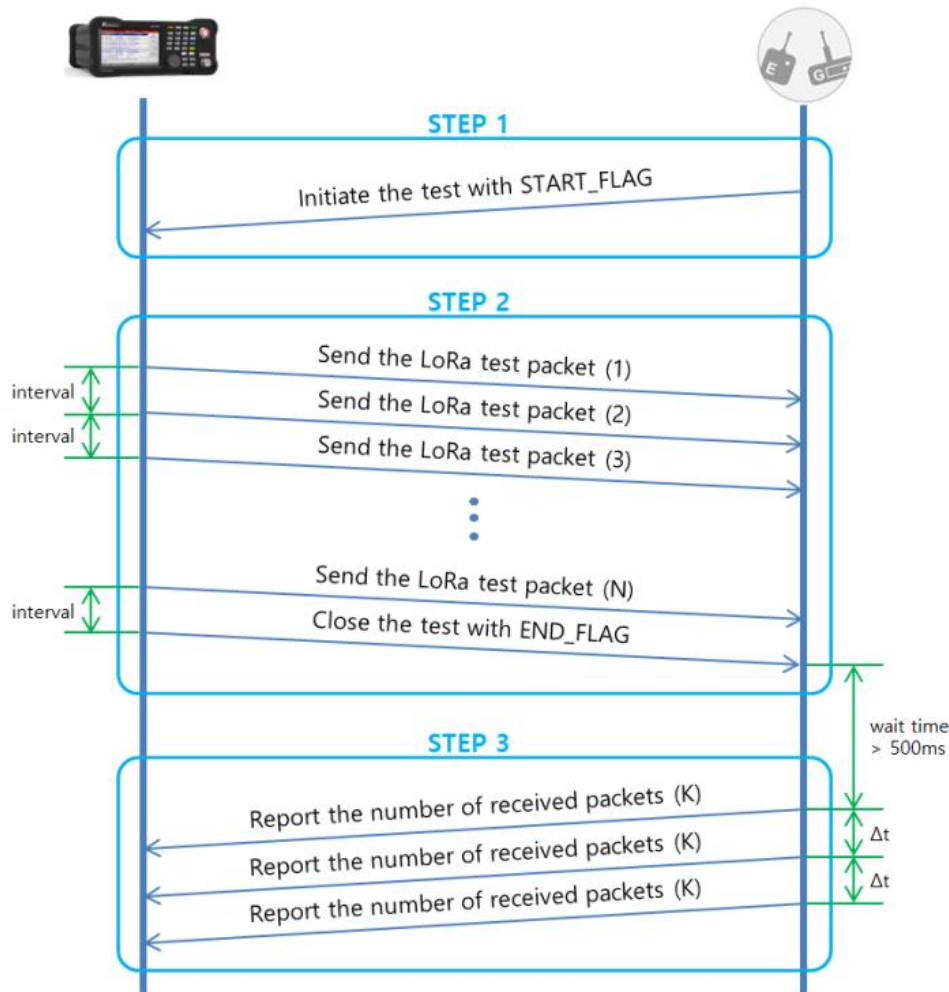
SAVE SPY MSG

View Remote Message [TEST TIME] Begin :
 Finish :

DUT Monitor DUT PORT

Test Procedure & State Diagram

Manufacturing Tests



Verified with customers' firmware!

Example of 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

Questions?

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