# LoRaWAN
# TEST SOLUTION

RedwoodComm is a professional developing company for wireless communication test solution. RedwoodComm develops and provides measurement system for R&D, mass-production of broadcast system and wireless communications such as DAB, DRM, RDS, NFC and LoRa technologies.

We will keep making every effort to be the world best company of test & measurement system based on technical know-how and experience of test & measurement system for wireless communications.

## Wide Area Network for IoT

**LoRaWAN**®

## RWC5020B
LoRaWAN Tester

RWC5020B is a compact all-in-one tester, providing a perfect solution for test and measurement of LoRa and LoRaWAN technology, which is fully suitable for R&D, QC, and manufacturers.

It provides various test functions that can be performed in signaling mode, e.g. including activation procedures, as well as non-signaling mode. Automated PC software will help users test and debug their devices by performing pre-certification tests, as specified by LoRa Alliance.

# LoRaWAN Compliance

## Confirming that the end device meets the functional requirements of the LoRaWAN® protocol specification

RWC5020B certification test is recommended for purpose of pre-qualification. Some of certificaion test items could be limited or not fully covered due to the limitation of maximum number of channels supported simultaneously.

## Supported Pre-certification Test Option

LoRa Alliance European EU 863-870MHz Region End Device Certification Requirements V1.5
LoRa Alliance US + Canada US902-928MHz Region End Device Certification Requirements V1.3
LoRa Alliance Asia AS 923MHz Region End Device Certification Requirements V1.1
LoRa Alliance South Korea 920-923MHz Region End Device Certification Requirements  V1.2
LoRa Alliance India 865-867MHz Region End Device Certification Requirements V1.1

## Supported LoRaWAN® Region

EU 868 // EU 433 // US 915 // AU 915 // CN 470 // KR 920 // AS 923 // IN 865 // RU 864 // KZ 865
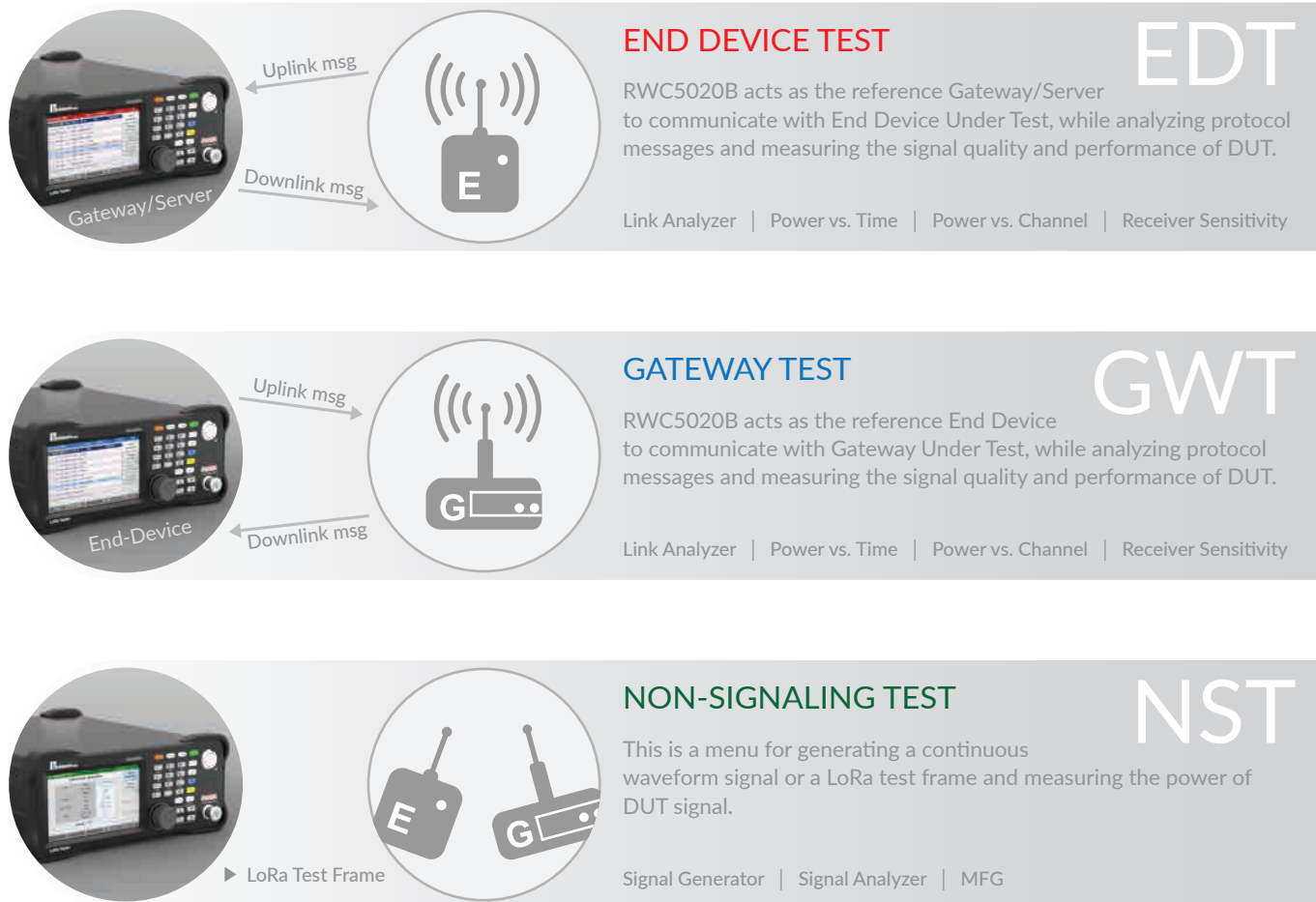
## Supported LoRaWAN®  Protocol

Compatible with LoRaWAN version of V1.0.2, V1.0.3 and V1.1
support of Class A, Class B and Class C

## MAIN MENU
## 3 OPERATIONAL MODES

### END DEVICE TEST
# EDT

RWC5020B acts as the reference Gateway/Server to communicate with End Device Under Test, while analyzing protocol messages and measuring the signal quality and performance of DUT.

Uplink msg

Downlink msg

Gateway/Server

E

Link Analyzer | Power vs. Time | Power vs. Channel | Receiver Sensitivity

### GATEWAY TEST
# GWT

RWC5020B acts as the reference End Device to communicate with Gateway Under Test, while analyzing protocol messages and measuring the signal quality and performance of DUT.

Uplink msg

Downlink msg

End-Device

G

Link Analyzer | Power vs. Time | Power vs. Channel | Receiver Sensitivity

### NON-SIGNALING TEST
# NST

This is a menu for generating a continuous waveform signal or a LoRa test frame and measuring the power of DUT signal.

▶ LoRa Test Frame

E  G

Signal Generator | Signal Analyzer | MFG

# LoRa/LoRaWAN Test Solutions

### Protocol Test Solutions
Support of LoRaWAN Pre-Certification Tests – EU V1.5, US/CA V1.3, AS V1.1, KR V1.2 and IN V1.1
Scriptable scenario for transmission of MAC commands and user data (or application data)

### RF Test Solutions
RF Performance Tests for End-device – TX Power and RX Sensitivity (downlink: RX1, RX2 or Ping-slot)
RF Performance Tests for Gateway – TX Power and RX Sensitivity (uplink)
Semtech's Non-regression Tests for Gateway – integrated with RWC2020A Interference Generator
LBT Test Solution for end-devices and gateways – integrated with RWC2020A Interference Generator

### Manufacturing Test Solutions
Separate T/RX Tests with DUT controls – power, frequency, and sensitivity
Simultaneous T/RX Tests (MFG) without wired DUT controls

# Link Analyzer
## Analyzing frames for MAC/PHY analysis

RWC5020B provides a function of Link Analyzer for EDT and GWT. Link Analyzer in EDT (or GWT) helps to create a link between RWC5020B and an End Device (or Gateway/Server) Under Test and to analyze the protocol messages.
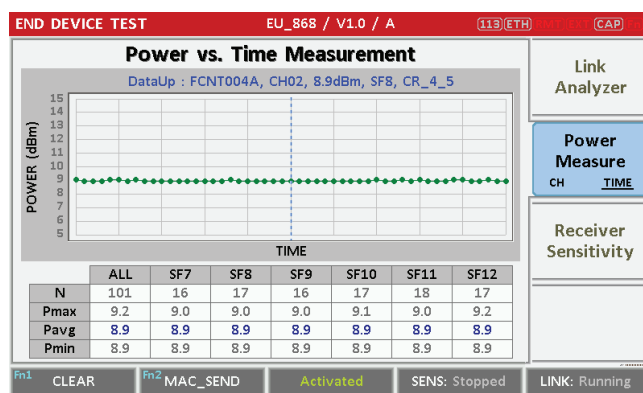
# Power vs. Time
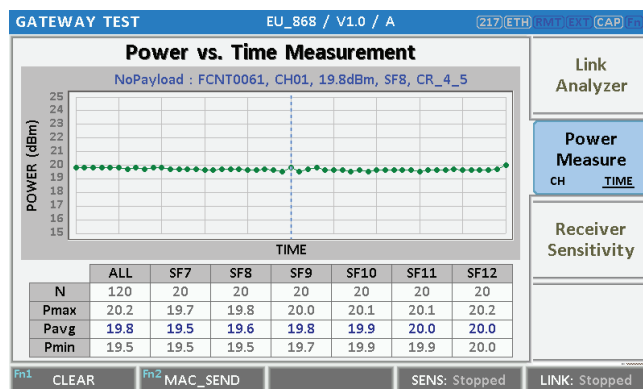## Continuously monitoring TX power of DUT with respect to data rates(SF)

RWC5020B provides a function of Power vs. Time measurement for EDT and GWT. Power vs. Time measurement in EDT (or GWT) helps to create a link between RWC5020B and an End Device (or Gateway/Server) Under Test and to measure the received power with respect to data rates.

### Link Analyzer for EDT

| L | CH | DR | SF | BW | Pow | Time | FCnt | Ack | Port | M | CMD |
|---|----|----|----|----|-----|------|------|-----|------|---|-----|
| U | 2 | 0 | 12 | 125 | 9.2 | 13.6s | 0000 | 0 | 000 | U | DeviceTimeReq |
| D | R2 | 0 | 12 | 125 | -50.0 | ---- | 0000 | 0 | 000 | U | DeviceTimeAns |
| D | B | 3 | 9 | 125 | -50.0 | ---- | ---- | 0 | --- | - | Beacon |
| U | 1 | 0 | 12 | 125 | 9.2 | 85.7s | 0001 | 0 | 000 | U | PingSlotInfoReq |
| D | R2 | 0 | 12 | 125 | -50.0 | ---- | 0001 | 0 | 000 | U | PingSlotInfoAns |
| U | 0 | 0 | 12 | 125 | 9.1 | 5.03s | 0002 | 0 | 000 | U | LinkCheckReq |
| D | R2 | 0 | 12 | 125 | -50.0 | ---- | 0002 | 0 | 000 | U | LinkCheckAns |
| D | B | 3 | 9 | 125 | -50.0 | ---- | ---- | 0 | --- | - | Beacon |
| D | P | 3 | 9 | 125 | -50.0 | ---- | 0003 | 0 | 000 | U | DevStatusReq |
| U | 1 | 0 | 12 | 125 | 9.2 | 146s | 0003 | 0 | 000 | U | DevStatusAns |

DutyCycle: 1.91%

60 01 00 00 00 80 03 00 00 06 DA BC 9B F8

END DEVICE TEST — EU_868 / V1.0 / B — [180] [ETH] [CAP]

Link Analyzer / Power Measure CH TIME / Receiver Sensitivity

Fn1 CLEAR | Fn2 MAC_SEND | Activated | SENS: Stopped | LINK: Run_30

Link Analyzer for EDT

### Power vs. Time for EDT

END DEVICE TEST — EU_868 / V1.0 / A — [113] [ETH] [CAP]

**Power vs. Time Measurement**
DataUp : FCNT004A, CH02, 8.9dBm, SF8, CR_4_5

POWER (dBm) axis: 5–15

| | ALL | SF7 | SF8 | SF9 | SF10 | SF11 | SF12 |
|------|-----|-----|-----|-----|------|------|------|
| N | 101 | 16 | 17 | 16 | 17 | 18 | 17 |
| Pmax | 9.2 | 9.0 | 9.0 | 9.0 | 9.0 | 9.0 | 9.2 |
| Pavg | 8.9 | 8.9 | 8.9 | 8.9 | 8.9 | 8.9 | 8.9 |
| Pmin | 8.9 | 8.9 | 8.9 | 8.9 | 8.9 | 8.9 | 8.9 |

Fn1 CLEAR | Fn2 MAC_SEND | Activated | SENS: Stopped | LINK: Running

Power vs. Time for EDT

### Link Analyzer for GWT

| L | CH | DR | SF | BW | Pow | Time | FCnt | Ack | Port | M | CMD |
|---|----|----|----|----|-----|------|------|-----|------|---|-----|
| U | 2 | 0 | 12 | 125 | -60.0 | REF | ---- | 0 | --- | - | Join-request |
| D | 2 | 0 | 12 | 125 | 19.5 | ---- | ---- | 0 | --- | - | Join-accept |
| U | 2 | 0 | 12 | 125 | -60.0 | 12.9s | 0000 | 0 | 000 | U | DeviceTimeReq |
| D | 2 | 0 | 12 | 125 | 19.5 | ---- | 0000 | 0 | 000 | U | DeviceTimeAns |
| D | B | 3 | 9 | 125 | 19.2 | ---- | ---- | 0 | --- | - | Beacon |
| U | 2 | 0 | 12 | 125 | -60.0 | 109s | 0001 | 0 | 000 | U | PingSlotInfoReq |
| D | 2 | 0 | 12 | 125 | 19.4 | ---- | 0001 | 0 | 000 | U | PingSlotInfoAns |
| U | 1 | 0 | 12 | 125 | -60.0 | 5.00s | 0002 | 0 | 000 | U | LinkCheckReq |
| D | 1 | 0 | 12 | 125 | 19.4 | ---- | 0002 | 0 | 000 | U | LinkCheckAns |
| D | B | 3 | 9 | 125 | 19.1 | ---- | ---- | 0 | --- | - | Beacon |

Epoch=0x45944200

00 00 00 42 94 45 83 BF 00 C4 CB D3 25 C6 62 29 C9

GATEWAY TEST — EU_868 / V1.0 / B — [180] [ETH] [RMT] [EXT] [CAP] [Fn]

Fn1 CLEAR | Fn2 MAC_SEND | Activated | SENS: Stopped | LINK: Running

Link Analyzer for GWT

### Power vs. Time for GWT

GATEWAY TEST — EU_868 / V1.0 / A — [217] [ETH] [RMT] [EXT] [CAP] [Fn]

**Power vs. Time Measurement**
NoPayload : FCNT0061, CH01, 19.8dBm, SF8, CR_4_5

POWER (dBm) axis: 15–25

| | ALL | SF7 | SF8 | SF9 | SF10 | SF11 | SF12 |
|------|-----|-----|-----|-----|------|------|------|
| N | 120 | 20 | 20 | 20 | 20 | 20 | 20 |
| Pmax | 20.2 | 19.7 | 19.8 | 20.0 | 20.1 | 20.2 | 20.2 |
| Pavg | 19.8 | 19.5 | 19.6 | 19.8 | 19.9 | 20.0 | 20.0 |
| Pmin | 19.5 | 19.5 | 19.5 | 19.7 | 19.9 | 19.9 | 20.0 |

Fn1 CLEAR | Fn2 MAC_SEND | SENS: Stopped | LINK: Stopped
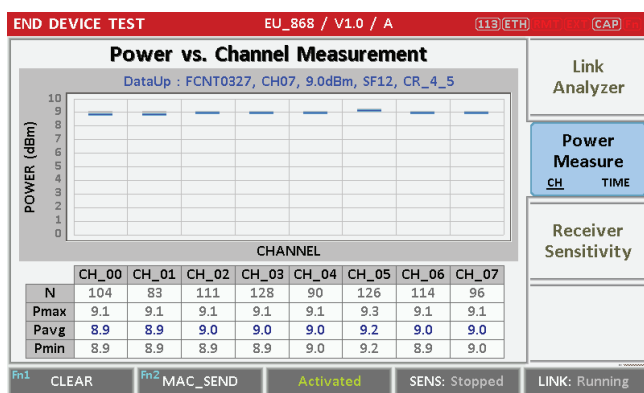
Power vs. Time for GWT

## MAC command Test

○ Multiple MAC commands in a single frame
○ All MAC commands defined in LoRaWAN with user-configurable parameters
○ Field selection: frame payload or frame options
○ Message type selection: confirmed or unconfirmed
○ User defined message: editable payload data and port field

LINK | PROTOCOL | RF

MAC_CMD_TYPE | INSTANT_MAC_CMD | CONFIRMED
MAC_CMD_FIELD | | PAYLOAD
INSTANT_MAC_ | LINK_CHECK | INK_CHECK
PERIODIC_UPLINK | DEVICE_TIME | FIRMED_UP
INTERVAL | DEVICE_MODE | 5 sec
PAYLOAD_TYPE | 0000_0000
FPORT | 99

POP-UP | EXIT

# Power vs. Channel

## Continuously monitoring TX power of DUT with respect to channels

RWC5020B provides a function of Power vs. Channel measurement for EDT and GWT. Power vs. Channel measurement in EDT (or GWT) helps to create a link between RWC5020B and an End Device (or Gateway/Server) Under Test and to measure the received power with respect to RF channels.
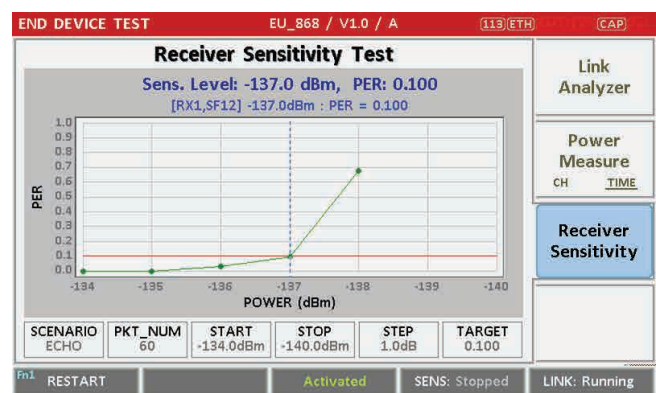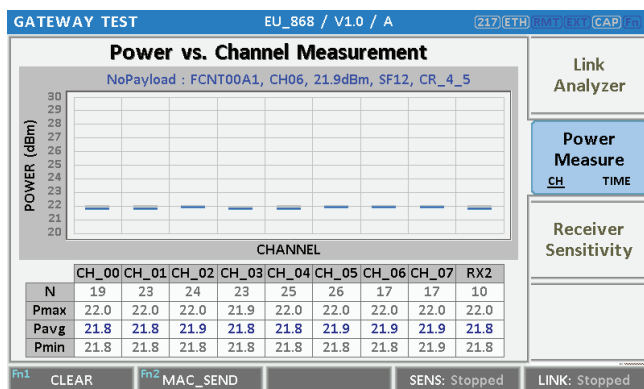
# Receiver Sensitivity

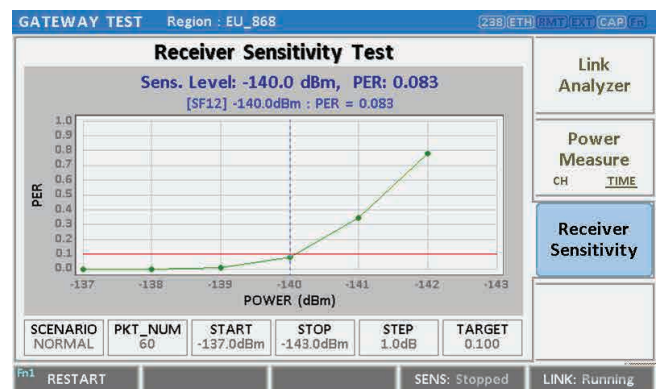## Finding the minimum power level which DUT can receive frames from the Tester

Receiver Sensitivity is a function of testing the receiver performance of DUT. RWC5020B sweeps its power level from the start value to the stop value with the step value and checks whether DUT functions properly, and stops immediately after DUT does not function properly.



Power vs. Channel for EDT



Receiver Sensitivity Test for EDT



Power vs. Channel for GWT



Receiver Sensitivity Test for GWT

○ Continuous monitoring of DUT's TX Power w.r.t. Channel
○ Calculating the maximum/average/minimum values

○ Determine power range and step for testing
○ The result value is the minimum power level at which DUT can receive the Tester's frame

# Signal Generator
## Transmiting LoRa test frames/CW

Signal Generator is a function of transmitting the defined test waveform to DUT repeatedly. Two different modes are provided; LoRa and CW. Especially in case of LoRa mode, various parameters are configurable to compose a LoRa test frame.



PHY Protocol Parameters for Signal Analyzer



Example of Generating LoRa Test Frames

# Signal Analyzer
## Receiving LoRa frames and measuring the power

Signal Analyzer is a function of analyzing LoRa frames received from DUT repeatedly. Various parameters are configurable to receive a specific LoRa frame. Additionally TX power of DUT is measured in LoRa or CW mode.



PHY Protocol Parameters for Signal Analyzer



Example of Receiving LoRa Test Frames

## DUT's RX Performance Test
○ Set the DUT to always listen the pre-defined packet
○ Tester transmit pre-defined number of packets
○ DUT needs to calculate PER by itself

## DUT's TX Performance Test
○ Set the DUT to always transmit the pre-defined packet
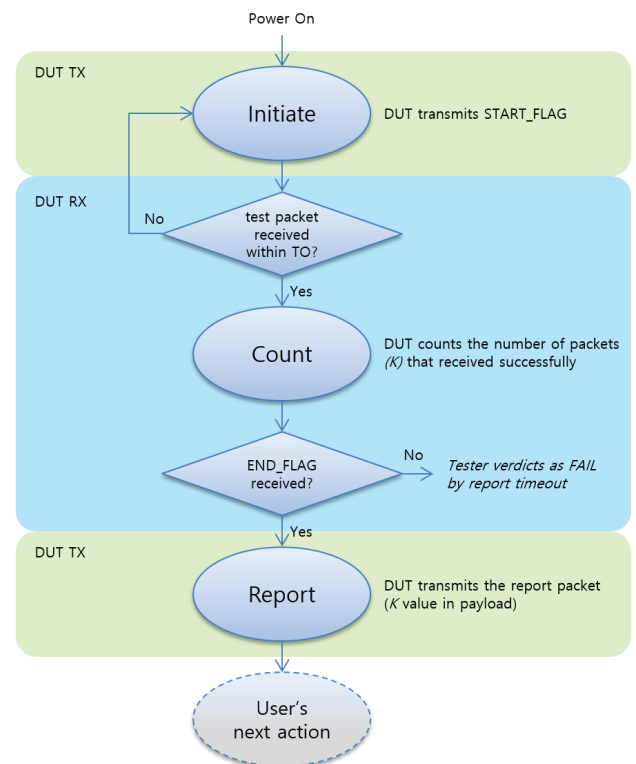○ Tester measures CW frequency

# MFG
## Speeding up the test time in production lines

MFG is a function of manufacturing tests to measure the TX and RX performances of DUT simultaneously; power measurement for TX and sensitivity measurement for RX respectively.

Basically 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 about a type of DUT, in other words, either an End-device or a Gateway can be tested under the same test concept.
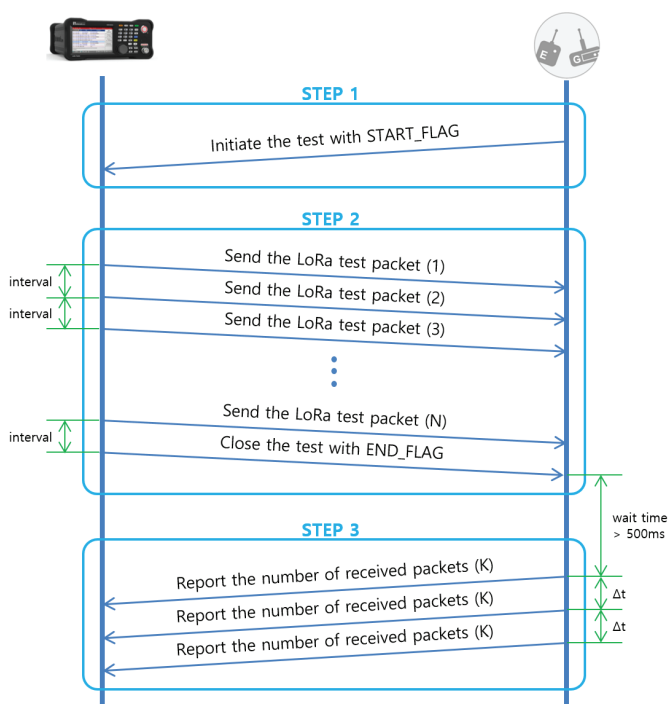
Test Procedure for MFG Test

State Transition Diagram during MFG Test

PHY Protocol Parameters for MFG

Users' Criteria for MFG

# PC Software

This PC application provides a variety of special measurement functions such as LoRa pre-certificaion test, performance measurement, link message logging and DUT control. The RWC5020B automatically measures specified characteristics such as the PER of the DUT, obtains data such as link messages or measurement data according to the LoRa Alliance standard, and summarizes and creates the report in one click.
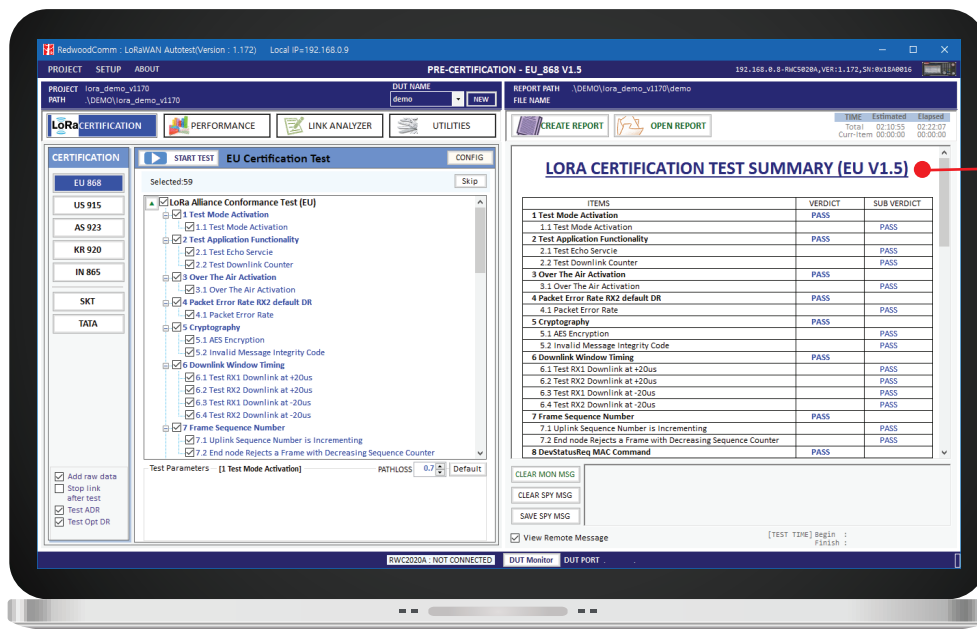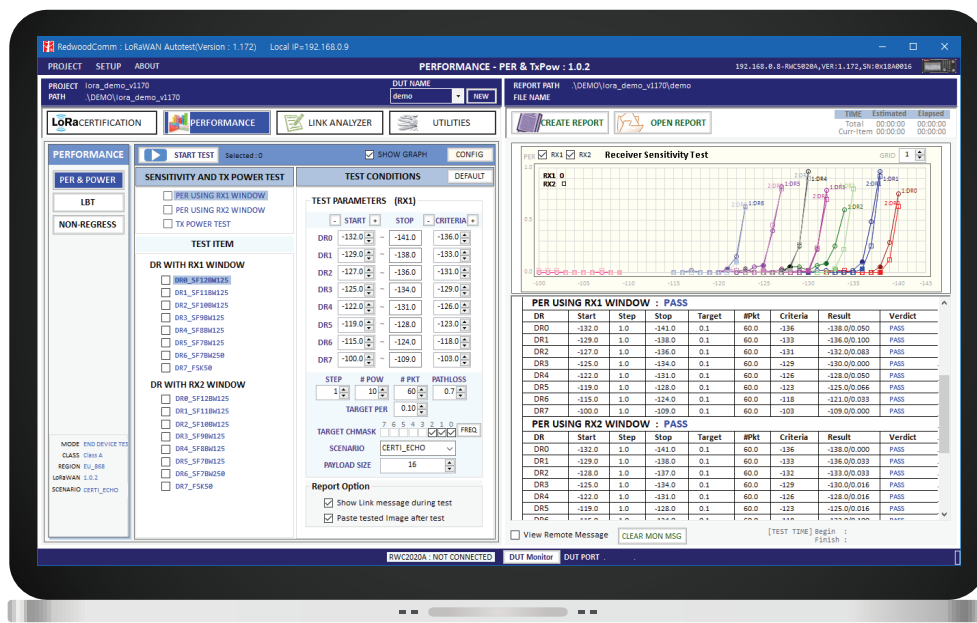


## LoRa Pre-certification Tests

It provides each regional pre-certification test which follows the procedures in LoRaWAN Specification.

.doc



## TX/RX Performance Tests

It provides fully automated RF performance measurement functions such as TX Power and RX sensitivity.
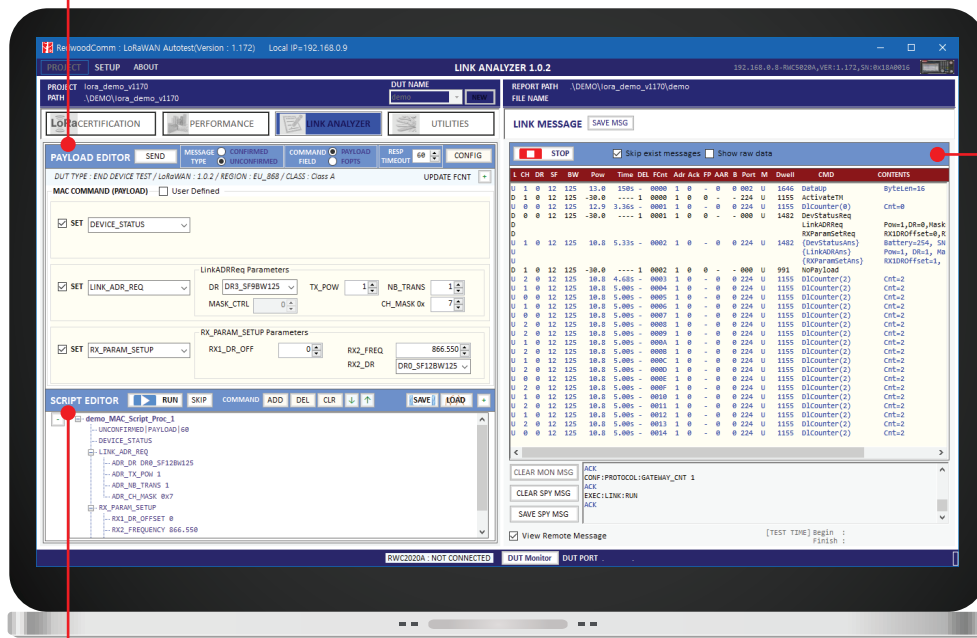
Ethernet

# PC Software

## Payload Editor

You can transmit any type of LoRa MAC commands defined in LoRa protocol.
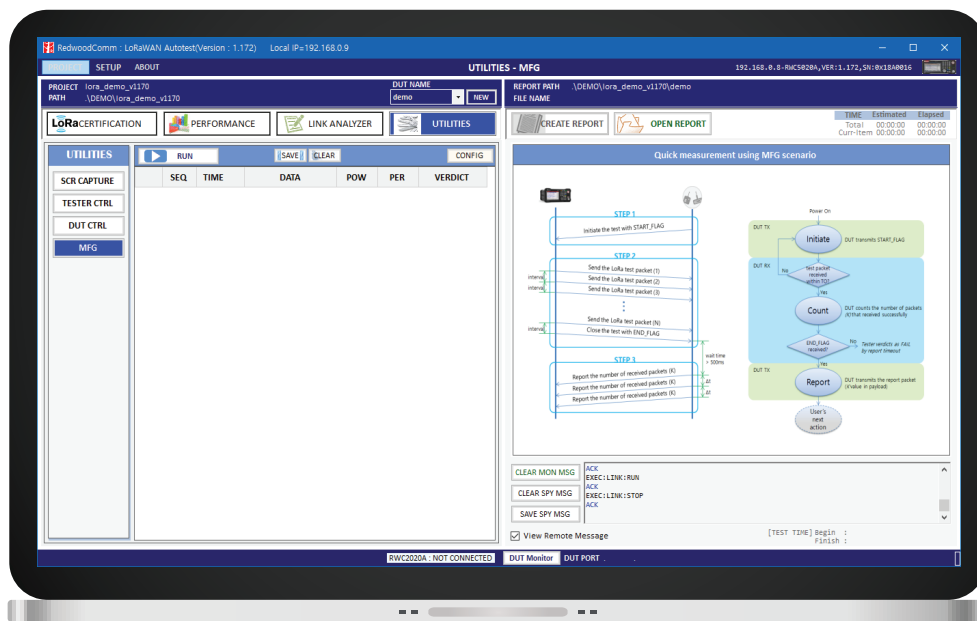


## Link Analyzer

You can gether and save all protocol messages with link analyzer function.

## Script Editor

You can add, remove or edit MAC command even multi-commands as you wish.
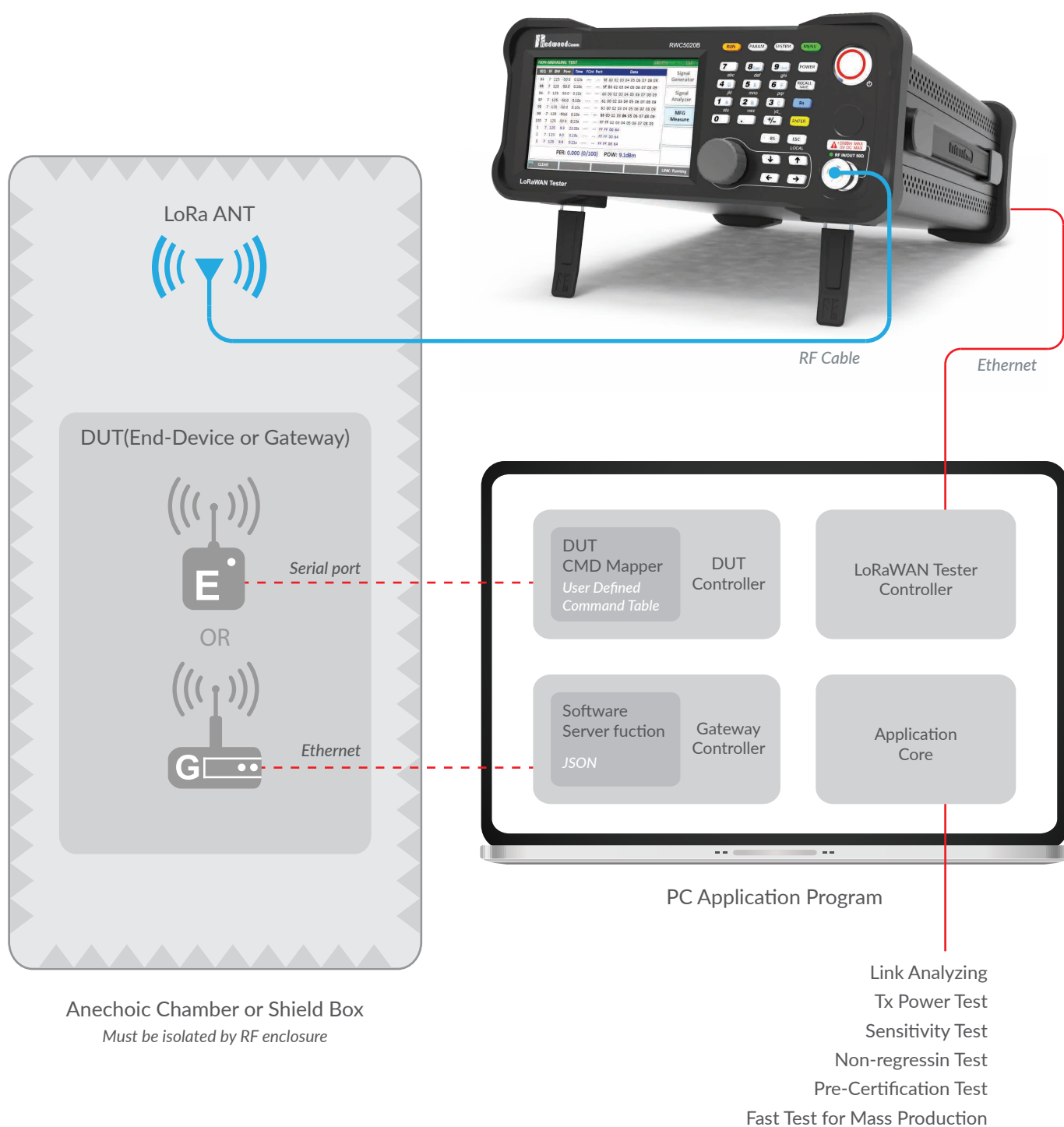
## Manufacturing Tests

It provides Non-signaling functions such as TX/RX/MFG Test for fast manufacturing Tests.

User can measure TX power and RX sensitivity simultaneously using MFG function on the production line.



Ethernet

# Structure of automated PC software and example of test setup

LoRa ANT

RF Cable

Ethernet

DUT(End-Device or Gateway)

E

Serial port

OR

G

Ethernet

Anechoic Chamber or Shield Box
*Must be isolated by RF enclosure*

| DUT CMD Mapper *User Defined Command Table* | DUT Controller | LoRaWAN Tester Controller |

| Software Server fuction *JSON* | Gateway Controller | Application Core |

PC Application Program

Link Analyzing
Tx Power Test
Sensitivity Test
Non-regressin Test
Pre-Certification Test
Fast Test for Mass Production

# Specifications

| | |
|---|---|
| Frequency | Range: 400MHz ~ 510MHz, 862MHz ~ 960MHz<br>Resolution: 100Hz<br>Stability vs. +25℃: ±0.5ppm standard<br>Stability vs. Aging: ±1ppm/1st year |
| Output Level | Range: -10dBm ~ -150dBm<br>Resolution: 0.1dB<br>Accuracy: ±1dB<br>Impedance: 50Ω |
| Input Level | +30dBm ~ -80dBm for Power Measurement<br>+30dBm ~ -50dBm for Frequency Measurement |
| Measurement Accuracy | ±1dB for Power<br>±1KHz for Frequency (Single Tone) |
| VSWR | Better than 1:1.5 |
| External Frequency Reference | Frequency: 10MHz<br>Power Range: 0dBm ~ +20dBm |
| Remote Programming Ports | RJ45(Ethernet)<br>RS-232C |
| Miscellaneous | Operating temperature: 5 ~ 40℃<br>Line Voltage: 100 to 240 VAC, 50/60Hz<br>Dimension: 250(w) x 110(h) x 348(d) mm<br>Weight: 5kg |

## Order code  (for RWC5020B LoRaWAN Tester)

○ **C5020B-00**  *EDT+GWT+NST*
○ **C5020B-01**  *EDT+GWT*
○ **C5020B-02**  *NST*
○ **C5020B-03**  *EDT*
○ **C5020B-04**  *GWT*
○ **C5020B-05**  *EDT+NST*
○ **C5020B-06**  *GWT+NST*

○ **O5020B-01**  *LoRaWAN Pre-Certification Test EU Option*
○ **O5020B-03**  *LoRaWAN Pre-Certification Test US/CA Option*
○ **O5020B-04**  *LoRaWAN Pre-Certification Test AS Option*
○ **O5020B-05**  *LoRaWAN Pre-Certification Test KR Option*
○ **O5020B-06**  *LoRaWAN Pre-Certification Test IN Option*
○ **O5020B-95**  *Eextra Hardware Warranty Option*
○ **O5020B-99**  *Maintenance option for software and firmware upgrade*

*Each option can be purchased later as an upgrade method.*

RWC2020A is an interference generator being able to be used for the purpose of various tests or measurements, e.g. the Listen Before Talk (LBT) test, the Gateway Non-regression tests, the Intermodulation Immunity test and so on. It can generate up to eight multi-tone signals with different output levels per each tone for the LBT test and two tones of up to 20MHz distant for the Intermodulation Immunity test. It also can generate a single tone with phase noise of high performance for the Gateway Non-regression tests.
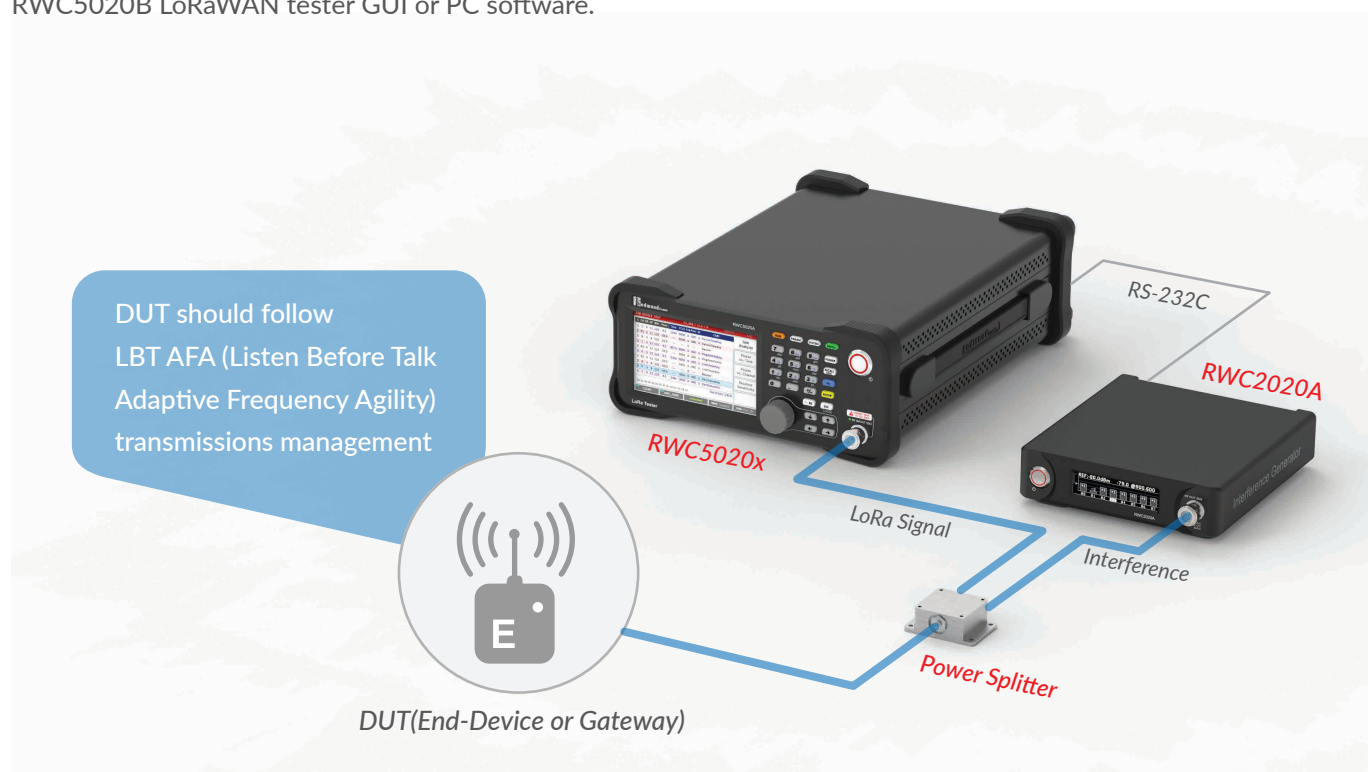
# RWC2020A
## Interference Generator



RWC2020A shall be connected to RWC5020B via RS-232C for control and setup of the full automation tests.

# LBT Test

Listen Before Talk (LBT) is a technique that device enters RX mode and senses the interference signal level before it starts a transmission. It is used to prevent interference or collision between devices that use common frequency bands. RWC2020A provides a perfect solution to verify LBT functionality of DUT, gateways or end-devices, as a supplementary equipment synchronized with RWC5020A. It generates up to eight interference signals to occupy frequency bands. The interference signal level, the number of channels, and channel frequencies are editable through RWC5020B LoRaWAN tester GUI or PC software.



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

RS-232C

RWC2020A

RWC5020x

LoRa Signal

Interference

Power Splitter

DUT(End-Device or Gateway)

# CW Interferer Immunity Test

The CW Interferer Immunity Test and Intermodulation Immunity Test which are ones of the Gateway Non-regression tests require CW interference signals with high performance phase noise.
RWC2020A generates a single-tone or dual-tone interference signal for those tests.



# Specifications

| Frequency | Range : 400MHz ~ 1000MHz<br>Resolution : 100Hz<br>Accuracy : ±2ppm/year@operating temperature |
|---|---|
| Output Level | Range : -10dBm ~ -100dBm<br>Resolution : 0.1dB<br>Accuracy : ±1dB |
| RF Characteristics | Phase Noise (Single tone mode) :<br>-103dBc@1kHz  /  -110dBc@10kHz  /  -110dBc@100kHz  / -138dBc@1MHz<br>VSWR : Better than 1:1.5<br>Impedance : 50Ω |
| Remote Interface | RS-232C |
| Miscellaneous | Operating temperature : 5 ~ 40℃<br>Input : DC 12V, 3A<br>Dimension : 166(w) x 50(h) x 194(d) mm<br>Weight : 950g |