# F-LoRa
# LoRaWAN Conformance
# Test Description

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## 1. Scope

This document describes the different tools and tests scenarios provided by F-LoRa as an extension to the F-Interop platform in order to confirm that a LoRaWAN implementation fulfils the requirements of the LoRaWAN protocol specification.

This document describes:
- The testbed architecture, showing which LoRaWAN components are involved, and how they inter-work in the interoperation focus.
- The configurations used during test sessions.
- The interoperability test descriptions, describing the scenarios the participants follow to perform the tests.
- The test commands interchanged between the Test Server and the DUT during a test session.

# 2. References

## 2.1 Normative references

The following referenced documents are necessary for the application of the present document.

[1] LoRaWAN Specification v1.0.2 (2016-06). LoRa Alliance.

[2] LoRaWAN Regional Parameters v1.0.2rB (2017-02). LoRa Alliance.

## 2.1  Informative references

[3] ETSI EG 202 237 V1.1.2 (2007-04). ETSI Guide. Methods for Testing and Specification (MTS), Internet Protocol Testing (IPT), Generic approach to interoperability testing.

[4] ETSI EG 202 568 V1.1.3 (2007-04). ETSI Guide. Methods for Testing and Specification (MTS); Internet Protocol Testing (IPT); Testing: Methodology and Framework.

# 3. Abbreviations

For the purposes of the present document, the following abbreviations apply:

ABP         Activation By Personalization.

ACK         Acknowledgement packet.

AppSKey     Application Session Key is the key used for end to end data encryption between the application server and the DUT. Unique per device and per session.

DevAddr     Device Address is the short (non-unique) address of the end device.

DL          Downlink.

DUT         Device Under Test.

FCntDown    Frame Counter Down.

FCtrl       Frame Control field of the Frame Header.

FOpts       Frame Options field of the Frame Header.

FRMPayload  Frame Payload.

MIC         Message Integrity Code.

NwkSKey     Network Session Key is the key used for message integrity check and encryption of MAC commands between the DUT and the Network Server. Unique per device and per session.

OTAA        Over The Air Activation.

RxDelay     Reception Delay.

TAS         Test App Server, controls the tests running the test scripts.

TA          Test Activation Message.

TAOK        Test Activation OK Message.

TD          Test Description.

UL          Uplink.

# 4. Conventions

## 4.1 Interoperability test process

The Device Under Test (DUT) is a low power wireless end device implementing a LoRa PHY layer and the LoRaWAN MAC layer Implementation Under Test (IUT). It runs a test application on top of that MAC layer. Duty cycle restrictions must be disabled and the normal application should be suspended when the node enters the test mode.

The test bench consist of an Agent service running on the user side connected to a standard LoRa Gateway (provided by the user) and a Test Application Server (TAS) that performs the tests. This tests will check that the devices behave according to the specification, including the adaptive data rate mechanisms, encryption and message integrity code calculation, frame format and timing of the reception windows.

The tests proforma table steps can be of different types, depending on their purpose:
- **stimulus** corresponds to an event that triggers a specific protocol action on a DUT, such as sending a message.
- **configure** corresponds to an action to modify the DUT configuration.
- **IOP check** (IOP stands for "Interoperation") consists of observing that one DUT behaves as described in the standard. For each IOP check in the Test Sequence, a result can be recorded.
- **CON checks** (CON stands for "Conformance") are used to verify the appropriate sequence and contents of protocol messages.

A test fails if at least one of the check results is FAIL.

## 4.2 Test Description naming convention

All the tests described in this document can be classified in different groups, based on the type of features they verify:

- ACT - Device activation.
- FUN - Basic functionalities and timing.
- SEC - Security, encryption and message integrity checks.
- MAC - MAC commands.

**Naming convention:**
TD_LoRaWAN_<test group>_<test number within the group>

## 4.3 LoRaWAN Tests Summary

| Test Number | Test ID | Test Summary | Test Group |
|---|---|---|---|
| 1 | TD_LoRaWAN_ACT_01 | Test Mode activation to test the device's Activation By Personalization (ABP). | ACT |
| 2 | TD_LoRaWAN_ACT_02 | Test Over the Air Activation, changing DR of RX windows. Check that the node can join using OTAA in RX1 and RX2. | ACT |
| 3 | TD_LoRaWAN_ACT_03 | Test Over the Air Activation modifying the RX windows delay. Check that the node can join using OTAA in RX1 and RX2. | ACT |
| 4 | TD_LoRaWAN_ACT_04 | Test Over the Air Activation configuring 5 new channels. | ACT |
| 5 | TD_LoRaWAN_ACT_05 | Uses Join-accept message to initiate a new session restoring the default LoRaWAN MAC parameters. | ACT |
| 6 | TD_LoRaWAN_FUN_01 | Checks basic communication functionality: the DUT can respond to an Ping Pong request. | FUN |
| 7 | TD_LoRaWAN_FUN_02 | Test the node's tolerance to timing errors in the download reception windows. Verifies that downlink messages with +/- 20us in RX1 and RX2 are correctly received. | FUN |
| 8 | TD_LoRaWAN_FUN_03 | Check increasing frame sequence numbers. | FUN |
| 9 | TD_LoRaWAN_FUN_04 | End node rejects frames with decreasing sequence numbers. | FUN |
| 10 | TD_LoRaWAN_FUN_05 | Verifies the confirmed type messages and the ACK processing. | FUN |
| 11 | TD_LoRaWAN_FUN_06 | Checks uplink retransmission of confirmed uplink messages. | FUN |
| 12 | TD_LoRaWAN_SEC_01 | Verify AES encryption sending Ping Pong messages of different lengths and analyzing the responses. MIC correctness is also checked. | SEC |
| 13 | TD_LoRaWAN_SEC_02 | Test if a message with a wrong MIC is ignored as expected. | SEC |
| 14 | TD_LoRaWAN_MAC_01 | Check MAC commands in FRMPayload and in FOpts field (DevStatus command). | MAC |

| 15 | TD_LoRaWAN_MAC_02 | Verifies that messages with MAC commands in both FRMPayload and piggybacked in FOpts of FCtrl field are ignored. | MAC |
|----|-------------------|---|-----|
| 16 | TD_LoRaWAN_MAC_03 | Try to modify read-only default channels. | MAC |
| 17 | TD_LoRaWAN_MAC_04 | Adds multiple channels using NewChannelReq. | MAC |
| 18 | TD_LoRaWAN_MAC_05 | Adds a single channel using NewChannelReq. | MAC |

*Table 1. F-LoRa LoRaWAN tests*

# 5. LoRaWAN Test Configurations

## 5.1 Test topology overview

Fig. 1 shows the testing platform topology. The user must provide the Device Under Test (DUT) with the LoRaWAN Implementation Under Test (IUT) and a LoRa Gateway running the Semtech packet forwarder. The Agent is provided by the testing platform. But, it is located in the user side running in a user's PC. The Test Application Server (TAS) is deployed using a docker container that is instantiated under user's request by the F-Interop platform. The TAS simulates some functions of a LoRaWAN Network Server and Application server to test the IUT.
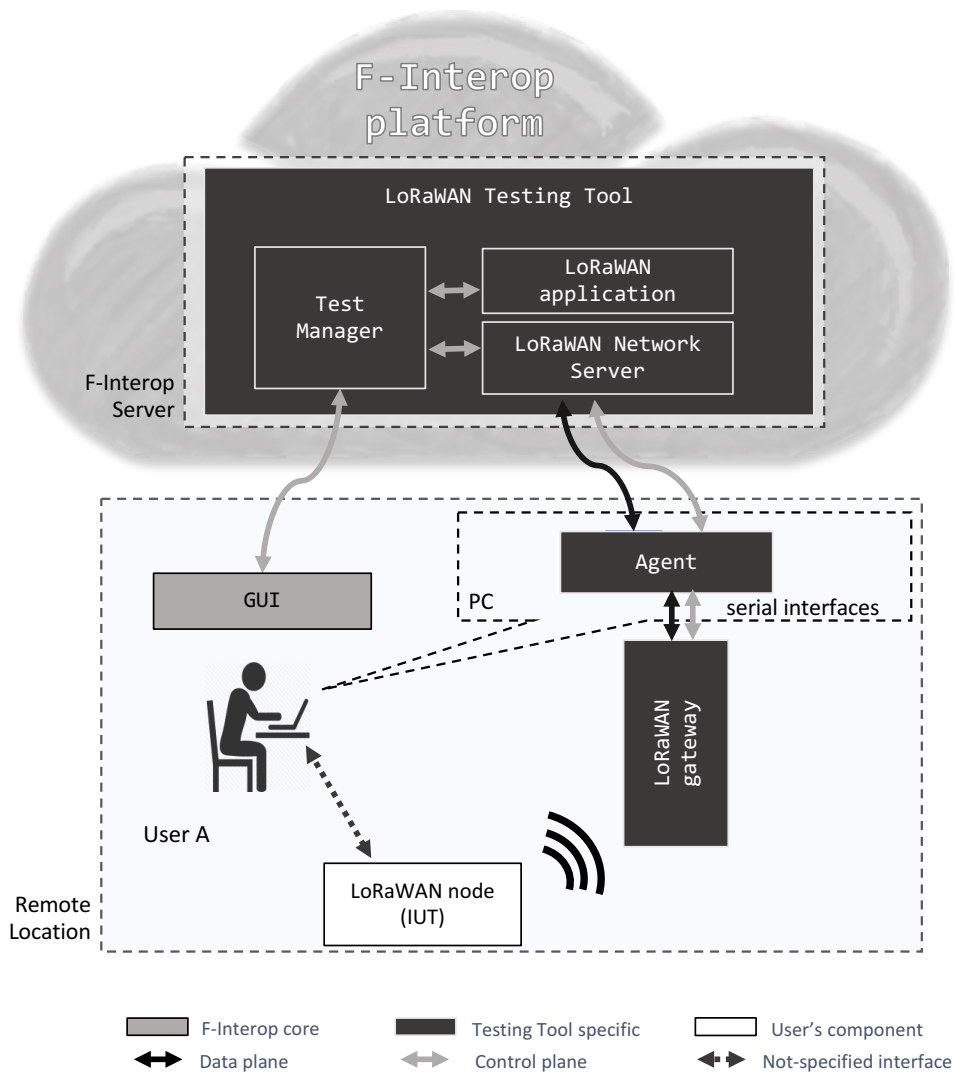
*Figure 1 Testing platform topology*

## 5.2   Device Under Test (DUT)

A Device Under Test is a low-power wireless node equipped with a LoRa-compliant radio, and implementing the LoRaWAN protocol [1] and a Test Mode application that uses a Test Application Protocol to interact with the Test Server.

## 5.3  Test Application Protocol

This section describes the different messages exchanged between the DUT and the Test App Server. The Test ID refers to the first byte of the FRMPayload of each application test message and identifies its purpose.

In order to be tested against the F-LoRa platform the DUT must implement a Test Mode in which the device is capable of interacting with the Test App Server in order to follow the different steps of a test. The normal traffic of the regular applications of the node must be ignored until the test is deactivated.

When the DUT is configured in Test Mode it must send a periodic Test Activation OK (TAOK) message periodically (period between 5 and 10 seconds). The TAOK message has a length of 2 bytes and consists of a downlink counter that is incremented by the DUT every time it receive a test message from the TAS.

## 5.3.1  Test Application Messages

| Test ID | First Byte (FRMPayload) | Name | Description |
|---------|-------------------------|------|-------------|
| 0 | 0x00 | Test Deactivation | Deactivates the Test Mode in the DUT. |
| 1 | 0x01 | Test Activation | The DUT activates the Test Mode after the reception of FRMPayload=0x01010101 in port 224. After activating the test mode the DUT sends an Activation OK message with a downlink counter. |
| 2 | 0x02 | Confirmed Uplink | Configures the test application in the DUT to use CONFIRMED uplink frames. |
| 3 | 0x03 | Unconfirmed Uplink | Configures the test application in the DUT to use UNCONFIRMED uplink frames. |
| 4 | 0x04 | Ping Pong | When a Ping request message is sent, the first byte is 0x04, the Pong response of the DUT must contain a FRMPayload starting with the same Test ID and with the rest of the bytes incremented by one (modulo 256). For instance, <br> • Ping request:    0x04ca32f5a5b7f1187583d3 <br> • Pong response: 0x04cb33f6a6b8f2197684d4 |
| 6 | 0x06 | Session Update | Triggers a join request message exchange in order to update the device OTAA session. |

# 6. Test Descriptions

## 6.1 Activation (ACT)

| Test Number | 1 | | | | |
|---|---|---|---|---|---|
| Test ID | **TD_LoRaWAN_ACT_01** | | | | |
| Test Objective | Check that the node can join using ABP and enter Test Mode Activation. | | | | |
| References | LoRaWAN Specification v1.0.2. | | | | |
| Pre-test conditions | The end device has a pre-configured DevAddr, NwkSKey and AppSKey. The Test Application Server has the end device registered in its device list and knows its NwkSkey, AppSKey and DevAddr. | | | | |
| Test sequence | Step | Type | Description | | Result |
| | 1 | Stimulus | - Reception from DUT: DATA packet.<br>- TAS sends: Test Mode activation message (DL packet with payload 0x01010101 sent to port 224) to the DUT. The payload is encrypted with the AppSKey. | | |
| | 2 | IOP Check | - Reception from DUT: TAOK message with the downlink counter.<br>- TAS sends: none | | |
| Verdict | | | | | |

| Test Number | 2 | |
|---|---|---|
| Test ID | **TD_LoRaWAN_ACT_02** | |
| Test Objective | Test Over the Air Activation, changing DR of RX windows. Check that the node can join using OTAA in RX1 and RX2. | |
| References | LoRaWAN Specification v1.0.2. | |
| Pre-test conditions | The DUT is in Test Mode and supports Over The Air Activation (OTAA). | |

| Test sequence | Step | Type | Description | Result |
|---|---|---|---|---|
| | 1 | Stimulus | - Reception from DUT: TAOK message with the downlink counter.<br>- TAS sends: Trigger join request with test ID 6. | |
| | 2 | IOP Check | - Reception from DUT: Join Request message.<br>- TAS sends: Join Accept message configuring DLSettings (RX1DRoffset=2 and RX2DR=3). | |
| | 3 | Stimulus | A data message is expected, and the Test Mode will be activated after its reception.<br>- Reception from DUT: DATA packet.<br>- TAS sends: Test Mode activation message to the DUT (DL packet with payload 0x01010101 sent to port 224) | |
| | 4 | IOP Check | After receiving an Activation OK message with the current downlink counter, a PING message will be sent PING message in RX1 using a DR offset of 2.<br>- Reception from DUT: TAOK message with the downlink counter.<br>- TAS sends: PING message in RX1 using a DR offset of 2 | |
| | 5 | IOP Check | Waits for the PONG message and sends another PING, now using RX2.<br>- Reception from DUT: PONG message.<br>- TAS sends: PING message using RX2. | |
| | 6 | IOP Check | Checks the last PONG message.<br>- Reception from DUT: PONG message.<br>- TAS sends: none. | |
| Verdict | | | | |

| | |
|---|---|
| Test Number | 3 |
| Test ID | **TD_LoRaWAN_ACT_03** |
| Test Objective | Test Over the Air Activation modifying the RX windows delay. Check that the node can join using OTAA in RX1 and RX2. |
| References | LoRaWAN Specification v1.0.2. |

| Pre-test conditions | DUT has an active session with the TAS and is configured in test mode. | | | | |
|---|---|---|---|---|---|
| Test sequence | Step | Type | Description | | Result |
| | 1 | Stimulus | - Reception from DUT: TAOK message with the downlink counter.<br>- TAS sends: Trigger join request with test ID 6. | | |
| | 2 | IOP Check | - Reception from DUT: Join Request message.<br>- TAS sends: Join Accept message configuring RXDalay=3s. | | |
| | 3 | Stimulus | A data message is expected, and the Test Mode will be activated after its reception.<br>- Reception from DUT: DATA packet.<br>- TAS sends: Test Mode activation message to the DUT (DL packet with payload 0x01010101 sent to port 224) | | |
| | 4 | IOP Check | After receiving an Activation OK message with the current downlink counter, a PING message will be sent PING message in RX1 using a DR offset of 2.<br>- Reception from DUT: TAOK message with the downlink counter.<br>- TAS sends: PING message in RX1 with the configured 3 seconds delay. | | |
| | 5 | IOP Check | Waits for the PONG message and sends another PING, now using RX2.<br>- Reception from DUT: PONG message.<br>- TAS sends: PING message using RX2. | | |
| | 6 | IOP Check | Checks the last PONG message.<br>- Reception from DUT: PONG message.<br>- TAS sends: none. | | |
| Verdict | | | | | |


| Test Number | 4 |
|---|---|
| Test ID | **TD_LoRaWAN_ACT_04** |
| Test Objective | Test Over the Air Activation configuring 5 new channels. |
| References | LoRaWAN Specification v1.0.2. |

| Pre-test conditions | DUT has an active session with the TAS and is configured in test mode. | | | | |
|---|---|---|---|---|---|
| Test sequence | Step | Type | Description | | Result |
| | 1 | Stimulus | - Reception from DUT: TAOK message with the downlink counter.<br>- TAS sends: Trigger join request with test ID 6. | | |
| | 2 | IOP Check | - Reception from DUT: Join Request message.<br>- TAS sends: Join Accept message configuring CFList adding new channels. | | |
| | 3 | Stimulus | A data message is expected, and the Test Mode will be activated after its reception.<br>- Reception from DUT: DATA packet.<br>- TAS sends: Test Mode activation message to the DUT (DL packet with payload 0x01010101 sent to port 224) | | |
| | 4 | IOP Check | The test stays in this steps and verifies that all the configured frequencies are being used.<br>- Reception from DUT: TAOK message with the downlink counter.<br>- TAS sends: none. | | |
| Verdict | | | | | |


| Test Number | 5 |
|---|---|
| Test ID | **TD_LoRaWAN_ACT_05** |
| Test Objective | Uses Join-accept message to initiate a new session restoring the default LoRaWAN MAC parameters. |
| References | LoRaWAN Specification v1.0.2. |
| Pre-test conditions | DUT has an active session with the TAS and is configured in test mode. |

| Test sequence | Step | Type | Description | Result |
|---|---|---|---|---|
| | 1 | Stimulus | Waits and Activation Ok message with the current downlink counter of the session and, after it's received, a new session will be requested.<br>- Reception from DUT: TAOK message with the | |

| | | | | |
|---|---|---|---|---|
| | | | downlink counter.<br>- TAS sends: Trigger join request with test ID 6. | |
| | 2 | IOP Check | Waits for a join request message. A Join Accept will be sent in response with the default configuration.<br>- Reception from DUT: Join Request message.<br>- TAS sends: Join Accept message. | |
| | 3 | Stimulus | A data message is expected, and the Test Mode will be activated after its reception.<br>- Reception from DUT: DATA packet.<br>- TAS sends: Test Mode activation message to the DUT (DL packet with payload 0x01010101 sent to port 224). | |
| | 4 | IOP Check | After receiving an Activation OK message with the current downlink counter, a PING message will be sent.<br>- Reception from DUT: TAOK message with the downlink counter.<br>- TAS sends: PING message in RX1. | |
| | 5 | CON Check | Waits for the PONG message and sends another PING, now using RX2.<br>- Reception from DUT: PONG message.<br>- TAS sends: PING message using RX2. | |
| | 6 | CON Check | Checks the last PONG.<br>- Reception from DUT: PONG message.<br>- TAS sends: none | |
| Verdict | | | | |

## 6.2  Basic Functionalities and timing (FUN)

| | |
|---|---|
| Test Number | 6 |
| Test ID | **TD_LoRaWAN_FUN_01** |
| Test Objective | Checks basic communication functionality: the DUT can respond to a Ping Pong request. |
| References | LoRaWAN Specification v1.0.2. |

| Pre-test conditions | The DUT has an active session with the TAS and is in Test Mode. | | | | |
|---|---|---|---|---|---|
| Test sequence | Step | Type | Description | | Result |
| | 1 | Stimulus | Waits for a TAOK message with the current downlink counter of the session and after it's received a PING PONG exchange will be initiated.<br>- Reception from DUT: TAOK message with the downlink counter.<br>- TAS sends: PING message. | | |
| | 2 | IOP Check | After the PONG message is received, a count is started.<br>- Reception from DUT: PONG message.<br>- TAS sends: None. | | |
| | 3 | IOP Check | Count a predefined amount (2) of TAOK messages.<br>- Reception from DUT: TAOK message with the downlink counter.<br>- TAS sends: None. | | |
| Verdict | | | | | |

| Test Number | 7 |
|---|---|
| Test ID | **TD_LoRaWAN_FUN_02** |
| Test Objective | Test the node's tolerance to timing errors in the download reception windows.<br>Verifies that downlink messages with +/- 20us in RX1 and RX2 are correctly received. |
| References | LoRaWAN Specification v1.0.2. |
| Pre-test conditions | The DUT has an active session with the TAS and is in Test Mode. |

| Test sequence | Step | Type | Description | Result |
|---|---|---|---|---|

| | 1 | Stimulus | Waits and Activation Ok message with the current downlink counter of the session and after it's received a PING PONG exchange will be initiated, using **RX1** with a timing error of **+20** microseconds.<br>- Reception from DUT: TAOK message with the downlink counter.<br>- TAS sends: PING message with a **+20** microseconds delay in **RX1**. | |
| --- | --- | --- | --- | --- |
| | 2 | IOP Check | Checks the reception of the PONG message.<br>- Reception from DUT: PONG message.<br>- TAS sends: None | |
| | 3 | Stimulus | Waits and Activation Ok message with the current downlink counter of the session and after it's received a PING PONG exchange will be initiated, using **RX2** with a timing error of **+20** microseconds.<br>- Reception from DUT: TAOK message with the downlink counter.<br>- TAS sends: PING message with a **+20** microseconds delay in **RX2**. | |
| | 4 | IOP Check | Checks the reception of the PONG message.<br>- Reception from DUT: PONG message.<br>- TAS sends: None | |
| | 5 | Stimulus | Waits and Activation Ok message with the current downlink counter of the session and after it's received a PING PONG exchange will be initiated, using **RX1** with a timing error of **-20** microseconds.<br>- Reception from DUT: TAOK message with the downlink counter.<br>- TAS sends: PING message with a **-20** microseconds delay in **RX1**. | |
| | 6 | IOP Check | Checks the reception of the PONG message.<br>- Reception from DUT: PONG message.<br>- TAS sends: None | |
| | 7 | Stimulus | Waits and Activation Ok message with the current downlink counter of the session and after it's received a PING PONG exchange will be initiated, using **RX2** with a timing error of **-20** microseconds.<br>- Reception from DUT: TAOK message with the downlink counter.<br>- TAS sends: PING message with a **-20** microseconds | |

| | | | delay in **RX2**. | |
|---|---|---|---|---|
| | 8 | IOP Check | Checks the reception of the PONG message.<br>- Reception from DUT: PONG message.<br>- TAS sends: None | |
| Verdict | | | | |

| Test Number | 8 |
|---|---|
| Test ID | **TD_LoRaWAN_FUN_03** |
| Test Objective | Check the handling of the uplink sequence number. |
| References | LoRaWAN Specification v1.0.2. |
| Pre-test conditions | The DUT has an active session with the TAS and is in Test Mode. |

| Test sequence | Step | Type | Description | Result |
|---|---|---|---|---|
| | 1 | CON Check | Count TAOK messages with the current downlink counter of the session and check that the uplink frame counter is incremented.<br>- Reception from DUT: TAOK message with the downlink counter.<br>- TAS sends: None. | |
| Verdict | | | | |

| Test Number | 9 |
|---|---|
| Test ID | **TD_LoRaWAN_FUN_04** |
| Test Objective | Checks that a message with decreasing downlink frame counter is ignored. |
| References | LoRaWAN Specification v1.0.2. |

| Pre-test conditions | The DUT has an active session with the TAS and is in Test Mode. | | | | |
|---|---|---|---|---|---|
| Test sequence | Step | Type | Description | | Result |
| | 1 | Stimulus | Waits and Activation Ok message with the current downlink counter of the session and after it's received a message with a decreasing frame downlink counter will be sent. This messages must be ignored.<br>- Reception from DUT: TAOK message with the downlink counter.<br>- TAS sends: message with wrong frame downlink counter. | | |
| | 2 | IOP Check | Waits and Activation Ok message with the current downlink counter.<br>- Reception from DUT:<br>- TAS sends: None. | | |
| Verdict | | | | | |

| Test Number | 10 |
|---|---|
| Test ID | **TD_LoRaWAN_FUN_05** |
| Test Objective | Test the implementation of confirmed packets, verifies the handling of the ACK bit in the uplink messages. |
| References | LoRaWAN Specification v1.0.2. |
| Pre-test conditions | The DUT has an active session with the TAS and is in Test Mode. |

| Test sequence | Step | Type | Description | Result |
|---|---|---|---|---|
| | 1 | Stimulus | Checks the downlink counter of the TAOK message and configures the node to use CONFIRMED uplink frames sending a test ID 2.<br>- Reception from DUT: TAOK message with the downlink counter.<br>- TAS sends: Triggers the usage of CONFIRMED | |

| | | | uplink frames (plain text FRMPaylod=0x02). | |
|---|---|---|---|---|
| | 2 | CON Check | Configures again the usage of UNCONFIRMED frames and sends the ACK.<br>- Reception from DUT: TAOK message with the downlink counter.<br>- TAS sends: ACK the messages and configures the UNCONFIRMED uplink frames (plain text FRMPaylod=0x03). | |
| Verdict | | | | |

| Test Number | 11 | | | |
|---|---|---|---|---|
| Test ID | **TD_LoRaWAN_FUN_06** | | | |
| Test Objective | Test the handling of the ACK bit in the confirmed message exchange, verifying the uplink retransmission of a message when the server does not send the acknowledgement. | | | |
| References | LoRaWAN Specification v1.0.2. | | | |
| Pre-test conditions | The DUT has an active session with the TAS and is in Test Mode. | | | |
| Test sequence | Step | Type | Description | Result |
| | 1 | Stimulus | Checks the downlink counter of the TAOK message and configures the node to use CONFIRMED uplink frames sending a test ID 2.<br>- Reception from DUT: TAOK message with the downlink counter.<br>- TAS sends: Triggers the usage of CONFIRMED uplink frames (plain text FRMPaylod=0x02). | |
| | 2 | CON Check | The TAS don't send the acknowledgment of the uplink messages to verify the node retransmissions. After checking 2 retransmissions the UNCONFIRMED messages are configured again for all subsequent uplink communication.<br>- Reception from DUT: TAOK message with the downlink counter.<br>- TAS sends: ACK the messages and configures the | |

| | | | | |
|---|---|---|---|---|
| | | | UNCONFIRMED uplink frames (plain text FRMPaylod=0x03). | |
| Verdict | | | | |

## 6.3 Security (SEC)

| Test Number | 12 | | | |
|---|---|---|---|---|
| Test ID | **TD_LoRaWAN_SEC_01** | | | |
| Test Objective | Verify AES encryption sending Ping Pong messages of different lengths and analyzing the responses. MIC correctness is also checked. | | | |
| References | LoRaWAN Specification v1.0.2. | | | |
| Pre-test conditions | The DUT has an active session with the TAS and is in Test Mode. | | | |
| Test sequence | Step | Type | Description | Result |
| | 1 | Stimulus | Wait an ACT OK from the DUT to initiate a PING PONG exchange.<br>- Reception from DUT: TAOK message with the downlink counter.<br>- TAS sends: PING message. | |
| | 2 | CON Check | Initiates 10 PING PONG exchanges to check the cryptography implementation.<br>- Reception from DUT: PONG message (response of a previously sent PING).<br>- TAS sends: PING message. | |
| | 3 | CON Check | Verifies the last PONG message, if it is correct the test case result is PASS.<br>- Reception from DUT: PONG message (response of a previously sent PING).<br>- TAS sends: None. | |
| Verdict | | | | |

| Test Number | 13 | | | | |
|---|---|---|---|---|---|
| Test ID | **TD_LoRaWAN_SEC_02** | | | | |
| Test Objective | Test if a message with a wrong MIC is ignored as expected. | | | | |
| References | LoRaWAN Specification v1.0.2. | | | | |
| Pre-test conditions | The DUT has an active session with the TAS and is in Test Mode. | | | | |
| Test sequence | Step | Type | Description | | Result |
| | 1 | Stimulus | Wait an ACT OK from the DUT to send a PING with wrong MIC.<br>- Reception from DUT: TAOK message with the downlink counter.<br>- TAS sends: PING message with wrong MIC. | | |
| | 2 | IOP Check | Check that the last PING was ignored.<br>- Reception from DUT: TAOK message<br>- TAS sends: None. | | |
| Verdict | | | | | |

## 6.4  MAC Commands (MAC)

| Test Number | 14 |
|---|---|
| Test ID | **TD_LoRaWAN_MAC_01** |
| Test Objective | Check MAC commands in FRMPayload and in FOpts field (DevStatus command). |
| References | LoRaWAN Specification v1.0.2. |
| Pre-test conditions | The DUT has an active session with the TAS and is in Test Mode. |

| Test sequence | Step | Type | Description | Result |
|---|---|---|---|---|
| | 1 | Stimulus | After receiving a Act Ok message, a DevStatusReq is sent piggybacked using the FOpts field.<br>- Reception from DUT: TAOK message with the downlink counter.<br>- TAS sends: DevStatusReq MAC command piggybacked in FOpts field. | |
| | 2 | CON Check | Verifies the reception of the DevStatusAns.<br>- Reception from DUT: TAOK message with a DevStatusAns MAC Command.<br>- TAS sends: None. | |
| | 3 | Stimulus | After receiving a Act Ok message, a DevStatusReq is sent in FRMPayload using FPort=0.<br>- Reception from DUT:After receiving a Act Ok message, a DevStatusReq is sent in FRMPayload using FPort=0.<br>- TAS sends: DevStatusReq MAC command in FRMPayload using port 0. | |
| | 4 | CON Check | Verifies the reception of the DevStatusAns.<br>- Reception from DUT: TAOK message with a DevStatusAns MAC Command.<br>- TAS sends: None. | |
| Verdict | | | | |

| Test Number | 15 |
|---|---|
| Test ID | **TD_LoRaWAN_MAC_02** |
| Test Objective | Test that the DUT ignores a frame if MAC commands are present both in payload and in FOpts field. |
| References | LoRaWAN Specification v1.0.2. |
| Pre-test conditions | The DUT has an active session with the TAS and is in Test Mode. |

| Test sequence | Step | Type | Description | Result |
|---|---|---|---|---|

| | 1 | Stimulus | After receiving a TAOK two DevStatusReq are sent, in the FRMPayload and in FOpts field. This message must be ignored.<br>- Reception from DUT: TAOK message with the downlink counter.<br>- TAS sends: Two DevStatusReq mac commands, one in FRMPayload and other piggybacked. | |
|---|---|---|---|---|
| | 2 | CON Check | Verifies that the TAOK message doesn't have a DevStatusAns and sends another DevStatusReq in FRMPayload and in FOpts field. This message must be ignored.<br>- Reception from DUT: TAOK message with the downlink counter.<br>- TAS sends: Two DevStatusReq mac commands, one in FRMPayload and other piggybacked. | |
| | 3 | Stimulus | After receiving a TAOK, two DevStatusReq are sent in the FRMPayload and in FOpts field. This message must be ignored.<br>- Reception from DUT: TAOK message with the downlink counter.<br>- TAS sends: Two DevStatusReq mac commands, one in FRMPayload and other piggybacked. | |
| | 4 | CON Check | Verifies that the TAOK message doesn't have a DevStatusAns and sends other DevStatusReq in FRMPayload and in FOpts field. This message must be ignored.<br>- Reception from DUT: TAOK message with the downlink counter.<br>- TAS sends: Two DevStatusReq mac commands, one in FRMPayload and other piggybacked. | |
| Verdict | | | | |

| Test Number | 16 |
|---|---|
| Test ID | **TD_LoRaWAN_MAC_03** |
| Test Objective | Check the channel addition implementation, try to remove a read-only default channel. |

| References | LoRaWAN Specification v1.0.2. | | | | |
|---|---|---|---|---|---|
| Pre-test conditions | The DUT has an active session with the TAS and is in Test Mode. | | | | |
| Test sequence | Step | Type | Description | | Result |
| | 1 | Stimulus | Checks the TAOK message and tries to disable a default channel of the current LoRaWAN region.<br>- Reception from DUT: TAOK message with the downlink counter.<br>- TAS sends: NewChannelReq MAC Command disabling a default channel. | | |
| | 2 | CON Check | Verifies that the default channel deletion was rejected by the DUT.<br>- Reception from DUT: message with the NewChannelAns with status Not OK.<br>- TAS sends: None. | | |
| | 3 | CON Check | The previous step had verified that the NewChannelAns contained a Not OK status. Now, this step checks a set of messages and all the configured frequencies must be used.<br>- Reception from DUT: TAOK message with the downlink counter.<br>- TAS sends: None. | | |
| | 4 | CON Check | Verifies that the TAOK message doesn't have a DevStatusAns and sends other DevStatusReq in FRMPayload and in FOpts field. This message must be ignored.<br>- Reception from DUT: TAOK message with the downlink counter.<br>- TAS sends: Two DevStatusReq mac commands, one in FRMPayload and other piggybacked. | | |
| Verdict | | | | | |

| Test Number | 17 |
|---|---|
| Test ID | **TD_LoRaWAN_MAC_04** |

Rev. 1.0 – F-LoRa - LoRaWAN Interoperability Test Descriptions

| Test Objective | Checks the channel addition implementation verifying that the new added frequencies are used. Adds multiple channels in a single message. |
|---|---|
| References | LoRaWAN Specification v1.0.2. |
| Pre-test conditions | The DUT has an active session with the TAS and is in Test Mode. |

| Test sequence | Step | Type | Description | Result |
|---|---|---|---|---|
| | 1 | Stimulus | Adds new frequencies using NewChannelReq MAC Commands.<br>- Reception from DUT: TAOK message with the downlink counter.<br>- TAS sends: message with multiple NewChannelReq MAC Commands. | |
| | 2 | CON Check | Verifies that the DUT sends a NewChannelAns MAC Command accepting the new added frequencies.<br>- Reception from DUT: message with NewChannelAns answer from the DUT accepting the added channels (Status OK).<br>- TAS sends: None. | |
| | 3 | Stimulus | Removes the previously added channels.<br>- Reception from DUT: TAOK message with the downlink counter.<br>- TAS sends: NewChannelReq removing the previously added channels. | |
| | 4 | CON Check | Verifies that the DUT sends a NewChannelAns MAC Command accepting the removed frequencies.<br>- Reception from DUT: message with NewChannelAns answer from the DUT accepting the removed channels (Status OK).<br>- TAS sends: None. | |
| Verdict | | | | |

| Test Number | 18 |
|---|---|
| Test ID | **TD_LoRaWAN_MAC_05** |
| Test Objective | Checks the channel addition implementation verifying that the new added frequencies are used. Addition of a single channel. |

| | | | | |
|---|---|---|---|---|
| References | LoRaWAN Specification v1.0.2. | | | |
| Pre-test conditions | The DUT has an active session with the TAS and is in Test Mode. | | | |
| Test sequence | Step | Type | Description | Result |
| | 1 | Stimulus | Adds a single new channel in the channel index 3.<br>- Reception from DUT: TAOK message with the downlink counter.<br>- TAS sends: NewChannelReq MAC Command adding a new channel. | |
| | 2 | CON Check | Verifies that the DUT accepted the new added channel.<br>- Reception from DUT: NewChannelAns MAC Command with Status OK.<br>- TAS sends: None. | |
| | 3 | Stimulus | Count TAOK messages to check that the new frequency is used.<br>- Reception from DUT: TAOK messages until all the configured frequencies (including the newly added) are used.<br>- TAS sends: None. | |
| | 4 | CON Check | Removes the previously added channel.<br>- Reception from DUT: TAOK message with the downlink counter.<br>- TAS sends: NewChannelReq removing the previously added channels. | |
| | 5 | | Verifies that the DUT accepted the channel removal.<br>- Reception from DUT: NewChannelAns MAC Command with Status OK.<br>- TAS sends: None. | |
| | 6 | | Verifies that the removed frequency is not used after the reception of a given number of downlink messages.<br>- Reception from DUT: TAOK message with the downlink counter.<br>- TAS sends: None. | |
| | 7 | | Final step, check the last TAOK message.<br>- Reception from DUT: TAOK message with the downlink counter. | |

| | | | - TAS sends: None. | |
|---|---|---|---|---|
| Verdict | | | | |

## Change History

| Revision | Status | Author | Date |
|:---:|:---:|:---:|:---:|
| 0.1 | Preliminary TD | P. Modernell | 22 December 2017 |
| 0.2 | Preliminary TD. Test topology diagram included. | P. Modernell | 5 January 2018 |
| 1.0 | First implementation of the testing tool. | P. Modernell | 20 September 2018 |