



SIGFOX RF & PROTOCOL TEST SPECIFICATION

Version 5.0.3

PUBLIC

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1. Introduction

1.1. Purpose

This document is intended to specify technical requirements for Sigfox RF & PROTOCOL Tests :

- RF requirements
- Sigfox Protocol Requirements.

1.2. Scope

The present document focuses on **Sigfox system**.

A commercial product might also integrate other systems (multi-system device) which are not covered by this document.

The Applicability Annexe details mandatory requirements per supported feature.

1.3. The whole requirement template

In order to enable requirement traceability, each requirement is referenced as following:

Example :

[PRS-RFP-xxx] Requirement title FEATURE

Specification description

requirement body

test execution :

- ...
- ...

Note :

- Not all the requirements are mandatory : when they are defined for a specific feature (indicated with the **FEATURE** keyword), if the UUT does not support the feature, the associated requirement is not mandatory.
- When no keyword **FEATURE** is mentioned, the requirement is mandatory

1.4. Definitions and Acronyms

1.4.1. Definitions

- **Candidate Modular Design/Device/Development Solution**: One unit of a Candidate Modular Design /Device/Development Solution model sent for RF & Protocol testing, also called UUT in this document. Can be a prototype but shall be representative to series.
- **Device**: Manufactured end-product that is intended for use by end-user customers on the Sigfox network
- **Modular Design**: is defined as HW/SW design which must :

- be integrated into a Device to operate on Sigfox Network
- fulfill Sigfox Verified TM modular design requirements
- **Partner:** Person/company developing a Sigfox product that can be either a Modular Design, a Device or a Development Solution, and intended to pass through Sigfox Certification process.
- **Sigfox Protocol Library:** SW binary file for management of the protocol part of the Sigfox communication.
- **Product :** term used in this document covering Devices and modular designs.
- **Development Solution :** Engineering board, technology evaluation board or prototyping tool that is not used to operate on Sigfox network for commercial service delivery. It can be a development kit, breakout, shield board, expansion/extension board...

1.4.2. Accronyms

- **2GFSK:** 2-Level Gaussian Frequency Shift Keying
- **AES:** Advanced Encryption Standard
- **CBC:** Cipher Block Chaining
- **CS:** Carrier Sense
- **Cold Test:** Test executed in initial condition (wait till the UUT come back to the initial system between two tests)
- **DBPSK:** Differential Binary Phase-Shift Keying
- **UUT :** Unit Under Test (Device, Modular Design or Development Solution)
- **DC :** Duty Cycle: part of a period in which a signal is active (high state/Period)
- **ENC:** Encrypted
- **FH :** Frequency Hopping
- **Keep-Alive :** Keep-Alive Control Message
- **Legacy Uplink:** initial payload format of Sigfox Uplink without encryption
- **LBT:** Listen Before Talk
- **PER:** Packet Error Rate
- **RC:** Radio Configuration
- **RF:** Radio Frequency
- **Sigfox Message:** Three frames with payload 303132333435363738393A3B
- **TS_{UL} :** Duration of an Uplink symbol

1.5. Radio Configurations overview

Radio Configuration	Uplink Frequency (Hz)	Downlink Frequency (Hz)	Baudrate (bps)	TS _{UL} (s)	Spectrum Access	Monarch Beacon Frequency (Hz)
RC1	868130000	869525000	100	1 /100	DC	869505000
RC2	902200000	905200000	600	1 /600	FH	905180000
RC3c	923200000	922200000	100	1 /100	LBT	922250000
RC4	920800000	922300000	600	1 /600	FH	922250000
RC5	923300000	922300000	100	1 /100	LBT	922250000
RC6	865200000	866300000	100	1 /100	DC	866250000
RC7	868800000	869100000	100	1 /100	DC	869160000

1.6. References

- Sigfox Device Radio Specifications (<https://build.sigfox.com/sigfox-device-radio-specifications>)

2. Requirements

The following requirements have to be followed on all range of the **input power supply**.

RF tests will be executed on nominal, minimum and maximum value of the range.

All others tests will be executed on nominal value of the range.

Note :

- Cold tests have to be done to validate all RF requirements, the goal is to validate the UUT in worst condition (before established system) .
- Cold tests will be done only on the Sigfox RF part.

2.1. Operational Frequencies

[PRS-RFP-001] Spectral Occupation product's population

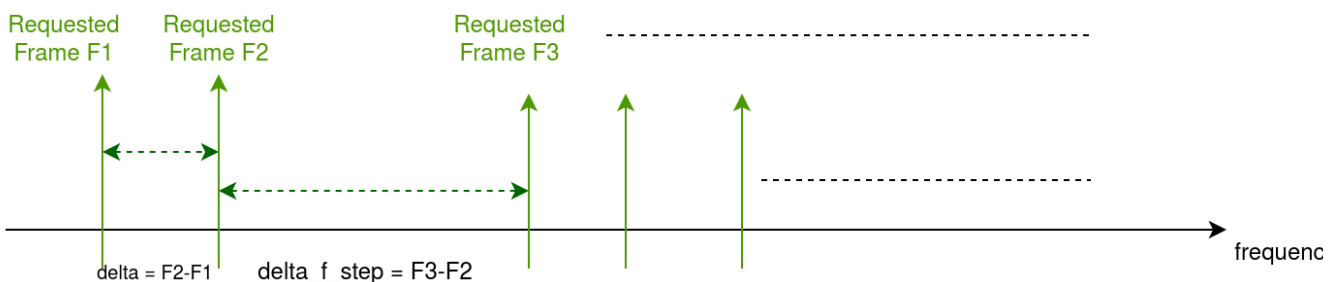
Specification description

UUT shall ensure that its radio contribution makes the overall spectral occupation of all the same product Units uniform over the uplink usable macro-channel.

Test Execution to be executed on **Nominal Voltage**:

- Configure [TX Test Setup - Demodulated Information](#)
- Execute the Test Procedure
- Set the UUT in **Nominal Voltage**
- Execute **Device Test Mode A**
- Get the frequency delta between two adjacent frequencies (example : F2-F1, F3-F2, etc..)
- Keep the max one : $|\text{delta_f_step}|$ (example : F3-F2 on the following picture)
- Compute the Fulmax = center UL frequency + 96000Hz (example : In RC1 Fulmax = 868130000 + 96000)
- **Test is PASSED if $(\text{static_frequency_accuracy_declared} * \text{Fulmax})/3 \geq |\text{delta_f_step}| > 50\text{Hz}$** Other wise test is FAILED.

Example :



[PRS-RFP-002] Operational Frequencies Range

Specification description

Range of frequencies used during transmission has to be between 136800 Hz and 192000 Hz.

Test Execution to be executed on **Nominal Voltage**:

- Configure [TX Test Setup - Demodulated Information](#)
- Execute the Test Procedure
- Set the UUT in **Nominal Voltage**
- Execute **Device Test Mode B**
- Take the minimum and the maximum frequencies
- Delta is Fmax-Fmin
- **Test is PASSED if Delta >= 136800 Hz and Delta <= 192000Hz** . Otherwise test is FAILED.

[PRS-RFP-003] Operational Frequencies Distribution

Specification description

The distribution of all frequencies used during transmission has to be uniform.

access spectrum	DC/LBT	FH
n	20	6

Test Execution to be executed on **Nominal Voltage**:

- Configure [TX Test Setup - Demodulated Information](#)
- Set the UUT in **Nominal Voltage**
- Execute **Device Test Mode B**
- Take the minimum (Fmin) and the maximum (Fmax) frequencies
- The number 'n' used for the uniform distribution check depends on spectrum access :
- Divide in (Fmax-Fmin / n) part
- Should have (300 / n) for each part
- Apply Pearson's formula, (Khi2 5%)
- **Test is PASSED if the distribution is uniform (Pearson' sum < khi2 5% value)**. Otherwise test is FAILED

[PRS-RFP-004] Static Frequency Tolerance

Specification description

UUT carrier frequency (absolute value) must be at +/- 20 ppm for operational bands.

Temperature Frequency tolerance added to Aging frequency tolerance and Static Frequency Tolerance (static imprecision of the UUT) must be less or equal to +/- 20 ppm during all the product life.

Test Execution to be executed on **Nominal, Minimum and Maximum Voltage**:

- Configure [TX Test Setup - DBPSK Modulation Quality](#)
- Execute **Device Test Mode C**
- Get Frequency
- Identify the Static Frequency accuracy measured.
- Based on this value and the datasheet, compute the global frequency accuracy taking care of aging (on 5 years) and temperature.
- The global frequency accuracy (|(Static Freq accuracy Measured + aging (on 5 years) + max temperature tolerance)| <= 20 ppm (17363 Hz for 868.13 MHz) = RESULT1
- Compare the |Static Freq accuracy Measured| should be <= |Freq accuracy Declared| = RESULT2
- **Test PASSED if both RESULT1 and RESULT2 are passed**. Otherwise test is FAILED.

2.2. TX RF

2.2.1. modulation

[PRS-RFP-010] DBPSK Modulation

Specification description

UUT must use DBPSK modulation. Modulation mapping (0: modulate 1: do not modulate)

Test Execution to be executed on **Nominal, Minimum and Maximum Voltage:**

- Configure [TX Test Setup - DBPSK Modulation Quality](#)
- Execute *Device Test Mode C*
- **Test PASSED if the signal is modulated with phase when a 0 occurs.** Otherwise test is FAILED.

[PRS-RFP-011] Phase Measurement

Specification description

UUT DBPSK modulation must be compliant with following performances :

- Maximum modulation RMS phase error : 10 degree from one symbol to another.
- Maximum modulation peak phase error : 30 degree from one symbol to another.

Test Execution to be executed on **Nominal, Minimum and Maximum Voltage:**

- Configure [TX Test Setup - DBPSK Modulation Quality](#)
- Execute *Device Test Mode C*
- Measure the phase shifting for all block of symbols.
- **Test is PASSED if phase shifting is 10 degree RMS and 30 degree Peak.** Otherwise test is FAILED.
- Note : The measurement takes care of the frequency drift.

[PRS-RFP-012] Extra symbols before the first Sigfox bit of the frame

Specification description

Transmission must include an extra symbol timing from 0 to 2 TSul before the first Sigfox bit.

No phase shifting is allowed during this phase except at the TSul.

Test Execution to be executed on **Nominal, Minimum and Maximum Voltage:**

- Configure [TX Test Setup - DBPSK Modulation Quality](#)
- Execute *Device Test Mode C*
- Check the extra symbols timing of all frames
- **Test is PASSED if $0 \text{ TSul} \leq \text{Extra Symbol Timing in ms} \leq 2 \text{ TSul}$.** Otherwise test is FAILED.

[PRS-RFP-013] Extra symbols after the last Sigfox bit of the frame

Specification description

Transmission must include an extra symbol timing from 0 to 2 TSul after the transmission of the last Sigfox bit.

No phase shifting is allowed during this phase except at the TSul.

Test Execution to be executed on **Nominal, Minimum and Maximum Voltage:**

- Configure [TX Test Setup - DBPSK Modulation Quality](#)
- Execute **Device Test Mode C**
- Check the extra symbols timing of all frames
- **Test is PASSED if $0 \text{ TSul} \leq \text{Extra Symbol Timing in ms} \leq 2 \text{ TSul}$.** Otherwise test is FAILED.

2.2.2. TX Baudrate

[PRS-RFP-014] TX Max Symbol duration

Specification description

UUT must be able to transmit at the defined baudrate (for its RC) with DBPSK modulation with tolerances on the symbol duration of +/- 1 %

Test Execution to be executed on **Nominal, Minimum and Maximum Voltage:**

- Configure [TX Test Setup - DBPSK Modulation Quality](#)
- Execute **Device Test Mode C**
- Compute time between 2 symbols on all frames, and compute the Error.
- **Test is PASSED if symbol rate is baudrate +/-1 %.** Otherwise test is FAILED.

[PRS-RFP-015] Max TX Baudrate Cumulated Error

Specification description

UUT must have a maximum baudrate cumulated error of 3% of the whole ideal transmission time. (i.e : for a 26 bytes frame (2.08 s duration on RC1), tolerance of 62.4 ms)

Test Execution to be executed on **Nominal, Minimum and Maximum Voltage:**

- Configure [TX Test Setup - DBPSK Modulation Quality](#)
- Execute **Device Test Mode C**
- Compute time between 2 symbols on all frames, and compute the Cumulated Error.
- **Test is PASSED if Cumulated Error rate is baudrate +/-3 % .** Otherwise test is FAILED.

2.2.3. Output Spectrum

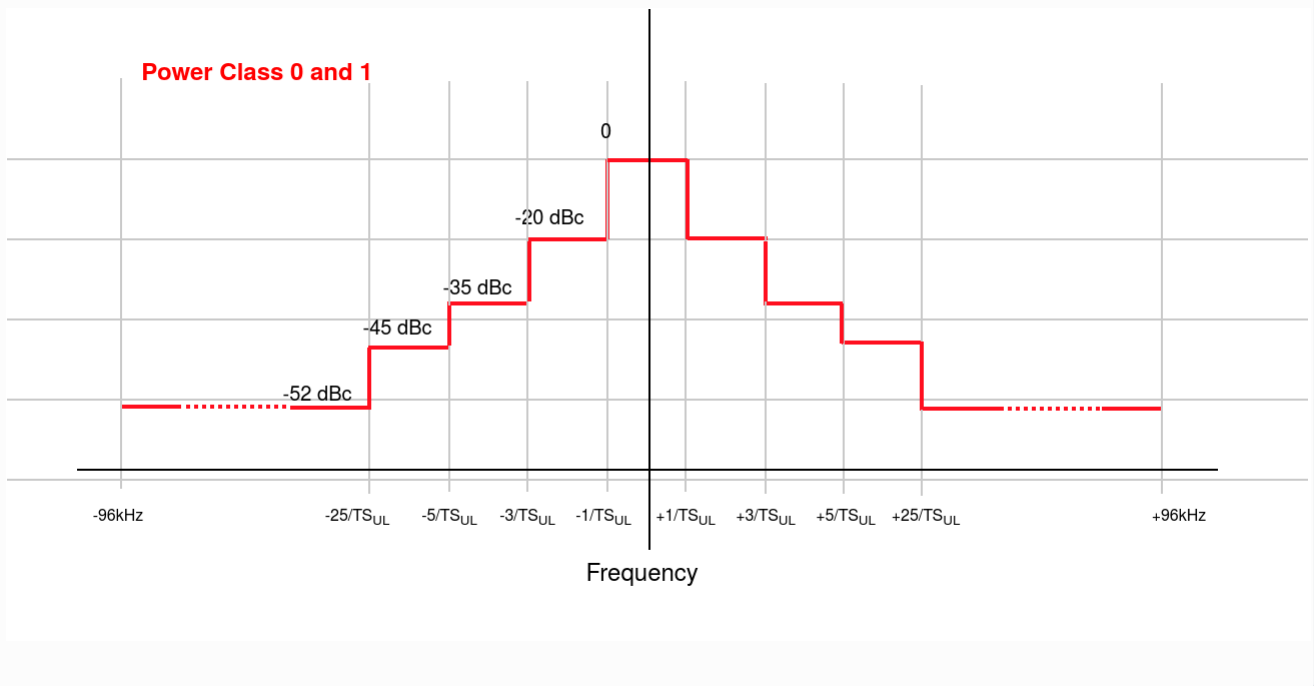
[PRS-RFP-016] Power Spectral Density for class 0 and 1

Specification description

UUT shall respect the following spectrum occupation (averaged power spectral density on associated frequency interval).

A modular design respecting class 0 and 1 spectrum occupation can be used for devices or Development Solution with any Sigfox class.

TS_{UL} is the duration of an uplink symbol : it depends on the baudrate of the selected RC.



Test Execution to be executed on **Nominal, Minimum and Maximum Voltage:**

- Configure [TX Test Setup - DBPSK Modulation Quality](#)
- Execute **Device Test Mode C**
- Export all values
- Calculate the power for each part to compute power spectral density
- Normalize the first part to 0 and all others part according to the first to have dBc values
- **Test is PASSED if the UUT respect the Sigfox spectrum occupation.** Otherwise test is FAILED

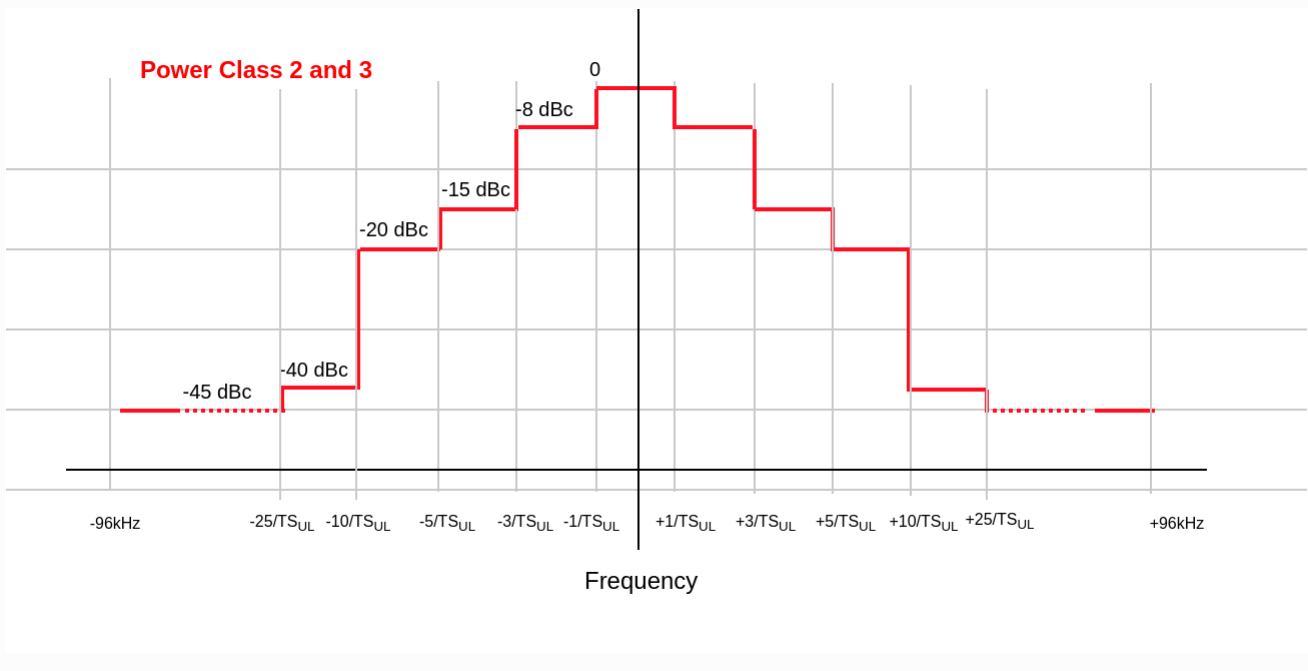
[PRS-RFP-017] Power Spectral Density for class 2 and 3

Specification description

UUT shall respect the following spectrum occupation (averaged power spectral density on associated frequency interval).

A modular design respecting only class 2 and 3 spectrum occupation can only be used in class 2 and 3 devices or Development Solution.

TS_{UL} is the duration of an uplink symbol : it depends on the baudrate of the selected RC.



Test Execution to be executed on **Nominal, Minimum and Maximum Voltage:**

- Configure [TX Test Setup - DBPSK Modulation Quality](#)
- Execute **Device Test Mode C**
- Export all values
- Calculate the power for each part to compute power spectral density
- Normalize the first part to 0 and all others part according to the first to have dBc values
- **Test is PASSED if the UUT respect the Sigfox spectrum occupation.** Otherwise test is FAILED

2.2.4. Carrier frequency stability

[PRS-RFP-018] Transitional Frequency Dynamic Drift

Specification description

UUT carrier frequency must respect a max absolute frequency shifting peak of

- 30 Hz/s from the first quarter of the synchro bits to the end of the synchro bits for 100bps baudrate RCs
- 100 Hz/s from the first quarter of the synchro bits to the end of the synchro bits for 600bps baudrate RCs

Test Execution to be executed on **Nominal, Minimum and Maximum Voltage:**

- Configure [TX Test Setup - DBPSK Modulation Quality](#)
- Execute **Device Test Mode C**
- Check the transitional frequency Drift measurement
- **Test is PASSED if the transitional frequency drift has a max absolute frequency shifting peak of 30 Hz/s on 100bps signal or 100Hz/s on 600bps signal** . Otherwise test is FAILED.

[PRS-RFP-019] Established Frequency Dynamic Drift

Specification description

UUT carrier frequency must respect a max absolute frequency shifting of :

- 20 Hz/s from end of synchro bits to the end of a transmission of the maximum Sigfox frame for 100bps baudrate RCs.
- 50 Hz/s from end of synchro bits to the end of a transmission of the maximum Sigfox frame for 600bps baudrate RCs.

Method of the least squares will be used for the measurement.

Test Execution to be executed on **Nominal, Minimum and Maximum Voltage:**

- Configure [TX Test Setup - DBPSK Modulation Quality](#)
- Execute **Device Test Mode C**
- Check the established frequency Drift measurement
- **Test is PASSED if the establish frequency drift has a max absolute frequency shifting of 20 Hz/s on 100bps signal or 50Hz/s on 600bps signal**. Otherwise test is FAILED.

2.3. RX

2.3.1. Demodulation

[PRS-RFP-020] 2GFSK 600bps **DOWNLINK**

Specification description

UUT must be able to demodulate 2GFSK at 600bps (BT = 1.0, $\Delta f = \pm 800\text{Hz}$) with the following duration ($T_{Sdl} = 1/600\text{ s}$) :

- duration of the start of radio burst less or equal to $0,5 \times T_{Sdl}$,
- duration of the end of radio burst less or equal to $0,5 \times T_{Sdl}$.

Test Execution to be executed on **Nominal Voltage:**

- Configure [RX Test Setup](#) at level (-100 dBm)
- Execute **Device Test Mode D**
- Check the packet received by the device
- **Test is PASSED if the device receives the frame with specific RX-GFSK Sigfox pattern**. Otherwise test is FAILED.

2.3.2. Sigfox Link Budget

[PRS-RFP-021] Sigfox Link Budget **DOWNLINK**

Specification description

UUT link budget should be ≤ -126 dBm with a PER at 10 % within a confidence interval greater or equal to 95% when the Modulated Output Power is the one mentioned in table below, to keep the link budget balanced.

	RC1 / RC6 / RC7 / RC3	RC2 / RC4	RC5
Output power value ERP	14 dBm	22 dBm	12 dBm

If the Modulated Output Power is less than the expected value in dBm, so all dB lost in Tx will be added at -126 to keep the link budget balanced.

At the balanced link budget, the Rx level should be : $RxLevelAtBalancedLinkBudget = -126 + OutputPowerValueERP - TxPower$

Test Execution to be executed on Nominal Voltage:

- Configure **TX/RX Test Setup** at $RxSensiAtBalancedLinkBudget$ (as described above) with $Time = (T_{DL Min} + T_{DL MAX})/2$
- Execute **Device Test Mode E**
- After each sent frame, count the number of frames received by the UUT and calculate the estimated PER interval for 95% confidence.
- If less than 300 frames were sent and 10% PER is within the estimated PER interval, repeat the procedure, Otherwise check the final verdict condition.
- Test is FAILED if less than 300 frames were sent and 10 % PER is below the estimated PER interval for 95% confidence. **Otherwise Test is PASSED**

With the above rules, the verdict can be identified much before the 300 frames sent.

2.4. Protocol

[PRS-RFP-030] AES

Specification description

UUT must include an AES module with CBC mode with a 16 bytes key (Hardware or Software) for authentication on network.

The Init Vector (IV) is set to 0.

Test Execution to be executed on Nominal Voltage:

- Configure **TX Test Setup - Demodulated Information**
- Execute **Device Test Mode J**
- Check on the Test Equipment that the same payload is received.
- **Test is PASSED if HMAC is OKAY for all frames.** Otherwise test is FAILED

[PRS-RFP-031] Frequency Storage

Specification description

UUT frequency selection shall be random uniformly on its entire range of operation and this along its complete life-cycle, including in case of reboot of the UUT (i.e. no repeatable sequence if frequency selection from a boot to another).

Test Execution to be executed on **Nominal Voltage**:

- Configure [TX Test Setup - Demodulated Information](#)
- Execute *Device Test Mode L*
- Get back frequencies that has been demodulated
- Power Down the UUT and execute the test again twice.
- Compare 1st frequency of each reboot, 2nd frequency of each reboot and 3rd frequency of each reboot
- **Test is PASSED if all 1st frequencies , all 2nd frequencies, all 3rd frequencies are different.** Otherwise test is FAILED

[PRS-RFP-032] Message counter Storage

Specification description

The message counter should be increased MC+1 for each new message, or 0 if MC+1 = rollover counter value, and this along its complete life-cycle, including in case of reboot of the end-point. The message counter must not be readable by application.

In case of ENCRYPTION, the message counter rollover must be 4096.

Test Execution to be executed on **Nominal Voltage**:

- Configure [TX Test Setup - Demodulated Information](#)
- Execute *Device Test Mode L*
- Check on the Test Equipment, the message counter that has been demodulated: MC1
- Power Down the UUT and execute the test again. Capture the message counter in MC2
- **Test is PASSED if MC2 = MC1 + 1 (or 0 if MC+1 = rollover counter value)** . Otherwise test is FAILED

[PRS-RFP-033] Public Key switch **PUBLIC KEY**

Specification description

UUT must allow a way to switch from private to public key.

KEY = 00112233445566778899AABBCCDDEEFF (KEY[0]=00, KEY[15]=FF)

Test Execution to be executed on **Nominal Voltage**:

- Configure [TX Test Setup - Demodulated Information](#)
- Switch the UUT to Public Key
- Configure the test equipment in public Key
- Execute *Device Test Mode K*
- **Test is PASSED if the UUT is able to switch to public key and HMAC is OKAY.** Otherwise test is FAILED.

[PRS-RFP-034] Number of frames per message in Uplink mode

Specification description

Without blocker, UUT must send NupFrame Sigfox RF frames per customer message (according to the following table).

Features	Number of frame per message (NupFrame)
Single Frame	1
Multi Frames	3

Test Execution to be executed on **Nominal Voltage**:

- Configure [TX Test Setup - Demodulated Information](#)
- Execute *Device Test Mode J*
- Get the demodulated data
- Count the number of frames that have been received by the UUT (check the ID)
- **Test is PASSED if number of frame is equal to NupFrame** . Otherwise test is FAILED

[PRS-RFP-035] Legacy Uplink

Specification description

UUT has to be able to send Sigfox Frame through the Sigfox Test Mode function

Test Execution to be executed on **Nominal Voltage**:

- Configure [TX Test Setup - Demodulated Information](#)
- Execute *Device Test Mode J*
- Check on the Test Equipment all demodulated data
- **Test is PASSED if all payload sizes have been received**. Otherwise test is FAILED

[PRS-RFP-036] Uplink Encrypted payload **PAYLOAD ENCRYPTION**

Specification description

UUT has to be able to send Sigfox encrypted Frames through the Sigfox Test Mode function.

Test Execution to be executed on **Nominal Voltage**:

- Configure [TX Test Setup - Demodulated Information](#)
- Execute *Device Test Mode J*
- Check on the Test Equipment all demodulated data
- **Test is PASSED if all payload encrypted sizes have been received** . Otherwise test is FAILED

[PRS-RFP-037] Downlink Legacy **DOWNLINK**

Specification description

UUT has to be able to receive Sigfox Frames through the Sigfox Test Mode function and to report if a frame has been received properly or not

Test Execution to be executed on Nominal Voltage:

- Configure **TX/RX Test Setup** with Time = $(T_{DL\ Min} + T_{DL\ MAX})/2$
- Execute **Device Test Mode F**
- **Test is PASSED if the UUT receives frame with specific Sigfox GFSK pattern.** Otherwise test is FAILED

[PRS-RFP-038] Downlink Encrypted Payload **DOWNLINK** and **PAYLOAD ENCRYPTION**

Specification description

UUT has to be able to receive Sigfox encrypted Frames

Test Execution to be executed on Nominal Voltage:

- Configure **TX/RX Test Setup** with Time = $(T_{DL\ Min} + T_{DL\ MAX})/2$
- Use the UUT in encrypted payload mode
- Execute **Device Test Mode F**
- **Test is PASSED if the UUT received encrypted frame.** Otherwise test is FAILED

[PRS-RFP-039] RSSI level **DOWNLINK**

Specification description

At a specific Downlink Frame level, the Confirmation Control Message shall return the same level of RSSI of the received GFSK (+/-2dB).

Test Execution to be executed on Nominal Voltage:

- Configure **TX/RX Test Setup** with Time = $(T_{DL\ Min} + T_{DL\ MAX})/2$
- Execute **Device Test Mode F**
- Execute this test with RSSI level set at -80 and store RSSI level from the UUT.
- Run again this test with RSSI level set at -100 and store RSSI level from the Device.
- **Test is PASSED if UUT RSSI (returned through the Confirmation Control Message) is +/-2dB GFSK RSSI level sent.** Otherwise test is failed

[PRS-RFP-040] Number of Uplink frame in bi-directional mode **DOWNLINK**

Specification description

UUT must send NupFrame Sigfox RF frames per customer message for a message requesting a downlink response.

Features	Number of frame per message (NupFrame)
Single Frame	1
Multi Frames	3

Test Execution to be executed on **Nominal Voltage**:

- Configure **TX/RX Test Setup** with Time = $(T_{DL\ Min} + T_{DL\ MAX})/2$
- Execute **Device Test Mode F**
- Count the number of frames that have been received by the UUT (check the ID)
- **Test is PASSED if the number of frames is equal to NupFrame** . Otherwise test is FAILED

[PRS-RFP-041] Carrier center frequencies in bi-directional mode **DOWNLINK and MULTI-FRAME**

Specification description

UUT shall ensure that the carrier center frequencies of the second and third radio bursts for a message requesting a downlink response are, as follows:

- $f_{UL2} = f_{UL1} + f_{MF}$
- $f_{UL3} = f_{UL1} - f_{MF}$

where f_{UL1} is the carrier center frequency of the first UL radio burst of the procedure.

Spectrum Access	DC/LBT	FH
f_{MF}	6kHz	25kHz

Test Execution to be executed on **Nominal Voltage**:

- Configure **TX/RX Test Setup** with Time = $(T_{DL\ Min} + T_{DL\ MAX})/2$
- Execute **Device Test Mode F**
- Take the carrier center frequency of the first frame : f_{UL1}
- Compare this carrier center frequency to the carrier center frequency of the 2nd and 3rd frame : f_{UL2} and f_{UL3}
- **Test is PASSED if $f_{UL2} = f_{UL1} + f_{MF}$ and $f_{UL3} = f_{UL1} - f_{MF}$** . Otherwise test is FAILED

2.5. Timings

2.5.1. Timings in Uplink Procedure

[PRS-RFP-050] TX Interframe Timing in Uplink mode **MULTI-FRAME**

Specification description

Without blocker, the TX interframe duration in Uplink mode has to be between min and max supporting interframes as defined in below table :

Access Spectrum	DC	FH	LBT
Min Interframe	10 ms	10 ms	10 ms
Max Interframe	2000 ms	2000 ms	N.A

Test Execution to be executed on Nominal Voltage:

- Configure [TX Test Setup - Demodulated Information](#)
- Execute **Device Test Mode J**
- Store the timestamp of each frame
- Compute delay with frame duration
- **Test is PASSED if min interframe <= delay <= max interframe.** Otherwise test is FAILED

[PRS-RFP-051] TX repeat timeout **LBT and MULTI-FRAME**

Specification description

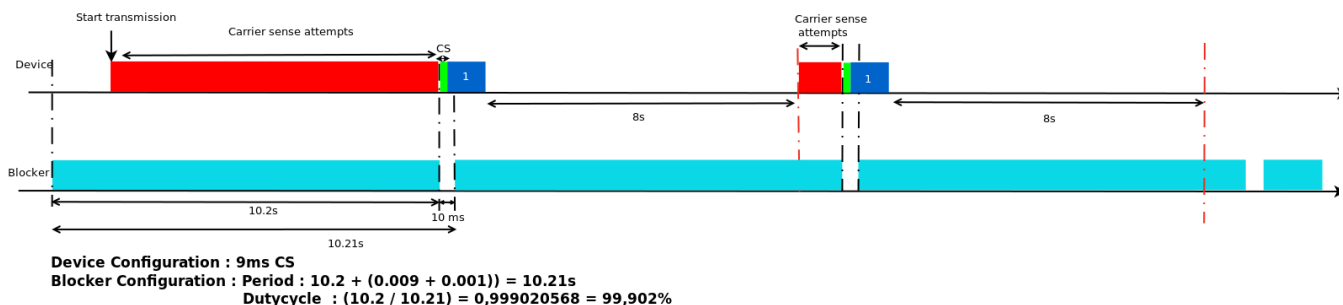
8s after the end of transmission of the first frame, UUT shall not start any repetition.

Note : End of transmission of the frame is considered when energy left is at 10% of its maximum

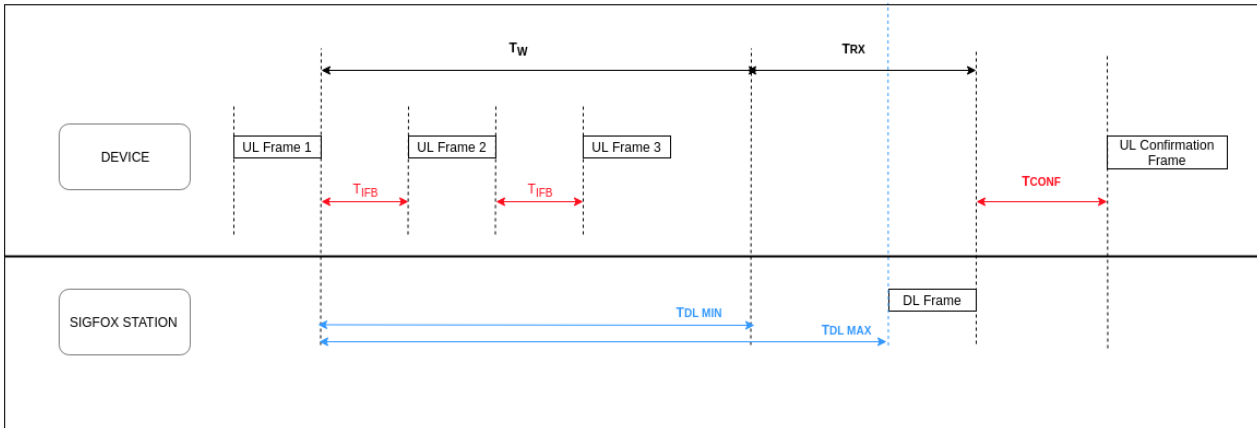
Test Execution to be executed on Nominal Voltage:

- Configure [TX Test Setup - LBT](#)
- Activate the blocker
- Execute **Device Test Mode G**
- With the blocker, both messages should transmit the first repetition only , and the message counter between first and second message should be MC+1
- Both trasmission should be separated by at least 8s
- **Test is PASSED if all conditions (repetition, MC, timing) have been validated.** Otherwise test is FAILED

Blocker setup example :



2.5.2. Timings in Bidirectional Procedure



Access spectrum	DC	FH	LBT
T _w	20s	20s	19s
T _{DL MIN}	20.1s	20.1s	19.1s
T _{DL MAX}	44.5s	44.5s	52.5s
T _{CONF MIN}	1.4s	1.4s	1.4s
T _{CONF MAX}	4s	4s	4s

[PRS-RFP-052] TX Interframe Timing in Bi-directional mode **DOWNLINK and MULTI-FRAME**

Specification description

Without blocker, the TX interframe duration in Uplink/Downlink mode has to be between min and max supporting interframes as defined in below table :

Access spectrum	DC	FH	LBT
Min Interframe	500 ms	500 ms	10 ms
Max Interframe	525 ms	525 ms	N.A

Test Execution to be executed on **Nominal Voltage**:

- Configure **TX/RX Test Setup** with Time = $(T_{DL\ Min} + T_{DL\ MAX})/2$
- Execute **Device Test Mode F**
- Store the timestamp of each frame
- Compute delay with frame duration
- **Test is PASSED if Min interframe <= delay <= Max interframe.** Otherwise test is FAILED.

[PRS-RFP-053] RX Start Of Listening **DOWNLINK**

Specification description

UUT must be able to receive a Downlink frame sent $T_{DL\ MIN}$ after the first frame (This timing takes into account the extra symbol time and the downlink frame duration).

Test Execution to be executed on **Nominal Voltage**:

- Configure **TX/RX Test Setup** with Time = $T_{DL\ Min}$
- Execute **Device Test Mode F**
- **Test is PASSED if the Confirmation Control Message has been received with the right payload and the test frame with 0x01**. Otherwise test is FAILED

[PRS-RFP-054] RX End Of Listening **DOWNLINK**

Specification description

UUT must be able to receive a Downlink frame sent $T_{DL\ MAX}$ after the first frame (This timing takes into account the extra symbol time and the downlink frame duration).

Test Execution to be executed on **Nominal Voltage**:

- Configure **TX/RX Test Setup** with Time = $T_{DL\ MAX}$
- Execute **Device Test Mode F**
- **Test is PASSED if the Confirmation Control Message has been received with the right payload and the test frame with 0x01**. Otherwise test is FAILED

[PRS-RFP-055] RX to Confirmation Control Message Timing **DOWNLINK**

Specification description

After receiving the downlink frame, UUT has to wait $T_{CONF\ MIN}$ and no later than $T_{CONF\ MAX}$ before sending the Confirmation Control Message.

Test Execution to be executed on **Nominal Voltage**:

- Configure **TX/RX Test Setup** with Time = $(T_{DL\ Min} + T_{DL\ MAX})/2$
- Execute **Device Test Mode F**
- Store the timestamp of each frame
- Compute delay between end of 2GFSK and beginning of the Confirmation Control Message
- **Test is PASSED if $T_{CONF\ MIN} \leq \text{delay} \leq T_{CONF\ MAX}$** . Otherwise test is FAILED

2.6. Monarch RC Determination

[PRS-RFP-060] RC determination from Monarch signal at High power level **MONARCH**

Specification description

UUT must be able to identify the current tested RC based on Monarch signal when only a current tested beacon is transmitted at -27dBm (power level of the whole beacon).

Test Execution to be executed on **Nominal Voltage**:

- Configure [Monarch Test Setup](#)
- Execute **Device Test Mode H**
- The equipment driven by the UUT (through a Sigfox frames) sends the current tested RC beacon , with a signal at -27 dBm (power level of the whole beacon). The loop is executed 10 times.
- Compute the error rate of the current tested RC beacon
- **Test is PASSED if the error rate <= 0 %**. Otherwise test is FAILED.

[PRS-RFP-061] Link Budget on Monarch signal **MONARCH**

Specification description

UUT Monarch link budget should be <= -126 dBm with a PER at 10 % within a confidence interval greater or equal to 95% when the Modulated Output Power is the one mentioned in table below, to keep the link budget balanced.

	RC1 / RC6 / RC7 / RC3	RC2 / RC4	RC5
Output power	14 dBm	22 dBm	12 dBm
value ERP			

If the Modulated Output Power is less than the expected value in dBm, so all dB lost in Tx will be added at -126 to keep the link budget balanced.

At the balanced link budget, the Rx level should be : $\text{MonarchRxLevelAtBalancedLinkBudget} = -126 + \text{OuptutPowerValueERP} - \text{TxPower}$

Test Execution to be executed on **Nominal Voltage**:

- Configure [Monarch Test Setup](#) at $\text{MonarchRxSensiAtBalancedLinkBudget}$ (as described above)
- Execute **Device Test Mode I**
- The equipment driven by the UUT (through a Sigfox frames) sends the beacon RCx , with a signal at $-126 + \text{OuptutPowerValueERP} - \text{TxPower}$ dBm (power level of the whole beacon).
- After each sent frame, count the number of frames received by the UUT and calculate the estimated PER interval for 95% confidence.
- If less than 300 frames were sent and 10% PER is within the estimated PER interval, repeat the procedure, Otherwise check the final verdict condition.
- Test is FAILED if less than 300 frames were sent and 10 % PER is below the estimated PER interval for 95% confidence or if other RC has been identified. **Otherwise Test is PASSED**

With the above rules, the verdict can be identified much before the 300 frames sent.

[PRS-RFP-062] Robustness to High Power Level interferer for Monarch signal **MONARCH**

Specification description

UUT must not detect current tested RC when only First pattern of current tested RC (orSecond Pattern of current tested RC) is sent during 400 ms at -27dBm (power level of the whole beacon).

Test Execution to be executed on **Nominal Voltage**:

- Configure [Monarch Test Setup](#)
- Execute ***Device Test Mode H***
- The equipment driven by the UUT (through a Sigfox frames) execute following sequence 5 times:
 - Send First Pattern of current tested RC during 400 ms once at -27dBm (power level of the whole beacon). The UUT must not detect any RC.
 - Send Second Pattern of current tested RC during 400 ms once at -27dBm (power level of the whole beacon). The UUT must not detect any RC, compute the error rate.
- **Test is PASSED if error rate ≤ 0 %. (if NO RC has been detected)** Otherwise test is FAILED.

[PRS-RFP-063] Robustness to Low Power Level interferer for Monarch signal **MONARCH**

Specification description

UUT must not detect the current tested RC when only First Pattern of the current tested RC (orSecond Pattern of the current tested RC) is sent during 400 ms at -120dBm.

Test Execution to be executed on **Nominal Voltage**:

- Configure [Monarch Test Setup](#)
- Execute ***Device Test Mode H***
- The equipment driven by the UUT (through a Sigfox frames) execute following sequence 5 times:
 - Send First Pattern of the current tested RC during 400 ms once at -120dBm. The UUT must not detect any RC
 - Send Second Pattern of the current tested RC during 400 ms once at -120dBm. The UUT must not detect any RC, compute the error rate.
- **Test is PASSED if error rate ≤ 0 %. (if NO RC has been detected)** Otherwise test is FAILED.

3. Additional Measurements

3.1. Modulated Conducted TX Output power

[PRS-RFP-070] Modulated Conducted Output Power

Specification description

To be able to benefit from optimal Quality of Service with a balanced link budget, Sigfox recommends to respect the following maximum output radiated power :

	RC1 / RC6 / RC7 / RC3	RC2 / RC4	RC5
Output power value	14 dBm (ERP)	22 dBm(ERP)	12 dBm(ERP)
	16 dBm (EIRP)	24 dBm(EIRP)	14dBm(EIRP)

Test Execution to be executed on **Nominal Voltage**:

- Configure [TX Test Setup - DBPSK Modulation Quality](#)
- Execute *Device Test Mode C*
- **Give the value of the Modulated Conducted Output Power measured**

3.2. Validation of the information contained in the Keep-Alive Control Message

[PRS-RFP-071] UUT Temperature level **Keep-Alive**

Specification description

The Keep-Alive Control Message shall return the level of Temperature at which the test is executed or 0 is the UUT is not able to return it.

Test Execution to be executed on **Nominal Voltage**:

- Configure [TX Test Setup - Demodulated Information](#)
- Execute *Device Test Mode J*
- Demodulate all frames
- **Give the temperature value (returned through the Keep-Alive Control Message)**

[PRS-RFP-072] UUT Voltage level **Keep-Alive**

Specification description

The Keep-Alive Control Message shall return the level of Voltage at which the test is executed or 0 is the UUT is not able to return it.

Test Execution to be executed on **Nominal Voltage**:

- Configure [TX Test Setup - Demodulated Information](#)
- Execute *Device Test Mode J*
- Demodulate all frames
- **Give the voltage value (returned through the Keep-Alive Control Message)**

3.3. I/Q Wave record

[PRS-RFP-073] I/Q Wave record

Specification description

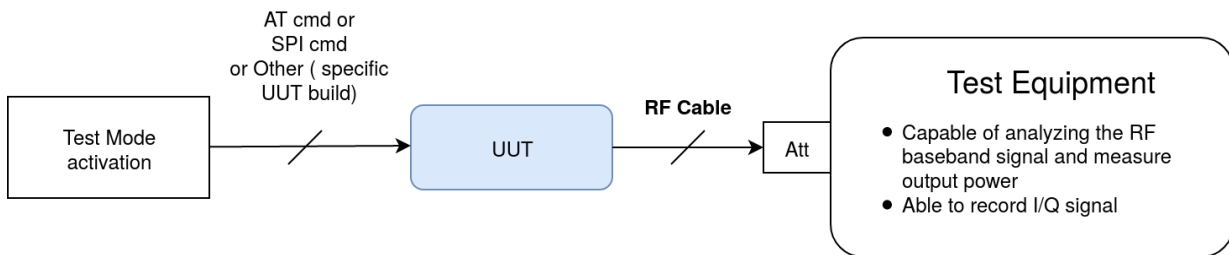
Test Mode C shall be recorded with a 20dB minimum SNR in .raw format.

Test Execution to be executed on **Nominal Voltage**:

- Configure [TX Test Setup - DBPSK Modulation Quality](#)
- Execute ***Device Test Mode C***
- **Record the wave with specific SNR (expected minimum 20dB)**

4. Annexe : GenericTest Setup

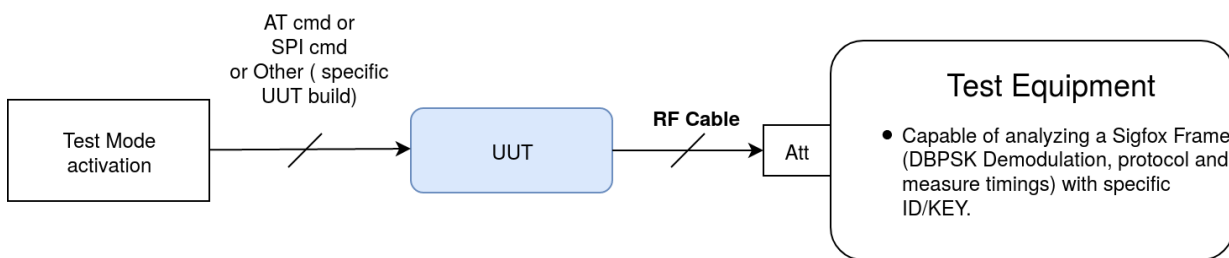
4.1. TX Test Setup - DBPSK Modulation Quality



Setup configuration :

- Configure the Test Equipment at the appropriate Radio Configuration Uplink Frequency
- Calibrate the Test Equipment (considering cable loss)

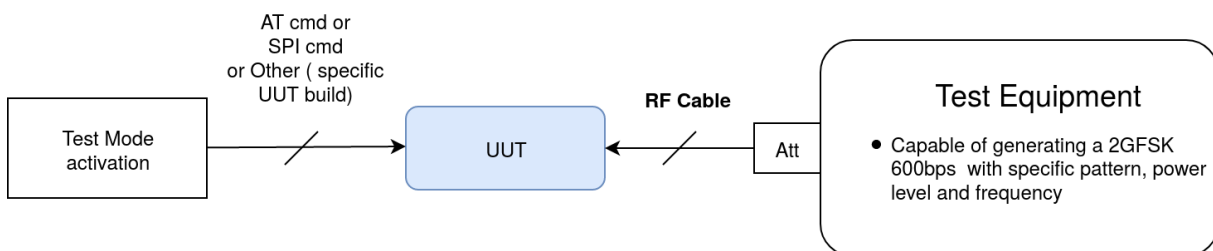
4.2. TX Test Setup - Demodulation Information



Setup configuration :

- Configure the Test Equipment at the appropriate Radio Configuration Uplink Frequency with specific UUT ID/KEY
- Calibrate the Test Equipment (considering cable loss)

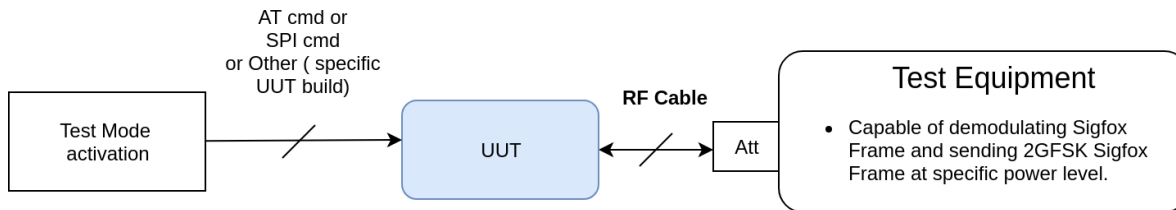
4.3. RX Test Setup **DOWNLINK**



Setup configuration :

- Calibrate the Test Equipment in Power level and Frequency (considering the Cable loss).
- Configure the level according to the Test Execution
- Send a specific number of 600bps 2GFSK Sigfox pre built frames at a specific power with the pattern (AA AA B2 27 1F 20 41 84 32 68 C5 BA 53 AE 79 E7 F6 DD 9B) at the downlink central frequency

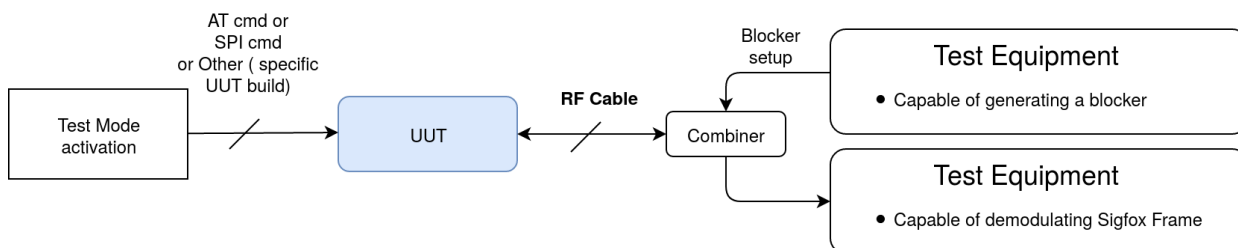
4.4. TX/RX Test Setup **DOWNLINK**



Setup configuration :

- Calibrate the Test equipment in Power level (considering the Cable loss)
- Configure the Test Equipment at the Uplink Central Frequency
- When receiving data with downlink request :
 - Prepare 2GFSK frame response (Id, Key, MC)
 - Configure the Test Equipment at the Downlink central frequency to send the response at Time seconds (Time is specified in the Test Description) after 1st repetition of uplink message
- After sending 2GFSK , reconfigure the Test Equipment at the Uplink Central Frequency

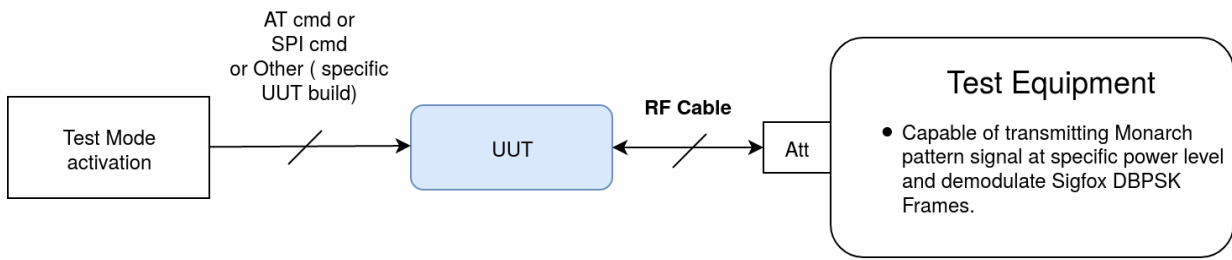
4.5. TX LBT Test Setup **LBT**



Setup configuration :

- Configure the Test Equipment to see the transmission
- Configure the Test Equipment at -40dBm with specific parameters to be able to block your UUT.
 - $Period = (10.2s + (CS_value_in_s + 0.001)) s$
 - $Duty Cycle = (10.2 / Period) * 100 \%$

4.6. Monarch Test Setup **MONARCH**



Test Procedure :

- Calibrate the Test equipment in Power level (considering the Cable loss) and Frequency
- Configure the Test Equipment at the Monarch Beacon Frequency
- Transmit Monarch Signal as defined in the test execution

5. Annexe : Device Test Mode Description

Test Mode Reference	Instructions
Device Test Mode A	<p>Loop (at least) on 9 repetitions of the following : (initial condition : F = Central Uplink Frequency)</p> <ul style="list-style-type: none"> • Within a window of 9s, Send <i>one Sigfox frame (repetition 1)**</i> at F. Hz • Update the frequency $F = F + 100\text{Hz}$
Device Test Mode B	<p>Loop (at least) on 300 repetitions of the following :</p> <ul style="list-style-type: none"> • Start a 18s timer. • Within the 12s after the start of the timer, Send <i>one of the supported types of Sigfox messages*</i>. • Wait for the end of this 18s before sending a new message.
Device Test Mode C	<p>In case of SINGLE-FRAME UUT :</p> <ul style="list-style-type: none"> • Send <i>the UUT's longer supported Sigfox frame (repetition 1)**</i>, uplink request only at the Central Uplink Frequency of the RC. (The payload is set to 0xAA * nbr of bytes if send byte supported or 0 in case of send bit only supported). <p>In case of MULTI-FRAME UUT, Loop on 3 repetitions of the following :</p> <ul style="list-style-type: none"> • Send <i>the UUT's longer supported Sigfox frame (repetition 1)**</i>, uplink request only, with 1s interframe at the Central Uplink Frequency of the RC. (The payload is set to 0xAA * nbr of bytes if send byte supported or 0 in case of send bit only supported). <p>Longer Sigfox Frame order : Send Frame (12 bytes), Send Frame (11 bytes), Send Frame (10 bytes), Send Frame (9 bytes), Send Frame (8 bytes), Send Frame (7 bytes), Send Frame (6 bytes), Send Frame (5 bytes), Send Frame (4 bytes), Send Frame (3 bytes), Send Frame (2 bytes), Send Frame (1 bytes), Keep-Alive, Send Bit (True), Send Bit (False), Send Frame (No Payload)</p>
Device Test Mode D	<p>Wait for a downlink message at the Downlink Central Frequency with AUTHENTICATION OFF with RXGFSK static buffer pattern value and 30s listening window duration.</p>
Device Test Mode E	<p>Loop (at least) on 300 repetitions of the following :</p> <ul style="list-style-type: none"> • Send <i>one Sigfox frame (repetition 1)**</i> : <ol style="list-style-type: none"> 1. If at least 8 bytes supported : with payload (Transmission counter byte[0] and byte [1], Reception counter byte[2] and byte[3], RSSI byte[4], Timeout counter byte[5] and byte [6], command byte[7]). <ol style="list-style-type: none"> a. command = 0x23 on the last frame 2. Otherwise bit 0 if no downlink frame received, bit 1 if downlink frame received <ol style="list-style-type: none"> a. bit 1 on the first frame to start <ul style="list-style-type: none"> • Wait for a downlink message during a listening window of 4s. • Wait for 6s before starting the next loop item.

Device Test Mode F	<ul style="list-style-type: none"> • Send <i>one of the supported types of Sigfox messages*</i> with downlink request • Check the response payload (has to be all bytes set with 0x30 + byte index) • Send one Sigfox frame (repetition 1)** without downlink request : <ol style="list-style-type: none"> 1. If at least 1byte supported : with payload (byte[0] = 1 if the downlink response was correct, byte[0] = 0 if the downlink response was not correct,) 2. Otherwise bit 1 if the downlink response was correct, 0 if the downlink response was not correct.
Device Test Mode G	Send twice, <i>one of the supported types of Sigfox messages*</i> (Uplink request only) with no delay between the messages.
Device Test Mode H	<ul style="list-style-type: none"> • Send one Sigfox frame (repetition 1)** without downlink request with payload 0x00 00 00 00 00 24 . • Execute monarch RC scan with a 4s listening window. • Wait for 6 seconds before running the next loop. <p>Loop on 8 repetitions of the following :</p> <ul style="list-style-type: none"> • Send one Sigfox frame (repetition 1)** without downlink request with payload (RC id on byte [0], successful receptions counter on byte[1]=MSB and byte [2]=LSB, RSSI on byte[3] =MSB and byte[4]=LSB, all other byte=0x00). • Execute monarch RC scan with a 4s listening window. • Wait for 6 seconds before running the next loop. <ul style="list-style-type: none"> • Send one Sigfox frame (repetition 1)** without downlink request with payload 0x00 00 00 00 00 25. • Execute monarch RC scan with a 4s listening window. • Wait for 6 seconds before running the next loop.
Device Test Mode I	<ul style="list-style-type: none"> • Send one Sigfox frame (repetition 1)** without downlink request with payload 0x00 00 00 00 00 24. • Execute monarch RC scan with a 4s listening window. • Wait for 6 seconds before running the next loop. <p>Loop (at least) on 298 repetitions of the following :</p> <ul style="list-style-type: none"> • Send one Sigfox frame (repetition 1)** without downlink request with payload (RC id on byte [0], successful receptions counter on byte[1]=MSB and byte [2]=LSB, RSSI on byte[3] =MSB and byte[4]=LSB, all other byte=0x00). • Execute monarch RC scan with a 4s listening window. • Wait for 6 seconds before running the next loop. <ul style="list-style-type: none"> • Send one Sigfox frame (repetition 1)** without downlink request with payload 0x00 00 00 00 00 25. • Execute monarch RC scan with a 4s listening window. • Wait for 6 seconds before running the next loop.

Device Test Mode J	<ul style="list-style-type: none"> • Send all supported types of Sigfox messages with all possible sizes. Each message has to be send following the below procedure : <ul style="list-style-type: none"> • Start a 18s timer. • Within the 12s after the start of the timer, send the message. • Wait for the end of this 18s before sending a new message. <p style="margin-left: 40px;">Sigfox messages could be :</p> <ul style="list-style-type: none"> • Send bit (0 or 1) • Keep-Alive Control Message • Send Frame (12 different payload), payload has to be set to 0x40 + byte index • Send Frame (no payload)
Device Test Mode K	<ul style="list-style-type: none"> • Switch the device in public key • Send <i>one of the supported types of Sigfox messages*</i> without downlink request • Switch the device back to private key.
Device Test Mode L	<p>In case of multiFrame feature :</p> <ul style="list-style-type: none"> • Send <i>one of the supported types of Sigfox messages*</i> without downlink request <p>In case of singleFrame feature : Loop on 3 repetitions of the following :</p> <ul style="list-style-type: none"> • Send <i>one of the supported types of Sigfox messages*</i> without downlink request

* : whatever the Sigfox Message type sent

** : whatever the Sigfox frame type sent, but only one repetition.

6. Annexe : Requirements Applicability

U : Unconditionnal

C : Conditionnal

Requirement title	Test Setup	Test Mode	U /C	Condition
[PRS-RFP-001] Spectral occupation product's population	TX Test Setup - DBPSK Modulation Quality	A	U	
[PRS-RFP-002] Operational Frequencies Range	TX Test Setup - Demodulated Information	B	U	
[PRS-RFP-003] Operational Frequencies Distribution	TX Test Setup - Demodulated Information	B	U	
[PRS-RFP-004] Static Frequency Tolerance	TX Test Setup - DBPSK Modulation Quality	C	U	
[PRS-RFP-010] DBPSK Modulation	TX Test Setup - DBPSK Modulation Quality	C	U	
[PRS-RFP-011] Phase Measurement	TX Test Setup - DBPSK Modulation Quality	C	U	
[PRS-RFP-012] Extra symbols before the first Sigfox bit of the frame	TX Test Setup - DBPSK Modulation Quality	C	U	
[PRS-RFP-013] Extra symbols after the last Sigfox bit of the frame	TX Test Setup - DBPSK Modulation Quality	C	U	
[PRS-RFP-014] TX Max Symbol duration	TX Test Setup - DBPSK Modulation Quality	C	U	
[PRS-RFP-015] Max TX Baudrate Cumulated Error	TX Test Setup - DBPSK Modulation Quality	C	U	
[PRS-RFP-016] Power Spectral Density for class 0 and 1	TX Test Setup - DBPSK Modulation Quality	C	U	
[PRS-RFP-017] Power Spectral Density for class 2 and 3	TX Test Setup - DBPSK Modulation Quality	C	U	
[PRS-RFP-018] Transitional Frequency Dynamic Drift	TX Test Setup - DBPSK Modulation Quality	C	U	
[PRS-RFP-019] Established Frequency Dynamic Drift	TX Test Setup - DBPSK Modulation Quality	C	U	
[PRS-RFP-020] 2GFSK 600bps	RX Test Setup	D	C	DOWNLINK
[PRS-RFP-021] Sigfox Link Budget	TX/RX Test Setup	E	C	DOWNLINK
[PRS-RFP-030] AES	TX Test Setup - Demodulated Information	J	U	

[PRS-RFP-031] Frequency Storage	TX Test Setup - Demodulated Information	G	U	
[PRS-RFP-032] Message counter Storage	TX Test Setup - Demodulated Information	G	U	
[PRS-RFP-033] Public Key switch	TX Test Setup - Demodulated Information	K	C	PUBLIC KEY
[PRS-RFP-034] Number of frames per message in Uplink mode	TX Test Setup - Demodulated Information	J	U	
[PRS-RFP-035] Legacy Uplink	TX Test Setup - Demodulated Information	J	U	
[PRS-RFP-036] Uplink Encrypted payload	TX Test Setup - Demodulated Information	J	C	PAYLOAD ENCRYPTION
[PRS-RFP-037] Downlink Legacy	TX/RX Test Setup	F	C	DOWNLINK
[PRS-RFP-038] Downlink Encrypted Payload	TX/RX Test Setup	F	C	DOWNLINK and PAYLOAD ENCRYPTION
[PRS-RFP-039] RSSI level	TX/RX Test Setup	F	C	DOWNLINK
[PRS-RFP-040] Number of Uplink frame in bi-directional mode	TX/RX Test Setup	F	C	DOWNLINK
[PRS-RFP-041] Carrier center frequencies	TX/RX Test Setup	F	C	DOWNLINK and MULTI-FRAME
[PRS-RFP-050] TX Interframe Timing in Uplink mode	TX Test Setup - Demodulated Information	J	C	MULTI-FRAME
[PRS-RFP-051] TX repeat timeout	TX Test Setup - LBT	G	C	LBT
[PRS-RFP-052] TX Interframe Timing in Bi-directional mode	TX/RX Test Setup	F	C	DOWNLINK and MUTI-FRAME
[PRS-RFP-053] RX Start Of Listening	TX/RX Test Setup	F	C	DOWNLINK
[PRS-RFP-054] RX End Of Listening	TX/RX Test Setup	F	C	DOWNLINK
[PRS-RFP-055] RX to Confirmation Control MessageTiming	TX/RX Test Setup	F	C	DOWNLINK
[PRS-RFP-060] RC determination from Monarch signal at High power level	Monarch Test Setup	H	C	MONARCH
[PRS-RFP-061] Link Budget on Monarch signal	Monarch Test Setup	I	C	MONARCH
[PRS-RFP-062] Robustness to High Power Level interferer for Monarch signal	Monarch Test Setup	H	C	MONARCH
[PRS-RFP-063] Robustness to Low Power Level interferer for Monarch signal	Monarch Test Setup	H	C	MONARCH

[PRS-RFP-070] Modulated Conducted Output Power	TX Test Setup - DBPSK Modulation Quality	C	U	
[PRS-RFP-071] UUT Temperature level	TX Test Setup - Demodulated Information	J	C	KEEP-ALIVE
[PRS-RFP-072] UUT Voltage level	TX Test Setup - Demodulated Information	J	C	KEEP-ALIVE
[PRS-RFP-073] I/Q Wave record	TX Test Setup - Demodulated Information	C	U	

7. Document history

Date	Version	Description
February 2020	V5.0.0	<ul style="list-style-type: none"> • gather the Test specification and the Test plan document into one single document • redefine the requirement numerotation : <ul style="list-style-type: none"> • unicity of each requirement number • rename req id with PRS-RFP-xxx to avoid any misleading with previous requirement naming • add 2 tables at the end of the documentation to gather all Device Test Modes and synthesis of the requirement applicability. • insert feature information along the requirement when needed and add new features consideration (Public Key, Multi-Frame, Keep Alive) • alignment of wording with current public protocol spec (OOB becomes Keep Alive Control Message, Ack frame in downlink becomes confirmation control message) • rephrase the Frequency Step requirement into "Product's population Spectral Occupation" and update the test execution and verdict • ensure that the measure Static Frequency is aligned with the Declared Static Frequency in the test verdict of the "Static Frequency Tolerance" requirement • relax the max TX Baudrate Cumulated error : set to 3% instead of 0.1% before • define power spectral density for Class 0/1 and Class 2/3 products • remove the "envelop" check in the DBPSK modulation • add rollover counter information in the "NVM message counter storage" requirement • ensure that "public key switch" requirement is dependant on the public key feature (requirement not applicable if feature is not supported) • update the "number of frames per message in Uplink mode" requirement : value is dependant on the feature single-frame / multi-frame • same change for the requirement in B-directionnal procedure • apply the "TX interframe timing in uplink" requirement only if Multi-frame feature is supported • apply the "TX repeat timeout" requirement only if Multi-frame feature is supported • apply the "TX interframe timing in bi-directional mode" requirement only if Multi-frame feature is supported • apply the "UUT Temperature" and "UUT Voltage" measurement only if Keep-Alive feature is supported • add a test requirement and test execution on carrier frequency spacing in bi-directional procedure. • rephrase the NVM Frequency and NVM Message counter storage to avoid any implementation dependant requirement.
February 2020	V5.0.1	<ul style="list-style-type: none"> ▪ Add precision on the GFSK pattern start and end duration. ▪ Ensure the pdf generation is fine
February 2020	V5.0.2	<ul style="list-style-type: none"> ▪ Update Power Template Class 2/3 requirement : the theshold at [-3/TSUL;-1/TSUL] and [1/TSUL;3/TSUL], has been moved to -8dBc
June 2020	V5.0.3	<ul style="list-style-type: none"> • Add explanations on Test Mode F description • Update start and stop command on Test Mode E description • Remove "in right order" from Test Mode J description • Improve Test Mode explanations • Add Test Mode L description • add explanations on TM C for multi-frame / single frame case