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Revision History

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Version	Author	Updates	Date
1.0	Nisha Bhaskaran	Derived from EndDeviceCertification_EU868-	4 th November 2019
Drafts		870 _V1.6	
		Initial Version 1.0 for LoRaWAN Version 1.0.4	
		and Regional Parameters RP2 1.0.1.	
		Combined the Certification Specification for	
		all regions into one specification.	
		Corrected terminologies to keep in sync with	
		LW 1.0.4 and RP2 1.0.1.	
Version	Nisha Bhaskaran /	First official release for Class A devices	28 Sept 2020
1.0	Derek Hunt	Approved at CC67 meeting	
Version	Nisha Bhaskaran /	First official release for Class A devices	16 Dec 2020
1.1	Derek Hunt	Approved at CC70 meeting	
Draft C			
Version	Nisha Bhaskaran	Updates made to	26 May 2021
1.2		- Test Notes, Section 2.5.8.a.i, 2.5.8.c.i,	
		2.5.11.c, 2.5.12.c, 2.5.14	



		New Section 5 – Retransmission back-off	
		tests	
		New Section 6 – Certification by Similarity	
		tests	
Version	Nisha Bhaskaran	Changes made to Section 6 – Certification by	23 June 2021
1.3		Similarity	
Version	Nisha Bhaskaran	Added a note to Back-off test regarding 64-	04 August 2021
1.4		channel GW	
		Updated Cert by Similarity Step 1	
Version	Nisha Bhaskaran	Updates made in the DevOps calls to Section	03 December 2021
1.5		2.5.6, 2.5.9 and 6	
Version	Nisha Bhaskaran	Added LR-FHSS tests, Section 2.5.11.e.i and	16 June 2022
1.6		Regional Parameters Specification version	





208 Glossary

LORaWAN Protocol specification developed and maintained by the LoRa Alliance.

Certification LogoLoRa Alliance defined logo that can be displayed on the Certified product

and any documentation and marketing information about the End-

Device.

LoRa Test House Organization and corresponding facility accredited by the LoRa Alliance

to perform Certification testing.

End Device Device submitted to a LoRa Test House for Certification.

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210 Abbreviations & Acronyms

ABP Activation by Personalization

ADR Adaptive Data Rate

AS Application Server

ATH Authorized Test House

AWG Arbitrary Waveform Generator

DR Data Rate

DUT Device Under Test

ERP Equivalent Radiated Power compared to a dipole antenna (expressed

in dBd)

EIRP Equivalent Isotropic Radiated Power: ERP = EIRP – 2.15dB (expressed

in dBi)

ETSI European Telecommunications Standards Institute

FSK Frequency Shift Keying modulation technique.

GW Gateway

LORAWAN Conformance Test Tool

MAC Media Access Control

NS Network Server





OTAA Over-the-Air Activation

TCL Test Control Layer of the Test Harness

TRP Total Radiated Power

211 Definitions of terms used in this document

XXXX X is a valid number which would vary based on the region being tested

DC Dynamic Channel

FC Fixed Channel

Minimum Data Rate for the region tested, as specified in the Regional

Parameters Specification [2]

Maximum Data Rate using 125 kHz bandwidth for the region tested, as

specified in the Regional Parameters Specification [2]

Nb Number

Repeat until the condition specified within brackets [] is completed

References

[1]	LoRaWAN Specifications L2 1.0.4.
[2]	LoRaWAN Regional Parameters Specification(RP2-v1.0.3).
[3]	LoRaWAN Certification Protocol Specification 1.0.0.



1. Introduction

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- 214 This document specifies the minimum testing requirements for an End-Device to be designated
- 215 "LoRaWAN Certified". LoRaWAN Certification will confirm that the End-Device meets the Functional
- 216 Requirements of the LoRaWAN Specification Version L2 1.0.4 [1] for the corresponding regional
- 217 parameters as defined in the LoRaWAN Regional Parameters Specification RP2-v1.0.3 [2].

1.1. Scope of LoRaWAN Certification

- The scope of this test specification is limited to validating compliant implementation of the LoRaWAN
- 220 protocol for Class A Devices.
- 221 For LoRaWAN Certification it is not mandatory that the End-Device has all the Regulatory approvals,
- but these will be required before the product can be sold or operated in the respective countries.
- 223 Intended or otherwise, the inevitable variability of performance and quality of the radio
- 224 implementation among End-Devices is too high to allow normalized-, practical evaluation. RF
- 225 performance measurement, whether radiated or conducted, is therefore considered out of scope for
- the tests described herein. The RF performance of the End-Device will be tested solely as part of the
- 227 RF Performance Testing, which will be a separate test conducted at the Authorized Test House to
- 228 evaluate the RF performance of the device as part of LoRaWAN Certification testing.

1.2. LoRaWAN Certification Process

- 230 A party seeking LoRaWAN Certification for their End-Device must be a member of the LoRa Alliance in
- 231 good standing and only Test Houses designated accredited by the LoRa Alliance may perform the tests
- 232 described herein to earn it.
- 233 The Authorized Test Houses must communicate the complete results to the LoRa Alliance. If the device
- has passed all mandatory tests, the LoRa Alliance will issue a certificate for the End-Device with respect
- to a version of this document and in turn corresponding versions of [1] and [2]. Additionally, the
- 236 Alliance will publish both the status and a results summary on its web site along with data for any
- 237 optional features tested.

1.3. Changes made in this version for the requirement changes from LoRaWAN Specifications v1.0.2 to LoRaWAN Specification v1.0.4

- Combined all 5 regional Certification specifications into one.
- Certification Application has been removed. All testing will be done in Application mode. Corresponding updates are made throughout the document to
 - Note down the default datarate of the device and reset to default if modified during the test
 - Set the ADR bit if not already set, before performing LinkADRReq command
- 247 o Turn off Duty cycle
 - MAC commands added: DutyCycleReq and DeviceTimeReq
- Requirement changes made
 - DeviceStatusReq: SNR Margin has been renamed to RadioStatus





251	0	NewChannelReq: For Fixed Channel plan devices, no test must be performed
252	0	TXParamSetupReq: This requirement must be tested for regions other than Asian
253		region as well to confirm that the command is ignored
254	0	LinkADRReq: The value [0x]F of either DataRate or TXPower means that the DUT must
255		ignore that field and keep the current parameter values
256	0	LinkADRReq - TXPower: When commanded to a valid TX power level lower than it is
257		capable of, the DUT must respond with an unsuccessful LinkADRAns and operates at
258		its previously configured TX power
259	0	LinkADRReq – TXPower: When commanded to a valid TX power level greater than it is
260		capable of, the DUT must respond with a successful LinkADRAns and operates at its
261		maximum TX power
262	0	New section added: Multiple MAC command prioritization
263	 Section 	added for Test Case mapping with LW 1.0.4
264	 Format 	ting:
265	0	Uplinks and the corresponding downlink are combined the same step to indicate the
266		exact sequence
267		



2. Functional Test Description for LoRaWAN Certification

The list of tests specified below reflects the functional requirements of a Class-A End-Device as defined in [1]. The tests are conducted in a test harness generally comprised of:

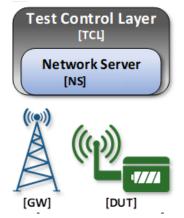


Figure 1: Test Harness Architecture

- A Test Control Layer [TCL]
- A LoRaWAN Network Server [NS]
- 8/16/64 channel LoRaWAN gateway [GW]
- The End-Device Under Test [DUT]

272 **Note**:

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- A 16-channel gateway device will be used for all official Dynamic Channel Plan device certification testing
- A 64-channel gateway device will be used for all official Fixed Channel Plan device certification
 testing
 - An 8-channel gateway device could be used for unofficial pre-testing conducted at LoRaWAN member labs. However, for official certification testing, 8-channel gateway devices will not be used. When using an 8-channel gateway, 125kHz Channels 0-7 and 500kHz Channel 64 must be configured on the gateway.

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- Implementation of this harness architecture is expected to vary among test houses. The Test Control Layer [TCL] is assumed to be a framework of automated scripts and tools that manipulates the Network Server [NS] to facilitate the tests. Specifically, the TCL drives events in the harness, controlling application and network-control content of downlinks. It also decrypts, inspects and validates content of uplinks sent by the DUT. This allows test coverage to include:
 - Cryptography
 - Timing of the **DUT** Receive Windows
 - Frequency Channel usage and Data Rate adaptation
- Max Payload handling
- 291 For brevity reasons, this document makes procedural reference to only the TCL, NS, the DUT.





- The LoRaWAN gateway [**GW**] and **DUT** are collocated in an RF-isolated environment, provisioned as necessary for reliable bi-directional communication. It is nonetheless expected that both the **DUT** and **GW** will not receive every frame intended for reception. The **TCL** should make reasonable effort to accommodate this inevitability. The RF-isolated environment mentioned above should mitigate any potential interference.
- Testing occurs to certify the **DUT** for each supported activation method, be it over-the-air activation (OTAA), activation-by-personalized (ABP), or both.
- The **TCL** must verify the following throughout the course of this certification test suite:
 - The **DUT**'s uplinks' size must respect the maximum allowed uplink size for the data rate used.
 - The length of the **DUT**'s uplinks based on the expected content to ensure no extraneous and unnecessary content is present.
- 303 When the **TCL** is restarted, the **DUT** must be set to the factory reset mode.

General Note

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- The TCL must handle the LoRaWAN protocol like a real network server, unless specified otherwise in the tests.
- Throughout the testing, the DUT MAY send the MAC commands and uplink frames and the TCL must respond appropriately as specified below:
 - If the DUT sends a Confirmed frame anytime, the TCL must respond with an Acknowledgement.
 - If the DUT sends a DeviceTimeReq MAC command or any other DUT triggered MAC command anytime, the TCL must respond with a DeviceTimeAns MAC answer or the appropriate MAC answer immediately.

Test Notes

- 1. **Default Data Rate:** All LinkADRReq MAC commands in this document must set the Data Rate to Max125kHzDR, unless specified otherwise.
- 318 2. **MIC check**: When the tool encounters an invalid MIC, it must fail the specific test being performed.
 - 3. **Downlink FPort**: All MAC commands sent by the TCL will be sent on FPort 0, unless specified otherwise in the Sequence charts in this document.
 - 4. **Missed MAC or Certification Protocol commands**: During testing, if MAC or Certification Protocol commands are missed by the DUT, the command must be re-sent by the TCL up to two additional times before failing the test.
 - 5. **Missed RxAppCntReq command**: When an RxAppCntReq command is sent from the TCL to the DUT, if the response is not received from the DUT, the request must be re-sent up to two additional times.





330 331 332	6.	Downlink after sending MAC commands which require a response: Unless specified otherwise, for all MAC response commands which require a response from the TCL (namely, RXParamSetupAns, RXTimingSetupAns, DIChannelAns), the TCL must send a downlink					
333334335	immediately after receiving this MAC response command.						
	Char	nel Mask configuration for LinkADRReq MAC command for pre-					
336 337		ng using an 8-channel gateway for Fixed Channel plan devices					
338		For Fixed channel plan devices, when the MAC-CMD LinkADRReq is required to be sent					
339		by the TCL, if the device is being pre-tested using an 8-channel gateway, the LinkADRRec					
340		in the sequence charts must be replaced by the LinkADRReq commands mentioned					
341		below. The LinkADRReq must first disable all 125kHz channels, enable only the channe					
342		64 – 500kHz, and then enable Channels 0-7 using a second LinkADRReq.					
343							
344		MAC-CMD LinkADRReq					
345		ChMaskCntl = 7					
346 347		ChMask = [0x]0001					
348		MAC-CMD LinkADRReq					
349		ChMaskCntl = 0					
350		ChMask = [0x]00FF					
351							
352		Payload = [0x]03XXXXXXXX[0x]03XXXXXXXX					
353							
354	If	a 64-channel gateway is being used for testing, then the LinkADRReq must be the same as					
355	m	entioned in the Sequence charts.					
356	Class	s B and C Testing					
357	Class B	: When testing Class B devices, the TCL must send beacons continuously even when performing					
358	Class A	tests. The DUT must be tested for all Class A tests and then the Class B tests must be performed					
359							
360	Class C	: The DUT must be tested for all Class A tests and then the Class C tests must be performed.					
361							
362	2.1.	Activation Pre-test					
363	Sa	ction 2.1.1 – DUT Pre-condition Activation tests - must be executed as the first test wher					
364		ecuting a single test or multiple tests.					
365	CA						
366	No	ete: The TCL sends frames only on the RX2 window of the previous frame of the DUT for all tests					

in this document, unless specified otherwise in the Sequence Charts of the Test cases.



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The DUT must support either over-the-air (OTA) activation or activation by personalization (ABP) or both. If the device supports both OTAA and ABP, the device vendor must provide 2 separate devices, one supporting OTAA and the other supporting ABP method of activation to the Authorised Test House (ATH). The ATH will use the appropriate device for each activation test. In the case where the device supports both OTAA and ABP for the same firmware version, the ATH will run the complete test cycle for the ABP device and then test only the OTAA specific tests for the OTAA device.

2.1.1. DUT Pre-condition Activation

After initial power-up — and activation if the **DUT** supports OTAA instead of ABP — the **DUT** must transmit an uplink packet as soon as possible (recommended within 10 seconds). Contents of this "I'm alive" packet are unimportant.

The **TCL** replies to this packet with a downlink payload frame of [0x]0601 (*TxPeriodicityChangeReq*) sent to port 224, setting the Uplink Periodicity value to 5 seconds. Upon setting the uplink periodicity value, the **DUT** must try to send an unconfirmed/confirmed uplink every 5 seconds.

If the uplink sent by the **DUT** is a Confirmed frame, the **TCL** sends a *TxFramesCtrlReq* command to the **DUT** to send Unconfirmed frames thereafter.

The **TCL** then checks the ADR Bit setting of the DUT and if disabled, it enables the ADR Bit using the *AdrBitChannelReq* command.

The **TCL** then sets the Data Rate to Max125kHzDR, refer [2], using the *LinkADRReq* command.

TCL finally sends the *DutVersionsReq* command to the **DUT** to obtain the version of the device.

Verify that

- **DUT** increments the DevNonce on reset
- **DUT** Uplink Periodicity is set to 5 seconds
- **DUT** sends Unconfirmed uplink frames
- **DUT** enables its ADR Bit
- **DUT** sets the Data Rate to Max125kHzDR
- **DUT** sends the version information in the *DutVersionsAns* response. TCL must store this version number for display in the final Test Report and Certificate.

For more details on the Certification Protocol implementation, refer to the Certification Protocol Specification [3].

2.1.1.a. **Test Procedure Frame Sequence Chart**

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Step	Procedure	Frame Sequence	Test Purpose	
		End Device - TCL	Frame	
1	If DUT = OTA device, DUT sends a Join- Request frame		DataRate (DR) = Any allowed DR, refer [2]	
	If DUT = ABP device, skip Step 1. TCL sends a Join-Accept frame	←	Note down the DevNonce	
2	DUT sends Unconfirmed or Confirmed frame FCntUp = n (where n = 0 or 1 for OTA devices and any random number for ABP devices)	→	If the DUT is an ABP device and ADR Bit is set, DataRate (DR) = Minimum DR allowed by the DUT, refer [2]	
	The TCL sends Unconfirmed frame	←	If DUT sent Confirmed uplink frame, TCL must Acknowledge CP-CMD DutResetReq FPort = 224 Payload = [0x]01	For ABP FC plan devices, if an 8-channel gateway is used for pretesting, Steps 2 and 3 must be skipped
3	If DUT = OTA device, DUT sends a Join-Request frame If DUT = ABP device, skip Step 3.	→	DevNonce is greater than DevNonce of previous JR	
	TCL sends Join-Accept response on RX1 window	+		
4	DUT sends Confirmed or Unconfirmed frame FCntUp = m For OTA device, m = 0 or 1 For ABP device, m > n	→	If the DUT is an ABP device, and ADR Bit is set, DataRate (DR) = Minimum DR allowed by the DUT, refer [2]	
	The TCL sends Unconfirmed frame	←	CP-CMD TxPeriodicityChangeReq FPort = 224 Periodicity = 5 sec Payload = [0x]0601 If DUT sent Confirmed uplink frame, TCL must Acknowledge	Uplink Periodicity set
5	DUT sends Confirmed or Unconfirmed frame FCntUp = m + 1	→	FPort = any allowed port except 224	



	If DUT sent a Confirmed frame, then	+	CP-CMD TxFramesCtrlReq	
	The TCL sends Unconfirmed frame		FPort = 224	
			Frame type = Unconfirmed	
	Else, this step must be skipped		Payload = [0x]0701	
			If DUT sent Confirmed uplink	
			frame, TCL must	
			Acknowledge	
6	DUT sends Unconfirmed frame	\rightarrow	7.Giti e Wiedge	
	FCntUp = m + 2			
	If FCtrl ADR Bit = false, then	+	CP-CMD AdrBitChangeReq-	
	,		ON	
	The TCL sends Unconfirmed frame		FPort = 224	
			Payload = [0x]0401	
	Else, this step is skipped			
7	DUT sends Unconfirmed frame	→	FCtrl ADR bit = true	Turn on the
	FCntUp = m + 3			ADR bit
	The TCL sends Unconfirmed frame	+	MAC-CMD LinkADRReq	For FC
			DataRate = Max125kHzDR,	device using
			refer [2]	8-channel
			Payload = [0x]03XXXXXXXX	gateway,
				refer to
			ChMaskCntl:	Section 2 for
			DC = 0,	ChMask
			FC = 6	settings
			ChMask:	
			DC - Enable only default	
			channels	
			FC = [0x]00FF	
8	DUT sends Unconfirmed frame in 5	\rightarrow	MAC-CMD LinkADRAns	Changed the
	seconds		Payload = [0x]0307	DR to
	FCntUp = m + 4			Max125kHz
				DR
	The TCL sends Unconfirmed frame	+	CP-CMD DutVersionsReq	
			FPort = 224	
			Payload = [0x]7F	
9	DUT sends Unconfirmed frame		CP-CMD DutVersionsAns	DUT version
	FCntUp = m + 5		FPort = 224	obtained and
			Payload =	stored for
				l
			[0x]7FXXXXXXXXXXXXXXXXX	future

Note: The FCntUp value can either start form 0 or 1. Some secure-elements implementations verify that the counter value is strictly greater than the previous value before performing the crypto operations. Thus, when resetting to 0 the value of the counter in OTAA mode, and the first time the crypto operations are performed, the counter is incremented. On other implementations, the counter value is initialized to the maximum 32-bit unsigned value [0x]FFFFFFFF which then becomes 0 when incremented by 1 prior to performing the crypto operation.

2.2. Over the Air Activation

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411 412 This test must be performed if the **DUT** supports over the air activation. The test verifies the correct functionality of the over-the-air activation. Furthermore, the fields within the Join-





Accept frame (DLSettings and RXDelay) used to modify the data rates and receive window 413 414 timing are tested to verify compliance. 2.2.1. **Pre-Join Behaviour** 415 2.2.1.a. For Dynamic Channel (DC) plan devices 416 417 The TCL commands a re-join, and the DUT must respond with a Join-Request frame. The TCL ignores the Join-Request frames until the **DUT** responds on all the default channels, refer [2]. 418 419 After this, the TCL responds with a Join-Accept frame. The TCL waits for a maximum of (number 420 of default channels * 3) Join-Request frames before responding with a Join-Accept frame. 421 Verify 422 **DUT** sends Join-Request frames until the **TCL** responds with a Join-Accept frame. 423 All the default channels must be used at least once in these requests. Record the DataRate of the initial Join Requests. 424 425 The duration between the Join-Request frames is the greater than JOIN ACCEPT DELAY2 which is 6 seconds. 426 427 • Check if the Major version in the MAC header is correct and the RFU bits are set to 0 428 • The DevNonce value sent by the **DUT** in the Join-Request must be incremented in each 429 Join-Request. • **DUT** successfully joins the network. 430 431 432 433 JoinNonce check 434 The TCL must trigger a Join-Request twice. The JoinNonce value of the second Join-Accept 435 frame must be the same as the first Join-Accept frame. 436 The TCL must trigger a Join-Request again and send a Join-Accept frame with a different 437 JoinNonce value. 438 Verify 439 440 DUT accepts the first Join-Accept frame 441 • **DUT** rejects the second Join-Accept frame 442 **DUT** resends the Join-Request after rejecting the second Join-Accept frame 443 **DUT** joins the network after the **TCL** sends a Join-Accept frame with a different JoinNonce value. 444 445 446 2.2.1.a.i. Test Procedure Frame Sequence Chart



Step	Procedure	ı	Frame Sequence	Test
		End Device - TCL	Frame	Purpose
1	DUT sends Unconfirmed frame	→		
	The TCL sends Unconfirmed frame	+	CP-CMD DutJoinReq FPort = 224 Payload = [0x]02	Device Reinitializes [Not Joined]
2	DUT sends a maximum of (3 * number of default channels) Join-Request frames, i.e. until Join-Request frames are sent on all the default channels TCL ignores all the Join-Request frames until all the default channels	→ R [3*NbCh] or [JR on AllCh] R [3*NbCh] or	 All Join-Request frames must be sent on all the default channels, refer [2], at least once. Duration between previous Join-Request and next Join-Request > 6 seconds for all JoinRequest frames Record the DataRate of the Join-Request frames Major version is correct RFU bits = 0 DevNonce is greater than DevNonce of previous JR 	
	are used for the Join-Request frames	[JR on AllCh]		
3	DUT sends Join-Request frame again	→	DataRate (DR) = any allowed DR, refer [2] DevNonce is greater than DevNonce of previous JR	
	TCL sends Join-Accept response on RX1 window	+	·	Join accepted
4	DUT sends Unconfirmed or Confirmed frame FCntUp = n (where n = 0 or 1 for OTA devices)	→		·
	The TCL sends Unconfirmed frame	+	CP-CMD TxPeriodicityChangeReq FPort = 224 Periodicity = 5 sec Payload = [0x]0601 If DUT sent Confirmed uplink frame, TCL must Acknowledge	Uplink Periodicity set
5	DUT sends Unconfirmed or Confirmed frame FCntUp = n + 1	→	FPort = any allowed port except 224	Next Uplink sent in 5 seconds



Step	Procedure	cedure Frame Sequence		
		End Device - TCL	Frame	Purpose
	If DUT sent a Confirmed frame, then	←	CP-CMD TxFramesCtrlReq	
	The TCL sends Unconfirmed frame		FPort = 224	
	Else, this step must be skipped		Frame type = Unconfirmed Payload = [0x]0701	
			If DUT sent Confirmed uplink frame, TCL must Acknowledge	
6	DUT sends Unconfirmed frame FCntUp = n + 2	→		
	If FCtrl ADR Bit = false, then	+	CP-CMD AdrBitChangeReq- ON	
	The TCL sends Unconfirmed frame		FPort = 224 Payload = [0x]0401	
7	Else, this step is skipped		FOUND Lite to	T
7	DUT sends Unconfirmed frame FCntUp = n + 3	→	FCtrl ADR bit = true	Turn on the ADR bit
	The TCL sends Unconfirmed frame	←	MAC-CMD LinkADRReq DataRate = Max125kHzDR, refer [2] Payload = [0x]03XXXXXXXX	
8	DUT sends Unconfirmed frame FCntUp = n + 4	→	MAC-CMD LinkADRAns Payload = [0x]0307	Changed the DR to Max125kHz DR
9	DUT sends Unconfirmed frame	→		
	The TCL sends Unconfirmed frames	+	CP-CMD RegionalDutyCycleCtrlReq- OFF Payload = [0x]0500 FPort = 224	Turn OFF Regional Duty Cycle
10	DUT sends Unconfirmed frame	→		
	The TCL sends Unconfirmed frame	+	CP-CMD DutJoinReq FPort = 224 Payload = [0x]02	Device Reinitializes [Not Joined]
11	DUT sends Join-Request	→	DevNonce is greater than DevNonce of previous JR	
	TCL sends Join-Accept response	+	JoinNonce = a	
12	DUT sends Unconfirmed or Confirmed frame	→		
	The TCL sends Unconfirmed frame	+	CP-CMD DutJoinReq FPort = 224 Payload = [0x]02 If DUT sent Confirmed uplink frame, TCL must Acknowledge	Device Reinitializes [Not Joined]
13	DUT sends Join-Request	→	DevNonce is greater than DevNonce of previous JR	



Step	Procedure	ı	Frame Sequence	Test Purpose	
		End Device - TCL	Frame	- I di pose	
	TCL sends Join-Accept response	+	JoinNonce = a	JoinNonce value must be the same as the previous one	
14	DUT sends Join-Request	→	DevNonce is greater than DevNonce of previous JR	DUT rejects the JoinAccept response and sends JoinReq again	
	TCL sends Join-Accept response	+	JoinNonce = b, where b NOT = a	Join accepted	
15	DUT sends Unconfirmed or Confirmed frame FCntUp = n (where n = 0 or 1 for OTA devices)	→			
	The TCL sends Unconfirmed frame	←	CP-CMD TxPeriodicityChangeReq FPort = 224 Periodicity = 5 sec Payload = [0x]0601 If DUT sent Confirmed uplink frame, TCL must Acknowledge	Uplink Periodicity set	
16	DUT sends Confirmed or Unconfirmed frame FCntUp = n + 1)	FPort = any allowed port except 224		
	If DUT sent a Confirmed frame, then The TCL sends Unconfirmed frame Else, this step must be skipped	+	CP-CMD TxFramesCtrlReq FPort = 224 Frame type = Unconfirmed Payload = [0x]0701 If DUT sent Confirmed uplink frame, TCL must Acknowledge		
17	DUT sends Unconfirmed frame FCntUp = n + 2	→			
	If FCtrl ADR Bit = false, then The TCL sends Unconfirmed frame Else, this step is skipped	+	CP-CMD AdrBitChangeReq- ON FPort = 224 Payload = [0x]0401		
18	DUT sends Unconfirmed frame FCntUp = n + 3	→	FCtrl ADR bit = true	Turn on the ADR bit	
	The TCL sends Unconfirmed frame	←	MAC-CMD LinkADRReq DataRate = Max125kHzDR, refer [2] Payload = [0x]03XXXXXXXX		



Step	Procedure	ı	Frame Sequence		
		End Device - TCL	Frame		
19	DUT sends Unconfirmed frame within 5 seconds FCntUp = n + 4	→	MAC-CMD LinkADRAns Payload = [0x]0307	Changed the DR to Max125kHz DR	
	The TCL sends Unconfirmed frames	←	CP-CMD RegionalDutyCycleCtrlReq- ON Payload = [0x]0501 FPort = 224	Revert to Regional Duty Cycle ON	

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2.2.1.b. For Fixed Channel (FC) plan devices

After the **TCL** commands a re-join to the DUT, the **DUT** sends a Join-Request frame on 125 kHz and 500 kHz channels using the minimum data rate allowed for these channels respectively (DR-X and DR-Y respectively), refer [2]. This is ignored by the server until a channel change from 125kHz at DR-X to 500kHz at DR-Y or vice versa is recognized by the **TCL**. The last Join-Request message indicating the channel change is processed and the server responds with a Join-Accept message.

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Verify

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JoinNonce check

alternate DR.

The **TCL** must trigger a Join-Request twice. The JoinNonce value of the second Join-Accept frame must be the same as the first Join-Accept frame.

- DUT sends Join-Request frames on 125 kHz channels using DR-X and 500 kHz channels using DR-Y. For example: For the US902-928 region, Join-Request must be sent on a random 125 kHz channel at DRO and a random 500kHz channel at DR4.
- The duration between the Join-Request frames is greater than the JOIN ACCEPT DELAY2 which is 6 seconds.
- Check if the Major version in the MAC header is correct and the RFU bits are set to 0
- The DevNonce value sent by the DUT in the Join-Request must be incremented in each Join-Request.
- **DUT** successfully joins the network.

Verify
DUT joins successfully by way of a Join-Request sent at the DR not responded earlier.

The TCL again commands a re-join, the DUT sends Join-Request messages on 125 kHz channels

using DR-X and 500 kHz channels using DR-Y. The **TCL** does not respond to requests with the same DR as the one responded in the previous test. It responds only to Join Requests with the





479	The TCL must trigger a Join-Request again and send a Join-Accept frame with the correct
480	JoinNonce value.
481	
482	Verify
483	DUT accepts the first Join-Accept frame
484	DUT rejects the second Join-Accept frame
485	DUT resends the Join-Request after rejecting the second Join-Accept frame
486	• DUT joins the network after the TCL sends a Join-Accept frame with the correct
487	JoinNonce value.
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489	2.2.1.b.i.Test Procedure Frame Sequence Chart
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Step	Procedure	ı	Frame Sequence	Test Purpose
		End Device - TCL	Frame	Fulpose
1	DUT sends Unconfirmed frame	→		
	The TCL sends Unconfirmed frames	+	CP-CMD RegionalDutyCycleCtrlReq- OFF Payload = [0x]0500 FPort = 224	Turn OFF Regional Duty Cycle
2	DUT sends Unconfirmed frame	→		
	The TCL sends Unconfirmed frame	+	CP-CMD DutJoinReq FPort = 224 Payload = [0x]02	Device Reinitializes [Not Joined]
3	DUT sends Join-Request frames.	→ R [2*NbCh] or [DR-X NOT = DR-Y]	Join-Request @ minimum default data rate for	
	TCL ignores the Join-Request frames and waits for a maximum of (2 * number of channels currently enabled on the DUT) uplink transmissions, until a channel change from 125kHz at DR-X to 500kHz at DR-Y or vice versa is recognized by the TCL.	R [2*NbCh] or [DR-X NOT = DR-Y]		
	TCL sends Join-Accept response when it receives a Join-Request with a channel change, on RX1 window.	← [DR-X → DR-Y]	Join-Accept is sent to DUT without a CFList. Pre-testing with 8-channel gateway: CFListType = [0x]01 ChMask0 = [0x]00FF ChMask1 = [0x]0000 ChMask2 = [0x]0000 ChMask3 = [0x]0000 ChMask4 = [0x]0001	Join accepted



		Procedure Frame Sequence		
		End Device - TCL	Frame	Purpose
4	DUT sends Unconfirmed or Confirmed frame FCntUp = n (where n = 0 or 1 for OTA devices)	÷		
<u>-</u>	The TCL sends Unconfirmed frame	+	CP-CMD DutJoinReq FPort = 224 Payload = [0x]02	Device Reinitializes [Not Joined]
5	DUT sends Join-Request frames. TCL ignores the Join-Request	→ R [2*NbCh] or [DR-X NOT = DR-Y]	Join-Request @ minimum default data rate for	
	frames and waits for a maximum of (2 * number of channels currently enabled on the DUT) uplink transmissions, until the DUT sends a Join-Request with a different DataRate from the one sent earlier.	[2*NbCh] or [JR-DR-X NOT = JR- DR-Y]		
	TCL sends Join-Accept response when it receives the Join-Request with the alternate DR	← [JR-DR-X NOT = JR- DR-Y]	Join-Accept is sent to DUT without a CFList. Pre-testing with 8-channel gateway: CFListType = [0x]01 ChMask0 = [0x]00FF ChMask1 = [0x]0000 ChMask2 = [0x]0000 ChMask3 = [0x]0000 ChMask4 = [0x]0001	Join accepted
6	DUT sends Unconfirmed frame	→	CHINGSKY = [OX]OOOT	
-	The TCL sends Unconfirmed frame	(CP-CMD DutJoinReq FPort = 224 Payload = [0x]02	Device Reinitializes [Not Joined]
7	DUT sends Join-Request	\rightarrow	DevNonce is greater than DevNonce of previous JR	1



Step	Procedure	ı	Frame Sequence	Test Purpose
		End Device - TCL	Frame	i urpose
8	DUT sends Unconfirmed or Confirmed frame	\rightarrow		
	The TCL sends Unconfirmed frame	+	CP-CMD DutJoinReq FPort = 224 Payload = [0x]02 If DUT sent Confirmed uplink frame, TCL must Acknowledge	Device Reinitializes [Not Joined]
9	DUT sends Join-Request	→	DevNonce is greater than DevNonce of previous JR	
	TCL sends Join-Accept response	+	JoinNonce = a	JoinNonce value must be the same as the previous one
10	DUT sends Join-Request	→	DevNonce is greater than DevNonce of previous JR	DUT rejects the JoinAccept response and sends JoinReq again
	TCL sends Join-Accept response	+	JoinNonce = b, where b NOT = a Official certification (64-channel gateway): Join-Accept is sent to DUT without a CFList Pre-testing with 8-channel gateway: CFListType = [0x]01 ChMask0 = [0x]00FF ChMask1 = [0x]0000 ChMask2 = [0x]0000 ChMask3 = [0x]0000 ChMask4 = [0x]0001	Join accepted
11	DUT sends Unconfirmed or Confirmed frame FCntUp = n (where n = 0 or 1 for OTA devices) The TCL sends Unconfirmed frame	→	CP-CMD TxPeriodicityChangeReq FPort = 224 Periodicity = 5 sec Payload = [0x]0601 If DUT sent Confirmed uplink frame, TCL must Acknowledge	Uplink Periodicity set



Step	Procedure		Frame Sequence	Test Purpose
		End Device - TCL	Frame	
12	DUT sends Confirmed or Unconfirmed frame FCntUp = n + 1	→	FPort = any allowed port except 224	
	If DUT sent a Confirmed frame, then The TCL sends Unconfirmed frame Else, this step must be skipped	←	CP-CMD TxFramesCtrlReq FPort = 224 Frame type = Unconfirmed Payload = [0x]0701	
			If DUT sent Confirmed uplink frame, TCL must Acknowledge	
13	DUT sends Unconfirmed frame FCntUp = n + 2	→		
	If FCtrl ADR Bit = false, then	+	CP-CMD AdrBitChangeReq-ON	
	The TCL sends Unconfirmed frame		FPort = 224 Payload = [0x]0401	
14	Else, this step is skipped DUT sends Unconfirmed frame FCntUp = n + 3	→	FCtrl ADR bit = true	Turn on the ADR bit
	The TCL sends Unconfirmed frame	+	MAC-CMD LinkADRReq DataRate = Max125kHzDR, refer [2] Payload = [0x]03XXXXXXXX ChMaskCntl = 6	For FC device using 8-channel gateway, refer to Section 2 for
			ChMask = [0x]00FF	ChMask settings
15	DUT sends Unconfirmed frame in 5 seconds FCntUp = n + 4	→	MAC-CMD LinkADRAns Payload = [0x]0307	Changed the DR to Max125kHz DR
	The TCL sends Unconfirmed frames	+	CP-CMD RegionalDutyCycleCtrlReq- ON Payload = [0x]0501 FPort = 224	Turn ON Regional Duty Cycle

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2.2.2. Join-Accept with DLSettings

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After the **TCL** triggers a Join-Request, the **DUT** starts the Join procedure for over-the-air activation. The **TCL** responds with a Join-Accept frame with RX1DRoffset = 2 and RX2DataRate = any applicable DataRate, except the default RX2DataRate as defined in [2]. After the join procedure succeeds, the **TCL** downlinks an echo command targeting the RX1 window to which the **DUT** must respond correctly. Next the **TCL** downlinks an echo command targeting the RX2

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Verify

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DUT successfully joins the network

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DUT implements RX1DRoffset correctly after processing the Join-Accept

window to which the **DUT** must respond correctly.





502		•	DUT implements RX2DataRate correctly after processing the Join-Accept	
503				
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505 506	2.2.2.a.	Test Pr	ocedure Frame Sequence Chart	



Step	Procedure		Test Purpose	
		End Device - TCL	Frame	Tarpose
1	DUT sends Unconfirmed frame	→		
	The TCL sends Unconfirmed frames	+	CP-CMD RegionalDutyCycleCtrlReq-OFF Payload = [0x]0500 FPort = 224	Turn OFF Regional Duty Cycle
2	DUT sends Unconfirmed frame	\rightarrow		
	The TCL sends Unconfirmed frame	+	CP-CMD DutJoinReq FPort = 224 Payload = [0x]02	Device Reinitializes [Not Joined]
3	DUT sends Join-Request	→	DR = Z (where Z = any allowed DR, refer [2]) DevNonce is greater than DevNonce of previous JR	
	TCL sends Join-Accept response	←	RX1DROffset = 2 RX2DataRate = Any DR except default RX2 DR, as defined in [2] Join-Accept is sent to DUT without a CFList. Pre-testing with 8-channel gateway: CFListType = [0x]01 ChMask0 = [0x]00FF ChMask1 = [0x]0000 ChMask2 = [0x]0000 ChMask3 = [0x]0000	Join accepted with modified parameters
4	DUT sends Unconfirmed or Confirmed frame FCntUp = n (where n = 0 or 1 for OTA devices)	→	ChMask4 = [0x]0001	
	The TCL sends Unconfirmed frame	+	CP-CMD TxPeriodicityChangeReq FPort = 224 Periodicity = 5 sec Payload = [0x]0601 If DUT sent Confirmed uplink frame, TCL must Acknowledge	Uplink Periodicity set
5	DUT sends Unconfirmed or Confirmed frame FCntUp = n + 1	→	Ü	
	If DUT sent a Confirmed frame, then The TCL sends Unconfirmed frame Else, this step must be skipped	←	CP-CMD TxFramesCtrlReq FPort = 224 Frame type = Unconfirmed Payload = [0x]0701 If DUT sent Confirmed uplink	
			frame, TCL must Acknowledge	



Step	Procedure		Test Purpose	
		End Device - TCL	Frame	
6	DUT sends Unconfirmed frame	\rightarrow		
	If FCtrl ADR Bit = false, then The TCL sends Unconfirmed frame Else, this step is skipped	+	CP-CMD AdrBitChangeReq-ON FPort = 224 Payload = [0x]0401	
7	DUT sends Unconfirmed frame	\rightarrow	FCtrl ADR Bit = true	ADR Bit
'	Bot serias effectivities frame	,	TOWNER BIL = lide	turned ON
	The TCL sends Unconfirmed frame	+	MAC-CMD LinkADRReq DataRate = Max125kHzDR, refer [2] Payload = [0x]03XXXXXXXX ChMaskCntl: DC = 0, FC = 6 ChMask: DC - Enable only default channels FC = [0x]00FF	For FC device using 8-channel gateway, refer to Section 2 for ChMask settings
8	DUT sends Unconfirmed frame	→	MAC-CMD LinkADRAns Payload = [0x]0307 DR = Max125kHzDR	
	The TCL sends Unconfirmed frame on RX1 window	+	DR = Max125kHzDR - 2 CP-CMD EchoPayloadReq FPort 224 Payload = [0x]08010203	
9	DUT sends Unconfirmed frame	→	DR = Max125kHzDR CP-CMD EchoPayloadAns FPort = 224 Payload = [0x]08020304	RX1 reply sent
	The TCL sends Unconfirmed frame on RX2 window	+	RX2DataRate - As set in Join- Accept frame above CP-CMD EchoPayloadReq FPort 224 Payload = [0x]080A0B0C	
10	DUT sends Unconfirmed frame	→	CP-CMD EchoPayloadAns FPort = 224 Payload = [0x]080B0C0D	RX2 reply sent
11	DUT sends Unconfirmed frame	\rightarrow		
	The TCL sends Unconfirmed frame	+	CP-CMD DutJoinReq FPort = 224 Payload = [0x]02	Revert the device to default values



Step	Procedure		Test Purpose	
		End Device - TCL	Frame	
12	DUT sends Join-Request	→	DR = Z (where Z = any allowed DR, refer [2]) DevNonce is greater than	
	TCL sends Join-Accept response	+	DevNonce of previous JR Join-Accept is sent to DUT	
			without a CFList. Pre-testing with 8-channel gateway: CFListType = [0x]01 ChMask0 = [0x]00FF ChMask1 = [0x]0000 ChMask2 = [0x]0000 ChMask3 = [0x]0000 ChMask4 = [0x]0001	
13	DUT sends Unconfirmed or Confirmed frame	→		
	The TCL sends Unconfirmed frame	←	CP-CMD TxPeriodicityChangeReq FPort = 224 Periodicity = 5 sec Payload = [0x]0601 If DUT sent Confirmed uplink frame, TCL must Acknowledge	Uplink Periodicity set
14	DUT sends Unconfirmed or Confirmed frame	→	name, real macricine age	
	If DUT sent a Confirmed frame, then The TCL sends Unconfirmed frame Else, this step must be skipped	+	CP-CMD TxFramesCtrlReq FPort = 224 Frame type = Unconfirmed Payload = [0x]0701 If DUT sent Confirmed uplink	
			frame, TCL must Acknowledge	
15	DUT sends Unconfirmed frame If FCtrl ADR Bit = false, then The TCL sends Unconfirmed frame Else, this step is skipped	→ ←	CP-CMD AdrBitChangeReq-ON FPort = 224 Payload = [0x]0401	
16	DUT sends Unconfirmed frame	\rightarrow	FCtrl ADR Bit = true	ADR Bit turned ON



Procedure		Test	
		Purpose	
	End	Frame	
	Device -		
	TCL		
The TCL sends Unconfirmed frame	-	MAC-CMD LinkADRReq	For FC
		DataRate = Max125kHzDR, refer	device using
		[2]	8-channel
		Payload = [0x]03XXXXXXXX	gateway,
			refer to
		ChMaskCntl:	Section 2 for
		DC = 0,	ChMask
		FC = 6	settings
		ChMask:	
		DC - Enable only default	
		channels	
		FC = [0x]00FF	
DUT sends Unconfirmed frame	\rightarrow		
		Payload = [0x]0307	
		DR = Max125kHzDR	
The TCL sends Unconfirmed	+	CP-CMD	Turn ON
frames		RegionalDutyCycleCtrlReq-ON	Regional
			Duty Cycle
		FPort = 224	
	The TCL sends Unconfirmed frame DUT sends Unconfirmed frame The TCL sends Unconfirmed	End Device - TCL The TCL sends Unconfirmed frame ← DUT sends Unconfirmed frame → The TCL sends Unconfirmed ←	End Device - TCL The TCL sends Unconfirmed frame ← MAC-CMD LinkADRReq DataRate = Max125kHzDR, refer [2] Payload = [0x]03XXXXXXXX ChMaskCntl: DC = 0, FC = 6 ChMask: DC - Enable only default channels FC = [0x]00FF DUT sends Unconfirmed frame → MAC-CMD LinkADRAns Payload = [0x]0307 DR = Max125kHzDR The TCL sends Unconfirmed frames ← CP-CMD RegionalDutyCycleCtrlReq-ON Payload = [0x]0501

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2.2.3. **Join-Accept with Delay Settings**

After the **TCL** triggers a JoinRequest, the **DUT** starts the Join procedure for over-the-air activation as above. The **TCL** responds with a Join-Accept frame containing Delay Settings on RX2 window, such that RX1 and subsequently RX2 timing is increased (at least 2 seconds are recommended). The **TCL** sends an echo command targeted to RX1 to which the **DUT** must respond correctly. The **TCL** repeats this same downlink test against the RX2 window, to which the **DUT** must respond correctly.

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Verify

- **DUT** successfully joins the network
 - **DUT** implements the new (non-default) Delay Settings
 - **DUT** restores the default settings for RXDelay

2.2.3.a. Test Procedure Frame Sequence Chart



Step	Procedure	1	Test Purpose	
		End Device - TCL	Frame	
1	DUT sends Unconfirmed frame	→		
	The TCL sends Unconfirmed frames	←	CP-CMD RegionalDutyCycleCtrlReq- OFF Payload = [0x]0500 FPort = 224	Turn OFF Regional Duty Cycle
2	DUT sends Unconfirmed frame	\rightarrow		
	The TCL sends Unconfirmed frame	+	CP-CMD DutJoinReq	Device
	on RX2 window		FPort = 224	Reinitializes
			Payload = [0x]02	[Not Joined]
3	DUT sends Join-Request	→	DR = Any allowed DR, refer [2]	
			DevNonce is greater than DevNonce of previous JR	
	TCL sends Join-Accept response on RX2 window	+	RXDelay = n, where 2 <= n <=15	Join accepted with modified
			Join-Accept is sent to DUT without a CFList.	parameters
			Pre-testing with 8-channel gateway: CFListType = [0x]01 ChMask0 = [0x]00FF ChMask1 = [0x]0000 ChMask2 = [0x]0000 ChMask3 = [0x]0000 ChMask4 = [0x]0001	
4	DUT sends Unconfirmed or Confirmed frame FCntUp = n (where n = 0 or 1 for OTA devices))		
	The TCL sends Unconfirmed frame	+	CP-CMD TxPeriodicityChangeReq FPort = 224 Periodicity = 5 sec Payload = [0x]0601 If DUT sent Confirmed uplink frame, TCL must Acknowledge	Uplink Periodicity set
5	DUT sends Unconfirmed or	→		
	Confirmed frame			
	FCntUp = n + 1			



Step	Procedure		Test Purpose	
		End Device - TCL	Frame	- ruiposs
	If DUT sent a Confirmed frame, then The TCL sends Unconfirmed frame Else, this step must be skipped	+	CP-CMD TxFramesCtrlReq FPort = 224 Frame type = Unconfirmed Payload = [0x]0701	
			If DUT sent Confirmed uplink frame, TCL must Acknowledge	
6	DUT sends Unconfirmed frame	\rightarrow		
	The TCL sends Unconfirmed frame on RX1 window	+	RX1Delay = n seconds	
			CP-CMD EchoPayloadReq FPort 224 Payload [0x]08010203	
7	DUT sends Unconfirmed frame	→	CP-CMD EchoPayloadAns FPort 224 Payload [0x]08020304	RX1 delay reply sent
	The TCL sends Unconfirmed frame on RX2 window	←	RX2Delay = n + 1 seconds CP-CMD EchoPayloadReq FPort 224 Payload [0x]080A0B0C	
8	DUT sends Unconfirmed frame)	CP-CMD EchoPayloadAns FPort = 224 Payload [0x]080B0C0D	RX2 delay reply sent
	The TCL sends Unconfirmed frame	+	CP-CMD DutJoinReq FPort = 224 Payload = [0x]02	Revert the device to default values
9	DUT sends Join-Request	→	DR = Z (where Z = any allowed DR, refer [2]) DevNonce is greater than DevNonce of previous JR	
40	TCL sends Join-Accept response	+	Join-Accept is sent to DUT without a CFList. Pre-testing with 8-channel gateway: CFListType = [0x]01 ChMask0 = [0x]00FF ChMask1 = [0x]0000 ChMask2 = [0x]0000 ChMask3 = [0x]0000 ChMask4 = [0x]0001	
10	DUT sends Unconfirmed or Confirmed frame	\rightarrow		



Step	Procedure	ı	Test	
		End Device - TCL	Frame	Purpose
	The TCL sends Unconfirmed frame	+	CP-CMD TxPeriodicityChangeReq FPort = 224 Periodicity = 5 sec Payload = [0x]0601 If DUT sent Confirmed uplink	Uplink Periodicity set
			frame, TCL must Acknowledge	
11	DUT sends Unconfirmed or Confirmed frame	→		
	If DUT sent a Confirmed frame, then The TCL sends Unconfirmed frame Else, this step must be skipped	←	CP-CMD TxFramesCtrlReq FPort = 224 Frame type = Unconfirmed Payload = [0x]0701	
			If DUT sent Confirmed uplink frame, TCL must Acknowledge	
12	DUT sends Unconfirmed frame	→ ←	OD OMB A LBWOL	
	If FCtrl ADR Bit = false, then The TCL sends Unconfirmed frame	-	CP-CMD AdrBitChangeReq- ON FPort = 224	
13	Else, this step is skipped DUT sends Unconfirmed frame	→	Payload = [0x]0401 FCtrl ADR Bit = true	ADR Bit
13				turned ON
	The TCL sends Unconfirmed frame	+	MAC-CMD LinkADRReq DataRate = Max125kHzDR, refer [2] Payload = [0x]03XXXXXXXX	For FC device using 8-channel gateway, refer to
			ChMaskCntl: DC = 0, FC = 6	Section 2 for ChMask settings
			ChMask: DC - Enable only default channels FC = [0x]00FF	
14	DUT sends Unconfirmed frame	→	MAC-CMD LinkADRAns Payload = [0x]0307 DR = Max125kHzDR	
	The TCL sends Unconfirmed frames	←	CP-CMD RegionalDutyCycleCtrlReq-ON Payload = [0x]0501 FPort = 224	Turn ON Regional Duty Cycle





523	2.2.4	Join-Accept with CFList
524	2.2.4.a.	For Dynamic Channel (DC) plan devices
525		After the TCL triggers a Join-Request, the DUT starts the Join procedure for over-the-
526		air activation as above. The TCL responds with a Join-Accept frame containing an
527		additional single channel in the CFList field. The DUT must use this additional channel
528		together with the default channels within the following uplinks.
529		The TCL again triggers the DUT to send a Join-Request. The TCL responds with a Join-
530		Accept frame containing a CFListType = 1. The DUT rejects the CFList and enables all
531		default channels. The DUT must not use the additional channel added earlier.
532		Verify
533		DUT successfully joins the network
534		 DUT uses the new channel in its random selection of frequencies
535		DUT removes the additional channel added earlier.
536		
537		2.2.4.a.i. Test Procedure Frame Sequence Chart
538		



Step	Procedure	F	Frame Sequence	Test Purpose
		End Device - TCL	Frame	ruipose
1	DUT sends Unconfirmed frame	\rightarrow		
	The TCL sends Unconfirmed frames	+	CP-CMD RegionalDutyCycleCtrlReq- OFF Payload = [0x]0500 FPort = 224	Turn OFF Regional Duty Cycle
2	DUT sends Unconfirmed frame	→	11 011 – 22 1	
	The TCL sends Unconfirmed frame	+	CP-CMD DutJoinReq FPort = 224 Payload = [0x]02	Device Reinitializes [Not Joined]
3	DUT sends Join-Request	→	DR = Any allowed DR, refer [2] DevNonce is greater than DevNonce of previous JR	
	TCL conds Join Account response	-	CFList = add single channel	Join
	TCL sends Join-Accept response		CFList = add single channel CFListType = 0	accepted
4	DUT sends Unconfirmed or Confirmed frame FCntUp = n (where n = 0 or 1 for OTA devices)	→	Gr Electrype – o	азоорюч
	The TCL sends Unconfirmed frame	←	CP-CMD TxPeriodicityChangeReq FPort = 224 Periodicity = 5 sec Payload = [0x]0601	Uplink Periodicity set
			If DUT sent Confirmed uplink frame, TCL must Acknowledge	
5	DUT sends Unconfirmed or Confirmed frame FCntUp = n + 1	→		
	If DUT sent a Confirmed frame, then The TCL sends Unconfirmed frame Else, this step must be skipped	+	CP-CMD TxFramesCtrlReq FPort = 224 Frame type = Unconfirmed Payload = [0x]0701	
			If DUT sent Confirmed uplink frame, TCL must Acknowledge	
6	DUT sends Unconfirmed frame FCntUp = n + 2	→		
7	Wait until the new channel which was added has been used at least once. Wait for a maximum of [5* (number of channels <i>currently enabled on the DUT</i>)] uplink packets to be sent.	→ R [5*NbCh] or [AllCh used]	Channel added is used at least once	DUT adds the additional channel to its default channel plan
8	DUT sends Unconfirmed frame	\rightarrow		



Step	Procedure		Frame Sequence		
		End Device - TCL	Frame	Purpose	
	The TCL sends Unconfirmed frame	+	CP-CMD DutJoinReq FPort = 224 Payload = [0x]02	Device Reinitializes [Not Joined]	
9	DUT sends Join-Request)	DR = Any allowed DR, refer [2] DevNonce is greater than DevNonce of previous JR		
	TCL sends Join-Accept response	+	CFList = add another channel CFListType = 1	Join-Accept sent with CFListType = 1	
10	DUT sends Unconfirmed or Confirmed frame FCntUp = n (where n = 0 or 1 for OTA devices)	→			
	The TCL sends Unconfirmed frame	←	CP-CMD TxPeriodicityChangeReq FPort = 224 Periodicity = 5 sec Payload = [0x]0601 If DUT sent Confirmed uplink frame, TCL must Acknowledge	Uplink Periodicity set	
11	DUT sends Unconfirmed or Confirmed frame FCntUp = n + 1	→	J		
	If DUT sent a Confirmed frame, then The TCL sends Unconfirmed frame Else, this step must be skipped	←	CP-CMD TxFramesCtrlReq FPort = 224 Frame type = Unconfirmed Payload = [0x]0701 If DUT sent Confirmed uplink frame, TCL must Acknowledge		
12	DUT sends Unconfirmed frame FCntUp = n + 2	→			
13	Wait for [5* (number of channels currently enabled on the DUT)] uplink packets to be sent.	→ R [5*NbCh] or [AllCh used]	 Default channels are used at least once. The additional channel is not used. 	DUT removes the additional channel from its default channel plan	
	The TCL sends Unconfirmed frames	+	CP-CMD RegionalDutyCycleCtrlReq- ON Payload = [0x]0501 FPort = 224	Turn ON Regional Duty Cycle	





540	2.2.4.b.	For Fixed Channel (FC) plan devices
541		After the TCL triggers a Join-Request, the DUT starts the Join procedure for over-the-
542		air activation as above.
543		The TCL responds with a Join-Accept frame with CFListType set to [0x]01 in the CFList
544		field. The ChMask fields must enable 3 channels (Channel 0, 1 and 64) and disable all
545		other channels.
546		Verify
547		 DUT successfully joins the network
548		 The DUT must use only the channels enabled for the uplinks.
549		
550		The TCL triggers a Join-Request again and responds with a Join-Accept frame with
551		CFListType set to [0x]00 in the CFList field. The ChMask fields must enable 3 channels
552		(Channel 0, 1 and 64) and disable all other channels.
553		Verify
554		 DUT successfully joins the network
555		• The DUT must reject the CFList as the value of the CFListType = [0x]00 and
556		must use all channels for uplinks. For the sake of verification, verify that any
557		other channel other than the channels enabled in the ChMask bits are used for
558		the uplinks.
559		
560		Finally, the TCL triggers a Join-Request again and responds with a Join-Accept frame
561		with CFListType set to [0x]01 in the CFList field. The ChMask fields must be set to
562		[0x]FFFF.
563		Verify
564		 DUT successfully joins the network
565		 The DUT must use all the channels for the uplinks.
566		
567		2.2.4.b.i. Test Procedure Frame Sequence Chart
568		



Step	Procedure	ı	Frame Sequence	Test Purpose
		End Device - TCL	Frame	1 4.600
1	DUT sends Unconfirmed frame	→		
	The TCL sends Unconfirmed frames	+	CP-CMD RegionalDutyCycleCtrlReq- OFF Payload = [0x]0500 FPort = 224	Turn OFF Regional Duty Cycle
2	DUT sends Unconfirmed frame	→	FF0It = 224	
2	The TCL sends Unconfirmed frame	+	CP-CMD DutJoinReq FPort = 224 Payload = [0x]02	Device Reinitializes [Not Joined]
3	DUT sends Join-Request frame	→	DevNonce is greater than DevNonce of previous JR	1
	TCL sends Join-Accept response	+	CFListType = [0x]01 ChMask0 = [0x]0003 ChMask1 = [0x]0000 ChMask2 = [0x]0000 ChMask3 = [0x]0000 ChMask4 = [0x]0001	Join accepted with CFList
4	DUT sends Unconfirmed or Confirmed frame FCntUp = n (where n = 0 or 1 for OTA devices)	→		
	The TCL sends Unconfirmed frame	+	CP-CMD TxPeriodicityChangeReq FPort = 224 Periodicity = 5 sec Payload = [0x]0601 If DUT sent Confirmed uplink frame, TCL must	Uplink Periodicity set
5	DUT sends Unconfirmed or Confirmed frame in 5 seconds	→	Acknowledge FPort = any allowed port except 224	Next Uplink sent in 5
	FCntUp = n + 1			seconds
6	Wait for a maximum of 5 uplinks to be sent.	→ R [max 5]	If DR = 125kHz DR, only Channels 0 and 1 must be used for all uplinks If DR = 500kHz DR, only channel 64 must be used for uplinks	Only the enabled channels are used for uplinks
	7 to 11 must be skipped when pre-testin		nnel gateway	
7	DUT sends a Confirmed or Unconfirmed frame	→		
	The TCL sends Unconfirmed frame	+	CP-CMD DutJoinReq FPort = 224 Payload = [0x]02 If DUT sent Confirmed uplink	Device Reinitializes [Not Joined]
			frame, TCL must Acknowledge	



Step	Procedure	F	Frame Sequence	Test Purpose
		End Device - TCL	Frame	i aiposo
8	DUT sends Join-Request frames.	→	DevNonce is greater than DevNonce of previous JR	
	TCL ignores the Join-Request frames and waits for a maximum of (2 * number of channels currently enabled on the DUT) uplink transmissions, until the Join-Request channel is a 500kHz channel	R [2*NbCh] or [500kHz channel]		
	TCL sends Join-Accept response	+	CFListType = [0x]00 ChMask0 = [0x]0003 ChMask1 = [0x]0000 ChMask2 = [0x]0000 ChMask3 = [0x]0000 ChMask4 = [0x]0001	Join accepted with CFListType = [0x]00
9	DUT sends Unconfirmed or Confirmed frame FCntUp = n (where n = 0 or 1 for OTA devices)	→		
	The TCL sends Unconfirmed frame	+	CP-CMD TxPeriodicityChangeReq FPort = 224 Periodicity = 5 sec Payload = [0x]0601	Uplink Periodicity set
			If DUT sent Confirmed uplink frame, TCL must Acknowledge	
10	DUT sends Unconfirmed or Confirmed frame in 5 seconds FCntUp = n + 1	→	FPort = any allowed port except 224	Next Uplink sent in 5 seconds
	If DUT sent a Confirmed frame, then The TCL sends Unconfirmed frame	+	CP-CMD TxFramesCtrlReq FPort = 224 Frame type = Unconfirmed	
	Else, this step must be skipped		Payload = [0x]0701 If DUT sent Confirmed uplink frame, TCL must Acknowledge	
11	If Data Rate = 500kHz DR, wait for (5 * number of 500kHz channels configured) uplink transmissions (max. 16 packets for 500kHz channels), i.e. until all	→ R [5*Nb500kH zCh] or [AllCh used]	Official certification (64- channel gateway): All 500kHz channels must be used at least once	All 500kHz channels must be used at least once
	500kHz channels configured are used at least once If Data Rate = 125kHz DR, skip this step		Pre-testing with 8-channel gateway: Channel 64 must be used at least once.	
Steps	7 to 11 must be skipped when pre-testing	g with 8-channe	I gateway	1
12	DUT sends a Confirmed or Unconfirmed frame	→		



Step	Procedure	1	Frame Sequence	Test
		End Device - TCL	Frame	Purpose
	The TCL sends Unconfirmed frame	+	CP-CMD DutJoinReq FPort = 224 Payload = [0x]02	Device Reinitializes [Not Joined]
			If DUT sent Confirmed uplink frame, TCL must Acknowledge	
13	DUT sends Join-Request frames.	\rightarrow	DevNonce is greater than DevNonce of previous JR	
	TCL ignores the Join-Request frames and waits for a maximum of (2 * number of channels currently enabled on the DUT) uplink transmissions, until the Join-Request channel is a 125kHz channel	R [2*NbCh] or [125kHz channel]		
	TCL sends Join-Accept response	+	Join-Accept must be sent without a CFList. Pre-testing with 8-channel gateway: CFListType = [0x]01 ChMask0 = [0x]00FF ChMask1 = [0x]0000 ChMask2 = [0x]0000 ChMask3 = [0x]0000 ChMask4 = [0x]0001	Join accepted without a CFList
14	DUT sends Unconfirmed or Confirmed frame FCntUp = n (where n = 0 or 1 for OTA devices)	→		
	The TCL sends Unconfirmed frame	+	CP-CMD TxPeriodicityChangeReq FPort = 224 Periodicity = 5 sec Payload = [0x]0601 If DUT sent Confirmed uplink frame, TCL must	Uplink Periodicity set
15	DUT sends Confirmed or Unconfirmed frame in 5 seconds FCntUp = n + 1	→	Acknowledge FPort = any allowed port except 224	Next Uplink sent in 5 seconds
	If DUT sent a Confirmed frame, then The TCL sends Unconfirmed frame Else, this step must be skipped	←	CP-CMD TxFramesCtrlReq FPort = 224 Frame type = Unconfirmed Payload = [0x]0701	
			If DUT sent Confirmed uplink frame, TCL must Acknowledge	



Step	Procedure	i	Test Purpose	
		End Device - TCL	Frame	
16	Wait for (2 * number of 125kHz channels configured) uplink transmissions (max. 128 packets for 125kHz channels), i.e. until all 125kHz channels configured are used at least once	→ R [2*Nb125kH zCh] or [AllCh used]	Official certification (64-channel gateway): All 125kHz channels must be used at least once Pre-testing with 8-channel gateway: Channels 0-7 must be used at least once.	All 125kHz channels must be used at least once
17	DUT sends Unconfirmed frame	\rightarrow		
	If FCtrl ADR Bit = false, then The TCL sends Unconfirmed frame Else, this step is skipped	←	CP-CMD AdrBitChangeReq- ON FPort = 224 Payload = [0x]0401	
18	DUT sends Unconfirmed frame	→	FCtrl ADR bit = true	Turn on the ADR bit
	The TCL sends Unconfirmed frame	←	MAC-CMD LinkADRReq DataRate = Max125kHzDR, refer [2] Payload = [0x]03XXXXXXXX ChMaskCntl = 6 ChMask = [0x]00FF	For FC device using 8-channel gateway, refer to Section 2 for ChMask settings
19	DUT sends Unconfirmed frame)	MAC-CMD LinkADRAns Payload = [0x]0307	Changed the DR to Max125kHz DR
	The TCL sends Unconfirmed frames	+	CP-CMD RegionalDutyCycleCtrlReq- ON Payload = [0x]0501 FPort = 224	Turn ON Regional Duty Cycle

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2.3. Activation by Personalization

This test must be performed if the **DUT** supports activation by personalization.

For this test, the Authorised Test Lab must use the device provided by the device vendor to test the ABP activation functionality.

After initial power-up, the **DUT** must be enabled for testing as specified in Section 2.1.1.

576 Verify

• **DUT** successfully joins the network.

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The Test Procedure Message Sequence Chart for this test is the same as Section 2.1.1.





580	
581	Additionally, the DUT must also retain its previous settings even after reset.
582	TCL sets the DUT's parameters using the MAC commands RXParamSetupReq, DIChannelReq
583	and RXTimingSetupReq.
584	The DUT is then reset using the CP-CMD DutResetReq.
585	
586	Verify
587	• The DUT 's parameters must be retained even after reset.
588	2.3.1. Dynamic channel plan devices
589 590	2.3.1.a. All regions - Test Procedure Frame Sequence Chart



Step	Procedure		Frame Sequence		
		End Devic e - TCL	Frame	Purpose	
1	Perform all steps mentioned in Section 2.1.1		Same results as mentioned in Section 2.1.1		
2	DUT sends Unconfirmed frame	\rightarrow			
	The TCL sends Unconfirmed frame	←	MAC-CMD LinkADRReq TXPower = Minimum, refer [2] DataRate = Max125kHzDR, refer [2] ChMaskCntl = 0 ChMask = [0x]0001 MAC-CMD RxParamSetupReq RX1DRoffset = any allowed offset value except default, refer [2] RX2DataRate = Any DataRate allowed except default, refer [2] RX2Frequency = Y (where Y = any frequency allowed except default, refer [2]) MAC-CMD DIChannelReq ChIndex = C (where C = Any default channel, refer [2]) Freq = X (where X = any allowed frequency except default, refer [2]) MAC-CMD RxTimingSetupReq Delay (i) = 2 Payload = [0x]03XXXXXXXXXXX[0x]05XXXXXXXX [0x]0AXXXXXXXXXX[0x]08XX	Channel 0 enabled RxParamSet upReq, DIChannelR eq, RxTimingSet upReq commands executed	
3	DUT sends Unconfirmed frame	→	MAC-CMD LinkADRAns MAC-CMD RxParamSetupAns MAC-CMD DIChannelAns MAC-CMD RxTimingSetupAns Payload = [0x]0307[0x]0507[0x]0A03[0x]08		
	The TCL sends Unconfirmed frame	+	CP-CMD DutResetReq FPort = 224 Payload = [0x]01	Reset the DUT	
4	DUT sends Confirmed or Unconfirmed frame	→	If the ADR Bit is set, DataRate (DR) = Minimum DR allowed by the DUT, refer [2]		



	The TCL sends Confirmed frame on RX1 window	+	RX1DRoffset = as set in Step 2 RX1Delay = as set in Step 2 Freq = as set in Step 2	RX1DRoffset , RX1Delay and Freq
			CP-CMD TxPeriodicityChangeReq	retained after reset
			FPort = 224	
			Periodicity = 5 sec	
			Payload = [0x]0601	
			If DUT sent Confirmed uplink frame,	
			TCL must Acknowledge	
5	DUT sends Confirmed or Unconfirmed frame	→	ACK Bit = True	
	If DUT sent a Confirmed frame, then	+	CP-CMD TxFramesCtrlReq	
	The TCL sends Unconfirmed frame		FPort = 224 Frame type = Unconfirmed	
	Else, this step must be skipped		Payload = [0x]0701	
			If DUT sent Confirmed uplink frame, TCL must Acknowledge	
6	Wait for a maximum of 5 * (number	→ R	All default channels must be used at	All channels
	of default channels)	[5*Nb	least once	must be
		ChDC		enabled after
] or		the reset
		[AllCh used]		
7	DUT sends Unconfirmed frame	useuj →		
•	If FCtrl ADR Bit = false, then	-	CP-CMD AdrBitChangeReq-ON	
			FPort = 224	
	The TCL sends Unconfirmed frame		Payload = [0x]0401	
	Else, this step is skipped			
8	DUT sends Unconfirmed frame	\rightarrow	FCtrl ADR bit = true	Turn on the ADR bit
	The TCL sends Confirmed frame on RX2 window	+	RX2DataRate = as set in Step 2 RX2Frequency = as set in Step 2	RX2DataRat e, RX2Freq
	OH 1002 WINDOW		TAZI requericy – as set in step 2	setting
			MAC-CMD RxParamSetupReq	retained
			RX1DRoffset = default, refer [2]	after reset
			RX2DataRate = default, refer [2]	
			RX2Frequency = default, refer [2]	Later, revert to default for
			MAC-CMD DIChannelReq	all settings.
			ChIndex = C	
			Freq = default, refer [2]	Set DR to
			MAC-CMD RxTimingSetupReq	Max125kHz DR
			Delay (i) = default, refer [2]	DK
			MAC-CMD LinkADRReq	
			DataRate = Max125kHzDR, refer [2]	
			Payload =	
			[0x]05XXXXXXXX[0x]0AXXXXXX	
			X[0x]08XX[0x]03XXXXXXX	



9	DUT sends Unconfirmed frame	\rightarrow	ACK Bit = True	
			MAC-CMD RxParamSetupAns MAC-CMD DIChannelAns MAC-CMD RxTimingSetupAns MAC-CMD LinkADRAns Payload = [0x]0507[0x]0A03[0x]08[0x]0307	

2.3.1.b. For regions with Dwell Time limitation only - Test Procedure Frame Sequence Chart

These tests must be performed only for regions with Dwell Time limitation. **TCL** sets the **DUT**'s UplinkDwellTime using the TXParamSetupReq MAC command. The **DUT** is then reset using the CP-CMD DutResetReq.

Verify

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599 600 The UplinkDwellTime setting must be retained even after reset.



Step	Procedure		Frame Sequence	Test Purpose
		End Devic e - TCL	Frame	, a pood
1	DUT sends Unconfirmed frame	\rightarrow		
	The TCL sends Unconfirmed frame	+	MAC-CMD TXParamSetupReq UplinkDwellTime = 0 Payload = [0x]09XX	TXParamSet upReq command executed
2	DUT sends Unconfirmed frame	→	MAC-CMD TXParamSetupAns Payload = [0x]09	
	The TCL sends Unconfirmed frame	+	CP-CMD DutResetReq FPort = 224 Payload = [0x]01	Reset the DUT
3	DUT sends Confirmed or Unconfirmed frame	\rightarrow		
	The TCL sends Confirmed frame on RX1 window	+	CP-CMD TxPeriodicityChangeReq FPort = 224 Periodicity = 5 sec Payload = [0x]0601	Change periodicity to 5sec
			If DUT sent Confirmed uplink frame, TCL must Acknowledge	
4	DUT sends Confirmed or Unconfirmed frame	→	ACK Bit = True	
	If DUT sent a Confirmed frame, then The TCL sends Unconfirmed frame Else, this step must be skipped	←	CP-CMD TxFramesCtrlReq FPort = 224 Frame type = Unconfirmed Payload = [0x]0701	
			If DUT sent Confirmed uplink frame, TCL must Acknowledge	
5	DUT sends Unconfirmed frame	\rightarrow	-	
	If FCtrl ADR Bit = false, then The TCL sends Unconfirmed frame Else, this step is skipped	+	CP-CMD AdrBitChangeReq-ON FPort = 224 Payload = [0x]0401	
6	DUT sends Unconfirmed frame	→	FCtrl ADR bit = true	Turn on the ADR bit
	The TCL sends Unconfirmed frame on RX2 window	+	MAC-CMD LinkADRReq DataRate = MinDR, refer [2] Payload = [0x]03XXXXXXXX	UplinkDwellT ime setting retained after resettested by setting to MinDR
7	DUT sends Unconfirmed frame in 5 seconds	→	MAC-CMD LinkADRAns Payload = [0x]0307	
8	DUT sends Unconfirmed frame	\rightarrow		





	The TCL sends Unconfirmed frame	+	MAC-CMD LinkADRReq	Revert to
			DataRate = Max125kHzDR, refer [2]	Max125kHz
				DR and
			MAC-CMD TXParamSetupReq	revert
			UplinkDwellTime = default, refer [2]	UplinkDwellT
				ime to
			Payload =	default
			[0x]03XXXXXXXX[0x]09XX	
9	DUT sends Unconfirmed frame	\rightarrow	MAC-CMD LinkADRAns	
			MAC-CMD TXParamSetupAns	
			Payload = $[0x]0307[0x]09$	

602

2.3.2. Fixed channel plan devices

603 604 2.3.2.a. All regions - Test Procedure Frame Sequence Chart

LoRaWAN 1.0.4 End Device Certification
Requirements for All Regions Version 1.6

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Step	Procedure		Frame Sequence	Test Purpose	
		End Devic e - TCL	Frame		
The er	ntire table for ABP testing must be skipp	ed when	pre-testing with an 8-channel gateway		
1	Perform all steps mentioned in Section 2.1.1		Same results as mentioned in Section 2.1.1		
2	DUT sends Unconfirmed frame	\rightarrow			
	The TCL sends Unconfirmed frame	+	MAC-CMD LinkADRReq TXPower = Minimum, refer [2] DataRate = Max500kHzDR, refer [2] ChMaskCntl = 7 ChMask = [0x]0001 MAC-CMD LinkADRReq TXPower = Minimum, refer [2] DataRate = Max125kHzDR, refer [2] ChMaskCntl = 0 ChMask = [0x]0003 MAC-CMD RxParamSetupReq RX1DRoffset = any allowed offset value except default, refer [2] RX2DataRate = Any DataRate allowed except default, refer [2] RX2Frequency = Y (where Y = any frequency allowed except default, refer [2]) MAC-CMD RxTimingSetupReq Delay (i) = 2 Payload = [0x]03XXXXXXXXXXX[0x]03XXXXXXXXX	Channels 0, 1 and 64 enabled RxParamSet upReq, RxTimingSet upReq commands executed	
3	DUT sends Unconfirmed frame	→	[0x]05XXXXXXXX[0x]08XX MAC-CMD LinkADRAns MAC-CMD LinkADRAns MAC-CMD RxParamSetupAns MAC-CMD RxTimingSetupAns Payload = [0x]0307[0x]0307[0x]0507[0x]08		
4	The TCL sends Unconfirmed frame	+	CP-CMD DutResetReq FPort = 224 Payload = [0x]01	Reset the DUT	
	DUT sends Confirmed or Unconfirmed frame	\rightarrow			



	The TCL sends Confirmed frame on RX1 window	+	RX1DRoffset = as set in Step 2 RX1Delay = as set in Step 2 Freq = as set in Step 2	RX1DRoffset , RX1Delay and Freq retained
			CP-CMD TxPeriodicityChangeReq FPort = 224 Periodicity = 5 sec Payload = [0x]0601	after reset
			If DUT sent Confirmed uplink frame, TCL must Acknowledge	
5	DUT sends Confirmed or Unconfirmed frame	\rightarrow	ACK Bit = True	
	If DUT sent a Confirmed frame, then The TCL sends Unconfirmed frame Else, this step must be skipped	+	CP-CMD TxFramesCtrlReq FPort = 224 Frame type = Unconfirmed Payload = [0x]0701	
			If DUT sent Confirmed uplink frame, TCL must Acknowledge	
6	If DR = 125kHz DR, wait for a maximum of 2 * (number of 125kHz channels configured) uplink packets to be sent, i.e. until all channels are used at least once.	→ R [2*Nb 125k HzCh] or [5*Nb	If DR = 125kHz DR, all 125kHz channels including the channels which were disabled earlier must be used at least once If DR = 500kHz DR, all 500kHz	All channels must be enabled after the reset
	If DR = 500kHz DR, wait for a maximum of 5 * (number of 500kHz channels configured)	500k HzCh] or	channels including the channels which were disabled earlier must be used at least once	
	uplink packets to be sent, i.e. until all channels are used at least once.	[AllCh used]	Pre-testing for FC plan with 8- channel gateway: Channels 0-7 (if DR = 125kHz DR) or channel 64 (if DR = 500kHz DR) must be used at least once.	
7	DUT sends Unconfirmed frame	\rightarrow		
	If FCtrl ADR Bit = false, then The TCL sends Unconfirmed frame	+	CP-CMD AdrBitChangeReq-ON FPort = 224 Payload = [0x]0401	
8	Else, this step is skipped DUT sends Unconfirmed frame	\rightarrow	FCtrl ADR bit = true	Turn on the
	201 School Millined Hame		1 Sai Abit bit – tide	ADR bit



	The TCL sends Confirmed frame	←	RX2DataRate = as set in Step 2	RX2DataRat
	on RX2 window		RX2Frequency = as set in Step 2	e, RX2Freq,
				retained
				after reset
			MAC-CMD RxParamSetupReq	
			RX1DRoffset = default, refer [2]	Revert to
			RX2DataRate = default, refer [2]	default for all
			RX2Frequency = default, refer [2]	settings.
			MAC-CMD RxTimingSetupReq	Changed the
			Delay (i) = default, refer [2]	DR to
				Max125kHz
			MAC-CMD LinkADRReq	DR
			DataRate = Max125kHzDR, refer [2]	
				For FC
			Payload =	device using
			[0x]05XXXXXXXX[0x]08XX[0x]03XX	8-channel
			XXXXXX	gateway,
				refer to
				Section 2 for
				ChMask
		_		settings
9	DUT sends Unconfirmed frame	\rightarrow	ACK Bit = True	
			MAC-CMD RxParamSetupAns	
			MAC-CMD RXFaramSetupAns MAC-CMD RxTimingSetupAns	
			MAC-CMD EXTINING SetupAris MAC-CMD LinkADRAns	
			Payload = [0x]0507[0x]08[0x]0307	
			Fayload = [0x]0007[0x]00[0x]0307	

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2.3.2.b. For regions with Dwell Time limitation only - Test Procedure Frame Sequence Chart

These tests must be performed only for regions with Dwell Time limitation. **TCL** sets the **DUT**'s UplinkDwellTime using the TXParamSetupReq MAC command. The **DUT** is then reset using the CP-CMD DutResetReq.

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• The UplinkDwellTime setting must be retained even after reset.



Step	Procedure		Frame Sequence	Test Purpose
		End Devic e - TCL	Frame	·
1	DUT sends Unconfirmed frame	\rightarrow		
	The TCL sends Unconfirmed frame	+	MAC-CMD TXParamSetupReq UplinkDwellTime = 0 Payload = [0x]09XX	TXParamSet upReq command executed
2	DUT sends Unconfirmed frame	→	MAC-CMD TXParamSetupAns Payload = [0x]09	
	The TCL sends Unconfirmed frame	+	CP-CMD DutResetReq FPort = 224 Payload = [0x]01	Reset the DUT
3	DUT sends Confirmed or Unconfirmed frame	\rightarrow		
	The TCL sends Confirmed frame on RX1 window	+	CP-CMD TxPeriodicityChangeReq FPort = 224 Periodicity = 5 sec Payload = [0x]0601 If DUT sent Confirmed uplink frame, TCL must Acknowledge	Change periodicity to 5sec
4	DUT sends Confirmed or Unconfirmed frame	>	ACK Bit = True	
	If DUT sent a Confirmed frame, then The TCL sends Unconfirmed frame Else, this step must be skipped	+	CP-CMD TxFramesCtrlReq FPort = 224 Frame type = Unconfirmed Payload = [0x]0701 If DUT sent Confirmed uplink frame,	
			TCL must Acknowledge	
5	DUT sends Unconfirmed frame If FCtrl ADR Bit = false, then The TCL sends Unconfirmed frame Else, this step is skipped	→ ←	CP-CMD AdrBitChangeReq-ON FPort = 224 Payload = [0x]0401	
6	DUT sends Unconfirmed frame	→	FCtrl ADR bit = true	Turn on the ADR bit



	The TCL sends Unconfirmed frame on RX2 window	+	MAC-CMD LinkADRReq DataRate = MinDR, refer [2] Payload = [0x]03XXXXXXXX	UplinkDwellT ime setting retained after reset- tested by setting to MinDR
				For FC device using 8-channel gateway, refer to Section 2 for ChMask settings
7	DUT sends Unconfirmed frame in 5 seconds	→	MAC-CMD LinkADRAns Payload = [0x]0307	
8	DUT sends Unconfirmed frame	\rightarrow		
	The TCL sends Unconfirmed frame	+	MAC-CMD LinkADRReq DataRate = Max125kHzDR, refer [2] MAC-CMD TXParamSetupReq UplinkDwellTime = default, refer [2] Payload = [0x]03XXXXXXXXX[0x]09XX	Revert to Max125kHz DR and revert UplinkDwellT ime to default
				For FC device using 8-channel gateway, refer to Section 2 for ChMask settings



2.4. Device Functionality Tests

617	2.4. Device Functionality Tests
618	2.4.1. Default Setting Tests
619	The TCL will test the basic functionality of the DUT using the current applicative 'RxAppCnt'
620	value and using the [0x]08 Echo command. The purpose of these tests is to detect
621	implementation errors in the DUT early, instead of failing later tests.
622	
623	2.4.1.a. Cryptography:
624	Verifies that AES encryption and message integrity code (MIC) algorithms are correctly
625	implemented by the DUT .
626	2.4.1.a.i. AES Encryption
627	TCL will send multiple [0x]08 Echo commands with varying length payloads to the DUT.
628	The varying payloads lengths must contain lengths
629	 Test with a physical frame size smaller than 16 bytes. (Less than block of 16
630	bytes,)
631	 Test with a physical frame size equal to 16 bytes. (16 bytes,)
632	 Test with a physical frame where the size is between 17 and 31 bytes.
633	(Greater than block of 16 bytes but lesser than the second block,)
634	 Test with a physical frame size equal to the maximum which is 255 bytes
635	(Max payload length). For this test used data rate is important as the max
636	length depends on it.
637	
638	The echo-replies from the DUT are verified to contain the same payload where
639	each byte is incremented by one. This test will only use echo commands whose
640	payload is less than or equal to the maximum allowed payload of the DUT 's current
641	uplink DR. Frame counter must increase for every received package. Oversized

payloads are tested separately in Section 2.5.11.d.



2.4.1.a.i.1. Test Procedure Frame Sequence Chart

Step	Procedure	I	Frame Sequence		
		End Device - TCL	Frame		
1	DUT sends Unconfirmed frame FCntUp = n	→			
	The TCL sends Unconfirmed frames	←	CP-CMD EchoPayloadReq FPort = 224 Payload = [0x]08 (Various) Note: See description for Various details		
2	DUT sends Unconfirmed frame FCntUp = n + 1 + i	→ R [3]	CP-CMD EchoPayloadAns (repeat i times- where i = 1 to 3) FPort = 224 Payload = [0x]08 (Various)' No ACK is sent for the previous Unconfirmed frame	Multiple Echo replies sent	
	The TCL sends Unconfirmed frames	← R [3]	CP-CMD EchoPayloadReq (repeat i times- where i = 1 to 3) FPort = 224 Payload = [0x]08 (Various)		
3	DUT sends Unconfirmed frames FCntUp = n + 5	→	CP-CMD EchoPayloadAns FPort = 224 Payload = [0x]08 (Various)'	Echo reply sent	

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2.4.1.a.ii. Message Integrity Code

TCL will send packets with purposely invalid message integrity codes. The **DUT** must ignore these packets.



2.4.1.a.ii.1. Test Procedure Frame Sequence Chart

Step	Procedure	ı	Frame Sequence		
				Purpose	
		End Device	Frame		
		- TCL			
1	DUT sends Unconfirmed frame	\rightarrow			
	FCntUp = n				
	The TCL sends Unconfirmed frames	←	CP-CMD EchoPayloadReq		
			FPort = 224		
			Payload = [0x]08 (Various)		
			MIC Invalid		
2	DUT sends Unconfirmed frame	→ R [4]		MIC Invalid	
	FCntUp = n + i			packets	
				ignored	
	The TCL sends Unconfirmed frames	← R [4]	CP-CMD EchoPayloadReq		
			(repeat i times- where i = 1 to		
			4)		
			FPort = 224		
			Payload = [0x]08 (Various)		
			MIC Invalid		
3	DUT sends Unconfirmed frame	\rightarrow		MIC Invalid	
	FCntUp = n + 5			packet	
				ignored	

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651 2.4.1.b. **Downlink Sequence Number**

This test verifies the **DUT** properly handles the frame sequence numbers that are used to prevent replay attacks on the communication.

TCL sends several packets with decreasing sequence number i such that:

 $1 \le i < Current FCntDown$

The **DUT** must ignore downlinks whose sequence numbers are less than its current internal downlink counter value.



2.4.1.b.i. Test Procedure Frame Sequence Chart

Step	Procedure	_	Frame Sequence	Test Purpose
		End Device - TCL	Frame	
1	DUT sends Unconfirmed frame FCntUp = n	→		
	The TCL sends Unconfirmed frame FCntDown = a	+	CP-CMD TxFramesCtrlReq FPort = 224 Frame type = No change Payload = [0x]0700	
2	DUT sends Unconfirmed frame FCntUp = n + y (where y = 1 to 4) Repeat 4 times	→ R [4]		
	The TCL sends Unconfirmed frame FCntDown = a - i (where i = [1, a-1]) Repeat 4 times	← R [4]	CP-CMD TxFramesCtrlReq FPort = 224 Frame type = Confirmed Payload = [0x]0702	
3	DUT sends Unconfirmed frame FCntUp = n + 5)		DUT ignores the 4 downlinks with FCntDown < current downlink counter and sends Unconfirmed frame.

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2.4.2. Confirmed Frames

This test verifies that the **DUT** properly handles confirmed frames as both the sender (uplinks) and receiver (downlinks).

2.4.2.a. **Confirmed Uplinks**

The **TCL** sends the [0x]0702 TxFramesCtrlReq command to the **DUT**. Verify all subsequent uplinks from the **DUT** are frame type *ConfirmedUp*.

2.4.2.a.i. Test Procedure Frame Sequence Chart

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Step	Procedure		Frame Sequence	Test Purpose
		End Device - TCL	Frame	
1	DUT sends Unconfirmed frame FCntUp = n	→		
	The TCL sends Unconfirmed frames	+	CP-CMD RxAppCntReq FPort = 224 Payload = [0x]09	
2	DUT sends Unconfirmed frame FCntUp = n + 1	→	CP-CMD RxAppCntAns FPort = 224 Payload = [0x]09XXXX RxAppCnt = x	
	The TCL sends Unconfirmed frame	+	CP-CMD TxFramesCtrlReq FPort 224 Frame Type = Confirmed Payload [0x]0702	
3	DUT sends Confirmed frame FCntUp >= n + 2	→		Confirmed frame sent
	The TCL sends Unconfirmed frame	+	Acknowledge No FPort and no payload	
4	DUT sends Confirmed frame FCntUp >= n + 3 The TCL sends Unconfirmed frame	→ ←		Confirmed frame sent
			Acknowledge CP-CMD TxFramesCtrlReq FPort = 224 Frame type = No change Payload [0x]0700	
5	DUT sends Confirmed frame FCntUp >= n + 4	→		Confirmed frame sent
	The TCL sends Unconfirmed frames	←	Acknowledge CP-CMD RxAppCntReq FPort = 224 Payload = [0x]09	
6	DUT sends Confirmed frame FCntUp >= n + 5	→	CP-CMD RxAppCntAns FPort = 224 Payload = [0x]09XXXX RxAppCnt >= x + 4	Refer to Section 2 – Test Notes for missed RxAppCntAn s
7	DUT sends Confirmed frame FCntUp >= n + 6	→		DUT increments the FCntUp even when no ACK is sent by TCL
	The TCL sends Unconfirmed frame	+	Acknowledge CP-CMD TxFramesCtrlReq FPort 224 Frame type = Unconfirmed Payload [0x]0701	





ſ	8	DUT sends Unconfirmed frame	\rightarrow	Switch back
		FCntUp >= n + 7		to
				Unconfirmed
				frame

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2.4.2.b. Confirmed Downlinks

TCL sends a *ConfirmedDown* packet. Verify the **DUT** sets the *ACK* bit in the subsequent uplink. The test also verifies that when the **TCL** sends a retransmission with the same FCntDown, the DUT ignores the downlink.

2.4.2.b.i.Test Procedure Frame Sequence Chart

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Step	Procedure	Frame Sequence		Test
				Purpose
		End Device - TCL	Frame	
1	DUT sends Unconfirmed frame	→		
	FCntUp = n The TCL send Confirmed frame FCntDown = m	←	CP-CMD TxFramesCtrlReq FPort 224 Frame type = Confirmed Payload [0x]0702	TCL sends Confirmed frame
2	DUT sends Confirmed frame FCntUp = n + 1	→	ACK Bit = True Note: The DUT may split this frame into first an empty Unconfirmed frame with ACK, followed by a Confirmed frame. This must be accepted as well.	
	The TCL sends Confirmed frame FCntDown = m + 1	+	Acknowledge CP-CMD TxFramesCtrlReq FPort 224 Frame type = Unconfirmed Payload [0x]0701	TCL sends Confirmed frame
3	DUT sends Unconfirmed frame FCntUp = n + 2	→	ACK Bit = True	
	The TCL sends Confirmed frames FCntDown = m + 2	+	CP-CMD TxFramesCtrlReq FPort 224 Frame type = No change Payload [0x]0700	
4	DUT sends Unconfirmed frame FCntUp = n + 3	→	ACK Bit = True	
5	DUT sends Unconfirmed frame FCntUp = n + y (where y = 1 to 4)	→ R [4]		
	The TCL sends Confirmed frames FCntDown = m + 2	← R [4]	CP-CMD TxFramesCtrlReq FPort 224 Frame type = No change Payload [0x]0700	
6	DUT sends Unconfirmed frame FCntUp = n + 8	→	No acknowledgement is sent	DUT ignores the downlink with incorrect frame counter



2.5. MAC Command Tests

The following tests will validate the **DUT**'s implementation of MAC command processing and the associated functional areas being controlled by the **TCL**. As previously stated, the **TCL** should allow for some reasonable amount of packet loss while facilitating tests. Specifically, where MAC commands are concerned, it is acceptable to retry commanding the device in the absence of a MAC command answer. Retries should be limited to a maximum of 5 attempts. After 5 uplinks are received from the **DUT**, if the **TCL** still does not get the expected response from the **DUT**, the test must fail, and the tool must move to the next test.

2.5.1. DevStatusReq

TCL sends a DevStatusReg command to the DUT.

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- The **DUT** must reply with a *DevStatusAns* packet.
- The signal-to-noise information in the RadioStatus field in the reply is a signed integer of 6 bits with a minimum value of -32 and maximum value of 31.

2.5.1.a. **Test Procedure Frame Sequence Chart**

Step	Procedure	F	Frame Sequence	
				Purpose
		End Device	Frame	
		- TCL		
1	DUT sends Unconfirmed frame	\rightarrow		
	The TCL sends Unconfirmed frame	+	MAC-CMD DevStatusReq	
			Payload [0x]06	
2	DUT sends Unconfirmed frame	\rightarrow	MAC-CMD DevStatusAns	DevStatusAn
			RadioStatus >= - 32 and <=	s sent and
			31	encoded
			Payload [0x]06XXXX	value tested

2.5.2. NewChannelReq

2.5.2.a. **Fixed Channel plan devices**

For Fixed channel plan devices, the NewChannelReq MAC command must be rejected and the **DUT** must silently drop the request packet. The **DUT** must continue normal operation.



2.5.2.a.i. Test Procedure Frame Sequence Chart

Step	Procedure		Frame Sequence	
		End Device - TCL	Frame	Purpose
1	DUT sends Unconfirmed frame	\rightarrow		
	The TCL sends Unconfirmed frame	←	MAC-CMD NewChannelReq ChIndex = 4 Freq = any applicable frequency, refer [2] Payload = [0x]07XXXXXXXXXX	
2	DUT sends Unconfirmed frame	→		No response to the command but DUT continues normal operation

2.5.2.b. For Dynamic Channel plan devices only

TCL sends a *NewChannelReq* command to the **DUT** for configuring new channel frequencies.

NewChannelReq command is supported for only Dynamic channel plan devices.

For Fixed channel plan devices, DUT must silently drop the request packet.

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2.5.2.b.i. Read-only default channels

The mandatory default channels are defined in [2]. The **TCL** will send *NewChannelReq* that tries to modify these channels. The **DUT** must reply with an unsuccessful *NewChannelAns NOT* = ([0x]0703).

2.5.2.b.ii. Addition of a channel

TCL sends a MAC command to add a single new channel.

The **DUT** must reply with a successful *NewChannelAns* and begin using the new channel in its random selection of frequencies. This test may use any frequency applicable for that region [2].

2.5.2.b.iii. Removal of a channel

TCL sends *NewChannelReq* to set the previously configured channel to 0 MHz frequency.

The **DUT** must reply with a successful *NewChannelAns* and stop using the additional channel in its uplink transmissions.

2.5.2.b.iv. Addition and removal of multiple channels

TCL sends multiple MAC commands in a single frame to configure the additional channels. Multiple such frames may be sent to configure all the additional non-default channels and to remove them.





723	The DUT must reply with a successful <i>NewChannelAns</i> to each request. The DUT mus
724	send an uplink on each channel configured.
725	2.5.2.b.v. Invalid command processing - Frequency
726	TCL sends NewChannelReq command including an invalid frequency located out of the
727	band to check that the DUT replies correctly.
728	2.5.2.b.vi. Invalid command processing – Data Rate Range
729	TCL sends NewChannelReq command including an invalid data rate range to check tha
730	the DUT replies correctly.
731	2.5.2.b.vii. Removal of default channels – not allowed
732	TCL tries to remove the default channels. DUT must reject the command and mus
733	continue to use the default channels.
734	
735	2.5.2.b.viii. Test Procedure Frame Sequence Chart
736	



Step	Procedure		Frame Sequence	Test Purpose
		End Device - TCL	Frame	r di poso
1	DUT sends Unconfirmed frame	→		
	The TCL sends Unconfirmed frame	+	MAC-CMD NewChannelReq ChIndex = 0	TCL attempts to
			Freq = Any allowed frequency for the channel, refer [2] DRRange = Any valid range, refer [2]	modify default channels
			Payload = [0x]07XXXXXXXXX	
2	DUT sends Unconfirmed frame	→ R [All default Ch]	MAC-CMD NewChannelAns Payload NOT = [0x]0703	
	The TCL sends Unconfirmed frame	← R [All default Ch]	MAC-CMD NewChannelReq ChIndex = All other default channels, refer [2] Freq = Any allowed frequency for that channel, refer [2] DRRange = Any valid range, refer [2] Payload = [0x]07XXXXXXXXXX	
3	DUT sends Unconfirmed frame	→	MAC-CMD NewChannelAns Payload NOT = [0x]0703	DUT shall not change its channel plan or transmission behaviour
	The TCL sends Unconfirmed frame	+	FPort = 0 MAC-CMD NewChannelReq ChIndex = 15 Freq = any applicable frequency, refer [2] Payload = [0x]07XXXXXXXXXX	
4	DUT sends Unconfirmed frame	\rightarrow	MAC-CMD NewChannelAns Payload = [0x]0703	
5	Wait for a maximum of (5 * number of channels <i>currently enabled on the DUT</i>) uplink packets, i.e. until the channel configured is used at least once	→ R [5*NbCh] or [AllCh used]	The new channel configured must be used at least once	New channel added
6	DUT sends Unconfirmed frame The TCL sends Unconfirmed frame	→ ←	MAC-CMD NewChannelReq ChIndex = 15 Freq = 0 MHz Payload = [0x]07XXXXXXXXXX	
7	DUT sends Unconfirmed frame	→	MAC-CMD NewChannelAns Payload = [0x]0703	



Step	Procedure	-	Frame Sequence	Test Purpose
		End Device - TCL	Frame	
8	Wait for (5 * number of channels currently enabled on the DUT) uplink packets, to confirm that the removed channel is not used.	→ R [5*NbCh]	The channel removed must not be used	
9	DUT sends Unconfirmed frame	\rightarrow		
	The TCL sends Unconfirmed frame	+	FPort = 0	
			MAC-CMD NewChannelReq	
			ChIndex = all non-default	
			channel indexes, refer [2]	
			Freq = any frequency	
			applicable for that region,	
			refer [2]. Each channel must have a different frequency,	
			as supported by the	
			gateway.	
			Payload = [0x]07XXXXXXXXXXX[0x]07X XXXXXXXXXX [repeat [0x]07XXXXXXXXX up to (16 - NbDefaultChannels)]	
			Note1: This downlink may be split into multiple downlinks so that the maximum FRMPayload is not exceeded	
			Note2: When performing pre-testing using an 8-channel gateway for DC plan devices, the Freq field must	
			be set to 8 different allowed frequencies for that region as supported by the gateway for the first 8 channels. The same set of 8 frequencies must be repeated for the next set of 8 channels as well.	



Step	Procedure		Frame Sequence	Test
		End Device	Frame	Purpose
		- TCL	rrame	
10	DUT sends Unconfirmed frame	→	FPort = 0	16 channels (default +
			MAC-CMD NewChannelAns	additional
			Payload =	channels)
			[0x]0703[0x]0703[0x]0703	configured
			[Repeat [0x]0703 "Y" times]	
			- where Y is the number of	
			channels configured	
			Note: This uplink may be	
			split into multiple uplinks so	
			that the maximum	
			FRMPayload is not	
			exceeded	
	The TCL sends Unconfirmed frame	←	MAC-CMD LinkADRReq	
			ChMaskCntl = 0	
			ChMask = [0x]F000	
			DataRate = Max125kHzDR	
			Payload = [0x]03XXXXXXXX	
11	DUT sends Unconfirmed frame	\rightarrow	MAC-CMD LinkADRAns	Enable
			Payload = [0x]0307	channel IDs
				12-15
12	Wait for 5 * 4 (number of channels	→ R	Only the 4 enabled channels	Checking
	currently enabled on the DUT) = 20	[5*NbCh]	must be used at least once,	channel
	uplink packets to be sent		and the disabled channels	usage
			must not be used	
13	DUT sends Unconfirmed frame	\rightarrow		
	The TCL sends Unconfirmed frame	←	MAC-CMD LinkADRReq	
			ChMaskCntl = 0	
			ChMask = [0x]0F00	
			DataRate = Max125kHzDR	
			Payload = [0x]03XXXXXXXX	
14	DUT sends Unconfirmed frame	\rightarrow	MAC-CMD LinkADRAns	Enable
			Payload = [0x]0307	channel IDs 8-11
15	Wait for 5 * 4 (number of channels	→R	Only the 4 enabled channels	Checking
	currently enabled on the DUT) = 20	[5*NbCh]	must be used at least once,	channel
	uplink packets to be sent	' '	and the disabled channels	usage
			must not be used	
16	DUT sends Unconfirmed frame	\rightarrow		
	The TCL sends Unconfirmed frame	+	MAC-CMD LinkADRReq	
			ChMaskCntl = 0	
			ChMask = [0x]00F0	
			DataRate = Max125kHzDR	
			Payload = [0x]03XXXXXXXX	
17	DUT sends Unconfirmed frame	→	MAC-CMD LinkADRAns	Enable
			Payload = [0x]0307	channel IDs
				4-7
18	Wait for 5 * 4 (number of channels	→ R	Only the 4 enabled channels	Checking
	currently enabled on the DUT) = 20	[5*NbCh]	must be used at least once,	channel
	uplink packets to be sent		and the disabled channels	usage
			must not be used	



Step	Procedure	Frame Sequence		Test Purpose
		End Device - TCL	Frame	•
19	DUT sends Unconfirmed frame	\rightarrow		
	The TCL sends Unconfirmed frame	←	MAC-CMD LinkADRReq ChMaskCntl = 0 ChMask = [0x]000F DataRate = Max125kHzDR Payload = [0x]03XXXXXXXX	
20	DUT sends Unconfirmed frame	→	MAC-CMD LinkADRAns Payload = [0x]0307	Enable channel IDs 0-3
21	Wait for 5 * 4 (number of channels currently enabled on the DUT) = 20 uplink packets to be sent	→ R [5*NbCh]	Only the 4 enabled channels must be used at least once, and the disabled channels must not be used	Checking channel usage
22	DUT sends Unconfirmed frame	\rightarrow		
	The TCL sends Unconfirmed frame	+	FPort = 0 MAC-CMD NewChannelReq	
			ChIndex = all non-default channel indexes, refer [2]	
			Freq = 0 MHz	
			Payload = [0x]07XXXXXXXXXX[0x]07X XXXXXXXXXX [repeat [0x]07XXXXXXXXXX for all channels removed]	
23	DUT sends Unconfirmed frame	→	FPort = 0 MAC-CMD NewChannelAns Payload = [0x]0703[0x]0703[0x]0703 [Repeat [0x]0703 "Y" times] – where Y is the number of channels removed	All additional Channels removed
24	Wait for 5 * (default number of channels currently enabled on the DUT) uplink packets to be sent	→ R [5*NbDefCh]	The additional channels which were removed must not be used and only the default channels must be used	Checking channel usage
25	DUT sends Unconfirmed frame	\rightarrow		
	The TCL sends Unconfirmed frame	+	CMD NewChannelReq ChIndex = Any channel index other than the default, refer [2] Freq = Any invalid Freq, refer [2] Payload = [0x]07XXXXXXXXXX	



Step	Procedure	Frame Sequence		Test Purpose
		End Device - TCL	Frame	
26	DUT sends Unconfirmed frame)	CMD NewChannelAns Payload NOT = [0x]0703	DUT shall not modify its frequency or transmission behaviour
	The TCL sends Unconfirmed frame	+	MAC-CMD NewChannelReq ChIndex = Any channel index other than the default, refer [2] Freq = Default, refer [2] DRRange = An invalid data range, refer [2] Payload = [0x]07XXXXXXXX	
27	DUT sends Unconfirmed frame)	MAC-CMD NewChannelAns Payload is NOT = [0x]0703	DUT shall not add the channel due to invalid Data Range
	The TCL sends Unconfirmed frame	←	MAC-CMD NewChannelReq ChIndex = All default channels, refer [2] Freq = 0 MHz Payload = [0x]07XXXXXXXXX[Repeat [0x]07XXXXXXXXX "Y" times] - where Y is the number of default channels	
28	DUT sends Unconfirmed frame)	MAC-CMD NewChannelAns Payload NOT =[0x]0703[Repeat "Y" times] - where Y is the number of default channels	Default channels not affected
29	Wait for 5 * (number of channels currently enabled on the DUT) uplink packets to be sent	→ R [5*NbDefCh]	Only the default channels must be used at least once	Checking channel usage

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2.5.3. DIChannelReq

2.5.3.a. **Fixed Channel plan devices**

For Fixed channel plan devices, the **DUT** must silently drop the DIChannelReq MAC command request. The **DUT** must continue normal operation.



2.5.3.a.i. Test Procedure Frame Sequence Chart

Step	Procedure		Frame Sequence	
		End Device	Frame	
		- TCL		
1	DUT sends Unconfirmed frame	\rightarrow		
	The TCL sends Unconfirmed frame	+	MAC-CMD DIChannelReq	
			ChIndex = Any default	
			channel, refer [2]	
			Freq = Any frequency other	
			than default freq, refer [2])	
			Payload = [0x]0AXXXXXXXX	
2	DUT sends Unconfirmed frame	\rightarrow		No response
				to the
				command but
				DUT
				continues
				normal
				operation

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2.5.3.b. **Dynamic Channel plan devices**

The **TCL** sends a MAC command to change the downlink frequency in RX1 for an existing channel. The **TCL** tests RX1 downlink window using the new frequency and then restores the default values. Retransmission is tested, as well. The **TCL** waits for an uplink, while the MAC answer should be [0x]0A03. Then the **TCL** sends a downlink and waits for the next uplink, while the MAC answer should not contain [0x]0A03. Finally, standard settings are applied and tested again. Additionally, the **TCL** sends *DIChannelReq* commands including invalid frequency and channel values to check that the **DUT** replies appropriately.

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2.5.3.b.i. Test Procedure Frame Sequence Chart



Step	Procedure	Frame Sequence		Test Purpose
		End Device - TCL	Frame	
1	DUT sends Unconfirmed frame	\rightarrow		
	The TCL sends Unconfirmed frame on RX1 window	+	MAC-CMD DIChannelReq ChIndex = C (where C = Any default channel, refer [2])	
			Freq = X (where X = any allowed frequency other than the default frequency, refer [2])	
	DUT 111 6 16	, ,	Payload = [0x]0AXXXXXXXX	
2	DUT sends Unconfirmed frame	→ R [max 3]	MAC-CMD DIChannelAns Payload = [0x]0A03	
	Repeat up to 3 times until a downlink is received confirming the receipt of the DIChannelAns			
3	DUT sends Unconfirmed frame	→	MAC-CMD DIChannelAns Payload = [0x]0A03	
	The TCL must send an Unconfirmed	←	CP-CMD EchoPayloadReq	Tests
	frame on RX1 window	·	FPort = 224 Payload = [0x]080A0B0C	downlink frequency settings for
			Chindex = Any one of the default channels, refer [2] Freq = The frequency set	the default channel
4	DUT sends Unconfirmed frame	→ R [5*NbDefCh]	If the EchoPayloadReq was sent in the previous	
	Repeat for a maximum of (5 * number of default channels) until the	OR [All default	downlink,	
	DUT sends an uplink on all default channels	channels]	CP-CMD EchoPayloadAns FPort = 224 Payload = [0x]080B0C0D	
	If the DUT sends an uplink on	←R	CP-CMD EchoPayloadReq	Tests
	another default channel, then the TCL sends Unconfirmed frame on RX1 window	[All default channels]	FPort = 224 Payload = [0x]080A0B0C	downlink frequency settings for
	Repeat for all default channels		ChIndex = Each of the remaining default channels, refer [2]	all default channels
	DUT 111 5 15		Freq = The frequency set	
5	DUT sends Unconfirmed frame	→	CP-CMD EchoPayloadAns FPort = 224 Payload = [0x]080B0C0D	Tests downlink frequency settings for the last default channel



Step	Procedure	ı	Frame Sequence	Test Purpose
		End Device - TCL	Frame	
	TCL sends Unconfirmed frame	-	MAC-CMD DIChannelReq ChIndex = C	
			Freq = default frequency, refer [2]	
			Payload = [0x]0AXXXXXXXX	
6	DUT sends Unconfirmed frame Repeat up to 3 times until a downlink	→ R [max 3]	MAC-CMD DIChannelAns Payload = [0x]0A03	DUT returns to its default settings
	is received confirming the receipt of the DIChannelAns			
7	DUT sends Unconfirmed frame)	MAC-CMD DIChannelAns Payload = [0x]0A03	
	The TCL must send an Unconfirmed frame on RX1 window	←	CP-CMD EchoPayloadReq FPort = 224 Payload = [0x]080A0B0C	Tests default frequency settings for the default
			ChIndex = Any one of the default channels, refer [2] Freq = Default frequency	channel
8	DUT sends Unconfirmed frame	→ R	If the EchoPayloadReq was	
	Repeat for a maximum of (5 * number of default channels) until the	[5*NbDefCh] OR [All default	sent in the previous downlink,	
	DUT sends an uplink on all default channels	channels]	CP-CMD EchoPayloadAns FPort = 224	
	If the DUT sends an uplink on	←R	Payload = [0x]080B0C0D CP-CMD EchoPayloadReq	Tests default
	another default channel, then the TCL sends Unconfirmed frame on RX1 window	[All default channels]	FPort = 224 Payload = [0x]080A0B0C	frequency settings for all default
	Repeat for all default channels		ChIndex = Each of the remaining default channels, refer [2] Freq = Default frequency	channels
9	DUT sends Unconfirmed frame)	CP-CMD EchoPayloadAns FPort = 224 Payload = [0x]080B0C0D	Tests default frequency settings for the last default channel
	The TCL sends Unconfirmed frame	←	MAC-CMD DIChannelReq ChIndex = C Freq = Any invalid frequency, refer [2] Payload = [0x]0AXXXXXXXX	
10	DUT sends Unconfirmed frame Repeat up to 3 times until a downlink is received confirming the receipt of the DIChannelAns	→ R [max 3]	MAC-CMD DIChannelAns Payload is NOT = [0x]0A03	Unsuccessfu I for invalid frequency



Step	Procedure	ı	Frame Sequence		
				Purpose	
		End Device	Frame		
		- TCL			
11	DUT sends Unconfirmed frame	\rightarrow	MAC-CMD DIChannelAns		
			Payload is NOT = [0x]0A03		
	The TCL must wait until the DUT	←	MAC-CMD DIChannelReq		
	sends an uplink on the same channel		ChIndex = Any channel not		
	configured in Step 4 and then sends		configured, refer [2]		
	Unconfirmed frame				
			Freq = default frequency		
			Payload = [0x]0AXXXXXXXX		
12	DUT sends Unconfirmed frame	→ R	MAC-CMD DIChannelAns	Unsuccessfu	
		[max 3]	Payload is NOT = [0x]0A03	I for channel	
	Repeat up to 3 times until a downlink			not	
	is received confirming the receipt of			configured	
	the DIChannelAns				
13	DUT sends Unconfirmed frame	\rightarrow	MAC-CMD DIChannelAns		
			Payload is NOT = [0x]0A03		
	The TCL sends Unconfirmed frame	←	CP-CMD TxFramesCtrlReq		
			FPort = 224		
			Frame type = No change		
			Payload = [0x]0700		
14	DUT sends Unconfirmed frame	\rightarrow			

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2.5.4. RXParamSetupReq

The **TCL** sends a MAC command to configure new *RX1DRoffset*, *RX2DataRate* and *Frequency*. The **DUT** must include a successful *RXParamSetupAns* in all subsequent uplinks until a downlink is received. The **TCL** will wait for more than one uplink containing the affirmative *RXParamSetupAns* of [0x]0507. The **TCL** then sends a downlink and verifies the next uplink does not contain the *RXParamSetupAns* [0x]0507. Both the RX1 and RX2 downlink windows are then tested using the new parameters. Finally, default settings are restored by way of MAC command and both RX windows tested again.

The **TCL** sends a MAC command with invalid RX2DRoffset, RX2DataRate and Frequency that is not supported. Verify that the **DUT** ignores the command and the previous parameters are kept.

2.5.4.a. **Test Procedure Frame Sequence Chart**



Step	Procedure	I	Frame Sequence	Test Purpose
		End Device - TCL	Frame	•
1	DUT sends Unconfirmed frame FCntUp = y + 1	→		
	The TCL sends Unconfirmed frame	←	MAC-CMD LinkADRReq TXPower = Maximum, refer [2] DataRate = Max125kHzDR, refer [2] ChMaskCntl = 0 (for DC) and 6 (for FC) ChMask = Enable only the default channels for DC, refer [2] and [0x]00FF for FC NbTrans = 1 Payload = [0x]03XXXXXXXXX	For FC device using 8-channel gateway, refer to Section 2 for ChMask settings
2	DUT sends Unconfirmed frame FCntUp = y + 2	→	MAC-CMD LinkADRAns DataRate = X Payload = [0x]0307	DataRate set to value configured
	The TCL sends Unconfirmed frame	←	MAC-CMD RxParamSetupReq RX1DRoffset = any allowed offset value, refer [2] RX2DataRate = Any DataRate allowed except the one set in Step 2 Frequency = Y (where Y = any frequency allowed, refer [2]) Payload = [0x]05XXXXXXXX	
3	DUT sends Unconfirmed frame Repeat up to 3 times until a downlink is received confirming the receipt of the RxParamSetupAns	→ R [max 3]	MAC-CMD RxParamSetupAns Payload = [0x]0507	
4	FCntUp >= y + 3 DUT sends Unconfirmed frame	→	MAC-CMD	
	2 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5		RxParamSetupAns Payload = [0x]0507	
	The TCL sends Unconfirmed frame on RX1 window	+	CP-CMD EchoPayloadReq FPort = 224 DR = X - RX1DRoffset Payload = [0x]08010203	
5	DUT sends Unconfirmed frame	→	CP-CMD EchoPayloadAns FPort = 224 Payload = [0x]08020304	Tested for new parameters on RX1
	The TCL sends Unconfirmed frame on RX2 window	+	CP-CMD EchoPayloadReq FPort = 224 Payload = [0x]08121314 Freq = Y DataRate = RX2DataRate as set	



Step	Procedure	I	Test Purpose	
		End Device - TCL	Frame	ruipose
6	DUT sends Unconfirmed frame	→	CP-CMD EchoPayloadAns FPort = 224 Payload = [0x]08131415	Tested for new parameters on RX2
	The TCL sends Unconfirmed frame	+	MAC-CMD RxParamSetupReq RX1DRoffset = 0 RX2DataRate = Default Frequency = Default Payload = [0x]05XXXXXXX The default values are defined in [2]	
7	DUT sends Unconfirmed frame	→	MAC-CMD RxParamSetupAns Payload = [0x]0507	Restored to default settings
	The TCL sends Unconfirmed frame on RX1 window	←	CP-CMD EchoPayloadReq FPort = 224 Payload = [0x]08010203	_
8	DUT sends Unconfirmed frame)	CP-CMD EchoPayloadAns FPort = 224 RX1DRoffset = 0 Payload = [0x]08020304	Default Rx1 Params verified
	The TCL sends Unconfirmed frame on RX2 window	+	CP-CMD EchoPayloadReq RX2DataRate = Default Frequency = Default FPort = 224 Payload = [0x]08121314	
9	DUT sends Unconfirmed frame)	CP-CMD EchoPayloadAns FPort = 224 Payload = [0x]08131415	Default Rx2 Params verified
	The TCL sends Unconfirmed frame Note: This step must be skipped for regions which do not have an invalid RX1DRoffset, i.e. AS923 and IN865-867	←	MAC-CMD RxParamSetupReq RX1DRoffset = Invalid, refer [2] RX2DataRate = default Frequency = default Payload = [0x]05XXXXXXXX	Invalid RX1DRoffset
10	DUT sends Unconfirmed frame Note: This step must be skipped for regions which do not have an invalid RX1DRoffset, i.e. AS923 and IN865-867)	MAC-CMD RxParamSetupAns Payload is NOT = [0x]0507	DUT confirms that the parameters were not set
	The TCL sends Unconfirmed frame	+	MAC-CMD RxParamSetupReq RX2DataRate = Invalid, refer [2] RX1DROffset = default Frequency = default Payload = [0x]05XXXXXXXX	Invalid RX2DataRat e



Step	Procedure		Frame Sequence	Test
				Purpose
		End Device - TCL	Frame	
11	DUT sends Unconfirmed frame	\rightarrow	MAC-CMD	DUT
			RxParamSetupAns	confirms that
			Payload is NOT = $[0x]0507$	the
				parameters
				were not set
	The TCL sends Unconfirmed frame	←	MAC-CMD	Invalid Freq
			RxParamSetupReq	
			RX1DROffset = default	
			RX2DataRate = default	
			Frequency = Invalid, refer [2]	
			Payload = [0x]05XXXXXXXX	
12	DUT sends Unconfirmed frame	\rightarrow	MAC-CMD	DUT
			RxParamSetupAns	confirms that
			Payload is NOT = [0x]0507	the
				parameters
				were not set
	The TCL sends Unconfirmed frame	+	CP-CMD EchoPayloadReq	
	on RX1 window		FPort = 224	
			Payload = [0x]08010203	
13	DUT sends Unconfirmed frame	\rightarrow	CP-CMD EchoPayloadAns	Default Rx1
			FPort = 224	Params
			Payload = [0x]08020304	verified
	The TCL sends Unconfirmed frame	←	CP-CMD EchoPayloadReq	
	on RX2 window		FPort = 224	
	 	ļ	Payload = [0x]08121314	5 (1) 5 3
14	DUT sends Unconfirmed frame	\rightarrow	CP-CMD EchoPayloadAns	Default Rx2
			FPort = 224	Params
			Payload = [0x]08131415	verified

768 **2.5.5. RXTimingSetupReq**

The **TCL** sends a MAC command to change the timing of the reception windows. The **DUT** must reply with [0x]08 (and no *RXTimingSetupAns* payload). The **TCL** tests RX1 and RX2 downlink windows using the new parameters.

Additionally, retransmission is tested. The **TCL** sends a MAC command to change the timing of the reception windows. The **TCL** waits for an uplink with *RXTimingSetupAns* [0x]08. The **TCL** does not send a downlink and instead waits for subsequent uplinks that must contain the *RXTimingSetupAns*. Once satisfied, the **TCL** sends a downlink and waits for the next uplink to ensure it does not contain the *RXTimingSetupAns* [0x]08. Finally, standard settings are applied and tested again with Echo command.

2.5.5.a. **Test Procedure Frame Sequence Chart**

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Step	Procedure		Test	
				Purpose
		End Device - TCL	Frame	
1	DUT sends Unconfirmed frame FCntUp = y	→		
	The TCL sends Unconfirmed frame	+	MAC-CMD RxTimingSetupReq Payload = [0x]08XX Delay (i) = [3-14]	
2	DUT sends Unconfirmed frame Repeat up to 3 times until a downlink is received confirming the receipt of the RxTimingSetupAns	→ R [max 3]	MAC-CMD RxTimingSetupAns Payload = [0x]08	
3	FCntUp >= y + n DUT sends Unconfirmed frame	→	MAC-CMD RxTimingSetupAns Payload = [0x]08	
	The TCL sends Unconfirmed frame on RX1 window	+	CP-CMD EchoPayloadReq FPort = 224 Payload = [0x]08010203	
4	DUT sends Unconfirmed frame	→	TXDelay = (i) seconds CP-CMD EchoPayloadAns FPort = 224 Payload = [0x]08020304	Tested for new parameters on RX1
	The TCL sends Unconfirmed frame on RX2 window	←	CP-CMD EchoPayloadReq FPort = 224 Payload = [0x]08121314	OHRAI
5	DUT sends Unconfirmed frame	→	TXDelay = (i + 1) seconds CP-CMD EchoPayloadAns FPort = 224 Payload = [0x]08131415	Tested for new parameters on RX2
	The TCL sends Unconfirmed frame	←	MAC-CMD RxTimingSetupReq Payload = [0x]08XX Delay = 2	Setting Delay = 2
6	DUT sends Unconfirmed frame Repeat up to 3 times until a downlink is received confirming the receipt of the RxTimingSetupAns	→ R [max 3]	MAC-CMD RxTimingSetupAns Payload = [0x]08	
7	DUT sends Unconfirmed frame	→	MAC-CMD RxTimingSetupAns Payload = [0x]08	
	The TCL sends Unconfirmed frame on RX1 window	+	CP-CMD EchoPayloadReq FPort = 224 Payload = [0x]08010203	
			TXDelay = 2 sec	





8	DUT sends Unconfirmed frame	\rightarrow	CP-CMD EchoPayloadAns	Tested for
			FPort = 224 Payload = [0x]08020304	delay settings on
			1 ayload = [0x]0002000+	RX1
	The TCL sends Unconfirmed frame	←	CP-CMD EchoPayloadReq	
	on RX2 window		FPort = 224	
			Payload = [0x]08121314	
			TXDelay = 3 seconds	
9	DUT sends Unconfirmed frame	\rightarrow	CP-CMD EchoPayloadAns	Tested for
			FPort = 224	delay
			Payload = [0x]08131415	settings on RX2
	The TCL sends Unconfirmed frame	←	MAC-CMD	Setting
			RxTimingSetupReq	Delay = 15
			Payload = [0x]08XX	
			Delay = 15	
10	DUT sends Unconfirmed frame	→ R	MAC-CMD	
	Repeat up to 3 times until a downlink	[max 3]	RxTimingSetupAns	
	is received confirming the receipt of the RxTimingSetupAns		Payload = [0x]08	
11	DUT sends Unconfirmed frame	\rightarrow	MAC-CMD	
			RxTimingSetupAns	
			Payload = [0x]08	
	The TCL sends Unconfirmed frame	←	CP-CMD EchoPayloadReq	
	on RX1 window		FPort = 224	
			Payload = [0x]08010203	
			TXDelay = 15 sec	
12	DUT sends Unconfirmed frame	\rightarrow	CP-CMD EchoPayloadAns	Tested for
			FPort = 224	delay
			Payload = [0x]08020304	settings on RX1
	The TCL sends Unconfirmed frame	←	CP-CMD EchoPayloadReq	
	on RX2 window		FPort = 224	
			Payload = [0x]08121314	
			TXDelay = 16 seconds	
13	DUT sends Unconfirmed frame	\rightarrow R	CP-CMD EchoPayloadAns	Tested for
			FPort = 224	delay
			Payload = [0x]08131415	settings on RX2
	The TCL sends Unconfirmed frame	(MAC-CMD	Setting
			RxTimingSetupReq	Delay to
			Payload = [0x]08XX	default = 0
			Delay = 0	
14	DUT sends Unconfirmed frame	→ R	MAC-CMD	
	Repeat up to 3 times until a downlink	[max 3]	RxTimingSetupAns	
	is received confirming the receipt of		Payload = [0x]08	
15	the RxTimingSetupAns DUT sends Unconfirmed frame	→	MAC-CMD	
13	201 Serius Officoriiii filed Italiie	,	RxTimingSetupAns	
			Payload = [0x]08	
			· ayloaa – [ox]oo	i



	The TCL sends Unconfirmed frame on RX1 window	(CP-CMD EchoPayloadReq FPort = 224 Payload = [0x]08010203	
16	DUT sends Unconfirmed frame	→	TXDelay = 1 sec CP-CMD EchoPayloadAns FPort = 224 Payload = [0x]08020304	Tested for delay settings on RX1
17	The TCL sends Unconfirmed frame on RX2 window	←	CP-CMD EchoPayloadReq FPort = 224 Payload = [0x]08121314 TXDelay = 2 seconds	
18	DUT sends Unconfirmed frame	→	CP-CMD EchoPayloadAns FPort = 224 Payload = [0x]08131415	Tested for delay settings on RX2

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2.5.6.TXParamSetupReq MAC command

Refer to [2] to obtain the list of regions for which the TXParamSetupReq command is applicable. If the TXParamSetupReq command is not applicable for the region being tested, the **DUT** must continue normal operation after receiving the TXParamSetupReq command hence ignoring the command.

2.5.6.a. **Test Procedure Frame Sequence Chart**

Step	Procedure		Frame Sequence	
				Purpose
		End Device	Frame	
		- TCL		
1	DUT sends Unconfirmed frame	\rightarrow		
	The TCL sends Unconfirmed frame	+	MAC-CMD	
			TXParamSetupReq	
			Payload = [0x]09XX	
			UplinkDwellTime = 0	
2	DUT sends Unconfirmed frame	\rightarrow		No response
				to the
				command but
				DUT
				continues
				normal
				operation

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If the TXParamSetupReq command is applicable for the region being tested, the following tests must be performed.

- 1. No dwell time setting: The **TCL** sends *LinkADRReq* to set the **DUT** to each valid DR which is not in the Join-Request Data Rate range, refer [2]. **DUT** must reply with an unsuccessful *LinkADRAns* and the **TCL** verifies that no packet is received using this data rate.
- 2. *UplinkDwellTime* set to 0 (unlimited): The **TCL** sends a *TXParamSetupReq* to set *UplinkDwellTime* to 0 (unlimited) and the **DUT** must reply with a *TXParamSetupAns*. Then, the **TCL** sends *LinkADRReq* to set the **DUT** to the Minimum Data Rate up to the Maximum Data Rate using 125kHz, refer [2].





- The **DUT** must reply to each request with a successful *LinkADRAns*. The **TCL** verifies that the uplink data rate is as requested.
 - 3. UplinkDwellTime set to 1 (400ms): The TCL sends a TXParamSetupReq to set UplinkDwellTime to 1 (400ms) and the DUT must reply with a TXParamSetupAns. Then, the TCL sends LinkADRReq to set the DUT to each DR which is in the invalid Data Rate range, refer [2]. The DUT must reply with an unsuccessful LinkADRAns and the server verifies that no packet is received using this data rate. For the data rates in the Join-Request Data Range, the DUT must reply to each request with a successful LinkADRAns. The TCL verifies that the uplink data rate is as requested.
- 802 4. MaxEIRP setting:

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- a. Set MaxEIRP = Highest: Uplink signal level is monitored on the gateway side (1).
- b. Set MaxEIRP = Lowest: Uplink signal level is monitored on the gateway side (2).
 - c. Check that (1) (2) is greater than 6 dB
- 2.5.6.b. **Test Procedure Frame Sequence Chart- if TXParamSetupReq command is** applicable for the region tested



Step	Procedure	ı	Frame Sequence	Test Purpose
		End Device - TCL	Frame	· mpses
1	DUT sends Unconfirmed frame	\rightarrow		
	The TCL sends Unconfirmed frame	+	MAC-CMD LinkADRReq DataRate = The first DR which is not in the Join- Request Data Rate range, refer [2] Payload = [0x]03XXXXXXXX	
2	DUT sends Unconfirmed frame	→R	MAC-CMD LinkADRAns	
_		[All DR not in JR range]	Payload NOT = [0x]0307	
	The TCL sends Unconfirmed frame	← R [All DR not in JR range]	MAC-CMD LinkADRReq DataRate = All other DR which are not in the Join- Request Data Rate range, refer [2] Payload = [0x]03XXXXXXXX	
3	DUT sends Unconfirmed frame)	MAC-CMD LinkADRAns Payload NOT = [0x]0307 Note: This response is for the last LinkADRReq with	LinkADRAns Status = Unsuccessful
	The TCL sends Unconfirmed frame	+	DR not in the JR range MAC-CMD TXParamSetupReq UplinkDwellTime = 0 Payload = [0x]09XX	
4	DUT sends Unconfirmed frame Repeat up to 3 times until a downlink is received confirming the receipt of the TXParamSetupAns	→ [max 3]	MAC-CMD TXParamSetupAns Payload = [0x]09	Uplink Dwell Time set to 0
5	DUT sends Unconfirmed frame	→	MAC-CMD TXParamSetupAns Payload = [0x]09	
	The TCL sends Unconfirmed frame	+	MAC-CMD LinkADRReq DataRate = MinDR, refer [2] Payload = [0x]03XXXXXXXX	
6	DUT sends Unconfirmed frame	→ R [All DR < Max125kHz DR]	MAC-CMD LinkADRAns Payload = [0x]0307 DataRate = X	DataRate set as required
	The TCL sends Unconfirmed frame Repeat this step for each DR up to the maximum DR	← R [All DR up to Max125kHz DR]	MAC-CMD LinkADRReq DataRate = Each other allowed DR up to Max125kHzDR, refer [2] Payload = [0x]03XXXXXXXX	



Step	Procedure	ı	Frame Sequence	Test Purpose
		End Device - TCL	Frame	•
7	DUT sends Unconfirmed frame	→	MAC-CMD LinkADRAns Payload = [0x]0307 DataRate = Max125kHzDR, refer [2]	DataRate set as required
			Note: This response is for the last LinkADRReq with Max125kHzDR.	
Testin	g UplinkDwellTime = 1			•
8	DUT sends Unconfirmed frame	\rightarrow		
	The TCL sends Unconfirmed frame	←	MAC-CMD TXParamSetupReq UplinkDwellTime = 1 (400ms) Payload = [0x]09XX	
9	DUT sends Unconfirmed frame Repeat up to 3 times until a downlink is received confirming the receipt of	→ [max 3]	MAC-CMD TXParamSetupAns Payload = [0x]09	Uplink Dwell Time set to 1 (400ms)
	the TXParamSetupAns			
10	DUT sends Unconfirmed frame	→	MAC-CMD TXParamSetupAns Payload = [0x]09	
	The TCL sends Unconfirmed frame	←	MAC-CMD LinkADRReq DataRate = The first DR in the invalid Data Rate range, refer [2] Payload = [0x]03XXXXXXXX	
11	DUT sends Unconfirmed frame	→ R [All invalid data rate range]	MAC-CMD LinkADRAns Payload NOT = [0x]0307	
	The TCL sends Unconfirmed frame	← R [All invalid data rate range]	MAC-CMD LinkADRReq DataRate = Each other DR which is in the invalid Data Rate range, refer [2] Payload = [0x]03XXXXXXXX	
12	DUT sends Unconfirmed frame	→	MAC-CMD LinkADRAns Payload NOT = [0x]0307	LinkADRAns Status = Unsuccessful
	The TCL sends Unconfirmed frame	+	MAC-CMD LinkADRReq Data Rate = The first DR in the Join-Request Data Rate range, refer [2]) Payload = [0x]03XXXXXXXX	
13	DUT sends Unconfirmed frame	→ R [All DR in the JR range]	MAC-CMD LinkADRAns Payload = [0x]0307 DataRate = Y	



Step	Procedure	I	Frame Sequence	Test Purpose
		End Device - TCL	Frame	. u.pess
	The TCL sends Unconfirmed frame	←R	MAC-CMD LinkADRReq	
		[All DR in JR	Data Rate = Y (where Y =	
	Repeat this step until DataRate	range]	Each other DR in the Join-	
	reaches the maximum data rate in		Request Data Rate range,	
	the Join-Request DataRange, refer		refer [2])	
	[2]		Payload = [0x]03XXXXXXXX	
14	DUT sends Unconfirmed frame	\rightarrow	MAC-CMD LinkADRAns	DataRate set
			Payload = [0x]0307	to Y
			DataRate = Y	
	RP testing			
15	DUT sends Unconfirmed frame	\rightarrow		
	The TCL sends Unconfirmed frame	+	MAC-CMD	
			TXParamSetupReq	
			Max EIRP = Highest, refer	
			[2]	
			Payload = [0x]09XX	
16	DUT sends Unconfirmed frame	\rightarrow	MAC-CMD	Max EIRP set
		[max 3]	TXParamSetupAns	to max value
	Repeat up to 3 times until a downlink		Payload = [0x]09	
	is received confirming the receipt of			
	the TXParamSetupAns			
17	DUT sends Unconfirmed frame	\rightarrow	MAC-CMD	
			TXParamSetupAns	
			Payload = [0x]09	
	The TCL sends Unconfirmed frame	+	MAC-CMD LinkADRReq	
			TXPower = Maximum, refer	
			[2]	
			DataRate = Max125kHzDR	
			Payload = [0x]03XXXXXXXX	
18	DUT sends Unconfirmed frame	\rightarrow	MAC-CMD LinkADRAns	TXPower set
			Payload = [0x]0307	to max value
19	DUT sends Unconfirmed frame	\rightarrow	Get RSSI value	
20	DUT sends Unconfirmed frame	→	Get RSSI value	
21	DUT sends Unconfirmed frame	\rightarrow	Get RSSI value	RSSI value
				avg checked
			X = Avg of last 3 RSSI value	
	The TCL sends Unconfirmed frame	←	MAC-CMD	
			TXParamSetupReq	
			Max EIRP = Lowest, refer [2]	
			Payload = [0x]09XX	
22	DUT sends Unconfirmed frame	\rightarrow	MAC-CMD	Max EIRP set
			TXParamSetupAns	to min value
			Payload = [0x]09	
	The TCL sends Unconfirmed frame	←	MAC-CMD LinkADRReq	
			TXPower = Maximum, refer	
			[2]	
			DataRate = Max125kHzDR	
			Payload = [0x]03XXXXXXXX	
23	DUT sends Unconfirmed frame	\rightarrow	MAC-CMD LinkADRAns	TXPower set
			Payload = [0x]0307	to max value
24	DUT sends Unconfirmed frame	\rightarrow	Get RSSI value	
25	DUT sends Unconfirmed frame	\rightarrow	Get RSSI value	



Step	Procedure	ı	Frame Sequence	Test
				Purpose
		End Device - TCL	Frame	
26	DUT sends Unconfirmed frame	→	Get RSSI value	RSSI value avg checked
			Y = Avg of last 3 RSSI value	Difference of
			Confirm: X – Y > 6 dB	RSSI values checked
	The TCL sends Unconfirmed frame	+	MAC-CMD LinkADRReq DataRate = Max125kHzDR, refer [2]	
			MAC-CMD TXParamSetupReq Max EIRP = Highest, refer [2] UplinkDwellTime = default, refer [2]	
			Payload = [0x]03XXXXXXXX [0x]09XX	
27	DUT sends Unconfirmed frame	→	MAC-CMD LinkADRAns MAC-CMD TXParamSetupAns	DUT reverted to default settings
			Payload = [0x]0307[0x]09	

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2.5.7. LinkCheckReq tests

After the **TCL** triggers a LinkCheckReq, the **DUT** must send a LinkCheckReq frame. The **TCL** responds with a LinkCheckAns frame.

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Verify

• After receiving the LinkCheckAns, the **DUT** continues normal operation and sends uplinks.



2.5.7.a. **Test Procedure Frame Sequence Chart**

Step	Procedure		Frame Sequence	Test
				Purpose
		End Device	Frame	
		- TCL		
1	DUT sends Unconfirmed frame	→		
	The TCL sends Unconfirmed frame	+	CP-CMD LinkCheckReq	
			FPort 224	
			Payload [0x]20	
2	DUT sends Unconfirmed frame	\rightarrow	MAC-CMD LinkCheckReq	
			Payload = [0x]02	
	The TCL sends Unconfirmed frame	+	MAC-CMD LinkCheckAns	
			Payload = [0x]02XXXX	
3	DUT sends Unconfirmed frame	\rightarrow		
	The TCL sends Unconfirmed frame	+	CP-CMD EchoPayloadReq	
			FPort 224	
			Payload [0x]08010203	
4	DUT sends Unconfirmed frame	\rightarrow	CP-CMD EchoPayloadAns	DUT
			FPort = 224	responds
			Payload [0x]08020304	normally after
				LinkCheck

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2.5.8. LinkADRReq

The following tests validate each aspect of the *LinkADRReg* command.

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2.5.8.a. **TXPower**

This test validates the **DUT** handles the TXPower indicated in the *LinkADRReq* command as an upper-limit (i.e. allowed maximum).

The **TCL** separately tests *LinkADRReq* commands with TXPower within and outside the range specified in [2]. As part of testing values within the valid range, the **TCL** will command the device to its minimum and maximum allowable TX power levels. TCL also checks for a TXPower value of [0x]F.

Verify

- When commanded to a valid TX power level lower than it is capable of, the **DUT** responds with an unsuccessful LinkADRAns and operates at its previously configured TX power
- When commanded to a valid TX power level greater than it is capable of, the DUT responds with a successful LinkADRAns and operates at its maximum TX power
- The **DUT** responds with a successful *LinkADRAns* for those commands whose TXPower is within the specified range. The **TCL** will monitor the RSSI reported by the gateway and verify a minimum difference of at least 6 dB between these settings.
- Commands whose TX power is outside the range or [0x]F, the **DUT** responds with an unsuccessful *LinkADRAns* and keep the current parameter values.

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Note: The ChMaskCntl and ChMask for Dynamic channel (DC) and Fixed channel (FC) plan devices are different. The difference is specified in the Sequence charts below.





2.5.8.a.i. Test Procedure Frame Sequence Chart



Step	Procedure	I	Frame Sequence	Test
				Purpose
		End Device - TCL	Frame	
1	DUT sends Unconfirmed frame	\rightarrow		
	The TCL sends Unconfirmed frame	←	MAC-CMD LinkADRReq TXPower = Minimum, refer [2] DataRate = Max125kHzDR, refer [2] ChMaskCntl = 0 (for DC) and 6 (for FC) ChMask = Enable only the default channels for DC, refer [2] and [0x]00FF for FC NbTrans = 1 Payload = [0x]03XXXXXXXXX	For FC device using 8-channel gateway, refer to Section 2 for ChMask settings
2	DUT sends Unconfirmed frame	→	MAC-CMD LinkADRAns If minimum TXPower the DUT is capable of is greater than the minimum allowed TXPower as refer [2], then PowerACK = false Payload NOT = [0x]0307 and DUT retains its previous TXPower Else, PowerACK = true Payload = [0x]0307	Command is rejected if minimum TXPower the DUT is capable of is greater than the minimum allowed TXPower else the command is accepted
3	If in Step 2, the minimum TXPower the DUT is capable of is greater than the minimum allowed TXPower, then perform Steps 3 and 4. Else, skip to the step 5. DUT sends Unconfirmed frame	→		·
	The TCL sends Unconfirmed frame	←	MAC-CMD LinkADRReq TXPower = Minimum supported by DUT, as mentioned in the Certification Questionnaire. DataRate = Max125kHzDR, refer [2] ChMaskCntl = 0 (for DC) and 6 (for FC) ChMask = Enable only the default channels for DC, refer [2] and [0x]00FF (for FC) NbTrans = 1 Payload = [0x]03XXXXXXXXX	For FC device using 8-channel gateway, refer to Section 2 for ChMask settings
4	DUT sends Unconfirmed frame	→	MAC-CMD LinkADRAns PowerACK = true Payload = [0x]0307	
5	DUT sends Unconfirmed frame	→	Get the RSSI value	
	DUT sends Unconfirmed frame	\rightarrow	Get the RSSI value	



Step	Procedure		Frame Sequence	Test Purpose
		End Device - TCL	Frame	i aiposo
7	DUT sends Unconfirmed frame	\rightarrow	Get the RSSI value	Avg RSSI checked
			X = Avg of last 3 RSSI value	
	The TCL sends Unconfirmed frame	+	MAC-CMD LinkADRReq TXPower = Maximum, refer [2] DataRate = Max125kHzDR for the region, refer [2] ChMaskCntl = 0 (for DC) and 6 (for FC) ChMask = Enable only the default channels for DC, refer [2] and [0x]00FF for FC NbTrans = 1 Payload = [0x]03XXXXXXXXX	For FC device using 8-channel gateway, refer to Section 2 for ChMask settings
8	DUT sends Unconfirmed frame	→	MAC-CMD LinkADRAns PowerACK = true DataRateACK = true ChannelMaskACK = true Payload = [0x]0307	Command accepted
9	DUT sends Unconfirmed frame	→	Get the RSSI value	
10	DUT sends Unconfirmed frame	→	Get the RSSI value	
11	DUT sends Unconfirmed frame	→	Get the RSSI value Y = Avg of last 3 RSSI value Confirm: Y - X > 6dB	RSSI value avg checked Difference of RSSI values checked
	The TCL sends Unconfirmed frame	+	MAC-CMD LinkADRReq TXPower = RFU, refer [2] DataRate = Max125kHzDR, refer [2] ChMaskCntl = 0 (for DC) and 6 (for FC) ChMask = Enable only the default channels for DC, refer [2] and [0x]00FF for FC NbTrans = 1 Payload = [0x]03XXXXXXXX Note: For FC plan devices, this step must be skipped as the TXPower cannot be set to RFU	For FC device using 8-channel gateway, refer to Section 2 for ChMask settings
12	DUT sends Unconfirmed frame	→	MAC-CMD LinkADRAns Payload NOT = [0x]0307 Note: For FC plan devices, this step must be skipped as the TXPower cannot be set to RFU	Command rejected



Step	Procedure	F	Test	
			T =	Purpose
		End Device	Frame	
	The TOL seed blue confirmed difference	- TCL	MAC OMP LinkADDD - T	F F0
	The TCL sends Unconfirmed frame	←	MAC-CMD LinkADRReq	For FC
			TXPower = [0x]F DataRate = Max125kHzDR,	device using 8-channel
			· ·	
			refer [2] ChMaskCntl = 0 (for DC) and	gateway, refer to
			6 (for FC)	Section 2 for
			ChMask = Enable only the	ChMask
			default channels for DC,	settings
			refer [2] and [0x]00FF for FC	Settings
			NbTrans = 1	
			Payload = [0x]03XXXXXXXX	
13	DUT sends Unconfirmed frame	\rightarrow	MAC-CMD LinkADRAns	Command
			PowerACK = true	accepted
			DataRateACK = true	•
			ChannelMaskACK = true	
			Payload = [0x]0307	
14	DUT sends Unconfirmed frame	\rightarrow		
	The TCL sends Unconfirmed frame	+	MAC-CMD LinkADRReq	For FC
			TXPower = Maximum, refer	device using
			[2]	8-channel
			DataRate = Max125kHzDR,	gateway,
			refer [2]	refer to
			ChMaskCntl = 0 (for DC) and	Section 2 for
			6 (for FC)	ChMask
			ChMask = Enable only the	settings
			default channels for DC, refer [2] and [0x]00FF for FC	
			NbTrans = 1	
			Payload = [0x]03XXXXXXXX	
15	DUT sends Unconfirmed frame	\rightarrow	MAC-CMD LinkADRAns	DUT
			Payload = [0x]0307	reverted to
				default
				settings

2.5.8.b. **Uplink Channel Management**

2.5.8.b.i. For Dynamic channel plan devices -

This section is applicable for only Dynamic channel plan devices.

2.5.8.b.i.1. Unsupported data rates

The **TCL** sends MAC commands to change the **DUT** to an unsupported data rate, refer [2].

The **DUT** must reply with an unsuccessful *LinkADRAns* and the uplink data rate must not change.

Verify

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- The **DUT** replies to each valid request with an unsuccessful *LinkADRAns*.
- The uplink data rate does not change.

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2.5.8.b.i.1.1. Test Procedure Frame Sequence Chart



Step	Procedure	ı	Frame Sequence	Test
		End Device	Frame	Purpose
		- TCL	Traine	
1	DUT sends Unconfirmed frame	\rightarrow		
	FCntUp = n			
	The TCL sends Unconfirmed frame	←	MAC-CMD LinkADRReq	
			TXPower = Maximum	
			DataRate = Unsupported data rate, refer [2]	
			ChMaskCntl = 0	
			ChMask - Enable only the	
			default channels, refer [2]	
			NbTrans = 1	
			Payload = [0x]03XXXXXXXX	
2	DUT sends Unconfirmed frame	→ R	MAC-CMD LinkADRAns	Request
	FCntUp = n		Payload NOT = [0x]0307	rejected
	The TCL sends Unconfirmed frame	← R	MAC-CMD LinkADRReq	
		[All optional data rates]	TXPower = Maximum DataRate = An optional data	
		data ratesj	rate except default data rate,	
			refer [2]	
			ChMaskCntl = 0	
			ChMask - Enable only the	
			default channels, refer [2]	
			NbTrans = 1	
			Payload = [0x]03XXXXXXXX	
			Note: Repeat for all optional data rates.	
3	DUT sends Unconfirmed frame	→	MAC-CMD LinkADRAns	Request
	FCntUp = n + 1	,	Payload NOT = [0x]0307	rejected
	The TCL sends Unconfirmed frame	←	MAC-CMD LinkADRReq	.,
			TXPower = Maximum	
			DataRate = [0x]F	
			ChMaskCntl = 0	
			ChMask - Enable only the	
			default channels, refer [2]	
			NbTrans = 1 Payload = [0x]03XXXXXXXX	
4	DUT sends Unconfirmed frame	→	MAC-CMD LinkADRAns	Request
7	FCntUp = n + 2	_	Payload = [0x]0307	accepted
	·		,	and no
				change to
				DR
	The TCL sends Unconfirmed frame	←	MAC-CMD LinkADRReq	
			TXPower = Maximum, refer	
			[2]	
			DataRate = Max125kHzDR, refer [2]	
			ChMaskCntl = 0	
			ChMask - Enable only the	
			default channels, refer [2]	
			NbTrans = 1	
			Payload = [0x]03XXXXXXXX	



5	DUT sends Unconfirmed frame	\rightarrow	MAC-CMD LinkADRAns	DUT
	FCntUp = n + 3		Payload = [0x]0307	reverted to
				default
				settings

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2.5.8.b.i.2. ChannelMask functionality & Disable all Channels

The **TCL** sends *NewChannelReq* command to configure a new channel and *LinkADRReq* to disable that channel using the channel mask. The **TCL** verifies that no transmissions are sent on the new channel. The **TCL** then sends a *LinkADRReq* to enable the new channel. The **TCL** verifies that the **DUT** begins using the new channel in a random sequence.

Finally, the additional channel is removed.

Disable all Channels

Lastly, the **TCL** tries to disable all channels by sending a *LinkADRReq* command with channel mask control index of 0 and a channel mask of [0x]0000. The **DUT** must reply with an unsuccessful *LinkADRAns*, (i.e. not [0x]0307).

The **TCL** verifies that **DUT** still uses the default uplink channels in random sequence at an appropriate data rate.

2.5.8.b.i.2.1. Test Procedure Frame Sequence Chart for Channel Mask and Disable all Channels



Step	Procedure		Frame Sequence	Test Purpose
		End Device - TCL	Frame	
1	DUT sends Unconfirmed frame FCntUp = n	\rightarrow		
	The TCL sends Unconfirmed frame	+	MAC-CMD NewChannelReq ChIndex = X (where X = any unused optional channel index) Freq = Any allowed frequency except the default frequency, refer [2] DRRange = Max125kHzDR to Max125kHzDR, refer [2]	Adds new channel and disables it
			MAC-CMD LinkADRReq TXPower = Maximum, refer [2] DataRate = Max125kHzDR, refer [2] ChMaskCntl = 0 ChMask - Enable only the default channels, refer [2] NbTrans = 1	
			Payload = [0x]07XXXXXXXXX[0x]03X XXXXXXX	
2	DUT sends Unconfirmed frame FCntUp = n + 1	→	DataRate = Max125kHzDR, refer [2] MAC-CMD NewChannelAns	
			MAC-CMD LinkADRAns Payload = [0x]0703[0x]0307	
3	Wait until all channels configured are used at least once to confirm the channel plan [Wait for a maximum of (5 * number of channels currently enabled on the DUT) uplink packets]	→ R [5*NbCh]	All default channels are used at least once. The newly added channel is not used.	DUT does not modify its channel plan
4	DUT sends Unconfirmed frame FCntUp = i	\rightarrow		
	The TCL sends Unconfirmed frame	←	MAC-CMD LinkADRReq TXPower = Maximum, refer [2] DataRate = Max125kHzDR, refer [2] ChMaskCntl = 0 ChMask - Enable the default channels and the newly added channel only, refer [2] NbTrans = 1 Payload = [0x]03XXXXXXXXX	Enables the new channel



Step	Procedure		Frame Sequence	Test Purpose
		End Device - TCL	Frame	
5	DUT sends Unconfirmed frame FCntUp = i + 1)	DataRate = Max125kHzDR, refer [2] MAC-CMD LinkADRAns Payload [0x10207]	
6	Wait until all channels configured are used at least once to confirm the channel plan [Wait for a maximum of (5 * number of channels currently enabled on the DUT) uplink packets]	→ R [5*NbCh]	Payload = [0x]0307 All default channels and the newly added channel are used at least once	New channel added to default plan
7	DUT sends Unconfirmed frame FCntUp = j The TCL sends Unconfirmed frame	→	MAC-CMD NewChannelReq ChIndex = X Freq = 0 MHz	Removes new channel
8	DUT sends Unconfirmed frame	→	Payload = [0x]07XXXXXXXXX MAC-CMD NewChannelAns	Channel removed
	FCntUp = j + 1		Payload = [0x]0703	Chamio romovod
9	DUT sends Unconfirmed frame FCntUp = k The TCL sends Unconfirmed frame DUT sends Unconfirmed frame	<i>→</i>	MAC-CMD LinkADRReq TXPower = Maximum, refer [2] DataRate = Max125kHzDR, refer [2] ChMaskCntl = 0 ChMask = [0x]0000 NbTrans = 1 Payload = [0x]03XXXXXXXX MAC-CMD LinkADRAns	Tries to disable all channels Channel plan not
10	FCntUp = k + 1 The TCL sends Unconfirmed frame	→	Payload NOT = [0x]0307 MAC-CMD LinkADRReq TXPower = Maximum, refer [2] DataRate = Max125kHzDR, refer [2] ChMaskCntl = 0 ChMask - Enable only the default channels, refer [2] NbTrans = 1 Payload = [0x]03XXXXXXXXX	modified modified
11	DUT sends Unconfirmed frame FCntUp = k + 2	→	MAC-CMD LinkADRAns Payload = [0x]0307	DUT reverted to default settings

2.5.8.b.ii. For Fixed channel plan Devices

This section is applicable for only Fixed channel plan devices.





880	2.5.8.b.ii.1. 125khz Uplink Channel Management
881	This test validates the DUT's ability to process commands to operate at Data Rates
882	allowed for 125 kHz uplink channels as defined in [2]. It also validates the DUT replies
883	appropriately to invalid LinkADRReq commands with unsuccessful LinkADRAns.
884	2.5.8.b.ii.1.1. Valid Command Processing
885	The TCL sends LinkADRReq commands to change the DUT's DataRate to each of
886	the allowed Data Rates for 125 kHz uplink channels, refer [2]. The commands use
887	channel mask control 6 and a channel mask value of [0x]00FF.
888	
889	Verify
890	 The DUT replies to each valid request with a successful LinkADRAns.
891	 The DataRate of subsequent uplinks is as commanded.
892	2.5.8.b.ii.1.1.1. Test Procedure Frame Sequence Chart
893	



Step	Procedure		Frame Sequence	Test Purpose
		End Device - TCL	Frame	
1	DUT sends Unconfirmed frame FCntUp = n	\rightarrow		
	The TCL sends Unconfirmed frames	+	CP-CMD RegionalDutyCycleCtrlReq- OFF Payload = [0x]0500 FPort = 224	
2	DUT sends Unconfirmed frame FCntUp = n + 1	→		
	The TCL sends Unconfirmed frame	←	MAC-CMD LinkADRReq TXPower = Maximum refer [2] DataRate = The first allowed data rates for 125 kHz uplink channels, refer [2] ChMaskCntl = 6 ChMask = [0x]00FF NbTrans = 1 Payload = [0x]03XXXXXXXX	For FC device using 8-channel gateway, refer to Section 2 for ChMask settings
3	DUT sends Unconfirmed frame FCntUp >= n + 2	→ R [All DR for 125kHz]	MAC-CMD LinkADRAns DataRate = As set in the LinkADRReq Payload = [0x]0307	
	The TCL sends Unconfirmed frame Repeat the test for all the remaining allowed Data Rates for 125 kHz uplink channels	← R [All DR for 125kHz]	MAC-CMD LinkADRReq TXPower = Maximum refer [2] DataRate = Each of the other allowed data rates for 125 kHz uplink channels, refer [2] ChMaskCntl = 6 ChMask = [0x]00FF NbTrans = 1 Payload = [0x]03XXXXXXXX	For FC device using 8-channel gateway, refer to Section 2 for ChMask settings
4	DUT sends Unconfirmed frame	→	MAC-CMD LinkADRAns DataRate = As set in the LinkADRReq Payload = [0x]0307	All allowed DRs tested
	The TCL sends Unconfirmed frame	+	MAC-CMD LinkADRReq TXPower = Maximum DataRate = [0x]F ChMaskCntl = 6 ChMask - [0x]00FF NbTrans = 1 Payload = [0x]03XXXXXXXX	Testing for DR = [0x]F For FC device using 8-channel gateway, refer to Section 2 for ChMask settings
5	DUT sends Unconfirmed frame	→	MAC-CMD LinkADRAns Payload = [0x]0307	Request accepted and no change to DR



Step	Procedure		Frame Sequence	Test Purpose
		End	Frame	
		Device		
		- TCL		
	The TCL sends Unconfirmed	←	MAC-CMD LinkADRReq	For FC device
	frame		TXPower = Maximum, refer	using 8-channel
			[2]	gateway, refer
			DataRate = Max125kHzDR,	to Section 2 for
			refer [2]	ChMask
			ChMaskCntl = 6	settings
			ChMask = [0x]00FF	
			NbTrans = 1	
			Payload =	
			[0x]03XXXXXXX	
6	DUT sends Unconfirmed frame	\rightarrow	MAC-CMD LinkADRAns	DUT reverted to
			Payload = [0x]0307	default settings
	The TCL sends Unconfirmed	←	CP-CMD	
	frames		RegionalDutyCycleCtrlReq-	
			ON	
			FPort = 224	
			Payload = [0x]0501	
7	DUT sends Unconfirmed frame	\rightarrow		

2.5.8.b.ii.1.2. Invalid Command Processing

Using separate downlinks, the **TCL** sends two commands: the first is a valid command disabling all 500 kHz uplink Channels with mask index 6, channel mask of [0x]0000 and an allowed Data Rate for 125 kHz uplink channels, refer [2]. The second is an invalid *LinkADRReq* command with channel mask control 6, channel mask of [0x]0000 and an allowed Data Rates for 500 kHz uplink channels, refer [2]

Verify

• The **DUT** replies to the first command with a successful LinkADRAns ([0x]0307) and to the second with an unsuccessful LinkADRAns. Acceptable values of the second LinkADRAns include (bad DR) [0x]0305, or (bad ChMask) [0x]0306 or (both bad DR & bad Channel) [0x]0304.

Next, using separate downlinks, the **TCL** sends two commands: the first is a valid command disabling all 125 kHz uplink Channels with mask index 7, channel mask of [0x]00FF and an allowed Data Rate for 500 kHz uplink channels, refer [2]. The second is an invalid command with a mask index 0, channel mask of [0x]0001 and an allowed Data Rate for 125 kHz uplink channels, refer [2].

Verify

• The **DUT** replies to the first command with a successful LinkADRAns ([0x]0307) and to the second with an unsuccessful LinkADRAns. Acceptable values of the second LinkADRAns include (bad DR) [0x]0305, or (bad ChMask) [0x]0306 or (both bad DR & bad Channel) [0x]0304.





2.5.8.b.ii.1.2.1. Test Procedure Frame Sequence Chart

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Step	Procedure		Frame Sequence	Test Purpose
		End Device - TCL	Frame	
1	DUT sends Unconfirmed frame FCntUp = n	→		
	The TCL sends Unconfirmed frame	+	For a 64-channel gateway: MAC-CMD LinkADRReq TXPower = Maximum refer [2] DataRate = An allowed data rate for 125 kHz uplink channels, refer [2] ChMaskCntl = 6 ChMask = [0x]0000 NbTrans = 1 Payload = [0x]03XXXXXXXXX	
			For an 8-channel gateway MAC-CMD LinkADRReq TXPower = Maximum refer [2] DataRate = An allowed data rate for 125 kHz uplink channels, refer [2] ChMaskCntl = 7 ChMask = [0x]0000 NbTrans = 1	
			MAC-CMD LinkADRReq TXPower = Maximum refer [2] DataRate = An allowed data rate for 125 kHz uplink channels, refer [2] ChMaskCntl = 0 ChMask = [0x]00FF NbTrans = 1	
			Payload = [0x]03XXXXXXXX[0x]03XXX XXXXX	
2	DUT sends Unconfirmed frame FCntUp = n + 1	→	MAC-CMD LinkADRAns DataRate = As set in the LinkADRReq Payload = [0x]0307	Successful LinkADRAns



Step	Procedure		Frame Sequence	Test Purpose
		End Device - TCL	Frame	
	The TCL sends Unconfirmed frame	+	MAC-CMD LinkADRReq TXPower = Maximum refer [2] DataRate = An allowed data rates for 500 kHz uplink channels, refer [2] ChMaskCntl = 6 ChMask = [0x]0000 NbTrans = 1 Payload = [0x]03XXXXXXXX	
3	DUT sends Unconfirmed frame FCntUp = n + 2	→	MAC-CMD LinkADRAns Payload = Any one of these- (bad DR) [0x]0305, or (bad ChMask) [0x]0306 or (both bad DR & bad Channel) [0x]0304.	Unsuccessful LinkADRAns
	The TCL sends Unconfirmed frame	←	For a 64-channel gateway: MAC-CMD LinkADRReq TXPower = Maximum refer [2] DataRate = An allowed data rate for 500 kHz uplink channels, refer [2] ChMaskCntl = 7 ChMask = [0x]00FF NbTrans = 1 Payload = [0x]03XXXXXXXX For an 8-channel gateway MAC-CMD LinkADRReq TXPower = Maximum refer [2] DataRate = An allowed data rate for 500 kHz uplink channels, refer [2] ChMaskCntl = 7 ChMask = [0x]0001	
4	DUT sends Unconfirmed frame FCntUp = n + 3	→	NbTrans = 1 Payload = [0x]03XXXXXXXX MAC-CMD LinkADRAns DataRate = As set in the	Successful LinkADRAns
			LinkADRReq Payload = [0x]0307	



Step	Procedure	Frame Sequence		Test Purpose
		End Device	Frame	
		- TCL		
	The TCL sends Unconfirmed frame	←	MAC-CMD LinkADRReq TXPower = Maximum refer [2] DataRate = An allowed data rate for 125 kHz uplink channels, refer [2] ChMaskCntl = 0 ChMask = [0x]0001 NbTrans = 1 Payload = [0x]03XXXXXXXX	
5	DUT sends Unconfirmed frame FCntUp = n + 4	→	MAC-CMD LinkADRAns Payload = Any one of these- (bad DR) [0x]0305, or (bad ChMask) [0x]0306 or (both bad DR & bad Channel) [0x]0304.	Unsuccessful LinkADRAns
	The TCL sends Unconfirmed frame	←	MAC-CMD LinkADRReq TXPower = Maximum, refer [2] DataRate = Max125kHzDR, refer [2] ChMaskCntl = 6 ChMask = [0x]00FF NbTrans = 1 Payload = [0x]03XXXXXXXX	For FC device using 8-channel gateway, refer to Section 2 for ChMask settings
6	DUT sends Unconfirmed frame	→	MAC-CMD LinkADRAns Payload = [0x]0307	DUT reverted to default settings

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2.5.8.b.ii.1.3. Enable All-Channels

The **TCL** then sends a LinkADRReq to enable all channels. In this case the command's channel mask control index is 6 and the DR specified must be appropriate for 125 kHz channels. The channel mask must be applied to the 500 kHz channels. The **DUT** must reply with a successful *LinkADRAns*. The TCL verifies that DUT resumes using the full range (64) of 125kHz uplink channels in random sequence at an appropriate DR.

2.5.8.b.ii.1.3.1. Test Procedure Frame Sequence Chart



Step	Procedure		Frame Sequence	Test Purpose
		End	Frame	
		Device -		
		TCL		
1	DUT sends Unconfirmed frame	\rightarrow]	
	FCntUp = n	_		
	The TCL sends Unconfirmed	←	MAC-CMD LinkADRReq	For FC device
	frame		TXPower = Maximum refer	using 8-channel
			[<u>2</u>]	gateway, refer
			DataRate = Max data rate	to Section 2 for
			for 125 kHz uplink	ChMask
			channels, refer [2]	settings
			ChMaskCntl = 6	
			ChMask = [0x]00FF NbTrans = 1	
			Payload =	
			[0x]03XXXXXXX	
2	DUT sends Unconfirmed frame	\rightarrow	MAC-CMD LinkADRAns	
	FCntUp = n + 1		DataRate = As set in the	
			previous step	
			Payload = [0x]0307	
3	Wait for a maximum of 2 *	→R	Official certification:	All channels
	(number of channels <i>currently</i>	[2*NbCh]	DUT resumes using the full	must be used at
	enabled on the DUT)	or	range (64) of 125kHz	least once
	uplink packets to be sent, i.e. until	[All Ch	uplink channels in random	
	all channels are used at least	used]	sequence at the DR set	
	once.			
			Pre-testing with 8-channel	
			gateway: Channels 0-7 must be	
			used at least once.	
4	DUT sends Unconfirmed frame	→	acca at loadt office.	
	The TCL sends Unconfirmed	<i>,</i> ←	MAC-CMD LinkADRReq	For FC device
	frame	,	TXPower = Maximum, refer	using 8-channel
			[2]	gateway, refer
			DataRate =	to Section 2 for
			Max125kHzDR, refer [2]	ChMask
			ChMaskCntl = 6	settings
			ChMask = [0x]00FF	_
			NbTrans = 1	
			Payload =	
			[0x]03XXXXXXX	
5	DUT sends Unconfirmed frame	\rightarrow	MAC-CMD LinkADRAns	DUT reverted to
			Payload = [0x]0307	default settings

2.5.8.b.ii.2. 500 kHz Uplink Channel Management

This test validates the **DUT**'s ability to process commands to operate at Data Rates allowed for 500 kHz uplink channels as defined in [2]. It also validates the **DUT** replies appropriately to invalid *LinkADRReq* commands with an unsuccessful *LinkADRAns*.

2.5.8.b.ii.2.1. Valid Command Processing

The **TCL** sends *LinkADRReq* commands the **DUT**'s Data Rate to an allowed DataRate for 500 kHz uplink channels, refer [2]. The commands use channel mask control 7 and a channel mask value of [0x]00FF.

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938	Verify
939	 The DUT replies to the valid request with a successful LinkADRAns ([0x]0307)
940	 The Data Rate of subsequent uplinks is as set by TCL command, and all 500kHz
941	uplink channels are used.
942	Next the TCL sends a single LinkADRReq command to the DUT with an allowed
943	DataRate for 500 kHz uplink channels, refer [2], channel mask control 7, and
944	channel mask value of [0x]0001.
945	Verify
946	 The DUT replies to the valid request with a successful LinkADRAns ([0x]0307)
947	 All subsequent uplinks are sent on Channel 64 at the DataRate set by the TCL
948	command.
949	2.5.8.b.ii.2.1.1. Test Procedure Frame Sequence Chart
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Step	Procedure		Frame Sequence	Test Purpose
		End Device - TCL	Frame	
1	DUT sends Unconfirmed frame FCntUp = n	\rightarrow		
	The TCL sends Unconfirmed frame	+	For a 64-channel gateway: MAC-CMD LinkADRReq TXPower = Maximum refer [2] DataRate = An allowed data rate for 500 kHz uplink channels, refer [2] ChMaskCntl = 7 ChMask = [0x]00FF NbTrans = 1 Payload = [0x]03XXXXXXXX	
			This step must be skipped as the following step checks for a single channel.	
2	DUT sends Unconfirmed frame FCntUp = n + 1)	MAC-CMD LinkADRAns DataRate = As set in the previous step Payload = [0x]0307	All allowed DRs tested
	The TCL sends Unconfirmed frame	←	MAC-CMD LinkADRReq TXPower = Maximum, refer [2] DataRate = An allowed DR for 500 kHz, refer [2] ChMaskCntl = 7 ChMask = [0x]0001 NbTrans = 1 Payload = [0x]03XXXXXXXX	
3	DUT sends Unconfirmed frame FCntUp = n + 2	\rightarrow	MAC-CMD LinkADRAns Payload = [0x]0307	
4	DUT sends Unconfirmed frame FCntUp = n + 3	→	DUT sends uplinks only on Channel 64 at the DataRate set	Channel and DR tested
5	DUT sends Unconfirmed frame FCntUp = n + 4	→	DUT sends uplinks only on Channel 64 at the DataRate set	
	The TCL sends Unconfirmed frame	+	MAC-CMD LinkADRReq TXPower = Maximum, refer [2] DataRate = Max125kHzDR, refer [2] ChMaskCntl = 6 ChMask = [0x]00FF NbTrans = 1 Payload = [0x]03XXXXXXXX	For FC device using 8-channel gateway, refer to Section 2 for ChMask settings





6	DUT sends Unconfirmed frame	\rightarrow	MAC-CMD LinkADRAns	DUT reverted to
	FCntUp = n + 5		Payload = [0x]0307	default settings

2.5.8.b.ii.2.2. Invalid Command Processing

Using separate downlinks, the **TCL** sends two commands: the first is a valid command disabling all 125 kHz uplink channels with mask index 7, channel mask of [0x]00FF and an allowed DataRate for 500 kHz uplink channels, refer [2]. The second is an invalid *LinkADRReq* command with channel mask control 7, channel mask of [0x]0000 (or [0x]FF00) and an allowed DataRate for 125 kHz uplink channels, refer [2].

Verify

- The **DUT** must reply to the first command with a successful LinkADRAns ([0x]0307) and to the second with an unsuccessful LinkADRAns of (bad DR) [0x]0305, or (bad ChMask) [0x]0306 or (both bad DR & bad Channel) [0x]0304. ([0x]0304).
- The DataRate of subsequent uplinks is as set by the **TCL** command.

2.5.8.b.ii.2.2.1. Test Procedure Frame Sequence Chart



Step	Procedure		Frame Sequence	Test Purpose
		End	Frame	
		Device		
		- TCL		
1	DUT sends Unconfirmed frame	\rightarrow		
	FCntUp = n			
	The TCL sends Unconfirmed	←	For a 64-channel gateway:	
	frame		MAC-CMD LinkADRReq	
			TXPower = Maximum refer	
			[2]	
			DataRate = An allowed data	
			rate for 500 kHz uplink	
			channels, refer [2] ChMaskCntl = 7	
			ChMask = [0x]00FF	
			NbTrans = 1	
			Payload =	
			[0x]03XXXXXXXX	
			[ox]oox o a a a a a a a	
			For an 8-channel gateway:	
			MAC-CMD LinkADRReg	
			TXPower = Maximum refer	
			[2]	
			DataRate = An allowed data	
			rate for 500 kHz uplink	
			channels, refer [2]	
			ChMaskCntl = 7	
			ChMask = [0x]0001	
			NbTrans = 1	
			Payload =	
	DUT and the coffee of frame		[0x]03XXXXXXXX	0
2	DUT sends Unconfirmed frame	\rightarrow	MAC-CMD LinkADRAns	Successful LinkADRAns
	FCntUp = n + 1		DataRate = As set in the LinkADRReq	LINKADRANS
			Payload = [0x]0307	
	The TCL sends Unconfirmed	←	MAC-CMD LinkADRReg	
	frame	`	TXPower = Maximum refer	
			[2]	
			DataRate = An allowed data	
			rate for 125 kHz uplink	
			channels, refer [2]	
			ChMaskCntl = 7	
			ChMask = [0x]0000	
			NbTrans = 1	
			Payload =	
			[0x]03XXXXXXX	
3	DUT sends Unconfirmed frame	\rightarrow	MAC-CMD LinkADRAns	Unsuccessful
	FCntUp = n + 2		Payload = Any one of these-	LinkADRAns
			(bad DR) [0x]0305, or (bad	
			ChMask) [0x]0306 or (both	
			bad DR & bad Channel)	
			[0x]0304.	



Step	Procedure	Frame Sequence		Test Purpose
		End Device - TCL	Frame	
	The TCL sends Unconfirmed frame	←	MAC-CMD LinkADRReq TXPower = Maximum, refer [2] DataRate = Max125kHzDR, refer [2] ChMaskCntl = 6 ChMask = [0x]00FF NbTrans = 1 Payload = [0x]03XXXXXXXXX	For FC device using 8-channel gateway, refer to Section 2 for ChMask settings
4	DUT sends Unconfirmed frame	\rightarrow	MAC-CMD LinkADRAns Payload = [0x]0307	DUT reverted to default settings

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2.5.8.b.ii.3. 1523 kHz Uplink Channel Management (only for LR-FHSS devices)

Note: These tests must be performed only if the DUT supports LR-FHSS

This test validates the **DUT**'s ability to process commands to operate at Data Rates allowed for 1523 kHz uplink channels as defined in [2]. It also validates the **DUT** replies appropriately to invalid *LinkADRReq* commands with an unsuccessful *LinkADRAns*.

2.5.8.b.ii.3.1. Valid Command Processing

The **TCL** sends *LinkADRReq* commands the **DUT**'s Data Rate to an allowed DataRate for 1523 kHz uplink channels, refer [2]. The commands use channel mask control 7 and a channel mask value of [0x]00FF.

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980 Verify

• The **DUT** replies to the valid request with a successful LinkADRAns ([0x]0307)

• The Data Rate of subsequent uplinks is as set by **TCL** command, and all 1523 kHz uplink channels are used.

Next the **TCL** sends a single *LinkADRReq* command to the **DUT** with an allowed DataRate for 1523 kHz uplink channels, refer [2], channel mask control 7, and channel mask value of [0x]0001.

Verify

- The **DUT** replies to the valid request with a successful LinkADRAns ([0x]0307)
- All subsequent uplinks are sent on Channel 64 at the DataRate set by the TCL command.

2.5.8.b.ii.3.1.1. Test Procedure Frame Sequence Chart



Step	Procedure		Frame Sequence	Test Purpose
		End Device - TCL	Frame	
1	DUT sends Unconfirmed frame FCntUp = n	\rightarrow		
	The TCL sends Unconfirmed frame	←	For a 64-channel gateway: MAC-CMD LinkADRReq TXPower = Maximum refer [2] DataRate = An allowed data rate for 1523 kHz uplink channels, refer [2] ChMaskCntl = 7 ChMask = [0x]00FF NbTrans = 1 Payload = [0x]03XXXXXXXX For an 8-channel gateway:	
			This step must be skipped as the following step checks for a single channel.	
2	DUT sends Unconfirmed frame FCntUp = n + 1	→	MAC-CMD LinkADRAns DataRate = As set in the previous step Payload = [0x]0307	All allowed DRs tested
	The TCL sends Unconfirmed frame	←	MAC-CMD LinkADRReq TXPower = Maximum, refer [2] DataRate = An allowed DR for 1523 kHz, refer [2] ChMaskCntl = 7 ChMask = [0x]0001 NbTrans = 1 Payload = [0x]03XXXXXXXX	
3	DUT sends Unconfirmed frame FCntUp = n + 2	→	MAC-CMD LinkADRAns Payload = [0x]0307	
4	DUT sends Unconfirmed frame FCntUp = n + 3	→	DUT sends uplinks only on Channel 64 at the DataRate set	Channel and DR tested
5	DUT sends Unconfirmed frame FCntUp = n + 4	→	DUT sends uplinks only on Channel 64 at the DataRate set	
	The TCL sends Unconfirmed frame	←	MAC-CMD LinkADRReq TXPower = Maximum, refer [2] DataRate = Max125kHzDR, refer [2] ChMaskCntl = 6 ChMask = [0x]00FF NbTrans = 1 Payload = [0x]03XXXXXXXX	For FC device using 8-channel gateway, refer to Section 2 for ChMask settings





6	DUT sends Unconfirmed frame	\rightarrow	MAC-CMD LinkADRAns	DUT reverted to
	FCntUp = n + 5		Payload = [0x]0307	default settings

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2.5.8.b.ii.3.2. Invalid Command Processing

Using separate downlinks, the **TCL** sends two commands: the first is a valid command disabling all 125 kHz uplink channels with mask index 7, channel mask of [0x]00FF and an allowed DataRate for 1523 kHz uplink channels, refer [2]. The second is an invalid *LinkADRReq* command with channel mask control 7, channel mask of [0x]0000 (or [0x]FF00) and an allowed DataRate for 125 kHz uplink channels, refer [2].

Verify

- The **DUT** must reply to the first command with a successful LinkADRAns ([0x]0307) and to the second with an unsuccessful LinkADRAns of (bad DR) [0x]0305, or (bad ChMask) [0x]0306 or (both bad DR & bad Channel) [0x]0304. ([0x]0304).
- The DataRate of subsequent uplinks is as set by the **TCL** command.

2.5.8.b.ii.3.2.1. Test Procedure Frame Sequence Chart



Step	Procedure		Frame Sequence	Test Purpose
		End	Frame	
		Device		
		- TCL		
1	DUT sends Unconfirmed frame	\rightarrow		
	FCntUp = n			
	The TCL sends Unconfirmed	←	For a 64-channel gateway:	
	frame		MAC-CMD LinkADRReq	
			TXPower = Maximum refer	
			[2] DataRate = An allowed data	
			rate for 1523 kHz uplink	
			channels, refer [2]	
			ChMaskCntl = 7	
			ChMask = [0x]00FF	
			NbTrans = 1	
			Payload =	
			[0x]03XXXXXXXX	
			For an 8-channel gateway:	
			MAC-CMD LinkADRReq	
			TXPower = Maximum refer	
			[2]	
			DataRate = An allowed data	
			rate for 500 kHz uplink	
			channels, refer [2]	
			ChMaskCntl = 7	
			ChMask = [0x]0001	
			NbTrans = 1	
			Payload =	
			[0x]03XXXXXXX	
2	DUT sends Unconfirmed frame	\rightarrow	MAC-CMD LinkADRAns	Successful
	FCntUp = n + 1		DataRate = As set in the	LinkADRAns
			LinkADRReq	
	The TCL sends Unconfirmed	←	Payload = [0x]0307 MAC-CMD LinkADRReq	
	frame	`	TXPower = Maximum refer	
			[2]	
			DataRate = An allowed data	
			rate for 125 kHz uplink	
			channels, refer [2]	
			ChMaskCntl = 7	
			ChMask = [0x]0000	
			NbTrans = 1	
			Payload =	
	DUT and de Hann (*		[0x]03XXXXXXXX	Harris C.
3	DUT sends Unconfirmed frame	\rightarrow	MAC-CMD LinkADRAns	Unsuccessful
	FCntUp = n + 2		Payload = Any one of these-	LinkADRAns
			(bad DR) [0x]0305, or (bad ChMask) [0x]0306 or (both	
			bad DR & bad Channel)	
			[0x]0304.	
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Step	Procedure		Frame Sequence	Test Purpose
		End Device - TCL	Frame	
	The TCL sends Unconfirmed frame	+	MAC-CMD LinkADRReq TXPower = Maximum, refer [2] DataRate = Max125kHzDR, refer [2] ChMaskCntl = 6 ChMask = [0x]00FF NbTrans = 1 Payload = [0x]03XXXXXXXX	For FC device using 8-channel gateway, refer to Section 2 for ChMask settings
4	DUT sends Unconfirmed frame	\rightarrow	MAC-CMD LinkADRAns Payload = [0x]0307	DUT reverted to default settings

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2.5.8.b.ii.4. Disable all Channels (125kHz and 500kHz channels)

Lastly, the **TCL** then tries to disable all channels by sending a LinkADRReq command with channel mask control index of 7 and a channel mask of [0x]0000. The **DUT** *must* reply with an unsuccessful *LinkADRAns* of (bad DR) [0x]0305, or (bad ChMask) [0x]0306 or (both bad DR & bad ChMask) [0x]0304.



2.5.8.b.ii.4.1. Test Procedure Frame Sequence Chart

Step	Procedure		Frame Sequence	Test Purpose
		End	Frame	
		Device		
		- TCL		
1	DUT sends Unconfirmed frame	\rightarrow		
	FCntUp = n			
	The TCL sends Unconfirmed	+	MAC-CMD LinkADRReq	
	frame		TXPower = Maximum refer	
			[2]	
			DataRate = An allowed data	
			rate, refer [2]	
			ChMaskCntl = 7	
			ChMask = [0x]0000	
			NbTrans = 1	
			Payload =	
			[0x]03XXXXXXX	
2	DUT sends Unconfirmed frame	\rightarrow	MAC-CMD LinkADRAns	Unsuccessful
	FCntUp = n + 1		DataRate = As set in the	LinkADRAns
			LinkADRReq	when disabling
			Payload = Any one of these-	all channels
			(bad DR) [0x]0305, or (bad	
			ChMask) [0x]0306 or (both	
			bad DR & bad ChMask)	
			[0x]0304.	

2.5.8.c. **Redundancy**

This test validates the **DUT**'s correct implementation *NbTrans* setting within the *LinkADRReq* command. The **TCL** sends *LinkADRReq* requesting a repetition count of 2.

Verify

- All subsequent unconfirmed/confirmed uplink frames from the **DUT** are transmitted twice (the same sequence number is received twice by the **TCL**). The number of redundant uplinks verified by the harness is at the discretion of the Test Tool vendor.
- The **DUT** does not repeat the transmission if a downlink is received during the RX1 window.
- The **DUT** does not repeat the transmission if a downlink is received during the RX2 window.

Once the above criteria are verified for a *NbTrans* setting of 2, the **DUT** is commanded back to the default of 1 by the **TCL** using a *LinkADRReq* command wherein the *NbTrans* value is 0. This default setting is also validated.

The above test is repeated for NbTrans = 3 within the LinkADRReq command.

2.5.8.c.i. Test Procedure Frame Sequence Chart

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Step	Procedure		Frame Sequence	Test Purpose
		End Device - TCL	Frame	i uipeee
1	DUT sends Unconfirmed frame FCntUp = n	→		
	The TCL sends Unconfirmed frames	+	CP-CMD RxAppCntReq FPort = 224 Payload = [0x]09	
2	DUT sends Unconfirmed frame FCntUp = n + 1	→	CP-CMD RxAppCntAns FPort = 224 Payload = [0x]09XXXX RxAppCnt = x	
3	DUT sends Unconfirmed frame FCntUp = n + 2	→		
	The TCL sends Unconfirmed frame	+	MAC-CMD LinkADRReq TXPower = Maximum, refer [2] DataRate = Max125kHzDR, refer [2] ChMaskCntl = 0 (for DC) and 6 (for FC) ChMask = Enable only the default channels for DC, refer [2] and [0x]00FF for FC NbTrans = 2 Payload = [0x]03XXXXXXXXX	For FC device using 8-channel gateway, refer to Section 2 for ChMask settings
4	DUT sends Unconfirmed frame FCntUp = n + 3	→	MAC-CMD LinkADRAns Payload = [0x]0307	
5	DUT sends Unconfirmed frame FCntUp = n + 3	→	MAC-CMD LinkADRAns Payload = [0x]0307	Uplink sent twice
6	DUT sends Unconfirmed frame FCntUp = n + 4	→		
7	DUT sends Unconfirmed frame FCntUp = n + 4	→		
8	DUT sends Unconfirmed frame FCntUp = n + 5 The TCL sends Unconfirmed frames	→ ←	CP-CMD RxAppCntReq	
	on RX1 window		FPort = 224 Payload = [0x]09	
9	DUT sends Unconfirmed frame FCntUp = n + 6)	CP-CMD RxAppCntAns FPort = 224 Payload = [0x]09XXXX RxAppCnt >= x + 1	Transmit not repeated when downlink received on RX1 Refer to Section 2 – Test Notes for missed RxAppCntAn s



Step	Procedure	Frame Sequence		Test Purpose
		End Device - TCL	Frame	-
10	DUT sends Unconfirmed frame FCntUp = n + 6	→	CP-CMD RxAppCntAns FPort = 224 Payload = [0x]09XXXX RxAppCnt = x + 1	Refer to Section 2 – Test Notes for missed RxAppCntAn s
11	DUT sends Unconfirmed frame FCntUp = n + 7	→		
	The TCL sends Unconfirmed frame on RX2 window	+	CP-CMD RxAppCntReq FPort = 224 Payload = [0x]09	
12	DUT sends Unconfirmed frame FCntUp = n + 8	→	CP-CMD RxAppCntAns FPort = 224 Payload = [0x]09XXXX RxAppCnt >= x + 2	Transmit not repeated when downlink received on RX2 Refer to Section 2 – Test Notes for missed RxAppCntAn s
	The TCL sends Unconfirmed frame	←	MAC-CMD LinkADRReq TXPower = Maximum, refer [2] DataRate = Max125kHzDR, refer [2] ChMaskCntl = 0 (for DC) and 6 (for FC) ChMask = Enable only the default channels for DC, refer [2] and [0x]00FF for FC NbTrans = 1 Payload = [0x]03XXXXXXXX	For FC device using 8-channel gateway, refer to Section 2 for ChMask settings
13	DUT sends Unconfirmed frame FCntUp = n + 9	→	MAC-CMD LinkADRAns Payload = [0x]0307	Uplink sent once
14	DUT sends Unconfirmed frame FCntUp = n + 10	→		
	The TCL sends Unconfirmed frame	+	CP-CMD TxFramesCtrlReq FPort = 224 Frame type = Confirmed Payload = [0x]0702	Switch to Confirmed frames
15	DUT sends Confirmed frame FCntUp = n + 11	→		



Step	Procedure		Frame Sequence	Test
			1	Purpose
		End Device - TCL	Frame	
	The TCL sends Unconfirmed frame	+	Acknowledge	For FC device using
			MAC-CMD LinkADRReq	8-channel
			TXPower = Maximum, refer	gateway,
			[2]	refer to
			DataRate = Max125kHzDR, refer [2]	Section 2 for ChMask
			ChMaskCntl = 0 (for DC) and 6 (for FC)	settings
			ChMask = Enable only the	
			default channels for DC, refer	
			[2] and [0x]00FF for FC	
			NbTrans = 3	
			Payload = [0x]03XXXXXXXX	
16	DUT sends Confirmed frame FCntUp = n + 12	→	MAC-CMD LinkADRAns Payload = [0x]0307	
17	DUT sends Confirmed frame	\rightarrow	MAC-CMD LinkADRAns	
	FCntUp = n + 12		Payload = [0x]0307	
18	DUT sends Confirmed frame	\rightarrow	MAC-CMD LinkADRAns	Uplink sent
	FCntUp = n + 12		Payload = [0x]0307	thrice
19	DUT sends Confirmed frame FCntUp = n + 13	\rightarrow		
	The TCL sends Unconfirmed frame	+	Acknowledge	Revert to Unconfirmed
			CP-CMD TxFramesCtrlReq	frames
			FPort = 224 Frame type = Unconfirmed	
			Payload = [0x]0701	
20	DUT sends Unconfirmed frame FCntUp = n + 14	→	Tayload = [0x]0701	
	The TCL sends Unconfirmed frame	←	CP-CMD RxAppCntReq	
		_	FPort = 224	
			Payload = [0x]09	
21	DUT sends Unconfirmed frame FCntUp = n + 15	→	CP-CMD RxAppCntAns FPort = 224	Transmit not repeated
			Payload = [0x]09XXXX RxAppCnt >= x + 6	when downlink
				received Refer to
				Section 2 –
				Test Notes
				for missed RxAppCntAn
				s



Step	Procedure		Frame Sequence	Test Purpose
		End Device - TCL	Frame	
22	DUT sends Unconfirmed frame FCntUp = n + 15	→	CP-CMD RxAppCntAns FPort = 224 Payload = [0x]09XXXX RxAppCnt >= x + 6	Refer to Section 2 – Test Notes for missed RxAppCntAn s
23	DUT sends Unconfirmed frame FCntUp = n + 15	→	CP-CMD RxAppCntAns FPort = 224 Payload = [0x]09XXXX RxAppCnt >= x + 6	Refer to Section 2 – Test Notes for missed RxAppCntAn s
	The TCL sends Unconfirmed frame	+	MAC-CMD LinkADRReq TXPower = Maximum, refer [2] DataRate = Max125kHzDR, refer [2] ChMaskCntl = 0 (for DC) and 6 (for FC) ChMask = Enable only the default channels for DC, refer [2] and [0x]00FF for FC NbTrans = 0 Payload = [0x]03XXXXXXXX	For FC device using 8-channel gateway, refer to Section 2 for ChMask settings
24	DUT sends Unconfirmed frame FCntUp = n + 16	→	MAC-CMD LinkADRAns Payload = [0x]0307	Uplink sent once
25	DUT sends Unconfirmed frame FCntUp = n + 17	→	,	
	The TCL sends Unconfirmed frame	+	MAC-CMD LinkADRReq TXPower = Maximum, refer [2] DataRate = Max125kHzDR, refer [2] ChMaskCntl = 0 (for DC) and 6 (for FC) ChMask = Enable only the default channels for DC, refer [2] and [0x]00FF for FC NbTrans = 1 Payload = [0x]03XXXXXXXX	For FC device using 8-channel gateway, refer to Section 2 for ChMask settings
26	DUT sends Unconfirmed frame FCntUp = n + 18)	MAC-CMD LinkADRAns Payload = [0x]0307	DUT reverted to default settings

2.5.8.d. **Data Rate Decay**

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2.5.8.d.i. DR Decay test for all devices

This test validates the **DUT**'s implementation of the *ADR_ACK_LIMIT*, *ADR_ACK_DELAY*, and use of the *ADRACKReq* bit in its uplinks' frame header. A tolerance of +/- 2 uplinks is allowed for the **DUT**'s implementation of both the *ADR_ACK_LIMIT* and *ADR_ACK_DELAY* parameters.





1042	
1043	The TCL adds a new channel.
1044	The TCL sends LinkADRReq to configure the DUT to use
1045	 the Max125kHzDR data rate for DC and 500kHz for FC,
1046	- TXPower Index = 1,
1047	- For DC devices: Disable all default channels and enable only the newly added
1048	channel,
1049	- For FC devices: Enable channel 0, 1 and 64,
1050	- NbTrans set to 2.
1051	
1052	It then stops sending downlinks until the DUT decays to the minimum default data
1053	rate, refer [2] .
1054	
1055	Verify
1056	 After sending ADR_ACK_LIMIT (64) uplinks the DUT must - in a sustained
1057	absence of downlinks - set the ADRACKReq bit in the next ADR_ACK_DELAY
1058	(32) uplinks' frame headers.
1059	 As of its 96th consecutive uplink in the continued absence of downlinks, the
1060	DUT must change the TXPower Index to 0 and leave the ADRACKReq bit set.
1061	 As of its 128th consecutive uplink in the continued absence of downlinks, the
1062	DUT must lower its data rate to Default, leave the TXPower Index set to 0 and
1063	ADRACKReq bit set.
1064	 The DUT further lowers its data rate by 1 each time another ADR_ACK_DELAY
1065	cycle occurs (32) uplinks are sent in the sustained absence of downlinks.
1066	 For FC plan devices, when the DR is decayed from a 500kHz DR to a 125KHz
1067	DR, Channel 64 must be discontinued and Channels 0 and 1 must be used.
1068	 After the DR reaches MinDR, in the continued absence of downlinks, the DUT
1069	must re-enable all default uplink frequency channels for DC plan devices, re-
1070	enable all channels for FC plan devices, reset NbTrans to 1, retain the
1071	TXPower at Default, retain the DataRate at Default and the ADRACKReq bit is
1072	kept set in subsequent uplinks.
1073	 After receiving a downlink, the DUT unsets the ADRACKReq bit.
1074	
1075	
1076	2.5.8.d.i.1. Test Procedure Frame Sequence Chart

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Step	Procedure		Frame Sequence	Test Purpose
		End Device - TCL	Frame	розг
1	DUT sends Unconfirmed frame	\rightarrow		
	The TCL sends Unconfirmed frames	+	CP-CMD RegionalDutyCycleCtrlReq- OFF FPort = 224 Payload = [0x]0500	
2	DUT sends Unconfirmed frame	→	.,	
	The TCL sends Unconfirmed frame Note: This step is required for only regions with Dwell Time limitation	+	MAC-CMD TXParamSetupReq UplinkDwellTime = 0 Payload = [0x]09XX	Set TXParamSet upReq for regions with Dwell time limitation
3	DUT sends Unconfirmed frame)	For regions with Dwell time limitation only MAC-CMD TXParamSetupAns Payload = [0x]09	
	The TCL sends Unconfirmed frame Note: This step must be performed for DC plan devices only	+	MAC-CMD NewChannelReq ChIndex = The first non- default channel, refer [2] Freq = Any allowed frequency for the channel, refer [2] DRRange = 0-5, refer [2] Payload = [0x]07XXXXXXXXXXX	Create a new channel
4	DUT sends Unconfirmed frame Note: This step must be performed for DC plan devices only	→	MAC-CMD NewChannelAns Payload = [0x]0703	
	The TCL sends Unconfirmed frame Note: This step must be performed for DC plan devices only	+	MAC-CMD LinkADRReq TXPower Index = 1, refer [2] DataRate = X (where X = Max125kHzDR), refer [2] ChMaskCntl = 0 ChMask = Disable all default channels and enable only the newly added channel, refer [2] NbTrans = 2 Payload = [0x]03XXXXXXXX	
5	DUT sends Unconfirmed frame)	If the LinkADRReq was sent in the previous step, MAC-CMD LinkADRAns Payload = [0x]0307 NbTrans = 2	



Step	Procedure		Test Purpose	
		End Device - TCL	Frame	. u.pece
	The TCL sends Unconfirmed frame Note: This step must be performed for FC plan devices only	←	MAC-CMD LinkADRReq TXPower Index = 1, refer [2] DataRate = Max500kHzDR, refer [2] ChMaskCntl = 7 ChMask = [0x]0001 NbTrans = 2	
			MAC-CMD LinkADRReq TXPower Index = 1, refer [2] DataRate = X (where X = Max500kHzDR), refer [2] ChMaskCntl = 0 ChMask = [0x]0003 NbTrans = 2 Payload = [0x]03XXXXXXXXX[0x]03XXX	
6	DUT sends Unconfirmed frame	→	XXXXX MAC-CMD LinkADRAns	
	Note: This step must be performed for FC plan devices only	-	MAC-CMD LinkADRAns NbTrans = 2 Payload = [0x]0307[0x]0307	Daniel and
	This is a repeated frame DUT sends Unconfirmed frame		MAC-CMD LinkADRAns MAC-CMD LinkADRAns NbTrans = 2 Payload = [0x]0307[0x]0307	Repeat as NbTrans = 2
	Note: This step must be performed for FC plan devices only		[engelon [engelon [engelon]	
7	DUT sends Unconfirmed frame FCntUp = n Repeat 63 times without receiving	→ R [63]	FCtrl ADRAckReq = False DataRate = X NbTrans = 2 TXPower Index = 1	
	any downlinks		Only the channels enabled must be used	
	This is a repeated frame DUT sends Unconfirmed frame FCntUp = n		FCtrl ADRAckReq = False DataRate = X NbTrans = 2 TXPower Index = 1	Repeat as NbTrans = 2
	Repeat 63 times without receiving any downlinks		Only the channels enabled must be used	
8	DUT sends Unconfirmed frame FCntUp = n + 63	→ R [32]	FCtrl ADRAckReq = True DataRate = X NbTrans = 2	
	Repeat 32 times without receiving any downlinks (starting with n + 63)		TXPower Index = 1 Only the channels enabled	
			must be used	



Step	Procedure		Frame Sequence	Test Purpose
		End Device - TCL	Frame	
	This is a repeated frame		FCtrl ADRAckReq = True	Repeat as
			DataRate = X	NbTrans = 2
	DUT sends Unconfirmed frame		NbTrans = 2	
	FCntUp = n + 63		TXPower Index = 1	
	Repeat 32 times without receiving		Only the channels enabled	
	any downlinks (starting with n + 63)		must be used	
9	DUT sends Unconfirmed frame FCntUp = n + 95	→ R [32]	FCtrl ADRAckReq = True DataRate = X	
	·		NbTrans = 2	
	Repeat 32 times without receiving any downlinks (starting with n + 95)		TXPower Index = 0	
	arry downlinks (starting with 1 50)		Only the channels enabled	
			must be used	
	This is a repeated frame		FCtrl ADRAckReq = True	Repeat as
	This is a repeated frame		DataRate = X	NbTrans = 2
	DUT sends Unconfirmed frame		NbTrans = 2	140110115 = 2
	FCntUp = n + 95		TXPower Index = 0	
	Repeat 32 times without receiving		Only the channels enabled	
	any downlinks (starting with n + 95)		must be used	
10	DUT sends Unconfirmed frame	→ R [32]	FCtrl ADRAckReq = True	DUT
10		until minDR	DataRate = Next lower DR,	switches to
	FCntUp = FCntUp (previous) + 32	unui mindk		
	Donast 22 times with out receiving		refer [2], until it reaches the minimum DR	next lower
	Repeat 32 times without receiving		NbTrans = 2	DR, until it
	any downlinks		TXPower Index = 0	decays to the minimun
	Note: Repeat this step until the		TAPower index = 0	DR
	DUT decays to the minimum DR		Only the channels enabled	
	for the region, refer [2]. The test is repeated even when DR = minDR		must be used	
	Topoulou oven union ziv		For FC only: If DataRate	
			decays from 500kHz DR to	
			125kHz DR, DUT must	
			discontinue usage of Channel	
			64, and instead use Channel	
			0 and 1	
	This is a repeated frame		FCtrl ADRAckReq = True	DUT
			DataRate = Next lower DR,	switches to
	DUT sends Unconfirmed frame		refer [2], until it reaches the	next lower
	FCntUp = FCntUp (previous) + 32		minimum DR	DR, until it
			NbTrans = 2	decays to
	Repeat 32 times without receiving		TXPower Index = 0	the minimun
	any downlinks			DR
			Only the channels enabled	
	Note: Repeat this step until the		must be used	
	DUT decays to the minimum DR		F F0 1 15 5	
	for the region, refer [2]. The test is		For FC only: If DataRate	
	repeated even when DR = minDR		decays from 500kHz DR to	
			125kHz DR, DUT must	
			discontinue usage of Channel	
			64, and instead use Channel	
			0 and 1	



Step	Procedure		Frame Sequence	Test
		End Davis	Frome	Purpose
		End Device - TCL	Frame	
11	DUT sends Unconfirmed frame	÷	FCtrl ADRAckReq = True NbTrans = 1 DataRate = MinDR, refer [2] TXPower = 0	DUT switches to default settings for Nbtrans and channels
12	Wait for a <u>Dynamic channel</u> : maximum of 5 * (number of channels <i>currently enabled on the DUT</i>) <u>Fixed channel</u> : maximum of 2 * (number of channels <i>currently enabled on the DUT</i>) uplink packets to be sent, i.e. until all channels are used at least once.	→ R [5*NChDC] or [2*NbChFC] or [AllCh used]	Official certification (DC plan and FC plan): All channels configured must be used at least once Pre-testing for DC Plan: All default channels must be used at least once. Pre-testing for FC plan with 8-channel gateway: Channels 0-7 must be used at least once.	All channels must be used at least once
13	DUT sends Unconfirmed frame The TCL sends Unconfirmed frame	→ ←	MAC-CMD LinkADRReq TXPower = Maximum, refer [2] DataRate = Max125kHzDR, refer [2] ChMaskCntl = 0 (for DC) and 6 (for FC) ChMask = Enable only the default channels for DC, refer [2] and [0x]00FF for FC NbTrans = 1 Payload = [0x]03XXXXXXXXX	For FC device using 8-channel gateway, refer to Section 2 for ChMask settings
14	DUT sends Unconfirmed frame The TCL sends Unconfirmed frame	→	FCtrl ADRAckReq = False MAC-CMD LinkADRAns Payload = [0x]0307 CP-CMD RegionalDutyCycleCtrlReq-ON	DUT reverted to default settings
			ON FPort = 224 Payload = [0x]0501	
15	DUT sends Unconfirmed frame The TCL sends Unconfirmed frame Note: This step must be performed only for DC plan devices	<u>→</u>	MAC-CMD NewChannelReq ChIndex = The non-default channel added in Step 2 of this table. Freq = 0 MHz Payload = [0x]07XXXXXXXXXX	Remove additional channel added



Step	Procedure		Frame Sequence	Test
				Purpose
		End Device	Frame	
		- TCL		
16	DUT sends Unconfirmed frame	\rightarrow	If the NewChannelReq was	
			sent in the previous step,	
			MAC-CMD NewChannelAns	
			Payload = [0x]0703	
	The TCL sends Unconfirmed frame	←	MAC-CMD	Reset Dwell
			TXParamSetupReq	time setting
	Note: This step is required for only		UplinkDwellTime = default,	to default
	regions with Dwell Time limitation		refer [2]	
			Payload = [0x]09XX	
17	DUT sends Unconfirmed frame	\rightarrow	For regions with Dwell time	
			limitation only	
			MAC-CMD	
			TXParamSetupAns	
			Payload = [0x]09	

2.5.8.d.ii. Additional DR Decay test for only DC plan devices which support the optional data rates

This test validates that the **DUT** re-enables all the default channels when it decays from the Maximum optional Data Rate to Max125kHzDR.

The **TCL** adds a new channel for each optional data rate supported.

The TCL sends LinkADRReq to configure the DUT to use

- the Maximum data rate,
- TXPower Index = 1,
- Disable all default channels and enable only the newly added channel(s),
- NbTrans set to 2.

It then stops sending downlinks until the **DUT** decays from maximum optional data rate to Max125kHzDR, refer [2].

Verify

- After sending ADR_ACK_LIMIT (64) uplinks the **DUT** must in a sustained absence of downlinks set the ADRACKReq bit in the next ADR_ACK_DELAY (32) uplinks' frame headers.
- As of its 96th consecutive uplink in the continued absence of downlinks, the
 DUT must change the TXPower Index to 0 and leave the ADRACKReq bit set.
- As of its 128th consecutive uplink in the continued absence of downlinks, the
 DUT must lower its data rate to Default, leave the TXPower Power set to 0
 and ADRACKReq bit set.
- The **DUT** further lowers its data rate by 1 each time another *ADR_ACK_DELAY* cycle occurs (32) uplinks are sent in the sustained absence of downlinks.

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1104 1105 1106 1107	in the conti	R reaches decays from an optional DataRate to a Max125kHzDR, nued absence of downlinks, the DUT must re-enable all default sency channels.
1108 1109	2.5.8.d.ii.1.	Test Procedure Frame Sequence Chart



Step	Procedure		Frame Sequence	Test Purpose
		End Device - TCL	Frame	i uipose
1	DUT sends Unconfirmed frame	→		
	The TCL sends Unconfirmed frames	+	CP-CMD RegionalDutyCycleCtrlReq- OFF FPort = 224 Payload = [0x]0500	
2	DUT sends Unconfirmed frame	\rightarrow		
	The TCL sends Unconfirmed frame Note: This step is required for only regions with Dwell Time limitation	+	MAC-CMD TXParamSetupReq UplinkDwellTime = 0 Payload = [0x]09XX	Set TXParamSet upReq for regions with Dwell time limitation
3	DUT sends Unconfirmed frame	→	For regions with Dwell time limitation only MAC-CMD TXParamSetupAns Payload = [0x]09	mineaton
	The TCL sends Unconfirmed frame Note: This step must be performed only if the DUT supports 250kHz channels	+	MAC-CMD NewChannelReq ChIndex = An unused non- default channel, refer [2] Freq = Any allowed freq for a 250kHz channel, refer [2] DRRange = BW250OptionalDR- BW250OptionalDR, refer [2] Payload = [0x]07XXXXXXXXXXX	Create a new channel for 250kHz channel
4	DUT sends Unconfirmed frame	→	If the NewChannelReq was sent in the previous step, MAC-CMD NewChannelAns Payload = [0x]0703	
	The TCL sends Unconfirmed frame Note: This step must be performed only if the DUT supports FSK channels	←	MAC-CMD NewChannelReq ChIndex = An unused non- default channel, refer [2] Freq = Any allowed frequency for an FSK channel, refer [2] DRRange = FSK50OptionalDR- FSK50OptionalDR, refer [2] Payload = [0x]07XXXXXXXXXXX	Create a new channel for FSK channel if supported
5	DUT sends Unconfirmed frame	÷	If the NewChannelReq was sent in the previous step, MAC-CMD NewChannelAns Payload = [0x]0703	



Step	Procedure		Frame Sequence	Test
		F. J. D. C.	T e	Purpose
		End Device - TCL	Frame	
	The TCL sends Unconfirmed frame	←	MAC-CMD LinkADRReq	
			TXPower Index = 1, refer [2]	
			DataRate = X (where X =	
			Maximum Supported Data	
			Rate), refer [2]	
			ChMaskCntl = 0	
			ChMask = Disable all default	
			channels and enable only the	
			newly added channel(s), refer	
			[2]	
			NbTrans = 1	
			Payload = [0x]03XXXXXXXX	
6	DUT sends Unconfirmed frame	\rightarrow	MAC-CMD LinkADRAns	
			Payload = [0x]0307	
7	DUT sends Unconfirmed frame	→ R [63]	FCtrl ADRAckReq = False	
	FCntUp = n		DataRate = X	
			TXPower Index = 1	
	Repeat 63 times without receiving			
	any downlinks		Only the channels enabled	
			must be used	
8	DUT sends Unconfirmed frame	→ R [32]	FCtrl ADRAckReq = True	
	FCntUp = n + 63		DataRate = X	
			TXPower Index = 1	
	Repeat 32 times without receiving			
	any downlinks (starting with n + 63)		Only the channels enabled	
			must be used	
9	DUT sends Unconfirmed frame	→ R [32]	FCtrl ADRAckReq = True	
	FCntUp = n + 95		DataRate = X	
			TXPower Index = 0	
	Repeat 32 times without receiving		Only the abounds anabled	
	any downlinks (starting with n + 95)		Only the channels enabled	
10	DUT sends Unconfirmed frame	-> D [00]	must be used	DUT
10		→ R [32]	FCtrl ADRAckReq = True	DUT switches to
	FCntUp = FCntUp (previous) + 32	Until DUT	DataRate = Next lower DR,	switches to
	Repeat 32 times without receiving	switches from the	refer [2], until it reaches Max125kHzDR, refer [2]	next lower DR, until it
	any downlinks	OptionalDR	TXPower Index = 0	decays to
	any downlind	to	174 GWGI IIIQGA — U	the
	Note: Repeat this step until the	Max125kHz	Only the channels enabled	Max125kHz
	DUT decays to the Max125kHzDR,	DR	must be used	DR
	refer [2]. When DR =	DI.		
	Max125kHzDR, skip to the next			
	step.			
11	DUT sends Unconfirmed frame	\rightarrow	FCtrl ADRAckReq = True	DUT
			DataRate = Max125kHzDR,	reenables all
			refer [2]	default
			TXPower Index = 0	channels
			All default channels are	
			enabled	



Step	Procedure		Frame Sequence	Test Purpose
		End Device - TCL	Frame	
12	Wait for a maximum of 5 * (number of channels <i>currently enabled on the DUT</i>) uplink packets to be sent, i.e. until all channels are used at least once.	→ R [5*NChDC] or [AllDefCh used]	All default channels must be used at least once	All default channels must be used at least once
13	DUT sends Unconfirmed frame	\rightarrow		
	The TCL sends Unconfirmed frame	+	MAC-CMD LinkADRReq TXPower = Maximum, refer [2] DataRate = Max125kHzDR, refer [2] ChMaskCntl = 0 ChMask = Enable only the default channels, refer [2] NbTrans = 1 Payload = [0x]03XXXXXXXXX	
14	DUT sends Unconfirmed frame	→	FCtrl ADRAckReq = False MAC-CMD LinkADRAns Payload = [0x]0307	DUT reverted to default settings
	The TCL sends Unconfirmed frame	+	CP-CMD RegionalDutyCycleCtrlReq- ON FPort = 224 Payload = [0x]0501	Settings
15	DUT sends Unconfirmed frame	\rightarrow	, , , ,	
	The TCL sends Unconfirmed frame Note: This step is required for only regions with Dwell Time limitation	+	MAC-CMD TXParamSetupReq UplinkDwellTime = default, refer [2] Payload = [0x]09XX	Reset Dwell time to default
16	DUT sends Unconfirmed frame	→	For regions with Dwell time limitation only MAC-CMD TXParamSetupAns Payload = [0x]09	
	The TCL sends Unconfirmed frame Note: This step must be performed only if the DUT supports 250kHz channels	*	MAC-CMD NewChannelReq ChIndex = The channel used in Step3 Freq = 0 DRRange = BW250OptionalDR- BW250OptionalDR, refer [2] Payload = [0x]07XXXXXXXXXX	Removes the 250kHz channel
17	DUT sends Unconfirmed frame)	If the NewChannelReq was sent in the previous step, MAC-CMD NewChannelAns Payload = [0x]0703	



Step	Procedure		Frame Sequence	Test Purpose
		End Device - TCL	Frame	i di poss
	The TCL sends Unconfirmed frame Note: This step must be performed only if the DUT supports FSK channels	+	MAC-CMD NewChannelReq ChIndex = The channel used in Step4 Freq = 0 DRRange = FSK50OptionalDR- FSK50OptionalDR, refer [2] Payload = [0x]07XXXXXXXXXXX	Removes the FSK channel
18	DUT sends Unconfirmed frame	→	If the NewChannelReq was sent in the previous step, MAC-CMD NewChannelAns Payload = [0x]0703	

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LR-FHSS - DR Decay test for DC plan and FC plan devices

Note: These tests must be performed only if the DUT supports LR-FHSS.

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The test checks if the DUT decays from the higher to the lower DR for devices supporting LR-FHSS. This test also validates that the DUT re-enables all the default channels when it decays from the LR-FHSS Data Rate to Min125kHzDR.

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The **TCL** adds a new channel for each LR-FHSS data rate supported.

1119

The **TCL** sends *LinkADRReq* to configure the **DUT** to use

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Disable all default channels and enable only the newly added channel(s),

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- the highest LR-FHSS data rate,
- TXPower Index = 1,
- NbTrans set to 2.

It then stops sending downlinks until the **DUT** decays from higher LF-FHSS DR to the lower LR-FHSS DR, refer [2].

Verify

- After sending ADR_ACK_LIMIT (64) uplinks the DUT must in a sustained absence of downlinks - set the ADRACKReq bit in the next ADR_ACK_DELAY (32) uplinks' frame headers.
- As of its 96th consecutive uplink in the continued absence of downlinks, the **DUT** must change the TXPower Index to 0 and leave the *ADRACKReq* bit set.
- As of its 128th consecutive uplink in the continued absence of downlinks, the **DUT** must lower its data rate to Default, leave the TXPower Power set to 0 and ADRACKReq bit set.
- The **DUT** further lowers its data rate by 1 each time another *ADR_ACK_DELAY* cycle occurs (32) uplinks are sent in the sustained absence of downlinks.





1139	After the DR	reaches decays from an LR-FHSS DataRate to Min125kHzDR, in
1140	the continu	ed absence of downlinks, the DUT must re-enable all default
1141	uplink frequ	ency channels.
1142		
1143	2.5.8.d.iii.1.	Test Procedure Frame Sequence Chart
	2.3.0.u.m.1.	rest i roccuure rraine sequence chart
1144		



Step	Procedure	Frame Sequence		Test Purpose
		End Device - TCL	Frame	
1	DUT sends Unconfirmed frame	→		
	The TCL sends Unconfirmed frames	+	CP-CMD RegionalDutyCycleCtrlReq- OFF FPort = 224 Payload = [0x]0500	
2	DUT sends Unconfirmed frame	→	, , ,	
	The TCL sends Unconfirmed frame Note: This step is required for only regions with Dwell Time limitation	+	MAC-CMD TXParamSetupReq UplinkDwellTime = 0 Payload = [0x]09XX	Set TXParamSet upReq for regions with Dwell time limitation
3	DUT sends Unconfirmed frame)	For regions with Dwell time limitation only MAC-CMD TXParamSetupAns Payload = [0x]09	
4	If DUT = DC plan device, DUT sends Unconfirmed frame	→ R [all LR- FHSS DR]	If the NewChannelReq was sent in the previous step, MAC-CMD NewChannelAns Payload = [0x]0703	
	If DUT = DC plan device, the TCL sends Unconfirmed frame Repeat for all LR-FHSS DR	← R [all LR-FHSS DR]	MAC-CMD NewChannelReq ChIndex = An unused non- default channel, refer [2] Freq = An allowed frequency for the LR-FHSS channel added, refer [2] DRRange = Min-LR-FHSS- DR- Max-LR-FHSS-DR, refer [2] Payload = [0x]07XXXXXXXXXXX	
5	DUT sends Unconfirmed frame)	If the NewChannelReq was sent in the previous step, MAC-CMD NewChannelAns Payload = [0x]0703	



Step	Procedure		Test Purpose	
		End Device - TCL	Frame	
	The TCL sends Unconfirmed frame	÷	MAC-CMD LinkADRReq TXPower Index = 1, refer [2] DataRate = X (where X = Maximum Supported LR- FHSS Data Rate), refer [2] ChMaskCntl = 0 ChMask = Disable all default channels and enable only the newly added channel(s), refer [2] NbTrans = 1	
6	DUT sends Unconfirmed frame	→	Payload = [0x]03XXXXXXXX MAC-CMD LinkADRAns Payload = [0x]0307	
7	DUT sends Unconfirmed frame FCntUp = n Repeat 63 times without receiving any downlinks	→ R [63]	FCtrl ADRAckReq = False DataRate = X TXPower Index = 1 Only the channels enabled must be used	
8	DUT sends Unconfirmed frame FCntUp = n + 63 Repeat 32 times without receiving any downlinks (starting with n + 63)	→ R [32]	FCtrl ADRAckReq = True DataRate = X TXPower Index = 1 Only the channels enabled	
9	DUT sends Unconfirmed frame FCntUp = n + 95	→ R [32]	must be used FCtrl ADRAckReq = True DataRate = X TXPower Index = 0	
	Repeat 32 times without receiving any downlinks (starting with n + 95)		Only the channels enabled must be used	
10	DUT sends Unconfirmed frame FCntUp = FCntUp (previous) + 32 Repeat 32 times without receiving any downlinks Note: Repeat this step until the	→ R [32] Until DUT switches from the LR- FHSS DR to Min125kHzD R	FCtrl ADRAckReq = True DataRate = Next lower DR, refer [2], until it reaches Min125kHzDR, refer [2] TXPower Index = 0 Only the channels enabled	DUT switches to next lower DR, until it decays to the Min125kHzD
	DUT decays to Min125kHzDR, refer [2]. When DR = Min125kHzDR, skip to the next step.		must be used	R
11	DUT sends Unconfirmed frame	→	FCtrl ADRAckReq = True DataRate = Min125kHzDR, refer [2] NbTrans = 1 TXPower Index = 0 All default channels are enabled	DUT reenables all default channels



Step	Procedure		Frame Sequence	Test
			T	Purpose
		End Device - TCL	Frame	
12	Wait for a	→ R	Official certification (DC plan	All channels
	Dynamic channel: maximum of 5 *	[5*NChDC]	and FC plan):	must be
	(number of channels currently	or	All channels configured must	used at least
	enabled on the DUT)	[2*NbChFC]	be used at least once	once
	Fixed channel: maximum of 2 *	or		
	(number of channels <i>currently</i>	[AllCh used]	Pre-testing for DC Plan:	
	enabled on the DUT)	[/ tiloli dood]	All default channels must be	
	uplink packets to be sent, i.e. until all		used at least once.	
	channels are used at least once.		used at least office.	
	Charmers are used at least office.		Pre-testing for FC plan with 8-	
			channel gateway:	
			Channels 0-7 must be used	
			at least once.	
	For DC plan devices only - Repeat		or DR8 and DR9 LR-FHSS data	rates
13	DUT sends Unconfirmed frame	→		
	The TCL sends Unconfirmed frame	+	MAC-CMD LinkADRReq	
			TXPower = Maximum, refer	
			[2]	
			DataRate = Max125kHzDR,	
			refer [2]	
			ChMaskCntl = 0	
			ChMask = Enable only the	
			default channels, refer [2]	
			NbTrans = 1	
			Payload = [0x]03XXXXXXXX	
14	DUT sends Unconfirmed frame	\rightarrow	FCtrl ADRAckReq = False	DUT
			·	reverted to
			MAC-CMD LinkADRAns	default
			Payload = [0x]0307	settings
	The TCL sends Unconfirmed frame	-	CP-CMD	J
			RegionalDutyCycleCtrlReq-	
			ON	
			FPort = 224	
			Payload = [0x]0501	
15	DUT sends Unconfirmed frame	→	r ayread = [expect	
.0	De l'ecitae effectionime maine	,		
	The TCL sends Unconfirmed frame	+	MAC-CMD	Reset Dwell
	102 condo oncommitto mame	<u> </u>	TXParamSetupReq	time to
	Note: This step is required for only		UplinkDwellTime = default,	default
	regions with Dwell Time limitation		refer [2]	Joidan
	10gions war bweir rime iiriilauon		Payload = [0x]09XX	
16	DUT sends Unconfirmed frame	\rightarrow	For regions with Dwell time	
10	Do i serius officoriiiffied frame	7	<u> </u>	
			limitation only	
			MAC CNAD	
			MAC-CMD	
			TXParamSetupAns	
			Payload = [0x]09	
17	If DUT = DC plan device, DUT		If the NewChannelReq was	
		← R [all LR-	sent in the previous step,	
	sends Unconfirmed frame	_	! ! '	
	sends Unconfirmed frame	FHSS		
	sends Unconfirmed frame	_	MAC-CMD NewChannelAns	



Step	Procedure		Frame Sequence	Test
				Purpose
		End Device	Frame	
		- TCL		
	If DUT = DC plan device, the TCL		MAC-CMD NewChannelReq	
	sends Unconfirmed frame		Chindex = The channel used	
			to add the LR-FHSS channels	
			Freq = 0	
			DRRange = Min-LR-FHSS-	
			DR to max-LR-FHSS-DR,	
			refer [2]	
			Payload =	
			[0x]07XXXXXXXXX	
18	DUT sends Unconfirmed frame	\rightarrow	If the NewChannelReq was	
			sent in the previous step,	
			MAC-CMD NewChannelAns	
			Payload = [0x]0703	

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2.5.8.e. Command Block Channel Management

This test validates the **DUT** correctly processes blocks of multiple *LinkADRReq* commands included in the same downlink. The **DUT** is expected to service each of these MAC commands in the same sequence as it is ordered in the FOpts or FRMPayload field.

2.5.8.e.i. Dynamic channel plan devices

2.5.8.e.i.1.Successful LinkADRReq block

The TCL sends multiple *LinkADRReq* commands in a single downlink as shownError! Reference source not found.Error! Reference source not found. in Table 1: Successful LinkADRReq blockError! Reference source not found.Error! Reference source not found.Error! Reference source not found. The first command tries to disable all channels. The channel mask the second command enables is *channel 0*, and any default DR except the minimum DR, is appropriate for this channel. The last command enables all defined channels using the channel mask control 6 and configures any other default data rate except the ones used earlier for this test. The **DUT** is expected to respond with *LinkADRAns* [0x]0307 for all *LinkADRReq* commands.

LinkADRReq	DR	TXPower	Channel	MaskCntl	NbTrans
CMD Index			Mask		
1	Minimum	Any allowed	[0x]0000	0	0
		TXPower			
2	Any default	Any allowed	[0x]0001	0	0
	DR except the	TXPower,			
	one set above	other than			
		the one set			
		above			



3	Any default	Any other	[0x]0000	6	1
	DR except the	allowed			
	ones set	TXPower			
	above				

Table 1: Successful LinkADRReq block

Note:

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- The DR, TX Power, and NbTrans values of only the last command are implemented by the **DUT**. Values for these parameters in any preceding command must be ignored.
- After processing the command block shown above, the **DUT** is expected to be configured as follows:

Channel Plan: Default channels only

Data Rate: As set in Step 3 in Table 1: Successful LinkADRReq block

TXPower: As set in Step 3 in Error! Reference source not found. Table 1:

Successful LinkADRReq block

Verify

- The **DUT** replies with an uplink containing a successful *LinkADRAns* for each command in the block.
- The uplink containing the answers and all subsequent transmissions are sent using the default channels at the commanded DR.

2.5.8.e.i.1.1. Test Procedure Frame Sequence Chart



Step	Procedure	i	Frame Sequence	Test Purpose
		End Device - TCL	Frame	. u.pece
1	DUT sends Unconfirmed frame	\rightarrow		
	FCntUp = n			
	The TCL sends Unconfirmed frame	+	MAC-CMD1 LinkADRReq	
			TXPower = Any allowed	
			TXPower, refer [2]	
			DataRate = MinDR, refer [2]	
			ChMaskCntl = 0	
			ChMask = [0x]0000 NbTrans = 0	
			Notrans = 0	
			MAC-CMD2 LinkADRReq	
			TXPower = Any other	
			allowed TXPower, refer [2]	
			DataRate = Any default DR,	
			except the one set above in	
			this step, refer [2]	
			ChMaskCntl = 0	
			ChMask = [0x]0001	
			NbTrans = 0	
			MAC-CMD3 LinkADRReq	
			TXPower = Any other	
			TXPower, refer [2]	
			DataRate = Any default DR,	
			except the ones set above in	
			this step, refer [2]	
			ChMaskCntl = 6	
			ChMask = [0x]0000	
			NbTrans = 1	
			Payload =	
			[0x]03XXXXXXXX[0x]03XXX	
			XXXXX[0x]03XXXXXXX	
2	DUT sends Unconfirmed frame	\rightarrow	DataRate = same as set in	Uplinks as
	FCntUp = n + 1		CMD3 above	configured
			MAC-CMD1 LinkADRAns	
			MAC-CMD2 LinkADRAns	
			MAC-CMD3 LinkADRAns	
			Payload =	
			[0x]0307[0x]0307[0x]0307	
3	Wait for a maximum of 5 * (number	→ R	All default channels must be	All default
	of channels <i>currently enabled on the</i>	[5*NbCh] or	used at least once	channels
	DUT) = uplink packets to be sent, i.e.	[All Ch used]		must be
	until all default channels are used at least once.			used at least once
4	DUT sends Unconfirmed frame	→		OTICE
4	DO 1 SENUS UNCONMINIEU MAINE	1	1	



Step	Procedure	F	Frame Sequence	Test Purpos	se .
		End Device - TCL	Frame		
	The TCL sends Unconfirmed frame	+	MAC-CMD LinkADRReq TXPower = Maximum, refer [2] DataRate = Max125kHzDR, refer [2] ChMaskCntl = 0 ChMask = Enable only the default channels, refer [2] NbTrans = 1 Payload = [0x]03XXXXXXXX		
5	DUT sends Unconfirmed frame	→	MAC-CMD LinkADRAns Payload = [0x]0307	DUT reverted default settings	to

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2.5.8.e.i.2. Unsuccessful LinkADRReq block

The **TCL** sends several *LinkADRReq* commands in a single downlink as shown in Table 2: Unsuccessful LinkADRReq block. **Error! Reference source not found.**In this case the last command requires all channels to be disabled, all commands must be rejected.

LinkADRReq	DR	TXPow	Channel	MaskCntl	NbTrans
CMD Index		er	Mask		
1	Any mandatory	Any	[0x]0001	0	0
	DR, except				
	Max125kHzDR				
2	Any other	Any	[0x]0000	6	1
	mandatory DR,				
	except				
	Max125kHzDR				
3	Max125kHzDR	Any	[0x]0000	0	1

Table 2: Unsuccessful LinkADRReq block

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- The **DUT** replies with an uplink containing an unsuccessful LinkADRAns for each command in the block.
- The uplink data rate does not change and the **DUT** continues using the default channels at the previously configured data rate.

2.5.8.e.i.2.1. Test Procedure Frame Sequence Chart



Step	Procedure	Frame Sequence		Test
				Purpose
		End Device - TCL	Frame	
1	DUT sends Unconfirmed frame FCntUp = n	→		
	The TCL sends Unconfirmed frame	\	MAC-CMD1 LinkADRReq TXPower = Any allowed value, refer [2] DataRate = X (where X = any mandatory DR, except Max125kHzDR, refer [2]) ChMaskCntl = 0 ChMask = [0x]0001 NbTrans = 0	
			MAC-CMD2 LinkADRReq TXPower = Any allowed value, refer [2] DataRate = Any other mandatory DR, except Max125kHzDR, refer [2] ChMaskCntl = 6 ChMask = [0x]0000 NbTrans = 1	
			MAC-CMD3 LinkADRReq TXPower = Any allowed value, refer [2] DataRate = Max125kHzDR, refer [2] ChMaskCntl = 0 ChMask = [0x]0000 NbTrans = 1	
			Payload = [0x]03XXXXXXXXX[0x]03XXXXXXXI[0x]]03XXXXXXXXX	
2	DUT sends Unconfirmed frame FCntUp = n + 1	→	MAC-CMD1 LinkADRAns MAC-CMD2 LinkADRAns	All commands are rejected as the last
			MAC-CMD3 LinkADRAns Payload = [0x]030X[0x]030X[0x]030X (where X is NOT = 7)	command requires all channels to be disabled

2.5.8.e.ii. Fixed channel plan devices

2.5.8.e.ii.1. 125kHz Sub-Band Channel Plan

The **TCL** sends two *LinkADRReq* commands in a single downlink as shown in Table 3: 125kHz Sub-Band Channel Plan Command Block. The first command disables all 125 kHz channels and simultaneously enables the *channel 64* (500 kHz channel). The DataRate of the first command is any data rate allowed for uplinking on 500 kHz enabled channels. The channel mask control of the second command enables *channel 0 – 7*. The DataRate must be an allowed data rate allowed for 125 kHz

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uplink channels, refer [2]. The **DUT** is expected to respond with *LinkADRAns* [0x]0307 for both *LinkADRReq* commands.

LinkADRReq	DR	TXPower	Channel	Mask	NbTrans
CMD Index			Mask	Index	
1	Any DR	Maximum	[0x]0001	7	1
	allowed for				
	500 kHz uplink				
	channels				
2	Any DR	Any allowed	[0x]00FF	0	1
	allowed for	TXPower			
	125 kHz uplink	other than			
	channels	max			
		TXPower			

Table 3: 125kHz Sub-Band Channel Plan Command Block

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Note:

- The DR, TX Power, and NbTrans values of only the last command are implemented by the **DUT**. Values for these parameters in any preceding command must be ignored.
- After processing the command block shown above, the **DUT** is expected to be configured as follows:

Channel Plan: Channels 0-7

Data Rate: DataRate set in the second command above **TXPower**: TXPower set in the second command above

Verify

- The **DUT** replies with an uplink containing a successful *LinkADRAns* for each command in the block.
- The uplink containing the answers and all subsequent transmissions are sent only on the enabled 125kHz channel plan at the commanded DR.

If LR-FHSS is supported by the DUT, repeat the above procedure by replacing 500kHz uplink channels with 1.523MHz uplink channels

2.5.8.e.ii.1.1. Test Procedure Frame Sequence Chart



Step	Procedure	ı	Test Purpose	
		End Device - TCL	Frame	1 urpose
1	DUT sends Unconfirmed frame FCntUp = n	→		
	The TCL sends Unconfirmed frame	+	MAC-CMD1 LinkADRReq TXPower = Maximum, refer [2] DataRate = Any DR allowed for 500 kHz uplink channels, refer [2] ChMaskCntl = 7 ChMask = [0x]0001 NbTrans = 1 MAC-CMD2 LinkADRReq TXPower = Any allowed TXPower other than max TXPower, refer [2] DataRate = Any DR allowed for 125 kHz uplink channels, refer [2] ChMaskCntl = 0 ChMask = [0x]00FF NbTrans = 1	
			Payload = [0x]03XXXXXXXX[0x]03XXX XXXXX	
2	DUT sends Unconfirmed frame FCntUp = n + 1	→	DataRate and TXPower = same as set in CMD2 above Channel Plan = Channel 0-7	Uplinks as configured
			MAC-CMD1 LinkADRAns MAC-CMD2 LinkADRAns	
			Payload = [0x]0307[0x]0307	



	If LR-FHSS is supported, the TCL	+	MAC-CMD1 LinkADRReq	
	sends Unconfirmed frame	`	TXPower = Maximum, refer	
	Series Officeriniffice frame		[2]	
			DataRate = Any DR allowed	
			-	
			for 1.523 MHz uplink	
			channels, refer [2]	
			ChMaskCntl = 7	
			ChMask = [0x]0001	
			NbTrans = 1	
			MAC-CMD2 LinkADRReq	
			TXPower = Any allowed	
			TXPower other than max	
			TXPower, refer [2]	
			DataRate = Any DR allowed	
			for 125 kHz uplink channels,	
			refer [2]	
			ChMaskCntl = 0	
			ChMask = [0x]00FF	
			NbTrans = 1	
			110 110 0 1	
			Payload =	
			[0x]03XXXXXXXX[0x]03XXX	
			XXXXX	
3	If LR-FHSS is supported, DUT sends	\rightarrow	DataRate and TXPower =	Uplinks as
	Unconfirmed frame	-	same as set in CMD2 above	configured
			Channel Plan = Channel 0-7	
			MAC-CMD1 LinkADRAns	
			MAC-CMD2 LinkADRAns	
			IVIAC-CIVIDZ LITIKADINATIS	
	T. TO.	,	Payload = [0x]0307[0x]0307	F 50
	The TCL sends Unconfirmed frame	+	MAC-CMD LinkADRReq	For FC
			TXPower = Maximum, refer	device using
			[2]	8-channel
			DataRate = Max125kHzDR,	gateway,
			refer [2]	refer to
			ChMaskCntl = 6	Section 2 for
			ChMask = [0x]00FF	ChMask
			NbTrans = 1	settings
			Payload = [0x]03XXXXXXXX	
4	DUT sends Unconfirmed frame	\rightarrow	MAC-CMD LinkADRAns	DUT
			Payload = [0x]0307	reverted to
				default
1				settings

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2.5.9. Duty Cycle Req

The test validates that the **DUT** correctly updates its Duty Cycle – maximum aggregated transmit duty time.





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1232	TCL must then set the DUT to the Max125kHzDR, refer [2].
1233	DUT sends uplink frames and TCL stores the time of arrival of 2 consecutive uplink frames.
1234	TCL sends DutyCycleReq MAC command with a MaxDutyCycle value of 7 (Duty Cycle is smaller than
1235	1% duty-cycle used for default channels for duty cycle enabled regions)
1236	DUT again sends uplink frames and TCL stores the time of arrival of the next 2 consecutive uplink
1237	frames.
1238	TCL sends Echo command of length of 40 Bytes
1239	DUT sends Echo response of length of 40 Bytes
1240	Verify
1241	DUT responds with a <i>DutyCycleAns</i> command, adjusts its duty cycle as requested by the TCL and
1242	only transmits after the silence period Toff corresponding to the TimeOnAir of the previous
1243	uplink.
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1245	2.5.9.a. Test Procedure Frame Sequence Chart



Step	Procedure		Frame Sequence	Test Purpose
		End Device	Frame	Furpose
1	DUT sends Unconfirmed frame	→		
	The TCL sends Unconfirmed frame	-	MAC-CMD LinkADRReq DataRate = Max125KHzDR, refer [2] Payload = [0x]03XXXXXXXX	Set DataRate to Max125kHzD R
			ChMaskCntl: DC = 0, FC = 6 ChMask:	For FC device using 8-channel gateway, refer to
			DC - Enable only default channels FC = [0x]00FF	Section 2 for ChMask settings
2	DUT sends Unconfirmed frame	→	MAC-CMD LinkADRAns Payload = [0x]0307	
	The TCL sends Unconfirmed frame	+	MAC-CMD DutyCycleReq Payload = [0x]0407	
3	DUT sends Unconfirmed frame	→	MAC-CMD DutyCycleAns Payload = [0x]04	Max Duty Cycle set to 7
			Time of Arrival = A TimeOnAir = X $T_{off1} = X^*(2^7 - 1)$	
4	DUT sends Unconfirmed frame	→	Time of Arrival = B Verify that ((B - A)) >= (T _{off1} - 500ms)TimeOnAir = Y T _{off2} = Y*(2 ⁷ -1)	Uplink frames are sent not before the Toff.
	The TCL sends Unconfirmed frame	+	CP-CMD EchoPayloadReq FPort = 224 Payload = [0x]08XXXXXX(Length 40)	
5	DUT sends Unconfirmed frame	→	CP-CMD EchoPayloadAns FPort = 224 Payload = [0x]08YYYYYY(Length 40) Time of Arrival = C Verify that ((C - B)) >= (Toff2 -500ms) TimeOnAir = Z Toff3 = Z*(2 ⁷ -1)	Echo reply sent
6	DUT sends Unconfirmed frame	→	Time of Arrival = D Verify that ((D - C)) >= (T _{off3} – 500ms)	
	The TCL sends Unconfirmed frame	+	MAC-CMD DutyCycleReq Payload = [0x]0400	
7	DUT sends Unconfirmed frame	→	MAC-CMD DutyCycleAns Payload = [0x]04	Revert to default Duty cycle



1247 **2.5.10**. **DeviceTimeReq**

1248 The **DUT** is triggered to request the **TCL** for the current network time and the **TCL** must correctly send

the network time for the **DUT** to synchronize its time.

1250 TCL must trigger the DUT to send a DeviceTimeReq to the TCL. The TCL must reply with the

1251 DeviceTimeAns providing the current network time to the DUT. The DUT must return the value

received on *DeviceTimeAns* in the Payload of the next uplink.

1253 Verify

• **DUT** sends a *DeviceTimeReg* to the **TCL**.

• **DUT** resumes normal operation after **TCL** sends *DeviceTimeAns*.

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2.5.10.a. Test Procedure Frame Sequence Chart

Step	Procedure	Frame Sequence		Test Purpose
		End Device - TCL	Frame	
1	DUT sends Unconfirmed frame	\rightarrow		
2	TCL sends Unconfirmed frame	+	CP-CMD DeviceTimeReq FPort = 224 Payload = [0x]21	
3	DUT sends Unconfirmed frame	→	MAC-CMD DeviceTimeReq Payload = [0x]0D	
4	The TCL sends Unconfirmed frame	+	MAC-CMD DeviceTimeAns Payload = [0x]0DXXXXXXXXXX	DeviceTimeA ns sent
5	DUT sends Unconfirmed frame	\rightarrow		

2.5.11. RX Window test

2.5.11.a. **RX1 Receive Window Test**

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RX1DRoffset testing

This test validates the **DUT**'s capability to receive data on RX1 for data rates as specified in RX1DRoffset table in [2].

For each combination of Operating Uplink DR to RX1 offset:

- The TCL commands the DUT to implement the target configuration and subsequently validates corresponding *LinkADRAns* and *RXParamSetupAns* from the DUT indicating it has implemented the target configuration.
- The **TCL** then sends 5 consecutive downlinks to the **DUT** on the RX1 window where:
 - At least one of the frames is the maximum allowed payload for the current RX1
 DR (with respect to the current offset).
 - At least one of the frames is confirmed, requiring the **DUT** to set the ACK bit in the subsequent uplink.





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 The TCL validates reception by verifying for each downlink that the subsequent uplink contains a payload indicating the DUT's downlink counter has incremented by one. The uplink following the confirmed downlink must have its ACK bit set to true as well.

For the given RX1DRoffset, the **TCL** then transitions the **DUT** through the remaining Uplink DR settings, verifying the respective *LinkADRAns* and repeating the above procedure for each.

Once the combinations for the current RX1DRoffset are exhausted, the **TCL** commands the **DUT** to the next RX1DRoffset, verifies the *RXParamSetupAns* and repeats the same series of downlink tests. The **TCL** proceeds in this fashion exhausting all combinations.

Error Rate testing

For each unique RX1 DR in the RX1DRoffset table, the **TCL** will perform the Sufficient Reception test. For these tests, RX1DRoffset will be set to different values as required, to enable testing for each unique RX1 DR as defined in [2]. The **TCL** sends 60 downlink packets in the RX1 window and verifies that at least 57 frames were received by the **DUT**.

2.5.11.a.i. Test Procedure Frame Sequence Chart



Step	Procedure		Test	
		End Device - TCL	Frame	Purpose
1	DUT sends Unconfirmed frame	→ + + + + + + + + + + + + + + + + + + +		
	For DC only – If the DUT supports optional data rate(s), then The TCL sends Unconfirmed frame	+	CMD NewChannelReq ChannelIndex = any unused optional channel Frequency = any allowed frequency for the channel, refer [2] Payload = 0x07XXXXXXXXXXX	
			Note: If the DUT supports more than one optional data rate, a NewChannelReq must be sent for each of them.	
2	If the NewChannelReq was sent by the TCL, then DUT sends Unconfirmed frame)	CMD NewChannelAns Payload = [0x]0703[Repeat for all channel added]	Added new channel(s) for the optional data rate(s) supported
	For each RX1DRoffset combination in the RX1DRoffset table in [2], the TCL transitions the DUT to each Uplink Data Rate by repeating below Steps 3-9.	R Steps 3-9 for [All RX1DR in RX1DRoffse t table]		
3	DUT sends Unconfirmed frame The TCL sends Unconfirmed frame	<u>→</u>	MAC-CMD LinkADRReq DataRate = X (where X = Each DR supported by the DUT) ChMaskCntl: DC = 0, FC = 6 ChMask: DC - Enable only default channels FC = [0x]00FF	For FC device using 8-channel gateway, refer to Section 2 for ChMask settings
			MAC-CMD RxParamSetupReq RX1DRoffset = Offset value as defined in the RX1DRoffset table in [2] RX2DataRate = default DR, refer [2] RX2Frequency = default frequency, refer [2] Payload = [0x]03XXXXXXXXXX[0x]05XXX XXXXX	



Step	Procedure		Frame Sequence		
		End Device - TCL	Frame	Purpose	
4	DUT sends Unconfirmed frame	→	MAC-CMD LinkADRAns		
			MAC-CMD		
			RxParamSetupAns		
			Payload = [0x]0307[0x]0507		
	The TCL sends Unconfirmed frames	+	CP-CMD RxAppCntReq		
			FPort = 224		
			Payload = [0x]09		
5	DUT sends Unconfirmed frame	\rightarrow	CP-CMD RxAppCntAns		
			FPort = 224		
			Payload = [0x]09XXXX		
	TI TO!		RxAppCnt = x		
	The TCL sends Unconfirmed frames	+	CP-CMD		
			RegionalDutyCycleCtrlReq- OFF		
			FPort = 224		
			Payload = [0x]0500		
6	DUT sends Unconfirmed frame	→ R [4]	1 4/1044 = [0x]0000		
	Repeat 4 times				
	The TCL sends Unconfirmed frames	← R [4]	CP-CMD TxFramesCtrlReq		
	on RX1 window		FPort = 224		
			Frame type = No change		
	Repeat 4 times		Payload = [0x]0700		
7	DUT sends Unconfirmed frame	\rightarrow			
	The TCL sends a Confirmed frame	+	Payload = Max allowed		
	on RX1 window		payload as defined in		
			Maximum Payload size table		
0	DUT conde linearitime of trame		in [2]		
8	DUT sends Unconfirmed frame The TCL sends Unconfirmed frames	→ ←	ACK Bit = True CP-CMD RxAppCntReq		
	The TCL serius Officoninined frames		FPort = 224		
			Payload = [0x]09		
9	DUT sends Unconfirmed frame	→	CP-CMD RxAppCntAns	Refer to	
			FPort = 224	Section 2 -	
			Payload = [0x]09XXXX	Test Notes	
			RxAppCnt >= x + 4	for missed	
				RxAppCntAn s	
	Repeat steps 3-9 for each			3	
	RX1DRoffset combination in the				
	RX1DRoffset table in [2].				



Step	Procedure		Frame Sequence		
		End Device - TCL	Frame	Purpose	
	For each unique RX1 Data Rate in the RX1DRoffset table in [2], the TCL will perform the Sufficient Reception test by repeating Steps 10-15.	R Steps 10-15 for [All RX1DR in RX1DRoffse t table]			
10	DUT sends Unconfirmed frame	→ →			
	The TCL sends Unconfirmed frame	←	MAC-CMD LinkADRReq DataRate = X (where X = Each DR supported by the DUT) ChMaskCntl: DC = 0, FC = 6 ChMask: DC - Enable only default channels FC = [0x]00FF MAC-CMD RxParamSetupReq RX1DRoffset = As applicable for the DR being tested, refer RX1DRoffset table in [2] Payload = [0x]03XXXXXXXXXXX[0x]05XXX XXXXX	For FC device using 8-channel gateway, refer to Section 2 for ChMask settings	
11	DUT sends Unconfirmed frame	→	MAC-CMD LinkADRAns MAC-CMD RxParamSetupAns Payload = [0x]0307[0x]0507		
	The TCL sends Unconfirmed frames	+	CP-CMD RxAppCntReq FPort = 224 Payload = [0x]09		
12	DUT sends Unconfirmed frame	→	CP-CMD RxAppCntAns FPort = 224 Payload = [0x]09XXXX RxAppCnt = y		
13	DUT sends Unconfirmed frame	→ R [60]			
	Repeat 60 times The TCL sends Unconfirmed frame on RX1 window Repeat 60 times	← R [60]	CP-CMD TxFramesCtrlReq DataRate = X FPort = 224 Frame type = No change Payload = [0x]0700 (MaxLen for RX1 DR)		
14	DUT sends Unconfirmed frame	→	,		



Step	Procedure		Test	
		- ID :	l e	Purpose
		End Device - TCL	Frame	
	The TCL sends Unconfirmed frames	+	CP-CMD RxAppCntReq	
			FPort = 224	
			Payload = [0x]09	
15	DUT sends Unconfirmed frame	\rightarrow	CP-CMD RxAppCntAns	Reception
			FPort = 224	failure rate
			Payload = [0x]09XXXX	<=5%
			RxAppCnt >= y + 57 + 1	Refer to
				Section 2 –
				Test Notes
				for missed
				RxAppCntAn
				s
	Repeat steps 10-15 for each unique			
	RX1 Data Rate in the RX1DRoffset			
40	table in [2]			
16	DUT sends Unconfirmed frame The TCL sends Unconfirmed frame	→ ←	MAC-CMD LinkADRReg	For FC
	The TCL sends Unconfirmed frame		DataRate = Max125kHzDR,	device using
			refer [2]	8-channel
			ChMaskCntl:	gateway,
			DC = 0,	refer to
			FC = 6	Section 2 for
			ChMask:	ChMask
			DC - Enable only default	settings
			channels	
			FC = [0x]00FF	
			MAC-CMD	
			RxParamSetupReq	
			RX1DRoffset = 0	
			RX2DataRate = default DR,	
			refer [2]	
			Freq = default frequency,	
			refer [2]	
			Payload = [0x]03XXXXXXXX	
			[0x]05XXXXXXXX	
17	DUT sends Unconfirmed frame	→	MAC-CMD LinkADRAns	DUT
				reverted to
			MAC-CMD	default
			RxParamSetupAns	settings
			_ , ,	
	The TOL sendally Continue		Payload = [0x]0307[0x]0507	
	The TCL sends Unconfirmed frames	←	CP-CMD Regional Duty Cycle Ctrl Peg	
			RegionalDutyCycleCtrlReq-	
			FPort = 224	
			Payload = [0x]0501	
18	DUT sends Unconfirmed frame	→		
	1	1	I	1



Step	Procedure		Frame Sequence	Test
		End Device - TCL	Frame	Purpose
	For DC only – If the DUT supports optional data rate(s), then The TCL sends Unconfirmed frame	+	CMD NewChannelReq ChannelIndex = as added in Step 1 Frequency = 0 Payload = 0x07XXXXXXXXXXX Repeat the command for all	
			channels added in Step 1 of this table	
19	If the NewChannelReq was sent by the TCL, then DUT sends Unconfirmed frame	→	CMD NewChannelAns Payload = 0x0703[Repeat for all optional channels added]	Removed channel(s) added

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2.5.11.b. RX2 Receive Window Test

This test validates the **DUT**'s capability to receive data on RX2 for all data rates.

For each unique RX2DataRate, the **TCL** will perform the Sufficient Reception. For these tests RX1DROffset will be set to default. The **TCL** sends 60 downlink packets in the RX2 window and verifies that at least 57 messages were received by the **DUT**.

2.5.11.b.i. Test Procedure Message Sequence Chart



Step	Procedure	M	essage Sequence	Test Purpose
		End Device - TCL	Message	
1	DUT sends Unconfirmed frame	→		
-	For each RX2DataRate supported	R		
	by the DUT, the TCL will perform the	Steps 2-7 for		
	Sufficient Reception test by	[All RX2DR]		
	repeating Steps 2-7.	[/m/otzbit]		
2	DUT sends Unconfirmed frame	→		
_	The TCL sends Unconfirmed frame	-	MAC-CMD	
	The regional endominion name	,	RxParamSetupReq	
			RX1DROffset = default,	
			refer [2]	
			RX2DataRate = X (where X	
			= each supported data rate	
			for RX2)	
			RX2 Frequency = default,	
			refer [2]	
			Payload =	
			[0x]05XXXXXXX	
3	DUT sends Unconfirmed frame	→	MAC-CMD	
	Do i serias oricomirrica franc	,	RxParamSetupAns	
			Payload = [0x]0507	
	The TCL sends Unconfirmed frames	←	CP-CMD RxAppCntReq	
		-	FPort = 224	
			Payload = [0x]09	
4	DUT sends Unconfirmed frame	\rightarrow	CP-CMD RxAppCntAns	
			FPort = 224	
			Payload = [0x]09XXXX	
			RxAppCnt = y	
5	DUT sends Unconfirmed frame	→ R [60]		
	The TCL sends Unconfirmed frame	← R [60]	CP-CMD TxFramesCtrlReq	
	on RX2 window	(17 [00]	FrameType = No change	
	on rote window		DataRate = X	
	Repeat 60 times		FPort = 224	
	riopeat ee umee		Payload = [0x]0700 (MaxLen	
	For each unique RX2 Data Rate, the		for RX2 DR)	
	TCL will perform the Sufficient		,	
	Reception test.			
6	DUT sends Unconfirmed frame	\rightarrow		
	The TCL sends Unconfirmed frames	+	CP-CMD RxAppCntReq	
			FPort = 224	
			Payload = [0x]09	
7	DUT sends Unconfirmed frame	\rightarrow	CP-CMD RxAppCntAns	Reception
			FPort = 224	failure rate
			Payload = [0x]09XXXX	<=5%
			$RxAppCnt \le y + 60 + 1$	
			RxAppCnt >= y + 57 + 1	Refer to
				Section 2 –
				Test Notes
				for missed
				RxAppCntA
				ns



Step	Procedure	Me	essage Sequence	Tes	st
				Purpose	
		End Device - TCL	Message		
	Repeat above steps 2-7 until all RX2				
	DataRates are tested				
8	DUT sends Unconfirmed frame	\rightarrow			
	The TCL sends Unconfirmed frame	←	MAC-CMD	Revert	to
			RxParamSetupReq	default	RX2
			RX1DROffset = default,	DR	
			refer [2]		
			RX2DataRate = default,		
			refer [2]		
			RX2 Frequency = default,		
			refer [2]		
			Payload =		
			[0x]05XXXXXXX		
9	DUT sends Unconfirmed frame	\rightarrow	MAC-CMD		
			RxParamSetupAns		
			Payload = [0x]0507		

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2.5.11.c. RX1 and RX2 simultaneous frames

This test validates that when **TCL** sends frames on both RX1 and RX2 windows simultaneously, **DUT** responds to the frame on the RX1 window and rejects the frame on the RX2 window.

Please note that this test must be skipped for permanent Class C enabled devices.

1303 **2.5.11.c.i.** Test Procedure Message Sequence Chart

TI	DUT sends Unconfirmed frame The TCL sends Unconfirmed frame on RX1 window	End Device - TCL R [4] →	Message	-
TI	The TCL sends Unconfirmed frame	R [4]	CD CMD Ty-France CtdDag	
Or TI		\rightarrow	CD CMD Ty/Frames CtrlDes	
	The TCL sends Confirmed frame on RX2 window	←	CP-CMD TxFramesCtrlReq FrameType = No change FPort = 224 Payload = [0x]0700 CP-CMD TxFramesCtrlReq FrameType = No change FPort = 224 Payload = [0x]0700	
2 D	DUT sends Unconfirmed frame	←	No ACK is received	RX2 uplink is ignored and hence no ACK is sent
	he steps 1 and 2 'four' times. Confirm	\rightarrow		

2.5.11.d. **RX Oversized Payload**

A follow-up negative test must be performed for each oversized scenario. The Max Payload size for each region is defined in [2]. After commanding the **DUT** such that the target RX DR is





1307 1308	·	TCL sends a downlink whose payload is one byte greater than the scenario's e the payload content is random (i.e. not the echo command).
1309 1310	The TCL must receive window	use both confirmed and unconfirmed oversized frames; as well as target both vs.
1311	Verify	
1312		DUT continues normal operation in the presence of oversized downlinks. DUT
1313	must	t silently discard the oversized downlinks.
1314 1315	2.5.11.d.i.	Test Procedure Frame Sequence Chart



Step	Procedure	i	Frame Sequence	Test Purpose
		End Device - TCL	Frame	
1	DUT sends Unconfirmed frame	\rightarrow		
	The TCL sends Unconfirmed frames	+	CP-CMD RegionalDutyCycleCtrlReq- OFF FPort = 224 Payload = [0x]0500	
	Repeat Steps 2-7 'i' times, where i =	R		
	all possible combinations in the Maximum Payload size table in [2]	Steps 2-7 for [All DR in Max Payload table]		
2	DUT sends Unconfirmed frame	\rightarrow		
	The TCL sends Unconfirmed frame	←	MAC-CMD LinkADRReq DataRate = X (where X = Each DR supported by the DUT as defined in the Maximum Payload size table in [2]) ChMaskCntl: DC = 0, FC = 6 ChMask: DC - Enable only default channels FC = [0x]00FF MAC-CMD RxParamSetupReq RX1DRoffset = As applicable for the DR being tested, refer Maximum Payload size table in [2]. RX2DataRate = Y (where Y = Each RX2DataRate as defined in the Maximum Payload size table in [2]) Freq = default frequency [2] Payload = [0x]03XXXXXXXXXXX[0x]05XXX	For FC device using 8-channel gateway, refer to Section 2 for ChMask settings
2	DUT sends Unconfirmed frame		XXXXX MAC CMD LinkADBAna	
3		→	MAC-CMD LinkADRAns MAC-CMD RxParamSetupAns Payload = [0x]0307[0x]0507	
	The TCL sends Unconfirmed frame on RX1 window	←	CP-CMD TxFramesCtrlReq FPort = 224 FrameType = Confirmed Payload (i) = [0x]0702(MaxLen + 1 for UL DR-X)	



Step	Procedure	[Frame Sequence	Test
				Purpose
		End Device - TCL	Frame	
4	DUT sends Unconfirmed frame)		DUT discards the oversized frame and sends Unconfirmed frame
	The TCL sends Unconfirmed frame on RX2 window	←	CP-CMD TxFramesCtrlReq FPort = 224 FrameType = Confirmed Payload (i) = [0x]0702 (MaxLen + 1 for UL DR-Y)	
5	DUT sends Unconfirmed frame	→		DUT continues normal operation
	The TCL sends Confirmed frame on RX1 window	+	CP-CMD TxFramesCtrlReq FPort = 224 FrameType = No change Payload (i) = [0x]0700 (MaxLen + 1 for UL DR-X)	
6	DUT sends Unconfirmed frame	→	No ACK	DUT continues normal operation (RX1)
	The TCL sends Confirmed frame on RX2 window	+	CP-CMD TxFramesCtrlReq FPort = 224 FrameType = No change Payload (i) = [0x]0700 (MaxLen + 1 for UL DR-Y)	
7	DUT sends Unconfirmed frame)	No ACK	DUT continues normal operation (RX2)
	Repeat above steps 2-7 until all Data Rates in the Max Payload table are tested			
8	DUT sends Unconfirmed frame	\rightarrow		



Step	Procedure	Frame Sequence		Test
				Purpose
		End Device	Frame	
		- TCL		
	The TCL sends Unconfirmed frame	←	MAC-CMD LinkADRReq	For FC
			DataRate = Max125kHzDR,	device using
			refer [2]	8-channel
			ChMaskCntl:	gateway,
			DC = 0,	refer to
			FC = 6	Section 2 for
			ChMask:	ChMask
			DC - Enable only default	settings
			channels	
			FC = [0x]00FF	
			MAC-CMD	
			RxParamSetupReq	
			RX1DRoffset = 0	
			RX2DataRate = default, refer	
			[2]	
			Freq = default frequency,	
			refer [2]	
			Payload =	
			[0x]03XXXXXXXX[0x]05XXX	
			XXXXX	
9	DUT sends Unconfirmed frame	\rightarrow	MAC-CMD LinkADRAns	DUT
			MAC-CMD	reverted to
			RxParamSetupAns	default
			Payload = [0x]0307[0x]0507	settings
	The TCL sends Unconfirmed frames	+	CP-CMD	
			RegionalDutyCycleCtrlReq-	
			ON	
			FPort = 224	
			Payload = [0x]0501	
10	DUT sends Unconfirmed frame	\rightarrow		

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2.5.11.e. Maximum Allowed Payload

The purpose of this test is to validate the maximum allowable payload sizes in uplink transmissions. The test depends on properly functioning *LinkADRReq* and *RXParamSetupReq* MAC command control. The first part validates the maximum uplink payload for each of the five uplink data rates against both receive windows, testing both positive and negative scenarios. The second part validates the maximum downlink payload for the various RX1DR offsets as well as various RX2 data rates.

The **TCL** commands the **DUT** with some combination of the following settings and validates the device successfully implements them before proceeding to test max payload handling:

- RX1DRoffset = 0
- RX2DataRate = Maximum default Data Rate, refer [2]
- The Maximum Payload size for each region is defined in [2].





1329	2.5.11.e.i. Max Payload via Echo
1330	These tests are performed on both RX1 and RX2 Windows. For each 'Uplink DR'
1331	the TCL first commands the DUT to use the target 'Uplink DR' and verifies the
1332	configuration. It then sends an echo command ([0x]08) whose payload size is the
1333	minimum of (maximum allowed for the uplink DR or maximum allowed for the
1334	downlink DR) as defined in [2].
1335	
1336	Verify
1337	 The DUT responds to each echo command with an echo answer.
1338	 The payload size is in fact the maximum for the DUT's current DR and its
1339	content is correct.
1340	2.5.11.e.i.1. Test Procedure Frame Sequence Chart
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Step	Procedure	ı	Frame Sequence		
		End Device - TCL	Frame	Purpose	
1	DUT sends Unconfirmed frame	\rightarrow			
	The TCL sends Unconfirmed frames	+	CP-CMD RegionalDutyCycleCtrlReq- OFF FPort = 224 Payload = [0x]0500		
	Repeat Steps 2-5 'i' times, where i = all possible combinations in the Maximum Payload size table in [2]	R Steps 2-5 for [All DR in Max payload table]			
2	DUT sends Unconfirmed frame	\rightarrow			
	The TCL sends Unconfirmed frame	←	MAC-CMD LinkADRReq DataRate = X (where X = Each DR as defined in the Maximum Payload size table in [2]) ChMaskCntl: DC = 0, FC = 6 ChMask: DC - Enable only default channels FC = [0x]00FF MAC-CMD RxParamSetupReq RX1DRoffset = 0 RX2DataRate = Maximum default DR, refer [2] Freq = default frequency [2] Payload = [0x]03XXXXXXXXXX[0x]05XXX XXXX	For FC device using 8-channel gateway, refer to Section 2 for ChMask settings	
3	DUT sends Unconfirmed frame	→	MAC-CMD LinkADRAns MAC-CMD RxParamSetupAns Payload = [0x]0307[0x]0507 DataRate = X		
	The TCL sends Unconfirmed frame on RX1 window	+	CP-CMD EchoPayloadReq FPort = 224 Payload (i) = [0x]08XX minimum (MaxLen for UL DR-X, MaxLen for DL DR-X)		



Step	Procedure Frame Sequence			Test
		End Device - TCL	Frame	
4	DUT sends Unconfirmed frame	→	DataRate = X	DUT echos MaxLen
			CP-CMD EchoPayloadAns FPort = 224	PDU for each Uplink
			Payload (i)' = [0x]08XX (MaxLen for DR-X)	DR on RX1
	The TCL sends Unconfirmed frame	←	CP-CMD EchoPayloadReq	
	on RX2 window		FPort = 224 Payload (i) = [0x]08XX	
	DIT de lle ferre ed ferre		(MaxLen for UL DR-X)	DUT
5	DUT sends Unconfirmed frame	→	DataRate = X CP-CMD EchoPayloadAns	DUT echos MaxLen PDU for
			FPort = 224	each Uplink
			Payload (i)' = [0x]08XX (MaxLen for DR-X)	DR on RX2
	Repeat above Steps 2-5 for all DR in Max payload size table			
6	DUT sends Unconfirmed frame	\rightarrow		
	The TCL sends Unconfirmed frame	←	MAC-CMD LinkADRReq DataRate = Max125kHzDR, refer [2] ChMaskCntl: DC = 0, FC = 6 ChMask: DC - Enable only default channels FC = [0x]00FF MAC-CMD RxParamSetupReq RX1DRoffset = 0 RX2DataRate = default DR, refer [2] Freq = default frequency, refer [2] Payload = [0x]03XXXXXXXXXX[0x]05XXX	For FC device using 8-channel gateway, refer to Section 2 for ChMask settings
7	DUT sends Unconfirmed frame	→	MAC-CMD LinkADRAns	DUT
			MAC-CMD RxParamSetupAns	reverted to default settings
		_	Payload = [0x]0307[0x]0507	
	The TCL sends Unconfirmed frames	←	CP-CMD RegionalDutyCycleCtrlReq- ON FPort = 224 Payload = [0x]0501	
8	DUT sends Unconfirmed frame	→	i ayibau – [UX]UUUT	





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1344 1345	2.5.11.e.ii. Oversized Payload via Echo These tests are performed on RX2 Window only. For each 'Uplink DR', the TCL first
1346	commands the DUT to use the target 'Uplink DR' and verifies the configuration. It
1347	then sends an echo command ([0x]08) whose payload size is one byte greater than
1348	the current maximum allowed for the uplink DR. The Maximum Payload size for
1349	each region is defined in [2].
1350	Verify
1351	• The DUT does not uplink an echo response for any of the echo commands
1352	due to uplink size limitation. It may either respond with an uplink that
1353	has no payload, or silently discard the echo-command.
1354	 Subsequent to the first uplink sent after receiving the command, uplinks
1355	must resume containing only the default payload (downlink counter).
1356 1357 1358	2.5.11.e.ii.1. Test Procedure Frame Sequence Chart



Step	Procedure	ı	Test Purpose	
		End Device - TCL	Frame	•
1	DUT sends Unconfirmed frame	\rightarrow		
	The TCL sends Unconfirmed frames	+	CP-CMD RegionalDutyCycleCtrlReq- OFF FPort = 224 Payload = [0x]0500	
	Repeat Steps 2-4 'i' times, where i =	R		
	all possible combinations in the Maximum Payload size table in [2]	Steps 4-6 [All DR in Max Payload table]		
2	DUT sends Unconfirmed frame	\rightarrow		
	The TCL sends Unconfirmed frame	←	MAC-CMD LinkADRReq DataRate = X (where X = Each DR as defined in the Maximum Payload size table in [2]) ChMaskCntl: DC = 0, FC = 6 ChMask: DC - Enable only default channels FC = [0x]00FF MAC-CMD RxParamSetupReq RX1DRoffset = 0 RX2DataRate = Maximum default DR, refer [2] Freq = default frequency, refer [2] Payload = [0x]03XXXXXXXXXX[0x]05XX XXXXXX	For FC device using 8-channel gateway, refer to Section 2 for ChMask settings
3	DUT sends Unconfirmed frame	→	MAC-CMD LinkADRAns MAC-CMD RxParamSetupAns Payload = [0x]0307[0x]0507 DataRate = X	
	The TCL sends Unconfirmed frame on RX2 window	+	CP-CMD EchoPayloadReq FPort = 224 Payload (i) = [0x]08XX (MaxLen + 1 for UL DR-X)	



Step	Procedure	F	Test	
			Purpose	
		End Device - TCL	Frame	
4	DUT sends Unconfirmed frame	→	Payload does not exceed limits	DUT continues normal operation in the presence of oversized downlinks after each Uplink DR on RX2
	Repeat above Steps 2-4 for all DR in Max payload size table			
5	DUT sends Unconfirmed frame	\rightarrow		
	The TCL sends Unconfirmed frame	÷	MAC-CMD LinkADRReq DataRate = Max125kHzDR, refer [2] ChMaskCntl: DC = 0; FC = 6 ChMask: DC - Enable only default channels FC = [0x]00FF MAC-CMD RxParamSetupReq RX1DRoffset = 0 RX2DataRate = default DR, refer [2] Freq = default frequency, refer [2] Payload = [0x]03XXXXXXXXXX[0x]05XX XXXXXX	For FC device using 8-channel gateway, refer to Section 2 for ChMask settings
6	DUT sends Unconfirmed frame	→	MAC-CMD LinkADRAns MAC-CMD RxParamSetupAns Payload = [0x]0307[0x]0507	DUT reverted to default settings
	The TCL sends Unconfirmed frames	+	CP-CMD RegionalDutyCycleCtrlReq- ON FPort = 224 Payload = [0x]0501	
7	DUT sends Unconfirmed frame	\rightarrow		





2.5.12. MAC Command(s) in App-Payload and/or Frame Options

These tests ensure a **DUT** appropriately accepts and processes or discards a downlink whose contents include one or more MAC commands in the App-Payload (i.e. FRMPayload) and/or the Frame options (FOpts) portion of the frame.

2.5.12.a. App-Payload Only (FPort = 0)

Perform the test listed below such that all MAC commands are sent to the **DUT** within the App-Payload portion of a single downlink. Successful completion of each test indicates the MAC Command payload is properly decrypted using the Network Session Key and processed by the **DUT**. It is up to the **DUT** to choose how it answers: it can choose either the FOpts field or the FRMPayload. Some devices for example may use the FRMPayload when the MAC command answers are larger than the 15 bytes limit of the FOpts field.

- DevStatusReq
- RxParamSetupReq
- RxTimingSetupReq
- 1375LinkADRReq

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2.5.12.a.i. Test Procedure Frame Sequence Chart

Step	Procedure	Frame Sequence		Test
			T =	Purpose
		End Device	Frame	
		- TCL		
1	DUT sends Unconfirmed frame	→		
	FCntUp = n			
	The TCL sends Unconfirmed frame	+	App-Payload	For FC
			MAC-CMD1 DevStatusReq	device using
			MAC-CMD2	8-channel
			RxParamSetupReq	gateway,
			MAC-CMD3	refer to
			RxTimingSetupReq	Section 2 for
			MAC-CMD4 LinkADRReq	ChMask
			(DR = Max125kHzDR)	settings
			Doylood	
			Payload = [0x]06[0x]05XXXXXXXXX[0x]0	
			8XX[0x]03XXXXXXXX	
			8//[0/]03///////	
			FPort = 0	
2	DUT sends Unconfirmed frame	→	MAC-CMD1 DevStatusAns	Successful
_	FCntUp = n + 1		MAC-CMD2	completion
			RxParamSetupAns	of each
			MAC-CMD3	command
			RxTimingSetupAns	Command
			MAC-CMD4 LinkADRAns	
			WINTER CONTROL LINIO (E) O (TIE	
			Payload =	
			[0x]06XXXX[0x]0507[0x]08[0	
			x]0307	
3	The TCL sends Unconfirmed frame	+	CP-CMD TxFramesCtrlReq	
			FrameType = No change	
			FPort = 224	
			Payload = [0x]0700	
	DUT sends Unconfirmed frame	\rightarrow		
	FCntUp = n + 2			

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2.5.12.b. Frame Options Only (FPort NOT = 0)

Perform the test listed below such that all MAC commands are sent to the **DUT** within the Frame Options field (i.e. FOpts) portion of a single downlink. Successful completion of each test indicates the MAC Command payload is properly decrypted using the Application Session Key and processed by the **DUT**. It is up to the **DUT** to choose how it answers: it can choose either the FOpts field or the FRMPayload. Some devices for example may use the FRMPayload when the MAC command answers are larger than the 15 bytes limit of the FOpts field.

- DevStatusReg
- RxParamSetupReq
- RxTimingSetupReq
- 1388 LinkADRReq



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2.5.12.b.i. Test Procedure Frame Sequence Chart

Step	Procedure		Frame Sequence	Test Purpose
		End Device - TCL	Frame	peec
1	DUT sends Unconfirmed frame FCntUp = n	\rightarrow		
	The TCL sends Unconfirmed frame	+	Frame Options MAC-CMD1 DevStatusReq MAC-CMD2 RxParamSetupReq MAC-CMD3 RxTimingSetupReq MAC-CMD4 LinkADRReq (DR = Max125kHzDR) Payload = [0x]06[0x]05XXXXXXXXX[0x]0 8XX[0x]03XXXXXXXXX	For FC device using 8-channel gateway, refer to Section 2 for ChMask settings
2	DUT sends Unconfirmed frame FCntUp = n + 1	→	MAC-CMD1 DevStatusAns MAC-CMD2 RxParamSetupAns MAC-CMD3 RxTimingSetupAns MAC-CMD4 LinkADRAns Payload = [0x]06XXXX[0x]0507[0x]08[0 x]0307	Successful completion of each command
	The TCL sends Unconfirmed frame	+	CP-CMD TxFramesCtrlReq FrameType = No change FPort = 224 Payload = [0x]0700	
3	DUT sends Unconfirmed frame FCntUp = n + 2	>		

2.5.12.c. App-Payload and Frame Options 1390 1391 TCL sends Unconfirmed downlinks with MAC commands simulataneously in the App-Payload and Frame Options (FOpts) fields to the DUT. Repeat 4 times. 1392 1393 Verify the **DUT** silently discards the frames and does not send any MAC response. 1394 Repeat the above procedure for Confirmed downlinks. 1395 Verify the **DUT** silently discards the frames and does not send any MAC response. No ACK must 1396 be sent. 1397 1398 1399 2.5.12.c.i. **Test Procedure Frame Sequence Chart**



Step	Procedure	ı	Test Purpose	
		End Device - TCL	Frame	-
1	DUT sends Unconfirmed frame	→ R [4]	No MAC response	
	Repeat 4 times			
	The TCL sends Unconfirmed frame	← R [4]	Frame Options MAC-CMD1 LinkADRReq MAC-CMD2 LinkADRReq MAC-CMD3 RxParamSetupReq Payload = [0x]03XXXXXXXXXXX App-Payload MAC-CMD1' LinkADRReq MAC-CMD2' RxTimingSetupReq MAC-CMD3' DevStatusReq Payload = [0x]03XXXXXXXXXX[0x]08XX[0x]06	This frame must be silently discarded when MAC commands are present simultaneou sly in App- Payload and FOpts field
2	DUT sends Unconfirmed frame	→ R [4]	No MAC response No ACK	
	Repeat 4 times The TCL sends Confirmed frame	← R [4]	Frame Options MAC-CMD1 LinkADRReq MAC-CMD2 LinkADRReq MAC-CMD3 RxParamSetupReq Payload = [0x]03XXXXXXXX[0x]03XXX XXXXX[0x]05XXXXXXX App-Payload MAC-CMD1' LinkADRReq MAC-CMD2' RxTimingSetupReq MAC-CMD3' DevStatusReq Payload = [0x]03XXXXXXXXX[0x]08XX[0 x]06	This frame must be silently discarded when MAC commands are present simulaneousl y in App-Payload and FOpts field
3	DUT sends Unconfirmed frame	→	No MAC response No ACK	

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2.5.13. Incorrect MAC Commands

These tests ensure that a **DUT** behaves normally after it receives incorrect MAC commands from the

1405 The invalid commands are:

• LinkADRReq with value out of spec - Payload: [0x]0380000000

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1407	 Incomplete MAC command - Payload: [0x]03010000
1408	 Post Unknown MAC command ID - Payload: [0x]7F
1409	 Valid MAC command followed by invalid MAC commands – Payload: [0x]0603010000
1410	Verify:
1411	The DUT continues normal operation after receiving the invalid commands
1412	
1413	2.5.13.a. Test Procedure Frame Sequence Chart
1414	



Step	Procedure	Frame Sequence		Test Purpose
		End Device - TCL	Frame	
1	DUT sends Unconfirmed frame	\rightarrow		
	The TCL sends Unconfirmed frame	←	MAC-CMD LinkADRReq Payload = [0x]0380000000 FPort = 0	
2	DUT sends Unconfirmed frame	→	LinkADRAns NOT = OK	DUT continues normal operation after receiving LinkADRReq with 'out of spec' Payload
	The TCL sends Unconfirmed frame	←	MAC-CMD LinkADRReq Payload = [0x]03010000 FPort = 0	
3	DUT sends Unconfirmed frame	→	No response	DUT continues normal operation after incomplete MAC command Payload
	The TCL sends Unconfirmed frame	+	MAC-CMD Payload = [0x]7F FPort = 0	
4	DUT sends Unconfirmed frame	→	No response	DUT continues normal operation after unknown MAC command Payload
	The TCL sends Unconfirmed frame	+	MAC-CMD1 DevStatusReq MAC-CMD2 incomplete LinkADRReq Payload = [0x]0603010000 FPort = 0	
5	DUT sends Unconfirmed frame	→	MAC-CMD1 DevStatusAns Payload = [0x]06XXXX	DUT continues normal operation after incomplete MAC command Payload
	The TCL sends Unconfirmed frame	+	MAC-CMD1 LinkADRReq (DR = Max125kHzDR) MAC-CMD2 [0x]7F CMD3 DevStatusReq FPort = 0	For FC device using 8- channel gateway, refer to Section 2 for ChMask settings
6	DUT sends Unconfirmed frame	→	MAC-CMD1 LinkADRAns Payload = [0x]0307	DUT answers only the first MAC command and continues normal operation if the second MAC command is invalid





7	Wait for a	→ R	For DC plan devices: Only	
	Dynamic channel: maximum of 5 *	[5*NbCh	default channels must be	
	(number of channels currently	DC] or	used. The additional	
	enabled on the DUT)	[2*NbChF	channel must not be	
	Fixed channel: maximum of 2 *	C] or	added.	
	(number of channels currently	[AllCh		
	enabled on the DUT)	used]	For FC plan devices: The	
	uplink packets to be sent.		DUT must send an uplink	
			on any of the channels	
			enabled.	



1416 **2.5.14.** Multiple MAC commands prioritization

This test verifies that when a combination of application payload and MAC answers, or new MAC commands are sent by the DUT, the priority for including information in the frame is as shown below.

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Priority Level	Information type
Highest	MAC answers
	New MAC commands
Lowest	Application payload

1420 Table 4: Transmit data insertion prioritization

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Additionally, if the commands cannot fit in the same frame due to size restrictions, the message must be truncated.

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1426 Verification summary:

- Within a single frame, the DUT must send all higher-priority information before sending any lower- priority information.
- If the MAC command buffer is too large to fit in the frame, the DUT must truncate the buffer at the end of the last MAC command that is able to fit within the frame.
 - The DUT must execute the full list of MAC commands even if the buffer containing the MAC answers is truncated
- 1433 2.5.14.a. **Test Procedure Frame Sequence Chart**

1434

1431



Step	Procedure	Frame Sequence		Test Purpose
		End Device - TCL	Frame	
1	DUT sends Unconfirmed frame	→		
	The TCL sends Unconfirmed frame	+	FPort = 224 CP-CMD LinkCheckReq	For FC device using 8-channel
			MAC-CMD DevStatusReq	gateway, refer to
			MAC-CMD LinkADRReq DataRate = Max125kHzDR	Section 2 for ChMask settings
			Payload = [0x]20 FOpts = [0x]06[0x]03XXXXXXXX	ŭ
2	DUT sends Unconfirmed frame	→	MAC-CMD DevStatusAns	DUT
	Do i serius oficoniimieu frame		MAC-CMD LinkADRAns	prioritises MAC
			MAC-CMD LinkCheckReq Payload =	answers over
			[0x]06XXXX[0x]0307[0x]02	new MAC
			Note: The LinkCheckReq	and
			may be sent in a separate	application
			uplink. In that case, the MAC	payload
			commands must be	
			answered in the first uplink	
			and the LinkCheckReq must	
			be sent in the second uplink.	
	The TCL sends Unconfirmed frame	+	MAC-CMD LinkCheckAns	
0	DUT and de live a of mand from		Payload = [0x]02XXXX	
3	DUT sends Unconfirmed frame	\rightarrow		
	The TCL sends Unconfirmed frame	+	MAC-CMD	Set
			TXParamSetupReq	TXParamSet
	Note: This step is required for only		UplinkDwellTime = 0	upReq for
	regions with Dwell Time limitation		Payload = [0x]09XX	regions with Dwell time
				limitation
4	DUT sends Unconfirmed frame	→	For regions with Dwell time	
			limitation only	
			MAC-CMD	
			TXParamSetupAns	
			Payload = [0x]09	
			DataRate = Max125kHzDR	



	TCL also sends Unconfirmed frame	←	MAC CMD4 Day Ctatus Day	F F0
	TCL also sends Unconfirmed frame	_	MAC-CMD1 DevStatusReq	For FC device using
			MAC-CMD2	8-channel
			RxParamSetupReq	gateway,
				refer to
			Repeat the MAC-CMD	Section 2 for
			DevStatusReq until the MAC	ChMask
			command uplink response	settings
			buffer would be full for	· ·
			MinDR, refer [2]	
			MAC-CMDX LinkADRReq	
			(with DataRate = MinDR)	
			For example: For EU863-	
			870, the Max payload size is	
			51 bytes for MinDR. Hence	
			repeat the DevStatusReq	
			command 15 times to ensure	
			the MAC command response buffer is greater than 51	
			bytes.	
			Payload =	
			[0x]06[0x]05XXXXXXXX[0x]0	
			6[Repeat as	
			required][0x]03XXXXXXXX	
5	DUT sends Unconfirmed frame	→	DataRate = MinDR	Successful
		-		completion of
			MAC-CMD1 DevStatusAns	all MAC
			MAC-CMD2	commands in
			RxParamSetupAns	the correct
			MAC-CMD3 DevStatusAns	sequence.
				Message
			MAC-CMDX DevStatusAns	truncated.
			Payload =	
			[0x]06XXXX[0x]0507[0x]06X	
			XXX[0x]06XXXX	
			DUT truncates the MAC	
			command when max	
			payload size is exceeded.	
			The sequence of the	
			response must be exactly	
			the same as described.	
			The LinkADRAns is not sent	
			in the response as it must be	
			truncated due to payload	
			size restrictions. However,	
			the DD and Cl. 11	
			the DR must be set to MinDR.	



	TCL also sends Unconfirmed frame	+	MAC-CMD1 DevStatusReq	For FC
			MAC-CMD2	device using 8-channel
			RxParamSetupReq	gateway,
			The control of the q	refer to
			Repeat the MAC-CMD	Section 2 for
			DevStatusReq until the MAC	ChMask
			command uplink response	settings
			buffer would be full for	
			MinDR, refer [2] (i.e. same number of DevStatusReq	
			commands sent in the	
			previous step)	
			MAC OMBYL: LABBB	
			MAC-CMDX LinkADRReq (with DataRate =	
			Max125kHzDR)	
			Wax 125Ki 12DIY)	
			Payload =	
			[0x]06[0x]05XXXXXXX[0x]0	
			6[Repeat as	
	DUT 111 C 16	,	required][0x]03XXXXXXXX	0 (1
6	DUT sends Unconfirmed frame	\rightarrow	DataRate = Max125kHzDR	Successful completion of
			MAC-CMD1 DevStatusAns	all
			MAC-CMD2	commands.
			RxParamSetupAns	Message is
			MAC-CMD3 DevStatusAns	not truncated.
			 MAC-CMDX DevStatusAns	
			MAC-CMDX+1 LinkADRAns	
			Payload =	
			[0x]06XXXX[0x]0507[0x]06X	
			XXX[0x]06XXXX[0x]0307	
			DUT must not truncate the	
			frame.	

3. FPort 224 Deactivation

This test must be performed as the last step ever to be performed on the device. The test lab must ensure that all other tests are completed on the device before performing this test. When the FPort 224 is disabled, it cannot be re-enabled on the device again.

The **TCL** will send a downlink payload message of [0x]07E (*DutFPort224DisableReq*) over port 224, thus disabling FPort 224 for the DUT.

3.1. Test Procedure Message Sequence Chart

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	End		Purpose
	Device - TCL	Message	
DUT sends Unconfirmed frame	→		
The TCL sends Unconfirmed frame	←	CP-CMD DutFPort224DisableReq FPort = 224 Payload = [0x]07E	Disable the FPort 224 for the DUT as the last step of the Test cycle
If the device is an OTAA device, DUT sends Join-Request frame	→		
Else, skip to the next step			
If the device is an OTAA device, TCL sends Join-Accept response	←		Join accepted for OTAA device
DUT sends Unconfirmed or Confirmed frame	\rightarrow	FPort = any allowed port except 224	
The TCL sends Unconfirmed frame	+	CP-CMD TxPeriodicityChangeReq FPort = 224 Periodicity = 5 sec Payload = [0x]0601	Try to set Uplink Periodicity
		frame, TCL must Acknowledge	
DUT sends Unconfirmed or Confirmed frame	→		
If this uplink is not received within 2 minutes, then the test can be ended, and the next steps can be skipped.			
The TCL sends Unconfirmed frame	+	CP-CMD EchoPayloadReq FPort 224 Payload = [0x]08010203 If DUT sent Confirmed uplink	
Wait for a maximum of 3 minutes for the DUT to send an Unconfirmed or Confirmed frame If no uplink is sent, the test can be ended, and the next steps can be skipped.	→	No EchoPayloadAns response received	FPort 224 downlinks are not accepted.
The TCL sends Unconfirmed frame	+	CP-CMD EchoPayloadReq FPort 224 Payload = [0x]08010203 If DUT sent Confirmed uplink frame, TCL must	Repeat the EchoPayloa dReq
	Else, skip to the next step If the device is an OTAA device, TCL sends Join-Accept response DUT sends Unconfirmed or Confirmed frame The TCL sends Unconfirmed frame OUT sends Unconfirmed or Confirmed frame If this uplink is not received within 2 minutes, then the test can be ended, and the next steps can be skipped. The TCL sends Unconfirmed frame Wait for a maximum of 3 minutes for the DUT to send an Unconfirmed or Confirmed frame If no uplink is sent, the test can be ended, and the next steps can be skipped.	Else, skip to the next step If the device is an OTAA device, TCL sends Join-Accept response DUT sends Unconfirmed or Confirmed frame The TCL sends Unconfirmed frame ← DUT sends Unconfirmed or Confirmed frame The TCL sends Unconfirmed or Confirmed frame If this uplink is not received within 2 minutes, then the test can be ended, and the next steps can be skipped. The TCL sends Unconfirmed frame Wait for a maximum of 3 minutes for the DUT to send an Unconfirmed or Confirmed frame If no uplink is sent, the test can be ended, and the next steps can be skipped.	Else, skip to the next step If the device is an OTAA device, TCL sends Join-Accept response DUT sends Unconfirmed or Confirmed frame → FPort = any allowed port except 224 The TCL sends Unconfirmed frame ← CP-CMD TxPeriodicityChangeReq FPort = 224 Periodicity = 5 sec Payload = [0x]0601 If DUT sends Unconfirmed or Confirmed frame, TCL must Acknowledge DUT sends Unconfirmed or Confirmed frame If this uplink is not received within 2 minutes, then the test can be ended, and the next steps can be skipped. The TCL sends Unconfirmed frame ← CP-CMD EchoPayloadReq FPort 224 Payload = [0x]08010203 If DUT sent Confirmed uplink frame, TCL must Acknowledge Wait for a maximum of 3 minutes for the DUT to send an Unconfirmed or Confirmed frame If no uplink is sent, the test can be ended, and the next steps can be skipped. The TCL sends Unconfirmed frame FORT 224 Payload = [0x]08010203 If DUT sent Confirmed plink frame from 224 Payload = [0x]08010203 If DUT sent Confirmed uplink frame from 224 Payload = [0x]08010203 If DUT sent Confirmed uplink frame from 224 Payload = [0x]08010203 If DUT sent Confirmed uplink frame from 224 Payload = [0x]08010203





6	Wait for a maximum of 3 minutes.	\rightarrow	No EchoPayloadAns	FPort 224
			response received	downlinks
				are not
				accepted.



4. Test Case Mapping with LoRaWAN Specification [1]

The following table provides the section mapping between the LoRaWAN Specification [1] and this Certification Specification document

LoRaWAN Spec [1] section	This document section	Description
3.3	2.5.11	Receive Windows
4	0 2.4.1 and 2.4.2	MAC Packet Formats
5.1	2.5.7	LinkCheck
5.2	2.5.8	LinkADR
5.3	0	DutyCycle
5.4	2.5.4	RXParamSetup
5.5	2.5.1	DevStatus
5.6	2.5.2 and 2.5.3	NewChannel and DIChannel
5.7	2.5.5	RXTimingSetup
5.8	2.5.6	TXParamSetup
5.9	2.5.10	DeviceTime
6.2	2.2	Over the air Activation
6.3	2.3	Activation by Personalization

Table 5 LoRaWAN Spec vs Certification Spec mapping

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5. Retransmission back-off tests for power-up or reset of device – for OTAA device only

Note: A 64-channel gateway is required for running the Back-off tests for Fixed channel devices.

Dynamic channel devices may use an 8-channel or 16-channel gateway.

1493 1494

Manually reset the DUT. DUT starts the Join procedure.

1495 1496

TCL ignores the Join-Requests from the DUT.

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For the first one-hour, DUT sends Join-Requests such that the aggregated Transmit time of all uplinks < 36s per hour.

1499 < 36s per hour1500 For the next 10

For the next 10 hours, DUT sends Join-Requests such that the aggregated Transmit time of all uplinks < 36s per 10 hours.

For the next 24 hours, DUT sends Join-Requests such that the aggregated Transmit time of all uplinks < 8.7s per 24 hours.

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Note: The DUT must not reset itself during this period, unless the DUT ensures that it still complies with the above-mentioned transmission timing after reset.

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5.1. Test Procedure Frame Sequence Chart



Step	Procedure	Frame Sequence		Test Purpose
		End Device - TCL	Frame	·
	Manually reset the DUT			
1	DUT sends a Join-Request frame	\rightarrow		
	TCL ignores the Join-Requests from the DUT			
2	DUT sends a Join-Request frame	→ R [1 hour]	For the first one-hour, DUT sends Join-Requests such that the aggregated Transmit time of all uplinks < 36s per hour. For every JR, verify that the Sum of TimeonAir(Rx-Join-Requests) < 36s	
	TCL ignores the Join-Requests from the DUT			
Reset	the TimeonAir sum			
3	DUT sends a Join-Request frame	→ R [10 hours]	For the next 10 hours, DUT sends Join-Requests such that the aggregated Transmit time of all uplinks < 36s per 10 hours. For every JR, verify that the	
			Sum of TimeonAir(Rx-Join- Requests) < 36s	
	TCL ignores the Join-Requests from the DUT			
Reset	the TimeonAir sum	•		
4	DUT sends a Join-Request frame	→ R [24 hours]	For the next 24 hours, DUT sends Join-Requests such that the aggregated Transmit time of all uplinks < 8.7s per 24 hours.	
			For every JR, verify that the Sum of TimeonAir(Rx-Join- Requests) < 8.7s	
	TCL ignores the Join-Requests from the DUT			





6. Certification by Similarity

- This section defines the tests that are required to be performed for devices registering for Certification by Similarity.
- 1514 All devices registering for Certification by Similarity must run the Retransmission back-off tests 1515 specified in Section 5 above, along with all the tests in this section.

1517 A sub-test of the certification tests will be performed for all devices registering for Certification by 1518 Similarity. The tests performed will be:

- Join tests with various parameters
- MAC command tests
 - DevStatusReg
 - NewChannelReq 0
 - DIChannelReq
 - LinkADRReq \circ
- 1524

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- 1525 RXParamSetupReq
- 1526 RXTimingSetupReq \circ
- TXParamSetupReq 1527

1529 Note: In order to ensure that these tests execute quickly, we recommend the DUT to have a faster 1530 periodicity. Additionally, the uplink could be manually triggered to allow the tests to run faster.

6.1. Test Procedure Frame Sequence Chart

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Step	Procedure		Frame Sequence	Test Purpose
		End Device - TCL	Frame	
	Manually reset the DUT			
1	If DUT = OTA device, DUT sends a Join-Request frame If DUT = ABP device, skip to the MAC command tests (Step 2).	→		
	TCL sends Join-Accept response	*	RX1DROffset = 2 RX2DataRate = Any DR except default RX2 DR, as defined in [2] RXDelay = 3 For DC plan devices: CFList = add single channel CFListType = 0 For FC plan devices: CFListType = [0x]01 ChMask0 = [0x]00FF ChMask1 = [0x]0000 ChMask2 = [0x]0000 ChMask3 = [0x]0000 ChMask4 = [0x]0001	Send Join- Accept with varied parameters If the DUT is a FC plan device, it could take several Join- Requests.
2	DUT sends Confirmed or Unconfirmed frame	\rightarrow		
	The TCL sends Confirmed frame in RX1 window	+	MAC-CMD LinkADRReq DataRate = Max125kHzDR, refer [2] Payload = [0x]03XXXXXXXX ChMaskCntl: DC = 0, FC = 6 ChMask:	For FC device using 8-channel gateway, refer to Section 2 for ChMask settings Verify all
			DC - Enable only default channels FC = [0x]00FF	RX1 window parameters
3	DUT sends Confirmed or Unconfirmed frame	→	ACK Bit = True MAC-CMD LinkADRAns Payload = [0x]0307 (if ADR Bit = True) or [0x]030X (if ADR Bit = False)	Changed the DR to Max125kHz DR



	The TCL sends Unconfirmed frame in RX2 window	+	MAC-CMD RXTimingSetupReq Delay = default, refer [2] Payload = [0x]08XX If the uplink was a Confirmed frame, send ACK	For FC device using 8-channel gateway, refer to Section 2 for ChMask settings
4	DUT sends Confirmed or Unconfirmed	→	MAC-CMD	Verify all RX2 window parameters
	frame	-	RXTimingSetupAns Payload = [0x]08	
MAC	Command Tests		r ayream [enge	
5	DUT sends Confirmed or Unconfirmed	\rightarrow	MAC-CMD	
	frame		RxTimingSetupAns Payload = [0x]08	
	The TCL sends Unconfirmed frame	+	MAC-CMD DevStatusReq Payload = [0x]06	
			If the uplink was a Confirmed frame, send ACK	
6	DUT sends Confirmed or Unconfirmed frame	→	MAC-CMD DevStatusAns RadioStatus >= - 32 and <= 31 Payload = [0x]06XXXX	DevStatusAn s sent and encoded value tested
	The TCL sends Unconfirmed frame	+	FPort = 0 MAC-CMD NewChannelReq ChIndex = 7 Freq = any applicable frequency, refer [2] Payload = [0x]07XXXXXXXXXX If the uplink was a Confirmed frame, send ACK	New Observation
7	DUT sends Confirmed or Unconfirmed frame	→	MAC-CMD NewChannelAns Payload = [0x]0703 (for DC) Payload = [0x]0700 or no response is received (for FC)	NewChannel added
8	For DC plan devices only: Wait until the new channel which was added has been used at least once. Wait for a maximum of [5* (number of channels currently enabled on the DUT)] uplink packets to be sent	→ R [5*NbC h] or [AllCh used]	Channel added is used at least once	DUT adds the additional channel to its default channel plan
9	DUT sends Confirmed or Unconfirmed frame	\rightarrow		



	The TCL sends Unconfirmed frame	+	MAC-CMD NewChannelReq ChIndex = 7 Freq = 0 MHz Payload = [0x]07XXXXXXXXX	
			If the uplink was a Confirmed frame, send ACK	
10	DUT sends Confirmed or Unconfirmed frame	\rightarrow	MAC-CMD NewChannelAns Payload = [0x]0703 (for DC)	New channel removed
			Payload = [0x]0700 or no response is received (for FC)	
11	For DC plan devices only: Wait for [5* (number of channels <i>currently</i> enabled on the DUT)] uplink packets to be sent	→ R [5*NbC h] or [AllCh	Channel removed is not used	DUT does not use the removed channel
12	DUT sends Confirmed or Unconfirmed frame	used] →		
	The TCL sends Unconfirmed frame on RX1 window	+	MAC-CMD DIChannelReq ChIndex = C (where C = Any default channel, refer [2])	Change Freq
			Freq = X (where X = any allowed frequency other than the default frequency, refer [2])	
			Payload = [0x]0AXXXXXXXX	
			If the uplink was a Confirmed frame, send ACK	
13	DUT sends Confirmed or Unconfirmed frame	→	MAC-CMD DIChannelAns Payload = [0x]0A03 (for DC)	
			Payload = [0x]0A00 or no response is received (for FC)	
•	14-16 apply to only DC plan devices	T		
14	DUT sends Confirmed or Unconfirmed frame	→ R [max 3]	MAC-CMD DIChannelAns Payload = [0x]0A03	
	Repeat up to 3 times until a downlink is received confirming the receipt of the DIChannelAns			
15	DUT sends Confirmed or Unconfirmed frame	→	MAC-CMD DIChannelAns Payload = [0x]0A03	
	The TCL must send a Confirmed frame on RX1 window	+	If the uplink was a Confirmed frame, send ACK	
16	DUT sends Confirmed or Unconfirmed frame	→R	ACK Bit = True	
	The TCL must send a Confirmed frame on RX1 window	← R [All default	If the uplink was a Confirmed frame, send ACK	
	Repeat for a maximum of (5 * number of default channels) until the DUT sends an uplink on all default channels	channel s]		



47	DIT and Confirmed to the confirmed		If DC plan.	<u> </u>
17	DUT sends Confirmed or Unconfirmed	\rightarrow	If DC plan:	
	frame		ACK Bit = True	
			If FC plan:	
			MAC-CMD DIChannelAns	
			Payload = [0x]0A00 or no	
			response is received	
	TCL sends Unconfirmed frame	←	Freq = As set above	
			MAC-CMD DIChannelReq	
			ChIndex = C	
			Freq = default frequency,	
			refer [2]	
			Payload = [0x]0AXXXXXXXX	
			If the uplink was a Confirmed	
			frame, send ACK	
18	DUT sends Confirmed or Unconfirmed	\rightarrow	MAC-CMD DIChannelAns	Freq
	frame		Payload = [0x]0A03 (for DC)	reverted to
				its default
			Payload = [0x]0A00 or no	settings
			response is received (for	
			FC).	
	The TCL sends Unconfirmed frame	+	No FPort and no Payload	Change
				RX2DR
			MAC-CMD	
			RxParamSetupReq	
			RX1DRoffset = default, refer	
			[2]	
			RX2DataRate = Any	
			DataRate allowed except	
			default, refer [2]	
			Frequency = Y (where Y =	
			any frequency allowed, refer	
			[2])	
			Payload = [0x]05XXXXXXXX	
			If the uplink was a Confirmed	
			frame, send ACK	
19	DUT sends Confirmed or Unconfirmed	\rightarrow	MAC-CMD	
	frame		RxParamSetupAns	
			Payload = [0x]0507	
20	DUT sends Confirmed or Unconfirmed	\rightarrow	MAC-CMD	
	frame		RxParamSetupAns	
			Payload = [0x]0507	
			y and judges.	
	The TCL sends Unconfirmed frame in	+		
	RX2 window	`		
21	DUT sends Confirmed or Unconfirmed	→		
'	frame			
1		1		i



	The TCL sends Unconfirmed frame in RX2 window	+	RX2 DR = RX2DataRate set above MAC-CMD RxParamSetupReq RX1DRoffset = 0 RX2DataRate = Default Frequency = Default Payload = [0x]05XXXXXXXX The default values are defined in [2]				
			If the uplink was a Confirmed frame, send ACK				
22	DUT sends Confirmed or Unconfirmed frame	→	MAC-CMD RxParamSetupAns Payload = [0x]0507	RX2 DR to default settings			
	The TCL sends Unconfirmed frame	+					
23	DUT sends Confirmed or Unconfirmed frame	\rightarrow					
TXParamSetup tests must be performed only if applicable for the region							
22	DUT sends Confirmed or Unconfirmed frame	\rightarrow					
	The TCL sends Unconfirmed frame	←	MAC-CMD TXParamSetupReq UplinkDwellTime = 0 Payload = [0x]09XX If the uplink was a Confirmed frame, send ACK	UplinkDwellT ime set to 0			
23	DUT sends Confirmed or Unconfirmed frame	→	MAC-CMD TXParamSetupAns Payload = [0x]09				
24	DUT sends Confirmed or Unconfirmed frame	→	MAC-CMD TXParamSetupAns Payload = [0x]09				
	The TCL sends Unconfirmed frame	+	MAC-CMD DevStatusReq Payload = [0x]06 If the uplink was a Confirmed frame, send ACK				
25	DUT sends Confirmed or Unconfirmed frame	\rightarrow	MAC-CMD DevStatusAns Payload = [0x]06XXXX				





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