LoRaWAN® Regional Parameters RP002-1.0.4

NOTICE OF USE AND DISCLOSURE

LoRa Alliance®
5177 Brandin Court
Fremont, CA 94538
United States

LoRaWAN® Regional Parameters RP002-1.0.4

Authored by the LoRa Alliance Technical Committee Regional Parameters Workgroup

Technical Committee Chair and Vice-Chair:
A. YEGIN (Actility), O. SELLER (Semtech)

Working Group Chair:
D. KJENDAL (Senet)

Editor:
D. KJENDAL (Senet)

Contributors:
J. CATALANO (Kerlink), I. DI GIUSTO (Ventia), P. DUFFY (Cisco), Y. GAUDIN (Kerlink), M. GILBERT (Kerlink), R. GILSON (Comcast), D. HUNT (LoRa Alliance), R. HUSSON (Bouygues), J. JONGBOOM (arm), D. KJENDAL (Senet), J. KNAPP (Semtech), S. LEBRETON (Semtech), M. LEGOURRIEREC (Sagemcom), M. LUIS (Semtech), B. PARATTE (Semtech), D. SMITH (Multitech), N. SORNIN (Semtech), O. SELLER (Semtech), R. SOSS (Actility), P. STRUHSAKER (Carnegie Tech), Z. TAO (Alibaba), D. THOLL (Tektelic), P. THOMSEN (OrbiWise), A. YEGIN (Actility), X. YU (Alibaba), D. YUMING (ZTE)

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Contents

Tables

Figures

1 Introduction

This document describes the LoRaWAN regional parameters for different regulatory regions worldwide. This document is a companion document to the various versions of the *LoRaWAN MAC Layer Protocol Specification* [TS001]. Separating the regional parameters from the protocol specification allows addition of new regions to the former document without impacting the latter document.

The goal of the LoRa Alliance Regional Parameters Working Group is to allow the adoption of the LoRaWAN technology across as many countries as possible. It is to the benefit of the entire eco-system to minimize the number of distinct channel plan definitions. By re-using existing channel plans for regulatory regions that are newly adopting LoRaWAN, the overall effort and the time required for products to be available in the new market is minimized. The Regional Parameters Working Group welcomes and encourages collaboration with local companies and regulators when LoRaWAN is considered for introduction to a new country.

This document defines regional parameters described in all LoRaWAN Layer 2 Specifications published prior to the publication of this document. Where differences exist between LoRaWAN Layer 2 specification revisions, they are highlighted in the text.

Where various attributes of a transmission signal are stated with regard to a region or regulatory environment, this document is not intended to be an authoritative source of regional governmental requirements or regulations and we refer the reader to the specific laws and regulations of the country or region in which they desire to operate in order to obtain authoritative information.

It must be noted here that, regardless of the parameters specified or configured, at no time is any LoRaWAN equipment allowed to operate in a manner contrary to the prevailing local rules and regulations where it is operating. It is the responsibility of the LoRaWAN end-device or gateway to ensure that compliant operation is maintained without any outside assistance from a LoRaWAN network or any other external mechanism.

1.1 Conventions

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in BCP14 [RFC2119] [RFC8174] when, and only when, they appear in all capitals, as shown here.

The tables in this document are normative. The figures and notes in this document are informative.

Referenced document titles are written as *LoRaWAN MAC Layer Protocol Specification* and referenced section titles within this document are written as “Physical Layer”.

Commands are written ***NewChannelReq***, parameters, bits, and bit fields are written `CFListType`, constants are written RECEIVE_DELAY1, variables are written *N*.

In this document:

- The octet order for all multi-octet fields SHALL be little endian.
- EUI are 8-octet fields and SHALL be transmitted as little endian.
- By default, `RFU` bits are Reserved for Future Use and SHALL be set to 0 by the transmitter of the packet and SHALL be silently ignored by the receiver.

1.2 Country Cross Reference Table

In order to support the identification of LoRaWAN channel plans for a given country, the table below provides a quick reference of unlicensed frequency bands and suggested channel plans available to implementors for each country.

Please note that countries listed using italic font are expected to have changes made to their local regulations and therefore the specified channel plan may change.

The table also provides an indication of the existence of known end-devices that are LoRaWAN certified with, and have received, regulatory type approval in the given country.

ISO 3166-1 Country Name (Code alpha-2)	Band/Channels	Channel Plan	LoRaWAN Certified Devices with Regulatory Type Approval
Afghanistan (AF)			
Aland Islands (AX)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	
Albania (AL)	433.05 - 434.79 MHz	EU433	
	863 - 873 MHz	EU863-870	
	915 - 918 MHz	AS923-3	
Algeria (DZ)	862-870 MHz	EU863-870	
	865-868 MHz		
American Samoa (AS)	902 - 928 MHz	US902-928[1]	X
Andorra (AD)	433.05 – 434.79 MHz	EU433	
	863 – 870 MHz	EU863-870	
Angola (AO)			
Anguilla (AI)	915 - 928 MHz[2]	AU915-928[3]	
Antarctica (AQ)			
Antigua and Barbuda (AG)			
Argentina (AR)	915 - 928 MHz[2]**Error! Bookmark not defined.**	AU915-928	
Armenia (AM)	863 – 870 MHz	EU863-870	
	433.05 – 434.79 MHz	EU433	
Aruba (AW)			
Australia (AU)	915 - 928 MHz[4]	AS923-1	X
		AU915-928	X

[1] AU915-928 also applies to this band.
[2] Regulations imply 902-928 MHz, but only 915-928 MHz is available.
[3] AS923-1,2,3,4 also apply to this band.
[4] While multiple channel plans are applicable to this band, AS923-1 is recommended by the major public operators in Australia to facilitate roaming across networks in Australia and other APAC countries, while also simplifying manufacturing and supply-chain logistics for device manufacturers targeting Australia and other APAC countries supporting AS923-1.

Austria (AT)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	X
Azerbaijan (AZ)	433.05 – 434.79 MHz	EU433	
	868 – 868.6 MHz		
	868.7 – 869.2 MHz		
Bahamas (BS)	902 – 928 MHz	US902-928[1]	
Bahrain (BH)	433 – 434 MHz	EU433	
	863 - 870 MHz	EU863-870	
Bangladesh (BD)	433.05 - 434.79 MHz	EU433	
	866 - 868 MHz		
	922 - 925.0 MHz	AS923-1	
Barbados (BB)	902 - 928 MHz	AU915-928[5]	
Belarus (BY)	433.05 - 434.79 MHz	EU433	
	864.4 - 868.6 MHz	EU863-870	
	869-869.2 MHz	EU863-870	
	869.4 – 869.65 MHz	EU863-870	
	869.7 – 870 MHz	EU863-870	
Belgium (BE)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	X
Belize (BZ)	902 - 928 MHz	AU915-928[4]	
Benin (BJ)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	
Bermuda (BM)	902 - 928 MHz	US902-928[1]	
Bhutan (BT)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	
Bolivia (BO)	915 - 930 MHz	AS923-1[3]	
Bonaire, Sint Eustatius and Saba (BQ)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	Prohibited	
Bosnia and Herzegovina (BA)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	
Botswana (BW)	433.05 – 434.79 MHz	EU433	
	862 – 870 MHz	EU863-870	
Bouvet Island (BV)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	
	915 - 918 MHz	AS923-3	
Brazil (BR)	902 - 907.5 MHz		
	915 - 928 MHz	AU915-928	
	433 - 435 MHz	EU433	
British Indian Ocean Territory (IO)			
Brunei Darussalam (BN)	866 - 870 MHz	EU863-870	
	920 - 925 MHz	AS923-1	

[5] US902-928 also applies to this band.

	433 - 435 MHz	EU433	
Bulgaria (BG)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	X
Burundi (BI)	433.05 - 434.79 MHz	EU433	
	868 - 870 MHz	EU863-870	
Burkina Faso (BF)			
Cabo Verde (CV)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	
Cambodia (KH)	866 - 869 MHz	EU863-870	
	923 - 925 MHz	AS923-1	
Cameroon (CM)	433.05 – 434.79 MHz	EU433	
Canada (CA)	902 - 928 MHz	US902-928[1]	X
Central African Republic (CF)			
Chad (TD)			
Chile (CL)	433 – 434.79 MHz	EU433	
	915 - 928MHz[2]**Error! Bookmark not defined.**	AU915-928[3]	
China (CN)	920.5 - 924.5 MHz		
	779 - 787 MHz[6]	CN779-787	
	470 - 510 MHz	CN470-510	
	314 - 316 MHz		
	430 - 432 MHz		
	840 - 845 MHz		
Christmas Island (CX)	915 - 928 MHz[4]	AS923-1 AU915-928	
Cocos Islands (CC)	915 - 928 MHz[4]	AS923-1 AU915-928	
Colombia (CO)	433 – 434.79 MHz	EU433	
	915 - 928 MHz	AU915-928	
Comoros (KM)	433.05 - 434.79 MHz	EU433	
	862 – 876 MHz	EU863-870	
	915 - 921 MHz	AS923-3	
Congo, Democratic Republic of (CD)			
Congo (CG)			
Cook Islands (CK)	433.05 - 434.79 MHz	EU433	
	819 - 824 MHz		
	864 - 868 MHz	IN865-867	
	915 - 928 MHz[4]	AS923-1 AU915-928	
Costa Rica (CR)	433.05 - 434.79 MHz	EU433	
	920.5 - 928 MHz	AS923-1	

[6] CN779-787 devices may not be produced, imported, or installed after 2021-01-01; deployed devices may continue to operate through their normal end-of-life.

Côte d'Ivoire (CI)	868 – 870 MHz	EU863-870	
Croatia (HR)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	X
Cuba (CU)	433.05 - 434.79 MHz	EU433	
	915 - 921 MHz	AS923-3	
Curaçao (CW)	433.05 - 434.79 MHz	EU433	
	920 - 925 MHz	AS923-1	
Cyprus (CY)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	X
Czechia (CZ)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	X
Denmark (DK)	433.05 - 434.79 MHz	EU433	
	863 - 873 MHz	EU863-870	X
	915 - 918 MHz	AS923-3	
Djibouti (DJ)			
Dominica (DM)	902 - 928 MHz	AU915-928[4]	
Dominican Republic (DO)	915 - 928 MHz	AU915-928	
Ecuador (EC)	902 - 928 MHz	AU915-928**Error! Bookmark not defined.**[3] [4]	
Egypt (EG)	433.05 - 434.79 MHz	EU433	
	865 – 868 MHz	IN865-867	
	863 - 870 MHz	EU863-870	
El Salvador (SV)	915 – 928 MHz	AU915-928[3]	
Equatorial Guinea (GQ)	433.05 - 434.79 MHz	EU433	
	868 - 870 MHz	EU863-870	
Eritrea (ER)			
Estonia (EE)	433.05 - 434.79 MHz	EU433	
	863 - 873 MHz	EU863-870	X
	915 - 918 MHz	AS923-3	
Eswatini (SZ)			
Ethiopia (ET)			
Falkland Islands (FK)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	
Faroe Islands (FO)	433.05 - 434.79 MHz	EU433	
	863 - 873 MHz	EU863-870	
Fiji (FJ)			
Finland (FI)	433.05 - 434.79 MHz	EU433	
	863 - 873 MHz	EU863-870	X
France (FR)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	X
French Guiana (GF)	433.05 - 434.79 MHz	EU433	
	863 - 873 MHz	EU863-870	X

French Polynesia (PF)	433.05 - 434.79 MHz	EU433	
	863 - 873 MHz	EU863-870	X
French Southern Territories (TF)	433.05 - 434.79 MHz	EU433	
	863 - 873 MHz	EU863-870	X
Gabon (GA)			
Gambia (GM)	433.05 - 434.79 MHz	EU433	
Georgia (GE)	433.05 - 434.79 MHz	EU433	
	863 - 873 MHz	EU863-870	
Germany (DE)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	X
Ghana (GH)	430 - 435 MHz	EU433	
	830 - 850 MHz		
Gibraltar (GI)	433.05 - 434.79 MHz	EU433	
	863 - 873 MHz	EU863-870	X
Greece (GR)	433.05 - 434.79 MHz	EU433	
	868 - 870 MHz	EU863-870	X
Greenland (GL)	433.05 - 434.79 MHz	EU433	
	863 - 873 MHz	EU863-870	X
	915 - 918 MHz	AS923-3	
Grenada (GD)	902 - 928 MHz	AU915-928[4]	
Guadeloupe (GP)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	X
Guam (GU)	902 - 928 MHz	US902-928[1]	X
Guatemala (GT)	915 – 928 MHz**Error! Bookmark not defined.**	AU915-928[3]**Error! Bookmark not defined.**	
Guernsey (GG)	433.05 - 434.79 MHz	EU433	
	863 - 873 MHz	EU863-870	
	915 – 918 MHz	AS923-3	
Guinea (GN)	433.05 – 434.79 MHz	EU433	
Guinea-Bissau (GW)			
Guyana (GY)			
Haiti (HT)			
Heard Island and McDonald Islands (HM)	915 – 928 MHz[4]	AU915-928 AS923-1	
Holy See (VA)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	
Honduras (HN)	915-928 MHz	AU915-928	
Hong Kong (HK)	433.05 - 434.79 MHz	EU433	
	865 - 868 MHz	IN865-867	
	920 - 925 MHz	AS923-1	
Hungary (HU)	433.05 - 434.79 MHz	EU433	
	863 - 873 MHz	EU863-870	X

	915 - 918 MHz	AS923-3	
Iceland (IS)	433.05 - 434.79 MHz	EU433	
	863 - 873 MHz	EU863-870	X
India (IN)	865 - 867 MHz	IN865-867	X
Indonesia (ID)	920 - 923 MHz	AS923-2	
Iran (IR)	433.05 - 434.79 MHz	EU433	
	863 - 873 MHz	EU863-870	
	915 - 918 MHz	AS923-3	
Iraq (IQ)			
Ireland (IE)	433.05 – 434.79 MHz	EU433	
	863 – 873 MHz	EU863-870	X
	915 – 918 MHz	AS923-3	
Isle of Man (IM)	433.05 - 434.79 MHz	EU433	
	863 - 873 MHz	EU863-870	
	915 – 918 MHz	AS923-3	
Israel (IL)	917 - 920 MHz	AS923-4	
Italy (IT)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	X
Jamaica (JM)	915 - 928 MHz[2]	AU915-928	
Japan (JP)	920.6 - 928.0 MHz (steps of 200 kHz & 600 kHz)	AS923-1	X
Jersey (JE)	433.05 - 434.79 MHz	EU433	
	863 - 873 MHz	EU863-870	
	915 – 918 MHz	AS923-3	
Jordan (JO)	433.05 – 434.79 MHz	EU433	
	865 - 868 MHz	IN865-867	
	915 – 921 MHz	AS923-3	
Kazakhstan (KZ)	433.05 - 434.79 MHz	EU433	
	863 - 868 MHz	IN865-867	
Kenya (KE)	433 – 434 MHz	EU433	
	868 – 870 MHz	EU863-870	
Kiribati (KI)			
Korea, Democratic Peoples' Republic of (KP)			
Korea, Republic of (KR)	917 - 923.5 MHz	KR920-923	X
Kuwait (KW)	433.05 - 434.79 MHz	EU433	
	863 – 876 MHz	EU863-870	
	915 – 921 MHz	AS923-3	
Kyrgyzstan (KG)			
Lao People's Democratic Republic (LA)	433 - 435 MHz	EU433	
	862 - 875 MHz	EU863-870	
	923 - 925 MHz	AS923-1	
Latvia (LV)	433.05 - 434.79 MHz	EU433	

	863 - 870 MHz	EU863-870	X
Lebanon (LB)	433.05 – 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	
Lesotho (LS)	433.05 – 434.79 MHz	EU433	
Liberia (LR)			
Libya (LY)			
Liechtenstein (LI)	433.05 - 434.79 MHz	EU433	
	863 - 873 MHz	EU863-870	
	915 – 918 MHz	AS923-3	
Lithuania (LT)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	X
Luxembourg (LU)	433.05 - 434.79 MHz	EU433	
	863 - 873 MHz	EU863-870	X
	915 - 918 MHz	AS923-3	
Macao (MO)	433.05 - 434.79 MHz	EU433	
	920 – 925 MHz	AS923-1	
Macedonia (MK)	433.05 - 434.79 MHz	EU433	
	863 – 870 MHz	EU863-870	
Madagascar (MG)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	
Malawi (MW)			
Malaysia (MY)	433 - 435 MHz	EU433	
	916 – 919 MHz	AS923-1	
	919 – 924 MHz	AS923-1	
Maldives (MV)			
Mali (ML)	433.05 – 434.79 MHz	EU433	
Malta (MT)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	X
Marshall Islands (MH)			
Martinique (MQ)	433.05 - 434.79 MHz	EU433	
	863 – 870 MHz	EU863-870	X
Mauritania (MR)	433.05 - 434.79 MHz	EU433	
	863 – 870 MHz	EU863-870	
Mauritius (MU)	433.05 - 434.79 MHz	EU433	
	863 – 870 MHz	EU863-870	
Mayotte (YT)	433.05 - 434.79 MHz	EU433	
	863 – 870 MHz	EU863-870	X
Mexico (MX)	902 – 928 MHz	US902-928[1]	
Micronesia (FM)			
Moldova (MD)	433.05 - 434.79 MHz	EU433	
	862 - 873 MHz	EU863-870	
	915 - 918 MHz	AS923-3	
Monaco (MC)	433.05 - 434.79 MHz	EU433	

	863 - 870 MHz	EU863-870	
Mongolia (MN)	216 – 217 MHz		
	312 – 316 MHz		
	1427 – 1432 MHz		
Montenegro (ME)	433.05 – 434.79 MHz	EU433	
	863 – 870 MHz	EU863-870	
Montserrat (MS)	902 - 928 MHz	AU915-928[4]	
Morocco (MA)	433.05 - 434.79 MHz	EU433	
	869 – 870 MHz		
Mozambique (MZ)			
Myanmar (MM)	433 - 435 MHz	EU433	
	866 - 869 MHz		
	919 - 924 MHz	AS923-1	
Namibia (NA)	433.05 – 434.79 MHz	EU433	
	868 – 870 MHz	EU863-870	
Nauru (NR)			
Nepal (NP)			
Netherlands (NL)	433.05 – 434.79 MHz	EU433	
	863 – 870 MHz	EU863-870	X
New Caledonia (NC)	433.05 – 434.79 MHz	EU433	
	863 – 870 MHz	EU863-870	X
New-Zealand (NZ)	915 - 928 MHz[4]	AS923-1 AU915-928	
	819 - 824 MHz		
	864 - 868 MHz	IN865-867	
	433.05 - 434.79 MHz	EU433	
Nicaragua (NI)	915 - 928 MHz[2]	AU915-928	
Niger (NE)	865 – 865.6 MHz	IN865-867	
	865.6 – 867.6 MHz	IN865-867	
	867.6 – 868 MHz	IN865-867	
Nigeria (NG)	433.05 - 434.79 MHz	EU433	
	868 - 870 MHz	EU863-870	
Niue (NU)	433.05 - 434.79 MHz	EU433	
	819 - 824 MHz		
	864 - 868 MHz	IN865-867	
	915 - 928 MHz[4]	AS923-1 AU915-928	
Norfolk Island (NF)	915 - 928 MHz[4]	AS923-1 AU915-928	
Northern Mariana Islands (MP)	902 – 928 MHz	US902-928[1]	X
Norway (NO)	433.05 - 434.79 MHz	EU433	
	863 - 873 MHz	EU863-870	

	915 - 918 MHz	AS923-3	
Oman (OM)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	
Pakistan (PK)	433.05 - 434.79 MHz	EU433	
	865 - 869 MHz	IN865-867	
	920 - 925 MHz	AS923-1	
Palau (PW)			
Palestine (PS)			
Panama (PA)	902 - 928 MHz	AU915-928[3 4]	
Papua New Guinea (PG)	433.05 - 434.79 MHz	EU433	
	915 – 928 MHz[4]	AU915-928 AS923-1	
Paraguay (PY)	433.05 - 434.79 MHz	EU433	
	915 - 928 MHz	AU915-928[3]	
Peru (PE)	915 - 928 MHz	AU915-928[3]	
Philippines (PH)	915 – 918 MHz	AS923-3	
	868 – 869.2 MHz	EU863-870	
	869.7 – 870 MHz	EU863-870	
	433.05 – 434.79 MHz	EU433	
Pitcairn (PN)			
Poland (PL)	433.05 - 434.79 MHz	EU433	
	863 - 873 MHz	EU863-870	X
	915 - 918 MHz	AS923-3	
Portugal (PT)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	X
Puerto Rico (PR)	902 – 928 MHz	US902-928[1]	X
Qatar (QA)	433.05 – 434.79 MHz	EU433	
	863 – 870 MHz	EU863-870	
	915 – 921 MHz	AS923-3	
Reunion (RE)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	X
Romania (RO)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	X
Russian Federation (RU)	866 - 868 MHz	RU864-870	
	864 - 865 MHz	RU864-870	
	868.7 - 869.2 MHz	RU864-870	
	433.075 - 434.75 MHz	EU433	
	916 - 921 MHz (Licensed)	AS923-3	
Rwanda (RW)	433.05 - 434.79 MHz	EU433	
	868 - 870 MHz	EU863-870	
Saint Barthelemy (BL)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	X
Saint Helena, Ascension and Tristan da Cunha (SH)			

Saint Kitts and Nevis (KN)	902 – 928 MHz	AU915-928[4]	
Saint Lucia (LC)	902 – 928 MHz	AU915-928[4]	
Saint Martin (MF)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	X
Saint Pierre and Miquelon (PM)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	X
Saint Vincent and the Grenadines (VC)	902 – 928 MHz	AU915-928[4]	
Samoa (WS)	433.05 - 434.79 MHz	EU433	
	868 - 870 MHz	EU863-870	
San Marino (SM)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	
Sao Tome and Principe (ST)			
Saudi Arabia (SA)	863 – 875.8 MHz	EU863-870	
	433.05 - 434.79 MHz	EU433	
	915 – 921 MHz	AS923-3	
Senegal (SN)	868 – 870 MHz	EU863-870	
Serbia (RS)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	
Seychelles (SC)	433.05 - 434.79 MHz	EU433	
Sierra Leone (SL)			
Singapore (SG)	920 - 925 MHz	AS923-1	
	433.05 - 434.79 MHz	EU433	
	866 - 869 MHz		
Sint Maarten (SX)			
Slovakia (SK)	433.05 - 434.79 MHz	EU433	
	863 - 873 MHz	EU863-870	X
	915 - 918 MHz	AS923-3	
Slovenia (SI)	433.05 - 434.79 MHz	EU433	
	863 - 873 MHz	EU863-870	X
	915 - 918 MHz	AS923-3	
Solomon Islands (SB)	918 - 926 MHz	AS923-1	
Somalia (SO)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	
	915 - 918 MHz	AS923-3	
South Africa (ZA)	433.05 - 434.79 MHz	EU433	
	868 – 868.6 MHz	EU863-870	
	868.7 – 869.2 MHz	EU863-870	
	869.4 – 869.65 MHz	EU863-870	
	869.7 – 870 MHz	EU863-870	
South Georgia and the South Sandwich Islands (GS)	433.05 - 434.79 MHz	EU433	
	863 - 873 MHz	EU863-870	
	915 - 918 MHz	AS923-3	
South Sudan (SS)			

Spain (ES)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	X
Sri Lanka (LK)	433.05 - 434.79 MHz	EU433	
	868 – 869 MHz		
	920 – 924 MHz	AS923-1	
Sudan (SD)			
Suriname (SR)	915 – 928 MHz[2]	AU915-928[3]	
Svalbard and Jan Mayen (SJ)	433.05 - 434.79 MHz	EU433	
	863 - 873 MHz	EU863-870	
	915 - 918 MHz	AS923-3	
Sweden (SE)	433.05 - 434.79 MHz	EU433	
	868 - 870 MHz	EU863-870	X
Switzerland (CH)	433.05 - 434.79 MHz	EU433	
	863 - 873 MHz	EU863-870	X
	915 – 918 MHz	AS923-3	
Syrian Arab Republic (SY)	433.05 – 434.79 MHz	EU433	
	863 – 870 MHz	EU863-870	
	870 – 876 MHz	EU863-870	
	915 – 921 MHz	AS923-3	
Taiwan, Province of China (TW)	920 - 925 MHz	AS923-1	X
Tajikistan (TJ)			
Tanzania (TZ)	433.05 - 434.79 MHz	EU433	
	866 - 869 MHz		
	920 - 925 MHz	AS923-1	
Thailand (TH)	433.05 – 434.79 MHz	EU433	
	920 – 925 MHz	AS923-1	X
Timor-Leste (TL)			
Togo (TG)	433.05 - 434.79 MHz	EU433	
Tokelau (TK)	433.05 - 434.79 MHz	EU433	
	819 - 824 MHz		
	864 - 868 MHz	IN865-867	
	915 - 928 MHz[4]	AS923-1 AU915-928	
Tonga (TO)	433.05 – 434.79 MHz	EU433	
	915 – 928 MHz	AU915-928[3]	
Trinidad and Tobago (TT)	902 – 928 MHz	AU915-928[4]	
Tunisia (TN)	433.05 - 434.79 MHz	EU433	
	863 - 868 MHz	EU863-870	
	868 – 868.6 MHz	EU863-870	
	868.7 – 869.2 MHz	EU863-870	
	869.4 – 869.65 MHz	EU863-870	
	869.7 – 870 MHz	EU863-870	
Turkey (TR)	433.05 - 434.79 MHz	EU433	

	863 - 870 MHz	EU863-870	
Turkmenistan (TM)			
Turks and Caicos Islands (TC)	915 – 928 MHz[2]	AU915-928[3]	
Tuvalu (TV)			
Uganda (UG)	433.05 - 434.79 MHz	EU433	
	863 - 865 MHz	IN865-867	
	865 - 867.6 MHz	IN865-867	
	869.25 - 869.7 MHz		
	923 - 925 MHz	AS923-1	
Ukraine (UA)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	
United Arab Emirates (AE)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	
	870 - 875.8 MHz	EU863-870	
	915 - 921 MHz	AS923-3	
United Kingdom of Great Britain and Northern Ireland (GB)	433.05 - 434.79 MHz	EU433	
	863 - 873 MHz	EU863-870	X
	915 - 918 MHz	AS923-3	
United States Minor Outlying Islands (UM)	902 - 928 MHz	US902-928[1]	X
United States of America (US)	902 - 928 MHz	US902-928[1]	X
Uruguay (UY)	915 - 928 MHz[2]	AU915-928[3]**Error! Bookmark not defined.**	
Uzbekistan (UZ)	433.05 – 434.79 MHz	EU433	
Vanuatu (VU)	433.05 - 434.79 MHz	EU433	
	863 – 869 MHz	IN865-867	
	915 - 918 MHz	AS923-3	
Venezuela (VE)	922 - 928 MHz	AS923-1	
Vietnam (VN)	433.05 - 434.79 MHz	EU433	
	918 - 923 MHz[7]	AS923-2	
	920 - 922.5 MHz[8]	AS923-2	
Virgin Islands, UK (VG)	915 - 928 MHz[2]	AU915-928[3]	
Virgin Islands, US (VI)	902 - 928 MHz	US902-928[1]	X
Wallis and Futuna (WF)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	X
Western Sahara (EH)			
Yemen (YE)			
Zambia (ZM)	433.05 - 434.79 MHz	EU433	
	868 - 870 MHz	EU863-870	

[7] Band LIKELY available through 2021 – regulations in flux.
[8] Newly proposed band that LIKELY becomes available in 2021 – regulations in flux.

Zimbabwe (ZW)	433.05 - 434.79 MHz	EU433	
	868 - 870 MHz	EU863-870	

Table 1: Channel plan per ISO 3166-1 country

1.3 Regional Parameters Summary Tables

The following summary tables have been provided for quick reference to the various parameters described and defined, by channel plan region, in this document. These tables do not replace the full text in Section 2 and in the event of conflict, Section 2 is to be understood as the authoritative and normative text. The information is further broken down by channel plan type: dynamic channel plans, in which the majority of channel frequencies are defined after the join process; and fixed channel plans, where the majority of channel frequencies are defined statically and known prior to the join process.

1.3.1 Dynamic Channel Plan Regions

Plan	*KR920*	*AS923-1*	*AS923-2*	*AS923-3*	*AS923-4*	*RU864*	*EU868*	*IN865*	*EU433*
Default Freq Band	920.9 to 923.3 MHz	915 to 928 MHz	915 to 928 MHz	915 to 928 MHz	917 to 920 MHz	864 to 870 MHz	863 to 870 MHz	865 to 867 MHz	433 to 434
Mandatory Channel Freq (Join Req)	922.10 MHz 922.30 MHz 922.50 MHz	923.20 MHz 923.40 MHz	921.4 MHz 921.6 MHz	916.6 MHz 916.8 MHz	917.3 MHz 917.5 MHz	868.9 MHz 869.1 MHz	868.10 MHz 868.30 MHz 868.50 MHz	865.0625 MHz 865.4025 MHz 865.985 MHz	433.175 MHz 433.375 MHz 433.575 MHz
JoinReq DataRate [MinDR:MaxDR]	[0:5]	[2:5]				[0:5]			
CFList Type Supported	0 1 (900 MHz List)					0 1 (800 MHz List)			0
Mandatory Data Rate [MinDR:MaxDR]	[0:5]								
Optional Data Rate [MinDR:MaxDR]	N/A	[6:7]					[6:7] | [6:11]	[7]	[6:7]
Number of Channels	Minimum of 24 Maximum of 80								
ChMaskCtrl - ChMask	0 -> Channels 0-15 1 -> Channels 16-31 2 -> Channels 32-47 3 -> Channels 48-63 4 -> Channels 64-79 5 -> 10 LSBs control channel blocks 0 to 9, 6 MSBs are RFU 6 -> All channels on 7 -> RFU								
Default Channels	[0:2]	[0:1]					[0:2]		
Default RX1DRoffset	0								
Allowed RX1DRoffset	[0:5]	[0:7]				[0:5]		[0:7]	[0:5]
Duty Cycle	LBT	< 1%						N/A	< 10%
Dwell Time Limitation	No	Yes (400ms)				No			
TxParamSetupReq Support	No	Yes				No			
Max EIRP (Default) - TXPower 0	+14 dBm	+16 dBm						+30 dBm	+12dBm
Default RX2DataRate	DR0	DR2				DR0		DR2	DR0
Default RX2 Frequency	921.90 MHz	923.2 MHz	921.4 MHz	916.6 MHz	917.3 MHz	869.1 MHz	869.525 MHz	866.550 MHz	434.665 MHz
Class B Default Beacon Freq	923.1 MHz	923.4 MHz	921.6 MHz	916.8 MHz	917.5 MHz	869.1 MHz	869.525 MHz	866.550 MHz	434.665 MHz
Class B Default Downlink PingSlot Freq	923.1 MHz	923.4 MHz	921.6 MHz	916.8 MHz	917.5 MHz	868.9 MHz	869.525 MHz	866.550 MHz	434.665 MHz

Table 2: Dynamic channel plan summary

1.3.2 Fixed Channel Plan Regions

Plan	*US915*	*AU915*
Default Freq Band	902 to 928 MHz	915 to 928 MHz
Mandatory Channel Freq (Join Req)	upstream: 64 (902.3 to 914.9 [+ by 0.2]) + 8 (903.0 to 914.2 [+ by 1.6]) downstream: 8 (923.3 to 927.5 [+ by 0.6])	upstream: 64 (915.2 to 927.8 [+ by 0.2]) + 8 (915.9 to 927.1 [+ by 1.6]) downstream: 8 (923.3 to 927.5 [+ by 0.6])
JoinReq DataRate [MinDR:MaxDR]	64 (125 kHz channels) using DR0 and 8 (500 kHz channels) using DR4	64 (125 kHz channels) using DR2 and 8 (500 kHz channels) using DR6
CFList Type Supported	1	
Mandatory Data Rate [MinDR:MaxDR]	[0:4],[8:13]	[0:6],[8:13]
Optional Data Rate [MinDR:MaxDR]	[5:6]	[7]
Number of Channels	upstream: 64 (125 kHz) + 8 (500 kHz) + 8 (flexibly defined) downstream: 8 (500 kHz) + 72 (flexibly defined)	
ChMaskCtrl - ChMask	0 -> Channels 0 to 15 1 -> Channels 16 to 31 2 -> Channels 32-47 3 -> Channels 48-63 4 -> Channels 64 to 79 5 -> 10 LSBs controls Channel Blocks 0 to 9, 6 MSBs are RFU 6 -> All 125 kHz ON, `ChMask` applies to channels 64 to 79 7 -> All 125 kHz OFF, `ChMask` applies to channels 64 to 79	
Default Channels	[0:71]	
Default RX1DRoffset	0	
Allowed RX1DRoffset	[0:3]	[0:5]
Duty Cycle	No Limit	
Dwell Time Limitation	[0:63] 400ms [64:71] No	[0:63] 400ms (regional dependence) [64:71] No
TxParamSetupReq Support	No	Yes
Max EIRP (Default) - TXPower 0	+30 dBm	
Default RX2DataRate	DR8	
Default RX2 Frequency	923.3 MHz	
Class B Default Beacon Freq	Hops across all 8 downlink channels	
Class B Default Downlink PingSlot Freq	Follows beacon channel	

Table 3: Fixed channel plan summary

2 LoRaWAN Regional Parameters

2.1 Regional Parameter Channel Plan Common Names

In order to support the identification of LoRaWAN channel plans referenced by other specification documents, the table below provides a quick reference of common channel plan names and a channel plan identifier for each formal plan name.

Channel Plan	Common Name	Channel Plan ID
EU863-870	EU868	1
US902-928	US915	2
CN779-787	CN779	3
EU433	EU433	4
AU915-928	AU915	5
CN470-510	CN470	6
AS923-1[9]	AS923	7
AS923-2	AS923-2	8
AS923-3	AS923-3	9
KR920-923	KR920	10
IN865-867	IN865	11
RU864-870	RU864	12
AS923-4	AS923-4	13

Table 4: Regional parameter common names

2.2 Regional Parameter Revision Names

In order to support the identification of Regional Parameter Specification versions referenced by other specification documents, the table below provides a quick reference of a standard revision identifier listed for each formal revision name.

Specification Revision	Notes	Revision ID
LoRaWAN v1.0.1	Originally integrated in the LoRaWAN spec	RP1-1.0.1
Regional Parameters v1.0.2rB	Aligned with LoRaWAN 1.0.2	RP1-1.0.2
Regional Parameters v1.0.3rA	Aligned with LoRaWAN 1.0.3	RP1-1.0.3
Regional Parameters v1.1rA	Aligned with LoRaWAN 1.1	RP1-1.1.0
RP002-1.0.0	Supports both LoRaWAN 1.0.x and 1.1.x	RP2-1.0.0
RP002-1.0.1	Supports both LoRaWAN 1.0.x and 1.1.x	RP2-1.0.1
RP002-1.0.2	Supports both LoRaWAN 1.0.x and 1.1.x	RP2-1.0.2
RP002-1.0.3	Supports both LoRaWAN 1.0.x and 1.1.x	RP2-1.0.3
RP002-1.0.4	Supports both LoRaWAN 1.0.x and 1.1.x	RP2-1.0.4

Table 5: Regional parameter revision names

2.3 Default Settings

The following parameters are RECOMMENDED default values for all regions:

RECEIVE_DELAY1	1s
RECEIVE_DELAY2	2s (SHALL be RECEIVE_DELAY1 + 1s)
RX1DROffset	0 (table index)
JOIN_ACCEPT_DELAY1	5s
JOIN_ACCEPT_DELAY2	6s

[9] AS923 has been renamed AS923-1 as of RP002-1.0.2, however, the common name remains AS923

MAX_FCNT_GAP[10]	16384
ADR_ACK_LIMIT	64
ADR_ACK_DELAY	32
RETRANSMIT_TIMEOUT	2s +/- 1s (random delay between 1 and 3 seconds)
DownlinkDwellTime	0 (No downlink dwell time enforced; impacts data rate offset calculations)
UplinkDwellTime	Uplink dwell time is country-specific and it is the responsibility of the end-device to comply with such regulations
PING_SLOT_PERIODICITY	7 (2^7 = 128s)
PING_SLOT_DATARATE	The value of the BEACON data rate (DR) defined for each regional band
PING_SLOT_CHANNEL	Defined in each regional band
CLASS_B_RESP_TIMEOUT	8s[11]
CLASS_C_RESP_TIMEOUT	8s[12]

If the actual parameter values implemented in the end-device are different from these default values (for example, the end-device uses a longer JOIN_ACCEPT_DELAY1 and JOIN_ACCEPT_DELAY2 latency), those parameters SHALL be communicated to the Network Server using an out-of-band channel during the end-device commissioning process. The Network Server MAY reject parameters different from these default values.

RETRANSMIT_TIMEOUT was known as ACK_TIMEOUT in versions prior to 1.0.4 of the LoRaWAN specification. It is renamed in version 1.0.4 and subsequent versions of the LoRaWAN specification to better reflect its intended use.

Medium Access Control (MAC) commands exist in the LoRaWAN specification to change the value of RECEIVE_DELAY1 (using *RXTimingSetupReq*, *RXTimingSetupAns)* as well as ADR_ACK_LIMIT and ADR_ACK_DELAY (using ADRParamSetupReq, ADRParamSetupAns). Also, RXTimingSettings are transmitted to the end-device along with the JOIN_ACCEPT message in OTAA mode.

The default values for PING_SLOT_PERIODICITY, PING_SLOT_DATARATE, and PING_SLOT_CHANNEL MAY be adjusted using Class B MAC commands.

End-devices SHALL select transmit channels in a pseudo-random fashion and in such a way that all enabled channels that are not currently duty-cycle-restricted SHALL be used once before any channel is re-used for transmission.

> **Note**: End-devices are required to use all default channels when attempting to join a network. There is no requirement that the network or any specific gateway support all default channels for any given region.

[10] MAX_FCNT_GAP was deprecated and removed from LoRaWAN 1.0.4 and subsequent versions.
[11] CLASS_B_RESP_TIMEOUT must always be greater than the largest possible value of RETRANSMIT_TIMEOUT plus the maximum possible time-on-air of an uplink frame.
[12] CLASS_C_RESP_TIMEOUT must always be greater than the largest possible value of RETRANSMIT_TIMEOUT plus the maximum possible time-on-air of an uplink frame.

2.3.1 Join-Accept CFList Type 0

Dynamic channel plan regions SHALL support channel frequency list (CFList) Type 0.

Fixed channel plan regions SHALL NOT support CFList Type 0.

In this case, the CFList is a list of five channel frequencies for the channels *N* to *N+4,* where *N* is the number of default channels defined for the region, and whereby each frequency is encoded as a little-endian 24-bit unsigned integer (three octets). All of these channels are usable for DR0 to DR5 125 kHz LoRa modulation. The list of frequencies is followed by a single `CFListType` octet for a total of 16 octets. The `CFListType` SHALL be equal to zero (0) to indicate that the CFList contains a list of frequencies.

Size (bytes)	3	3	3	3	3	1
CFList	Freq Ch *N*	Freq Ch N+1	Freq Ch N+2	Freq Ch N+3	Freq Ch N+4	CFListType

The actual channel frequency in Hz is 100 x frequency, whereby values representing frequencies below 100 MHz are reserved for future use. This allows setting the frequency of a channel anywhere between 100 MHz to 1.678 GHz in 100 Hz increments. Unused channels have a frequency value of 0. The CFList is OPTIONAL, and its presence can be detected by the length of the join-accept message. If present, the CFList SHALL replace all the previous channels stored in the end-device apart from the *N* default channels. The newly defined channels are immediately enabled and usable by the end-device for communication.

2.3.2 Join-Accept CFList Type 1

End-devices implementing fixed channel plan regions SHALL support CFList Type 1 using each of their uniquely defined channel frequencies and numbering. End-devices implementing dynamic channel plan regions MAY support CFList Type 1 using either the 800 MHz or 900 MHz Fixed Channel List Definition.

If the CFlist is not empty, the `CFListType` field SHALL contain the value of one (0x01) to indicate the CFList contains a series of `ChMaskGrp` fields. `ChMaskGrp0` controls the first 16 channels, `ChMaskGrp1` the second 16 channels, up to a maximum of 96 channels. Within each `ChMaskGrp` field, each bit corresponds to a single channel identified by the following formula:

```
Channel-ID = ChMask-group-number * 16 + ChMask-bit-number
```

> **Note:** For fixed channel plans, each `ChMaskGrp` directly maps to the `ChMask` field of ***LinkADRReq***, for the corresponding value of `ChMaskCntl`. For dynamic channel plans, the mapping of `Channel-ID` to `ChMask` in ***LinkADRReq*** or `ChIndex` in ***NewChannelReq***, depends on the number of default channels and number of channels created by the CFList.

End-devices SHALL silently ignore bits set for channels not defined for the channel plan they are operating under. End-devices SHALL silently ignore bits sets for channels that refer to frequencies not available for use in the regulatory region the end-device is currently operating in. If no bits are set in the CFList `ChMaskGrp` fields, the end-device SHALL operate on all default channels.

Size (bytes)	[2]	[2]	[2]	[2]	[2]	[2]	[3]	[1]
CFList	***ChMask Grp0***	***ChMask Grp1***	***ChMask Grp2***	***ChMask Grp3***	***ChMask Grp4***	***ChMask Grp5***	***RFU***	***CFList Type***

> **Note:** For dynamic channel plans, CFList Type 0 and Type 1 both create new channels. Type 1 can create more channels thanks to a more compact description of the additional channels (enumeration vs exact frequencies). In both cases, default channels are not modified with the CFList. Default channels may be disabled with ***LinkADRReq*** or modified with ***NewChannelReq***.

2.3.2.1 800 MHz Fixed Channel List Definition

The 800 MHz fixed channel list defines 40 channels that may be created. `Channel-ID` 0 is 863.1 MHz; channels increase at 200 kHz spacing to `Channel-ID` 34 at 869.9 MHz. Five additional channels, identified as 35 to 39, are defined at 865.0625 MHz, 865.4025 MHz, 865.6025 MHz, 865.785 MHz, and 865.985 MHz respectively. ChMask3, ChMask4, and ChMask5 are RFU.

The end-device SHALL create an additional channel at the frequency specified by the `Channel-ID`, numbered sequentially in order of `Channel-ID`, starting after the last default channel, for each bit set in the CFList.

These channel definitions represent a superset of common channels in widespread use in EU868, IN865, and RU864.

> **Example:** If an end-device uses channel plan EU868, supports CFList Type 1, and receives it equal to 0x0100_A010_0000_0000_0000_0000, then `ChMaskGrp0` = 0x0100 and `ChMaskGrp1`=0xA010. Four bits are set, which correspond to valid channels, so the end-device will create four channels. EU868 has three default channels, so the first created channel will be for `ChIndex`=3. The end-device will create `ChIndex`=3 at center frequency 863.1MHz, `ChIndex`=4 at center frequency 863.1+21*0.2 = 867.3MHz, `ChIndex`=5 at center frequency 863.1+23*0.2 = 867.7MHz, and `ChIndex`=6 at center frequency 863.1+28*0.2 = 868.7MHz.
>
> **Note:** The frequencies of the three EU868 default channels correspond to `ChMaskGrp1` = 0x000E. Setting these bits would create new channels at the same frequency as default channels.
>
> The center frequencies of the four RFID channels under ETSI EN 302 208 correspond to `ChMaskGrp0` = 0x0020, `ChMaskGrp1` = 0x4900. Setting these bits would create channels with a higher risk of interference.

2.3.2.2 900 MHz Fixed Channel List Definition

The 900 MHz fixed channel list defines 96 channels. `Channel-ID` 0 is 915.1 MHz; channels increase at 100 kHz intervals to `Channel-ID` 95 at 924.6 MHz.

The end-device SHALL create an additional channel at the frequency specified by the `Channel-ID`, numbered sequentially in order of `Channel-ID`, starting after the last default channel, for each bit set in the CFList.

These channel definitions represent a superset of common channels in widespread use in AS-923-1, AS-923-2, AS-923-3, AS-923-4, and KR920.

2.4 EU863-870 MHz Band

2.4.1 EU863-870 Preamble Format

Refer to Section 4, "Physical Layer".

2.4.2 EU863-870 Band Channel Frequencies

This section applies to any region where the radio spectrum use is defined by the ETSI [EN300.220-2] standard.

The network channels can be freely attributed by the network operator. However, the three following default channels SHALL be implemented in every EU863-870 end-device. Network gateways SHALL be listening on one or more of these channels.

Modulation	Bandwidth [kHz]	Channel Frequency [MHz]	LoRa DR / Bitrate	Number of Channels	Duty Cycle
LoRa	125	868.10 868.30 868.50	DR0 to DR5 / 0.3-5 kbps	3	< 1%

Table 6: EU863-870 default channels

In order to access the physical medium, the ETSI regulations impose some restrictions, such as the maximum time the transmitter can be on, or the maximum time a transmitter can transmit per hour. The ETSI regulations allow the choice of using either a duty-cycle limitation or a so-called **Listen Before Talk Adaptive Frequency Agility** (LBT AFA) transmissions management. The current LoRaWAN specification exclusively uses duty-cycled limited transmissions to comply with the ETSI regulations.

EU868 end-devices SHALL be capable of operating in the 863 to 870 MHz frequency band and SHALL feature a channel data structure to store the parameters of at least 24 channels. A channel data structure corresponds to a frequency and a set of data rates usable on this frequency.

The first three channels correspond to 868.1, 868.3, and 868.5 MHz / DR0 to DR5 and SHALL be implemented in every end-device. For devices compliant with [TS001-1.0.x], those default channels SHALL NOT be modified through the ***NewChannelReq*** command. For devices compliant with [TS001-1.1.x] and beyond, these channels MAY be modified through ***NewChannelReq*** command but SHALL be reset during the back-off procedure defined in [TS001] to guarantee a minimal common channel set between end-devices and network gateways.

The following table gives the list of frequencies that SHALL be used by end-devices to broadcast the Join-Request message. The Join-Request message transmit duty-cycle SHALL follow the rules described in chapter "Retransmissions back-off" of the LoRaWAN [TS001] specification document.

Modulation	Bandwidth [kHz]	Channel Frequency [MHz]	LoRa DR / Bitrate	Number of Channels
LoRa	125	868.10 868.30 868.50	DR0 – DR5 / 0.3-5 kbps	3

Table 7: EU863-870 Join-Request channel list

2.4.3 EU863-870 Data Rate and End-Device Output Power Encoding

There is no dwell time limitation for the EU863-870 PHY layer. The ***TxParamSetupReq*** MAC command is not implemented in EU863-870 devices.

The following encoding is used for Data Rate (DR) and end-device EIRP (TXPower) in the EU863-870 band:

Data Rate	Configuration	Indicative Physical Bit Rate [bit/s]
0	LoRa: SF12 / 125 kHz	250
1	LoRa: SF11 / 125 kHz	440
2	LoRa: SF10 / 125 kHz	980
3	LoRa: SF9 / 125 kHz	1760
4	LoRa: SF8 / 125 kHz	3125
5	LoRa: SF7 / 125 kHz	5470
6	LoRa: SF7 / 250 kHz	11000
7	FSK: 50 kbps	50000
8	LR-FHSS[13] CR1/3: 137 kHz BW	162
9	LR-FHSS CR2/3: 137 kHz BW	325
10	LR-FHSS CR1/3: 336 kHz BW	162
11	LR-FHSS CR2/3: 336 kHz BW	325
12..14	RFU	
15	Defined in [TS001][14]	

Table 8: EU863-870 TX data rate

EU863-870 end-devices SHALL support one of the three following data rate options:

1. DR0 to DR5 (minimum set supported for certification)
2. DR0 to DR7
3. DR0 to DR11 (all data rates implemented)

For each of the three options, all data rates in the range specified SHALL be implemented (meaning no intermediate DR may be left unimplemented).

When the device is using the Adaptive Data Rate mode and transmits using the `DRcurrent` data rate, the following table defines the next data rate (`DRnext`) the end-device SHALL use during data rate back-off:

[13] Long-Range Frequency Hopping Spread Spectrum. Refer to Section 4.3.

[14] DR15 and TXPower15 are defined in the ***LinkADRReq*** MAC command of the LoRaWAN1.0.4 [TS001] and subsequent specifications and were previously RFU.

DRcurrent	DRnext	Comment
0	NA	Already the lowest data rate
1	0	
2	1	
3	2	
4	3	
5	4	
6	5	
7	6	
8	0	
9	8	
10	0	
11	10	

Table 9: EU863-870 data rate back-off

EIRP[15] refers to the Equivalent Isotropically Radiated Power, which is the radiated output power referenced to an isotropic antenna radiating power equally in all directions and whose gain is expressed in dBi.

TXPower	Configuration (EIRP)
0	Max EIRP
1	Max EIRP – 2dB
2	Max EIRP – 4dB
3	Max EIRP – 6dB
4	Max EIRP – 8dB
5	Max EIRP – 10dB
6	Max EIRP – 12dB
7	Max EIRP – 14dB
8..14	RFU
15	Defined in [TS001]

Table 10: EU863-870 TXPower

By default, the Max EIRP is considered to be +16 dBm. If the end-device cannot achieve 16 dBm EIRP, the Max EIRP SHOULD be communicated to the Network Server using an out-of-band channel during the end-device commissioning process.

2.4.4 EU863-870 Join-Accept CFList

The EU863-870 band LoRaWAN implements an OPTIONAL CFList of 16 octets in the Join-Accept message for both `CFListType` 0 and `CFListType`1. When receiving a `CFListType` 1, it SHALL be interpreted according to the channel list definition in Section 2.3.2.1 (*800 MHz Fixed Channel List Definition*).

[15] ERP = EIRP – 2.15dB; it is referenced to a half-wave dipole antenna whose gain is expressed in dBd.

2.4.5 EU863-870 *LinkADRReq* Command

The EU863-870 channel plan of LoRaWAN supports a minimum of 24 and a maximum of 80 channels. The `ChMaskCntl` field of the ***LinkADRReq*** command has the following meaning:

ChMaskCntl	ChMask Applies To
0	Channels 0 to 15
1	Channels 16 to 31
2	Channels 32 to 47
3	Channels 48 to 63
4	Channels 64 to 79
5	10 LSBs control channel blocks 0 to 9, 6 MSBs are RFU
6	All channels ON: The device SHALL enable all currently defined channels independently of the `ChMask` field value.
7	RFU

Table 11: EU863-870 ChMaskCntl value

If `ChMaskCntl` = 5, the corresponding bits in the `ChMask` enable and disable a bank of eight channels defined by the following calculation: [`ChannelMaskBit` * 8, `ChannelMaskBit` * 8 +7].

If the `ChMaskCntl` field value is RFU, the end-device SHALL[16] reject the command and unset the `Channel mask ACK` bit in its response.

2.4.6 EU863-870 Maximum Payload Size

The maximum `MACPayload` size length (*M)* is given by the following table. It is derived from a limitation of the PHY layer, depending on the effective modulation rate used, taking into account a possible repeater encapsulation layer. The maximum application payload length in the absence of the OPTIONAL `FOpts` control field (*N*) is also given for information only. The value of *N* MAY be smaller if the `FOpts` field is not empty.

Data Rate	M	N
0	59	51
1	59	51
2	59	51
3	123	115
4	230	222
5	230	222
6	230	222
7	230	222
8	58	50
9	123	115
10	58	50
11	123	115
12:15	Not defined	

Table 12: EU863-870 maximum payload size (repeater compatible)

[16] Made SHALL from SHOULD starting in LoRaWAN Regional Parameters Specification 1.0.3rA.

If the end-device will never operate with a repeater, the maximum application payload length in the absence of the OPTIONAL `FOpts` control field SHALL be:

Data Rate	M	N
0	59	51
1	59	51
2	59	51
3	123	115
4	250	242
5	250	242
6	250	242
7	250	242
8	58	50
9	123	115
10	58	50
11	123	115
12:15	Not defined	

Table 13 : EU863-870 maximum payload size (not repeater compatible)

2.4.7 EU863-870 Receive Windows

By default, the RX1 receive window uses the same channel as the preceding uplink. The data rate is a function of the uplink data rate and the `RX1DROffset`, as given by the following table. The allowed values for `RX1DROffset` are in the [0:5] range. Values in the [6:7] range are reserved for future use.

Upstream Data Rate	Downstream Data Rate in RX1 Slot					
RX1DROffset	**0**	**1**	**2**	**3**	**4**	**5**
DR0	DR0	DR0	DR0	DR0	DR0	DR0
DR1	DR1	DR0	DR0	DR0	DR0	DR0
DR2	DR2	DR1	DR0	DR0	DR0	DR0
DR3	DR3	DR2	DR1	DR0	DR0	DR0
DR4	DR4	DR3	DR2	DR1	DR0	DR0
DR5	DR5	DR4	DR3	DR2	DR1	DR0
DR6	DR6	DR5	DR4	DR3	DR2	DR1
DR7	DR7	DR6	DR5	DR4	DR3	DR2
DR8	DR1	DR0	DR0	DR0	DR0	DR0
DR9	DR2	DR1	DR0	DR0	DR0	DR0
DR10	DR1	DR0	DR0	DR0	DR0	DR0
DR11	DR2	DR1	DR0	DR0	DR0	DR0

Table 14: EU863-870 downlink RX1 data rate mapping

The RX2 receive window uses a fixed frequency and data rate. The default parameters are `869.525 MHz / DR0` (SF12, 125 kHz)

2.4.8 EU863-870 Class B Beacon and Default Downlink Channel

The beacon frame content is defined in section 4.1.3.[17]

The default beacon data rate is DR3.

The default beacon broadcast frequency is 869.525 MHz.

The default Class B default ping-slot frequency is 869.525 MHz.

2.4.9 EU863-870 Relay Parameters

The WOR default channels are:

Channel Index	**0**	**1**
Frequency WOR	865.1	865.5
Frequency WOR ACK	865.3	865.9
SF	SF9	
BW	BW125	

Table 15: EU863-870 WOR default channel

2.4.10 EU863-870 Default Settings

There are no specific default settings for the EU 863-870 MHz band.

[17] Prior to LoRaWAN 1.0.4, the EU863-870 beacon format was defined here as:

Size (bytes)	**2**	4	2	7	2
BCNPayload	**RFU**	Time	CRC	GwSpecific	CRC

2.5 US902-928 MHz ISM Band

This section defines the regional parameters for the USA, Canada, and all other countries in ITU Region 2 adopting the entire FCC 47 CFR Part 15 regulations in the 902-928 ISM band.

2.5.1 US902-928 Preamble Format

Refer to Section 4, "Physical Layer".

2.5.2 US902-928 Band Channel Frequencies

The 915 MHz ISM band SHALL be divided into the following channel plans:

- Upstream – 64 channels, numbered 0 to 63, utilizing LoRa 125 kHz BW, varying from DR0 to DR3, using coding rate 4/5, starting at 902.3 MHz and incrementing linearly by 200 kHz to 914.9 MHz
- Upstream – 8 channels, numbered 64 to 71, utilizing LoRa 500 kHz BW at DR4 or LR-FHSS 1.523 MHz BW at DR5-DR6, starting at 903.0 MHz and incrementing linearly by 1.6 MHz to 914.2 MHz
- Downstream – 8 channels, numbered 0 to 7, utilizing LoRa 500 kHz BW at DR8 to DR13, starting at 923.3 MHz and incrementing linearly by 600 kHz to 927.5 MHz

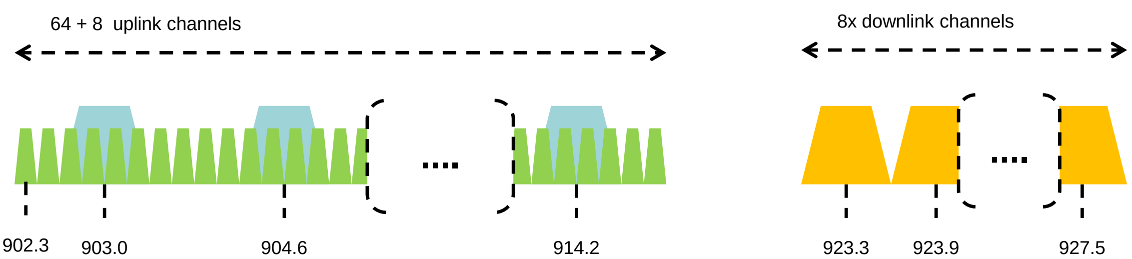

Figure 1: US902-928 channel frequencies

915 MHz ISM band end-devices are required to operate in compliance with the relevant regulatory specifications; the following note summarizes some of the current (as of the date of publication of this document) relevant regulations.

> Frequency-Hopping, Spread-Spectrum (FHSS) mode, which requires the device to transmit at a measured conducted power level no greater than +30 dBm, for a period of no more than 400 msec, and over at least 50 channels, each of which occupy no greater than 250 kHz of bandwidth and separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater.
>
> Digital Transmission System (DTS) mode, which requires that the device use channels greater than or equal to 500 kHz and comply to a conducted Power Spectral Density measurement of no more than +8 dBm per 3 kHz of spectrum. In practice, this limits the conducted output power of an end-device to +26 dBm.
>
> Hybrid mode, which requires that the device transmit over multiple channels (this may be less than the 50 channels required for FHSS mode but is recommended to be at least 4) while complying with the Power Spectral Density requirements of DTS mode and the 400 msec dwell time of FHSS mode. In practice, this limits the measured conducted power of the end-device to 21 dBm.

> Devices that use an antenna system with a directional gain greater than +6 dBi reduce the specified conducted output power by the amount in dB of directional gain over +6 dBi.

US902-928 end-devices SHALL be capable of operating in the 902 to 928 MHz frequency band and SHALL feature a channel data structure to store the parameters for 72 channels. This channel data structure contains a list of frequencies and the set of data rates available for each frequency.

If using the over-the-air activation procedure, the end-device SHALL transmit the Join-Request message on random 125 kHz channels amongst the 64 125 kHz channels defined using **DR0** and on 500 kHz channels amongst the 8 500kHz channels defined using **DR4**. The end-device SHALL change channels for every transmission.

For rapid network acquisition in mixed gateway channel plan environments, the device SHOULD follow a random channel selection sequence that efficiently probes the octet groups of eight 125 kHz channels, followed by probing one 500 kHz channel on each pass. Each consecutive pass SHOULD NOT select a channel that was used in a previous pass, until a Join-Request is transmitted on every channel, after which the entire process can restart.

> **Example**:
> First pass: Random channel from [0-7], followed by [8-15]… [56-63], then 64.
> Second pass: Random channel from [0-7], followed by [8-15]… [56-63], then 65.
> Last pass: Random channel from [0-7], followed by [8-15]… [56-63], then 71.

Personalized devices SHALL have all 72 channels enabled following a reset and SHALL use the channels for which the device's default data-rate is valid.

2.5.3 US902-928 Data Rate and End-Device Output Power Encoding

For frequency hopping systems, FCC regulations impose a maximum dwell time of 400ms on uplinks when the 20dB modulation bandwidth is less than 500 kHz. The ***TxParamSetupReq*** MAC command is not implemented by US902-928 devices.

The following encoding is used for Data Rate (DR) and end-device conducted power (TXPower) in the US902-928 band:

Data Rate	Configuration	Indicative Physical Bit Rate [bit/sec]
0	LoRa: SF10 / 125 kHz	980
1	LoRa: SF9 / 125 kHz	1760
2	LoRa: SF8 / 125 kHz	3125
3	LoRa: SF7 / 125 kHz	5470
4	LoRa: SF8 / 500 kHz	12500
5	LR-FHSS CR1/3: 1.523 MHz BW	162
6	LR-FHSS CR2/3: 1.523 MHz BW	325
7	RFU	
8	LoRa: SF12 / 500 kHz	980
9	LoRa: SF11 / 500 kHz	1760
10	LoRa: SF10 / 500 kHz	3900
11	LoRa: SF9 / 500 kHz	7000

12	LoRa: SF8 / 500 kHz	12500
13	LoRa: SF7 / 500 kHz	21900
14	RFU	
15	Defined in [TS001][18]	

Table 15: US902-928 TX data rate

Note: DR4 is purposely identical to DR12. DR8…13 refer to data rates that are only used for downlink messages.

US902-928 end-devices SHALL support one of the two following data rate options:

1. [DR0 to DR4] and [DR8 to DR13] (minimum set supported for certification)
2. [DR0 to DR13] (all data rates implemented)

For both options, all data rates in the range specified SHALL be implemented (meaning no intermediate DR may be left unimplemented).

When the end-device is using the Adaptive Data Rate mode and transmits using the `DRcurrent` data rate, the following table defines the next data rate (`DRnext`) the end-device SHALL use during data rate back-off:

DRcurrent	DRnext	Comment
0	NA	Already the default lowest data rate
1	0	
2	1	
3	2	
4	3	
5	0	
6	5	
DR 7 to DR15 are either RFU, reserved or only used in downlink		

Table 16: US902-928 data rate back-off

TXPower	Configuration (Conducted Power)
0	30 dBm – 2*TXPower
1	28 dBm
2	26 dBm
3 : 13	….
14	2 dBm
15	Defined in [TS001][18]

Table 17: US902-928 TXPower

2.5.4 US902-928 Join-Accept CFList

For LoRaWAN 1.0.1 and 1.0.2, the US902-928 region does not support the use of the OPTIONAL CFList appended to the Join-Accept message. If the CFList is not empty, it SHALL be ignored by the end-device.

The US902-928 LoRaWAN supports the use of the OPTIONAL CFList appended to the Join-Accept message. If the CFList is not empty, the `CFListType` field SHALL contain the value of one (0x01) to indicate the CFList contains a series of `ChMask` fields as defined in Section 2.3.2. `Channel-ID` values from 0 to 79 are supported and SHALL be interpreted as the channel number to be enabled or disabled. A cleared bit in the CFList SHALL disable the associated channel.

[18] DR15 and TXPower15 are defined in the ***LinkADRReq*** MAC command of the LoRaWAN 1.0.4 and subsequent specifications and were previously RFU.

2.5.5 US902-928 *LinkADRReq* Command

The US902-928 channel plan of LoRaWAN supports a minimum of 72 and a maximum of 80 channels. The `ChMaskCntl` field of the ***LinkADRReq*** command has the following meaning:

ChMaskCntl	ChMask Applies To
0	Channels 0 to 15
1	Channels 16 to 31
2	Channels 32 to 47
3	Channels 48 to 63
4	Channels 64 to 79
5	10 LSBs control channel blocks 0 to 9 (6 MSBs are RFU)
6	All default 125 kHz ON: `ChMask` applies to channels 64 to 79
7	All default 125 kHz OFF: `ChMask` applies to channels 64 to 79

Table 18: US902-928 ChMaskCntl value

If `ChMaskCntl` = 5[19], bits 0-7 in the `ChMask` enable and disable a bank of eight 125 kHz channels and the corresponding 500 kHz channel defined by the following calculation: [`ChannelMaskBit` * 8, `ChannelMaskBit` * 8 +7],64+`ChannelMaskBit`. Bits 8 and 9 in the `ChMask` enable and disable a bank of eight channels defined by the following calculation: [`ChannelMaskBit` * 8, `ChannelMaskBit` * 8 +7].

If `ChMaskCntl` = 6, all 125 kHz channels are enabled. If `ChMaskCntl` = 7, all 125 kHz channels are disabled. Simultaneously, the channels 64 to 71 are set according to the `ChMask` bit mask. The data rate specified in the command need not be valid for channels specified in the `ChMask`, as it governs the global operational state of the end-device.

> **Notes:**
>
> - FCC regulation requires hopping over at least 50 channels when using maximum output power. This is achieved either when more than 50 LoRa/125 kHz channels are enabled and/or when at least one LR-FHSS channel is enabled. It is possible to have end-devices with less channels when limiting the conducted transmit power of the end-device to 21 dBm.
>
> - A common Network Server action may be to reconfigure a device through multiple ***LinkADRReq*** commands in a contiguous block of MAC commands. For example, to reconfigure a device from 64 channel operation to the first 8 channels could contain two ***LinkADRReq*** commands, the first (`ChMaskCntl` = 7) to disable all 125 kHz channels and the second (`ChMaskCntl` = 0) to enable a bank of 8 125 kHz channels. Alternatively, using `ChMaskCntl` = 5, a device can be re-configured from 64 channel operation to support the first 8 channels in a single ***LinkADRReq***.

2.5.6 US902-928 Maximum Payload Size

The maximum `MACPayload` size length (*M*) is given by the following table. It is derived from the maximum allowed transmission time at the PHY layer, taking into account a possible repeater encapsulation. The maximum application payload length in the absence of the OPTIONAL `FOpts` MAC control field (*N*) is also given for information only. The value of *N* MAY be smaller if the `FOpts` field is not empty.

[19] Added in LoRaWAN Regional Parameters Specification version 1.0.3rA.

Data Rate	M	N
0	19	11
1	61	53
2	133	125
3	230	222
4	230	222
5	58	50
6	133	125
7	Not defined	
8	61	53
9	137	129
10	230	222
11	230	222
12	230	222
13	230	222
14:15	Not defined	

Table 19: US902-928 maximum payload size (repeater compatible)

If the end-device will never operate under a repeater, the maximum application payload length in the absence of the OPTIONAL `FOpts` control field SHALL be:

Data Rate	M	N
0	19	11
1	61	53
2	133	125
3	250	242
4	250	242
5	58	50
6	133	125
7	Not defined	
8	61	53
9	137	129
10	250	242
11	250	242
12	250	242
13	250	242
14:15	Not defined	

Table 20 : US902-928 maximum payload size (not repeater compatible)

2.5.7 US902-928 Receive Windows

- The RX1 receive channel is a function of the upstream channel used to initiate the data exchange. The RX1 receive channel can be determined as follows:
    - RX1 Channel Number = Transmit Channel Number modulo `NbChannel`, where `NbChannel` is the number of active receive channels.
- The RX1 window data rate depends on the transmit data rate (see Table 21 below).
- The RX2 (second receive window) settings use a fixed data rate and frequency. Default parameters are `923.3 MHz / DR8`.

Upstream Data Rate	Downstream Data Rate			
RX1DROffset	**0**	**1**	**2**	**3**
DR0	DR10	DR9	DR8	DR8
DR1	DR11	DR10	DR9	DR8
DR2	DR12	DR11	DR10	DR9
DR3	DR13	DR12	DR11	DR10
DR4	DR13	DR13	DR12	DR11
DR5	DR10	DR9	DR8	DR8
DR6	DR11	DR10	DR9	DR8

Table 21: US902-928 downlink RX1 data rate mapping[20]

The allowed values for `RX1DROffset` are in the [0:3] range. Values in the range [4:7] are reserved for future use.

2.5.8 US902-928 Class B Beacon[21]

The default downstream channel used for a given beacon is:

$$\text{Channel} = \left[floor\left(\frac{beacon\_time}{beacon\_period}\right)\right]\ modulo\ 8$$

- where `beacon_time` is the integer value of the 4 bytes `Time` field of the beacon frame
- where `beacon_period` is the periodicity of beacons, 128 seconds
- where *`floor`(x)* designates rounding to the integer immediately inferior or equal to x

> **Example**: The first beacon will be transmitted on 923.3 MHz, the second on 923.9 MHz, the 9th beacon will be on 923.3 MHz again.

Beacon Channel Number	Frequency [MHz]
0	923.3
1	923.9
2	924.5
3	925.1
4	925.7
5	926.3
6	926.9
7	927.5

Table 22: US902-928 beacon channels

The beacon frame content is defined in section 4.1.3.[17]

The default beacon data rate is DR8.

The default Class B PING_SLOT_CHANNEL is defined in the [TS001].

[20] Re-defined in the LoRaWAN 1.0.1 specification to eliminate `RX1DROffset` values beyond DR4.

[21] Class B beacon operation was first defined in the LoRaWAN 1.0.3 specification.

2.5.9 US902-928 Relay Parameters

The WOR default channels are:

Channel Index	**0**	**1**
Frequency WOR (MHz)	916.7	919.9
Frequency WOR ACK (MHz)	918.3	921.5
SF	SF10	
BW	BW500	

Table 23: US902-928 WOR default channel

2.5.10 US902-928 Default Settings

There are no specific default settings for the US902-928 MHz ISM band.

2.6 CN779-787 MHz Band[22]

CN779-787 devices may not be produced, imported, or installed after 2021-01-01; deployed devices may continue to operate through their normal end-of-life.

As of RP002-1.0.4, CN779-787 has been deprecated.

[22] Defined in the LoRaWAN 1.0.1 specification.

2.7 EU433 MHz ISM Band

2.7.1 EU433 Preamble Format

Refer to Section 4, “Physical Layer”.

2.7.2 EU433 ISM Band Channel Frequencies

The LoRaWAN can be used in the 433.05 to 434.79 MHz ISM band in ITU Region 1 as long as the radio device EIRP is less than 12 dBm.

The end-device transmit duty-cycle SHALL be lower than 10%.[23]

The LoRaWAN channel center frequency can be in the following range:

- Minimum frequency: 433.175 MHz
- Maximum frequency: 434.665 MHz

EU433 end-devices SHALL be capable of operating in the 433.05 to 434.79 MHz frequency band and SHALL feature a channel data structure to store the parameters of at least 24 channels. A channel data structure corresponds to a frequency and a set of data rates usable on this frequency.

The first three channels correspond to 433.175, 433.375, and 433.575 MHz with DR0 to DR5 and SHALL be implemented in every end-device. For devices compliant with [TS001-1.0.x], those default channels SHALL NOT be modified through the ***NewChannelReq*** command. For devices compliant with [TS001-1.1.x] and beyond, these channels MAY be modified through the ***NewChannelReq*** command but SHALL be reset during the back-off procedure defined in [TS001] to guarantee a minimal common channel set between end-devices and gateways of all networks. Other channels can be freely distributed across the allowed frequency range on a network-per-network basis.

The following table gives the list of frequencies that SHALL be used by end-devices to broadcast the Join-Request message. The Join-Request message transmit duty-cycle SHALL follow the rules described in chapter “Retransmissions Back-off” of the LoRaWAN [TS001] specification document.

Modulation	Bandwidth [kHz]	Channel Frequency [MHz]	LoRa DR / Bitrate	Number of Channels	Duty cycle
LoRa	125	433.175 433.375 433.575	DR0 – DR5 / 0.3-5 kbps	3	< 1%

Table 23: EU433 Join-Request channel list

[23] Defined in the LoRaWAN Regional Parameters 1.0.2 specification.

2.7.3 EU433 Data Rate and End-Device Output Power Encoding

There is no dwell time limitation for the EU433 PHY layer. The ***TxParamSetupReq*** MAC command is not implemented by EU433 devices.

The following encoding is used for Data Rate (DR) and end-device EIRP (TXPower) in the EU433 band:

Data Rate	Configuration	Indicative Physical Bit Rate [bit/s]
0	LoRa: SF12 / 125 kHz	250
1	LoRa: SF11 / 125 kHz	440
2	LoRa: SF10 / 125 kHz	980
3	LoRa: SF9 / 125 kHz	1760
4	LoRa: SF8 / 125 kHz	3125
5	LoRa: SF7 / 125 kHz	5470
6	LoRa: SF7 / 250 kHz	11000
7	FSK: 50 kbps	50000
8..14	RFU	
15	Defined in [TS001][24]	

TXPower	Configuration (EIRP)
0	Max EIRP
1	Max EIRP – 2dB
2	Max EIRP – 4dB
3	Max EIRP – 6dB
4	Max EIRP – 8dB
5	Max EIRP – 10dB
6..14	RFU
15	Defined in [TS001][24]

Table 24: EU433 data rate and TXPower

EU433 end-devices SHALL support one of the two following data rate options:

1. DR0 to DR5 (minimum set supported for certification)
2. DR0 to DR7

For both options, all data rates in the range specified SHALL be implemented (meaning no intermediate DR may be left unimplemented).

When the device is using the Adaptive Data Rate mode and transmits using the `DRcurrent` data rate, the following table defines the next data rate (`DRnext`) the end-device SHALL use during data rate back-off:

DRcurrent	DRnext	Comment
0	NA	Already the lowest data rate
1	0	
2	1	
3	2	
4	3	
5	4	
6	5	
7	6	

Table 25: EU433 data rate back-off

EIRP refers to the Equivalent Isotropically Radiated Power, which is the radiated output power referenced to an isotropic antenna radiating power equally in all directions and whose gain is expressed in dBi.

By default, the Max EIRP is considered to be +12 dBm. If the end-device cannot achieve 12 dBm EIRP, the Max EIRP SHALL be communicated to the Network Server using an out-of-band channel during the end-device commissioning process.

[24] DR15 and TXPower15 are defined in the ***LinkADRReq*** MAC command of the LoRaWAN 1.0.4 and subsequent specifications and were previously RFU.

2.7.4 EU433 Join-Accept CFList

The EU433 channel plan of LoRaWAN implements an OPTIONAL CFList of 16 octets in the Join-Accept message.

In this case, the CFList is a list of five channel frequencies for the channels three to seven, whereby each frequency is encoded as a 24-bit unsigned integer (three octets). All these channels are usable for DR0 to DR5 125 kHz LoRa modulation. The list of frequencies is followed by a single `CFListType` octet for a total of 16 octets. The `CFListType` SHALL be equal to zero (0) to indicate that the CFList contains a list of frequencies.

Size (bytes)	3	3	3	3	3	1
CFList	Freq Ch3	Freq Ch4	Freq Ch5	Freq Ch6	Freq Ch7	CFListType

Table 26: EU433 channel frequencies

The actual channel frequency in Hz is 100 x frequency, whereby values representing frequencies below 100 MHz are reserved for future use. This allows setting the frequency of a channel anywhere between 100 MHz to 1.678 GHz in 100 Hz steps. Unused channels have a frequency value of 0. The CFList is OPTIONAL and its presence can be detected by the length of the Join-Accept message. If present, the CFList SHALL replace all the previous channels stored in the end-device, apart from the three default channels.

The newly defined channels are immediately enabled and usable by the end-device for communication.

2.7.5 EU433 *LinkADRReq* Command

The EU433 channel plan of LoRaWAN supports a minimum of 24 and a maximum of 80 channels. The `ChMaskCntl` field of the ***LinkADRReq*** command has the following meaning:

ChMaskCntl	ChMask Applies To
0	Channels 0 to 15
1	Channels 16 to 31
2	Channels 32 to 47
3	Channels 48 to 63
4	Channels 64 to 79
5	10 LSBs control channel blocks 0 to 9, 6 MSBs are RFU
6	All channels ON: The device SHALL enable all currently defined channels regardless of the `ChMask` field value.
7	RFU

Table 27: EU433 ChMaskCntl value

If `ChMaskCntl` = 5, the corresponding bits in the `ChMask` enable and disable a bank of eight channels defined by the following calculation: [`ChannelMaskBit` * 8, `ChannelMaskBit` * 8 +7].

If the `ChMask` field value is RFU, the end-device SHALL[25] reject the command and unset the `Channel mask ACK` bit in its response.

2.7.6 EU433 Maximum Payload Size

The maximum `MACPayload` size length (*M*) is given by the following table. It is derived from a limitation of the PHY layer, depending on the effective modulation rate used, taking into account a possible repeater encapsulation layer. The maximum application payload length in

[25] Made SHALL from SHOULD starting in LoRaWAN Regional Parameters Specification 1.0.3rA.

the absence of the OPTIONAL `FOpts` control field (*N*) is also given for information only. The value of *N* might be smaller if the `FOpts` field is not empty.

Data Rate	M	N
0	59	51
1	59	51
2	59	51
3	123	115
4	230	222
5	230	222
6	230	222
7	230	222
8:15	Not defined	

Table 28: EU433 maximum payload size (repeater compatible)

If the end-device will never operate with a repeater, the maximum application payload length in the absence of the OPTIONAL `FOpts` control field SHALL be:

Data Rate	M	N
0	59	51
1	59	51
2	59	51
3	123	115
4	250	242
5	250	242
6	250	242
7	250	242
8:15	Not defined	

Table 29 : EU433 maximum payload size (not repeater compatible)

2.7.7 EU433 Receive Windows

By default, the RX1 receive window uses the same channel as the preceding uplink. The data rate is a function of the uplink data rate and the `RX1DROffset`, as given by the following table. The allowed values for `RX1DROffset` are in the [0:5] range. Values in the range [6:7] are reserved for future use.

Upstream Data Rate	Downstream Data Rate					
RX1DROffset	**0**	**1**	**2**	**3**	**4**	**5**
DR0	DR0	DR0	DR0	DR0	DR0	DR0
DR1	DR1	DR0	DR0	DR0	DR0	DR0
DR2	DR2	DR1	DR0	DR0	DR0	DR0
DR3	DR3	DR2	DR1	DR0	DR0	DR0
DR4	DR4	DR3	DR2	DR1	DR0	DR0
DR5	DR5	DR4	DR3	DR2	DR1	DR0
DR6	DR6	DR5	DR4	DR3	DR2	DR1
DR7	DR7	DR6	DR5	DR4	DR3	DR2

Table 30 : EU433 downlink RX1 data rate mapping

The RX2 receive window uses a fixed frequency and data rate. The default parameters are `434.665 MHz / DR0` (SF12, 125 kHz).

2.7.8 EU433 Class B Beacon and Default Downlink Channel

The beacon frame content is defined in section 4.1.3.[17]

The default beacon data rate is `DR3`.

The default beacon broadcast frequency is `434.665 MHz`.

The default class B downlink ping-slot frequency is `434.665 MHz`.

2.7.9 EU433 Default Settings

There are no specific default settings for the EU 433 MHz ISM band.

2.8 AU915-928 MHz Band[26]

This section defines the regional parameters for Australia and all other countries whose band extends from the 915 to 928 MHz spectrum.

2.8.1 AU915-928 Preamble Format

Refer to Section 4, "Physical Layer".

2.8.2 AU915-928 Band Channel Frequencies

The AU915-928 band SHALL be divided into the following channel plans:

- Upstream – 64 channels, numbered 0 to 63, utilizing LoRa 125 kHz BW, varying from DR0 to DR5, using coding rate 4/5, starting at 915.2 MHz and incrementing linearly by 200 kHz to 927.8 MHz
- Upstream – 8 channels, numbered 64 to 71, utilizing LoRa 500 kHz BW at DR6 or LR-FHSS 1.523 MHz BW at DR7, starting at 915.9 MHz and incrementing linearly by 1.6 MHz to 927.1 MHz
- Downstream – 8 channels, numbered 0 to 7, utilizing LoRa 500 kHz BW at DR8 to DR13), starting at 923.3 MHz and incrementing linearly by 600 kHz to 927.5 MHz

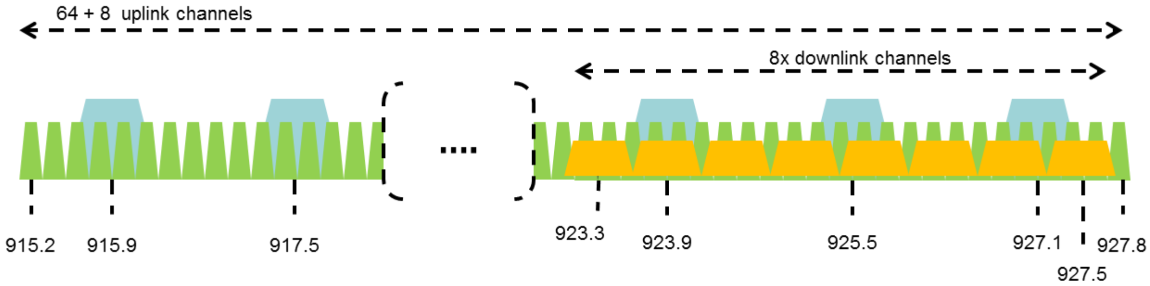

Figure 2: AU915-928 channel frequencies

AU915-928 band end-devices MAY use a maximum EIRP of +30 dBm.

AU915-928 end-devices SHALL be capable of operating in the 915 to 928 MHz frequency band and SHALL feature a channel data structure to store the parameters of 72 channels. A channel data structure corresponds to a frequency and a set of data rates usable on this frequency.

If using the over-the-air activation procedure, the end-device SHALL broadcast the Join-Request message alternatively on a random 125 kHz channel amongst the 64 channels defined using `DR2` and on a 500 kHz channel amongst the 8 channels defined using `DR6`. The end-device SHOULD change channel for every transmission.

For rapid network acquisition in mixed gateway channel plan environments, the device SHOULD follow a random channel selection sequence that efficiently probes the octet groups of eight 125 kHz channels followed by probing one 500 kHz channel each pass.

Each consecutive pass SHOULD NOT select a channel that was used in a previous pass, until a Join-Request is transmitted on every channel, after which the entire process can restart.

[26] Defined in the LoRaWAN 1.0.1 specification.

> **Example**:
> First pass: Random channel from [0-7], followed by [8-15] … [56-63], then 64.
> Second pass: Random channel from [0-7], followed by [8-15] … [56-63], then 65.
> Last pass: Random channel from [0-7], followed by [8-15] … [56-63], then 71.

Personalized devices SHALL have all 72 channels enabled following a reset and SHALL use the channels for which the device's default data-rate is valid.

The default Join-Request Data Rate SHALL be `DR2` (SF10/125 kHz); this setting ensures that end-devices are compatible with the 400ms dwell time limitation until the actual dwell time limit is notified to the end-device by the Network Server via the MAC command ***TxParamSetupReq***.

AU915-928 end-devices SHALL consider `UplinkDwellTime` = 1 during boot stage until reception of the ***TxParamSetupReq*** command.

AU915-928 end-devices SHALL always consider `DownlinkDwellTime` = 0, since downlink channels use 500 kHz bandwidth without any dwell time limit.

2.8.3 AU915-928 Data Rate and End-Point Output Power Encoding

The ***TxParamSetupReq*** and ***TxParamSetupAns*** MAC commands SHALL be implemented by AU915-928 devices.

If the field `UplinkDwellTime` is set to 1 by the Network Server in the ***TxParamSetupReq*** command, AU915-928 end-devices SHALL adjust the time between two consecutive uplink transmissions to meet the local regulations. Twenty seconds (20s) are recommended between two uplink transmissions when `UplinkDwellTime` = 1 but this value MAY be adjusted depending on local regulations.

There is no such constraint on time between two consecutive transmissions when `UplinkDwellTime` = 0.

The following encoding is used for Data Rate (DR) and end-point EIRP (TXPower) in the AU915-928 band:

Data Rate	Configuration	Indicative Physical Bit Rate [bit/sec]
0	LoRa: SF12 / 125 kHz	250
1	LoRa: SF11 / 125 kHz	440
2	LoRa: SF10 / 125 kHz	980
3	LoRa: SF9 / 125 kHz	1760
4	LoRa: SF8 / 125 kHz	3125
5	LoRa: SF7 / 125 kHz	5470
6	LoRa: SF8 / 500 kHz	12500
7	LR-FHSS CR1/3: 1.523 MHz BW	162
8	LoRa: SF12 / 500 kHz	980
9	LoRa: SF11 / 500 kHz	1760
10	LoRa: SF10 / 500 kHz	3900
11	LoRa: SF9 / 500 kHz	7000
12	LoRa: SF8 / 500 kHz	12500

13	LoRa: SF7 / 500 kHz	21900
14	RFU	
15	Defined in [TS001][27]	

Table 31: AU915-928 data rate

> **Note**: DR6 is purposely identical to DR12. DR8 to DR13 refer to data rates that are only used for downlink messages.

AU915-928 devices SHALL support one of the two following data rate options:

1. [DR0 to DR6] and [DR8 to DR13] (minimum set supported for certification)
2. [DR0 to DR13] (all data rates implemented)

For both options, all data rates in the range specified SHALL be implemented (meaning no intermediate DR may be left unimplemented).

When the device is using the Adaptive Data Rate mode and transmits using the `DRcurrent` data rate, the following table defines the next data rate (`DRnext`) the end-device SHALL use during data rate back-off:

UplinkDwellTime=0		UplinkDwellTime=1	
DRcurrent	**DRnext**	**DRcurrent**	**DRnext**
0	NA	NA	NA
1	0	NA	NA
2	1	2	NA
3	2	3	2
4	3	4	3
5	4	5	4
6	5	6	5
7	0	7	2
DR 8 to DR15 are either RFU, reserved or only used in downlink			

Table 32: AU915-928 data rate back-off

TXPower	Configuration (EIRP)
0	Max EIRP
1:14	Max EIRP – 2*TXPower
15	Defined in [TS001][27]

Table 33 : AU915-928 TXPower

EIRP refers to the Equivalent Isotropically Radiated Power, which is the radiated output power referenced to an isotropic antenna radiating power equally in all directions and whose gain is expressed in dBi.

By default, the Max EIRP of the end-device is considered to be +30dBm. The Max EIRP of the end-device can be modified by the Network Server through the ***TxParamSetupReq*** MAC command and SHALL be used by both the end-device and the Network Server as shown in Table 33 once ***TxParamSetupReq*** is acknowledged by the end-device via ***TxParamSetupAns***.

2.8.4 AU915-928 Join-Accept CFList

The AU915-928 LoRaWAN supports the use of the OPTIONAL CFlist appended to the Join-Accept message. If the CFlist is not empty, the `CFListType` field SHALL contain the value

[27] DR15 and TXPower15 are defined in the ***LinkADRReq*** MAC command of the LoRaWAN 1.0.4 and subsequent specifications and were previously RFU.

one (0x01) to indicate the CFList contains a series of `ChMask` fields as defined in 2.3.2. `Channel-ID` values from 0 to 79 are supported and SHALL be interpreted as the channel number to be enabled or disabled. A cleared bit in the CFList SHALL disable the associated channel.

2.8.5 AU915-928 *LinkADRReq* Command

The AU915-928 channel plan of LoRaWAN supports a minimum of 72 and a maximum of 80 channels. The `ChMaskCntl` field of the ***LinkADRReq*** command has the following meaning:

ChMaskCntl	ChMask Applies To
0	Channels 0 to 15
1	Channels 16 to 31
2	Channels 32 to 47
3	Channels 48 to 63
4	Channels 64 to 79
5	10 LSBs controls channel blocks 0 to 9 (6 MSBs are RFU)
6	All 125 kHz ON: `ChMask` applies to channels 64 to 79
7	All 125 kHz OF : `ChMask` applies to channels 64 to 79

Table 34: AU915-928 ChMaskCntl value

If `ChMaskCntl` = 5[19], bits 0-7 in the `ChMask` enable and disable a bank of eight 125 kHz channels and the corresponding 500 kHz channel defined by the following calculation: [`ChannelMaskBit` * 8, `ChannelMaskBit` * 8 +7],64+`ChannelMaskBit`. Bits 8 and 9 in the `ChMask` enable and disable a bank of eight channels defined by the following calculation: [`ChannelMaskBit` * 8, `ChannelMaskBit` * 8 +7].

If `ChMaskCntl` = 6, 125 kHz channels are enabled. If `ChMaskCntl` = 7, 125 kHz channels are disabled. Simultaneously the channels 64 to 71 are set according to the `ChMask` bit mask. The data rate specified in the command need not be valid for channels specified in the `ChMask`, as it governs the global operational state of the end-device.

2.8.6 AU915-928 Maximum Payload Size

The maximum `MACPayload` size length (*M*) is given by the following table for both uplink dwell time configurations: *No Limit* and *400ms*. It is derived from the maximum allowed transmission time at the PHY layer, taking into account a possible repeater encapsulation. The maximum application payload length in the absence of the OPTIONAL `FOpts` MAC control field (*N*) is also given for information only. The value of *N* might be smaller if the `FOpts` field is not empty.

Data Rate	UplinkDwellTime=0		UplinkDwellTime=1	
	M	N	M	N
0	59	51	N/A	N/A
1	59	51	N/A	N/A
2	59	51	19	11
3	123	115	61	53
4	230	222	133	125
5	230	222	230	222
6	230	222	230	222
7	58	50	58	50
8	61	53	61	53
9	137	129	137	129
10	230	222	230	222
11	230	222	230	222
12	230	222	230	222
13	230	222	230	222
14:15	Not defined		Not defined	

Table 35: AU915-928 maximum payload size (repeater compatible)

For AU915-928, `DownlinkDwellTime` SHALL be set to 0 (no limit). The 400ms dwell time MAY apply to uplink channels depending on the local regulations.

If the end-device will never operate with a repeater, the maximum application payload length in the absence of the OPTIONAL `FOpts` control field SHALL be:

Data Rate	UplinkDwellTime=0		UplinkDwellTime=1	
	M	N	M	N
0	59	51	N/A	N/A
1	59	51	N/A	N/A
2	59	51	19	11
3	123	115	61	53
4	250	242	133	125
5	250	242	250	242
6	250	242	250	242
7	58	50	58	50
8	61	53	61	53
9	137	129	137	129
10	250	242	250	242
11	250	242	250	242
12	250	242	250	242
13	250	242	250	242
14:15	Not defined		Not defined	

Table 36: AU915-928 maximum repeater payload size (not repeater compatible)

2.8.7 AU915-928 Receive Windows

- The RX1 receive channel is a function of the upstream channel used to initiate the data exchange. The RX1 receive channel can be determined as follows:
    - RX1 Channel Number = Transmit Channel Number modulo `NbChannel`, where `NbChannel` is the number of active receive channels.
- The RX1 window data rate depends on the transmit data rate (see Table 21).
- The RX2 (second receive window) settings uses a fixed data rate and frequency. Default parameters are `923.3 MHz` / `DR8`.

Upstream Data Rate	Downstream Data Rate					
RX1DROffset	**0**	**1**	**2**	**3**	**4**	**5**
DR0	DR8	DR8	DR8	DR8	DR8	DR8
DR1	DR9	DR8	DR8	DR8	DR8	DR8
DR2	DR10	DR9	DR8	DR8	DR8	DR8
DR3	DR11	DR10	DR9	DR8	DR8	DR8
DR4	DR12	DR11	DR10	DR9	DR8	DR8
DR5	DR13	DR12	DR11	DR10	DR9	DR8
DR6	DR13	DR13	DR12	DR11	DR10	DR9
DR7	DR9	DR8	DR8	DR8	DR8	DR8

Table 37: AU915-928 downlink RX1 data rate mapping

The allowed values for `RX1DROffset` are in the [0:5] range. Values in the range [6:7] are reserved for future use.

2.8.8 AU915-928 Class B Beacon

The downstream channel used for a given beacon is:

$$\text{Channel} = \left[floor\left(\frac{beacon\_time}{beacon\_period}\right)\right]\ modulo\ 8$$

- where `beacon_time` is the integer value of the 4-byte `Time` field of the beacon frame
- where `beacon_period` is the periodicity of beacons, 128 seconds
- where *`floor`(x)* designates rounding to the integer immediately inferior or equal to x

> **Example**: The first beacon will be transmitted on 923.3 MHz, the second on 923.9 MHz, the 9th beacon will be on 923.3 MHz again.

Beacon Channel Number	Frequency [MHz]
0	923.3
1	923.9
2	924.5
3	925.1
4	925.7
5	926.3
6	926.9
7	927.5

Table 38: AU915-928 beacon channels

The beacon frame content is defined in section 4.1.3.[17]

The default beacon data rate is `DR 8`.

The default Class B PING_SLOT_CHANNEL is defined in [TS001].

2.8.9 AU915-928 Relay Parameters

The WOR default channels are:

Channel Index	**0**	**1**
Frequency WOR (MHz)	916.7	919.9
Frequency WOR ACK (MHz)	918.3	921.5
SF	SF10	
BW	BW500	

Table 38: AU915-928 WOR default channel

2.8.10 AU915-928 Default Settings

There are no specific default settings for AU 915-928 MHz band.

2.9 CN470-510 MHz Band[28]

Notes:

- The CN470-510 channel plan has been significantly changed from prior revisions and should be considered experimental pending published documents confirming plan compliant devices have been granted local regulatory approval.
- The original CN470 channel plan (i.e., 96-channel plan) defined in RP001-1.0.0 is still in widespread use.

2.9.1 CN470-510 Preamble Format

Refer to Section 4, “Physical Layer”.

2.9.2 CN470-510 Band Channel Frequencies

In China, this band is defined by SRRC to be used for small scale networks covering civil metering applications in buildings, residential areas, and villages. The transmission time shall not exceed one second and is limited to one channel at a time. For interference mitigation, access to the physical medium requires a Listen Before Talk (LBT) with Adaptive Frequency Agility (AFA) transmission management or other similar mechanisms like channels blacklisting.

> **Note:** The limitation of scope to small-scale networks enters into effect after November 2021. Gateways and end-devices deployed prior to December 1, 2021 are not required to comply with this restriction.

In the areas where channels are used by China Broadcasting Services, they SHALL be disabled.

For the CN470-510 MHz band, the bandwidth is the biggest and the frequency is the lowest compared to all the countries and areas in this document. The bandwidth and the frequency affect the design of antennas. There are several different antenna solutions for CN470-510 MHz band.

The CN470-510 MHz SRD band shall be divided into the channel plans as follows:

- The channel plan for 20 MHz antenna (type A and B)
- The channel plan for 26 MHz antenna (type A and B)

20 common join channels are defined for all of the channel plans mentioned above:

Common Join Channel Index	UL (MHz)	DL (MHz)	Activate 20 MHz plan A	Activate 20 MHz plan B	Activate 26 MHz plan A	Activate 26 MHz plan B
0	470.9	484.5	X			
1	472.5	486.1	X			
2	474.1	487.7	X			
3	475.7	489.3	X			
4	504.1	490.9	X			
5	505.7	492.5	X			
6	507.3	494.1	X			
7	508.9	495.7	X			
8	479.9	479.9		X		
9	499.9	499.9		X		
10	470.3	492.5			X	
11	472.3	492.5			X	
12	474.3	492.5			X	
13	476.3	492.5			X	

[28] Heavily modified, and not backwardly compatible with, CN470-510 as previously defined in v1.0.

14	478.3	492.5			X	
15	480.3	502.5				X
16	482.3	502.5				X
17	484.3	502.5				X
18	486.3	502.5				X
19	488.3	502.5				X

Table 39: Common join channels for CN470-510 channel frequencies

All the above channel plans SHALL be implemented in the CN470 end-devices.

End-devices SHALL scan all of the common join channels. If the end-device receives the Join-Accept message from one of the above downlink (DL) common join channels, the end-device SHALL use the corresponding channel plan[29] in the above table.

2.9.2.1 Channel Plan for 20 MHz Antenna

For 20 MHz antennas, the CN470-510 MHz band shall be divided into two channel plans: Type A and plan Type B.

For channel plan Type A:

- Upstream (Group 1) – 32 channels, numbered 0 to 31, utilizing LoRa 125 kHz BW, varying from DR0 to DR5, using coding rate 4/5, starting at 470.3 MHz and incrementing linearly by 200 kHz to 476.5 MHz
- Downstream (Group 1) – 32 channels, numbered 0 to 31, utilizing LoRa 125 kHz BW, varying from DR0 to DR5, using coding rate 4/5, starting at 483.9 MHz and incrementing linearly by 200 kHz to 490.1 MHz
- Downstream (Group 2) – 32 channels, numbered 32 to 63, utilizing LoRa 125 kHz BW, varying from DR0 to DR5, using coding rate 4/5, starting at 490.3 MHz and incrementing linearly by 200 kHz to 496.5 MHz
- Upstream (Group 2) – 32 channels, numbered 32 to 63, utilizing LoRa 125 kHz BW, varying from DR0 to DR5, using coding rate 4/5, starting at 503.5 MHz and incrementing linearly by 200 kHz to 509.7 MHz

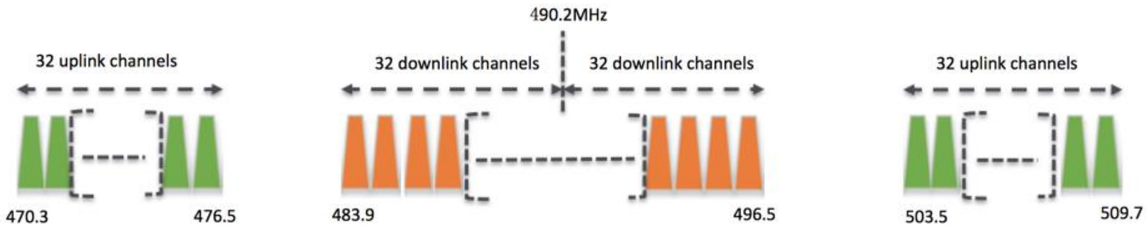

Figure 3: Channel plan type A for 20MHz antenna channel frequencies

For channel plan Type B:

- Upstream (Group 1) – 32 channels, numbered 0 to 31, utilizing LoRa 125 kHz BW, varying from DR0 to DR5, using coding rate 4/5, starting at 476.9 MHz and incrementing linearly by 200 kHz to 483.1 MHz
- Downstream (Group 1) – 32 channels, numbered 0 to 3,1 utilizing LoRa 125 kHz BW, varying from DR0 to DR5, using coding rate 4/5, starting at 476.9 MHz and incrementing linearly by 200 kHz to 483.1 MHz
- Upstream (Group 2) – 32 channels, numbered 32 to 63, utilizing LoRa 125 kHz BW, varying from DR0 to DR5, using coding rate 4/5, starting at 496.9 MHz and

[29] The corresponding channel plan can be determined by the uplink join channel, which corresponds to a pair of common join channels including UL and DL. The DL join channel is the channel from which the end-device receives the join-accept message.

incrementing linearly by 200 kHz to 503.1 MHz

- Downstream (Group 2) – 32 channels, numbered 32 to 63, utilizing LoRa 125 kHz BW, varying from DR0 to DR5, using coding rate 4/5, starting at 496.9 MHz and incrementing linearly by 200 kHz to 503.1 MHz

Figure 4: Channel plan type B for 20MHz antenna channel frequencies

2.9.2.2 Channel Plan for 26 MHz antenna

For 26 MHz Antennas, the CN470-510 MHz band shall be divided into two channel plans: plan Type A and plan Type B.

For channel plan Type A:

- Upstream – 48 channels, numbered 0 to 47, utilizing LoRa 125 kHz BW, varying from DR0 to DR5, using coding rate 4/5, starting at 470.3 MHz and incrementing linearly by 200 kHz to 479.7 MHz.
- Downstream – 24 channels, numbered 0 to 23, utilizing LoRa 125 kHz BW, at DR0 to DR5, starting at 490.1 MHz and incrementing linearly by 200 kHz to 494.7 MHz. Additional frequencies from 494.9 to 495.9 MHz are available for configurable downlink parameters (beacon frequency, ping-slot frequency and RX2 frequency).

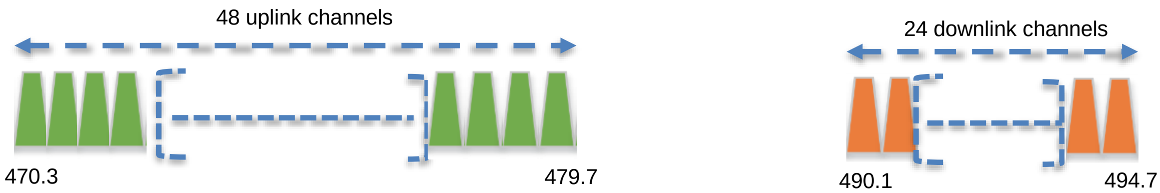

Figure 5: Channel plan type A for 26MHz antenna channel frequencies

For channel plan Type B:

- Upstream – 48 channels, numbered 0 to 47, utilizing LoRa 125 kHz BW, varying from DR0 to DR5, using coding rate 4/5, starting at 480.3 MHz and incrementing linearly by 200 kHz to 489.7 MHz.
- Downstream – 24 channels, numbered 0 to 23, utilizing LoRa 125 kHz BW, at DR0 to DR5, starting at 500.1 MHz and incrementing linearly by 200 kHz to 504.7 MHz. Additional frequencies from 504.9 to 505.9 MHz are available for configurable downlink parameters (beacon frequency, ping-slot frequency and RX2 frequency).

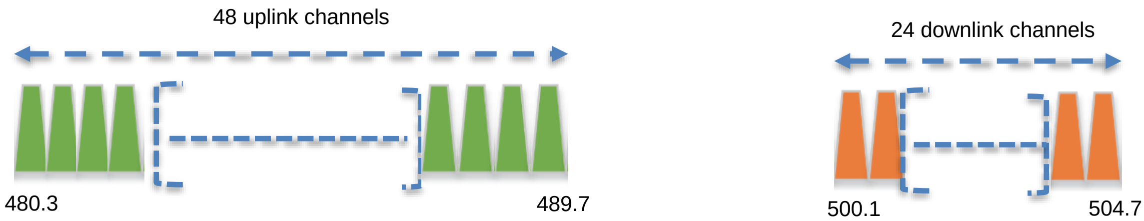

Figure 6: Channel plan type B for 26MHz antenna channel frequencies

If using the over-the-air activation procedure, the end-device SHALL broadcast the Join-Request message on a random 125 kHz channel amongst the 20 uplink channels defined previously in this section using `DR5` to `DR0`.

Personalized devices SHALL have all channels enabled following a reset, corresponding to an activation plan.

2.9.3 Ac718fCN470-510 Data Rate and End-Point Output Power Encoding

The ***TxParamSetupReq*** MAC command is not implemented by CN470-510 devices.

The following encoding is used for Data Rate (DR) and end-point EIRP (TXPower) in the CN470-510 band:

Data Rate	Configuration	Indicative Physical Bit Rate [bit/sec]
0[30]	LoRa: SF12/ 125 kHz	250
1	LoRa: SF11 / 125 kHz	440
2	LoRa: SF10 / 125 kHz	980
3	LoRa: SF9 / 125 kHz	1760
4	LoRa: SF8 / 125 kHz	3125
5	LoRa:SF7 / 125 kHz	5470
6	LoRa:SF7 / 500 kHz	21900
7	FSK: 50 Kbps	50000
8:14	RFU	
15	Defined in [TS001][31]	

TXPower	Configuration (EIRP)
0	Max EIRP
1	Max EIRP – 2dB
2	Max EIRP – 4dB
3	Max EIRP – 6dB
4	Max EIRP – 8dB
5	Max EIRP – 10dB
6	Max EIRP – 12dB
7	Max EIRP – 14dB
8…14	RFU
15	Defined in [TS001][31]

Table 40: CN470-510 Data rate and TXPower

CN470-510 end-devices SHALL support one of the two following data rate options:

1. DR0 to DR5 (minimum set supported for certification)
2. DR0 to DR7

For both options, all data rates in the range specified SHALL be implemented (meaning no intermediate DR may be left unimplemented).

When the device is using the Adaptive Data Rate mode and transmits using the `DRcurrent` data rate, the following table defines the next data rate (`DRnext`) the end-device SHALL use during data rate back-off:

[30] As of RP002-1.0.1, DR0 is unavailable for devices implementing CN470-510, but remains defined to better support existing implementations.

[31] DR15 and TXPower15 are defined in the ***LinkADRReq*** MAC command of the LoRaWAN 1.0.4 and subsequent specifications and were previously RFU.

DRcurrent	DRnext	Comment
0	NA	Already the lowest data rate
1	0	
2	1	
3	2	
4	3	
5	4	
6	5	
7	6	

Table 41: CN470-510 data rate back-off

EIRP refers to the Equivalent Isotropically Radiated Power, which is the radiated output power referenced to an isotropic antenna radiating power equally in all directions and whose gain is expressed in dBi.

By default, the Max EIRP is considered to be +19 dBm. If the end-device cannot achieve 19 dBm EIRP, the Max EIRP SHOULD be communicated to the Network Server using an out-of-band channel during the end-device commissioning process.

2.9.4 CN470-510 Join-Accept CFList

The CN470 LoRaWAN supports the use of the OPTIONAL CFList appended to the Join-Accept message. If the CFList is not empty, the `CFListType` field SHALL contain the value one (0x01) to indicate the CFList contains a series of `ChMask` fields. The `ChMask` fields are interpreted as being controlled by a virtual `ChMaskCntl` that initializes to a value of zero (0) and increments for each `ChMask` field to a value of three (3) for 20 MHz plans A or B and two (2) for 26 MHz plans A or B. (The first 16 bits control channels 0 to 15...)

For 20 MHz antenna systems:

Size (bytes)	[2]	[2]	[2]	[2]	[2]	[2]	[3]	[1]
CFList	ChMask0	ChMask1	ChMask2	ChMask3	RFU	RFU	RFU	CFListType

For 26 MHz antenna systems:

Size (bytes)	[2]	[2]	[2]	[2]	[2]	[2]	[3]	[1]
CFList	ChMask0	ChMask1	ChMask2	RFU	RFU	RFU	RFU	CFListType

2.9.5 CN470-510 *LinkADRReq* Command

2.9.5.1 Channel Plan for 20 MHz Antenna

For 20 MHz antenna, the `ChMaskCntl` field of the ***LinkADRReq*** command has the following meaning:

ChMaskCntl	ChMask Applies To
0	Channels 0 to 15
1	Channels 16 to 31
2	Channels 32 to 47
3	Channels 48 to 63
4	RFU
5	RFU
6	All channels enabled
7	All channels disabled[31]

Table 42:CH470 ChMaskCntl value table for 20M antenna

If the `ChMask` field value is one of the values indicating RFU, the end-device SHALL reject the command and unset the `Channel mask ACK` bit in its response.

2.9.5.2 Channel Plan for 26 MHz Antenna

The `ChMaskCntl` field of the ***LinkADRReq*** command has the following meaning:

ChMaskCntl	ChMask Applies To
0	Channels 0 to 15
1	Channels 16 to 31
2	Channels 32 to 47
3	All channels enabled
4	All channels disabled[31]
5	RFU
6	RFU
7	RFU

Table 43: CH470 ChMaskCntl value table for 26M antenna

If the `ChMask` field value is one of the values indicating RFU, the end-device SHALL reject the command and unset the `Channel mask ACK` bit in its response.

2.9.6 CN470-510 Maximum Payload Size

The maximum `MACPayload` size length (*M*) is given by the following table. It is derived from the maximum allowed transmission time at the PHY layer, taking into account a possible repeater encapsulation. The maximum application payload length in the absence of the OPTIONAL `FOpts` MAC control field (*N*) is also given for information only. The value of *N* might be smaller if the `FOpts` field is not empty.

Data Rate	M	N
0[30]	N/A	N/A
1	31	23
2	94	86
3	192	184
4	230	222
5	230	222
6	230	222
7	230	222
8:15	Not defined	

Table 44: CN470-510 maximum payload size (repeater compatible)

If the end-device will never operate with a repeater, the maximum application payload length in the absence of the OPTIONAL `FOpts` control field SHALL be:

Data Rate	M	N
0[30]	N/A	N/A
1	31	23
2	94	86
3	192	184
4	250	242
5	250	242
6	250	242
7	250	242
8:15	Not defined	

Table 45: CN470-510 maximum payload size (not repeater compatible)

2.9.7 CN470-510 Receive Windows

The RX1 data rate depends on the transmit data rate (see Table **46** below). The RX2 default data rate is `DR1`.

Upstream Data Rate	Downstream Data Rate					
RX1DROffset	0	1	2	3	4	5
DR0[30]	DR0	DR0	DR0	DR0	DR0	DR0
DR1	DR1	DR1	DR1	DR1	DR1	DR1
DR2	DR2	DR1	DR1	DR1	DR1	DR1
DR3	DR3	DR2	DR1	DR1	DR1	DR1
DR4	DR4	DR3	DR2	DR1	DR1	DR1
DR5	DR5	DR4	DR3	DR2	DR1	DR1
DR6	DR6	DR5	DR4	DR3	DR2	DR1
DR7	DR7	DR6	DR5	DR4	DR3	DR2

Table 46: CN470-510 downlink RX1 data rate mapping

The allowed values for `RX1DROffset` are in the [0:5] range. Values in the range [6:7] are reserved for future use.

2.9.7.1 Channel Plan for 20 MHz Antenna Systems

For channel plan Type A:

- The RX1 downlink channel is the same as the uplink channel number.
- The RX2 channel number for OTAA devices is defined in Table **47**.
- The RX2 channel number for ABP devices is 486.9 MHz.

Common Join Channel Index Used in OTAA	RX2 Default Frequency
0	485.3 MHz
1	486.9 MHz
2	488.5 MHz
3	490.1 MHz
4	491.7 MHz
5	493.3 MHz
6	494.9 MHz
7	496.5 MHz

Table 47: RX2 default frequency for channel plan type A for 20 MHz antenna

For channel plan Type B:

- The RX1 downlink channel is the same as the uplink channel number.
- The RX2 channel number for OTAA devices is defined in Table 48.
- The RX2 channel number for ABP devices is 498.3 MHz.

Common Join Channel Index Used in OTAA	RX2 Default Frequency
8	478.3 MHz
9	498.3 MHz

Table 48: RX2 default frequency for channel plan type B for 20 MHz antenna

2.9.7.2 Channel Plan for 26 MHz Antenna Systems

- For both plans, the RX1 receive channel is a function of the upstream channel used to initiate the data exchange. The RX1 receive channel can be determined as follows:
  - RX1 Channel Number = Transmit Channel Number modulo 24
- The RX2 default frequency is:
  - For Channel plan A: 492.5 MHz
  - For Channel plan B: 502.5 MHz

2.9.8 CN470-510 Class B Beacon

The beacon frame content is defined in section 4.1.3.[17]

The beacons are transmitted using the following settings:

DR	2	Corresponds to SF10 spreading factor with 125 kHz BW
CR	1	Coding rate = 4/5
Signal polarity	Non-inverted	As opposed to normal downlink traffic, which uses inverted signal polarity
frequencies	Defined per plan below	

Table 49: CN470-510 beacon settings

2.9.8.1 Default Beacon and Ping-Slot Channel Numbers and Ping-Slots for 20 MHz Antenna Systems

Defaults for Channel plan Type A are shown in the following table along with the downstream channel used for beacons, according to the common join channel the end-device used:

Common Join Channel Index	Beacon Channel Number
0	$\left[floor\left(\frac{beacon\_time}{beacon\_period}\right)\right]\ modulo\ 8$
1	$8+\left[floor\left(\frac{beacon\_time}{beacon\_period}\right)\right]\ modulo\ 8$
2	$16+\left[floor\left(\frac{beacon\_time}{beacon\_period}\right)\right]\ modulo\ 8$
3	$24+\left[floor\left(\frac{beacon\_time}{beacon\_period}\right)\right]\ modulo\ 8$
4	$32+\left[floor\left(\frac{beacon\_time}{beacon\_period}\right)\right]\ modulo\ 8$
5	$40+\left[floor\left(\frac{beacon\_time}{beacon\_period}\right)\right]\ modulo\ 8$
6	$48+\left[floor\left(\frac{beacon\_time}{beacon\_period}\right)\right]\ modulo\ 8$
7	$56+\left[floor\left(\frac{beacon\_time}{beacon\_period}\right)\right]\ modulo\ 8$

Table 50: Beacon channel number for channel plan type A for 20 MHz antenna

- where `beacon_time` is the integer value of the 4-byte `Time` field of the beacon frame
- where beacon_period is the periodicity of beacons, 128 seconds
- where *`floor`(x)* designates rounding to the integer immediately inferior or equal to x

The downstream channel used for a ping-slot channel is shown in the following table, according to the common join channel the end-device used:

Common Join Channel Index	Ping-Slot Channel Number

0	$\left[\text{DevAddr} + floor\left(\frac{beacon\_time}{beacon\_period}\right)\right]\ modulo\ 8$
1	$8 + \left[\text{DevAddr} + floor\left(\frac{beacon\_time}{beacon\_period}\right)\right]\ modulo\ 8$
2	$16 + \left[\text{DevAddr} + floor\left(\frac{beacon\_time}{beacon\_period}\right)\right]\ modulo\ 8$
3	$24 + \left[\text{DevAddr} + floor\left(\frac{beacon\_time}{beacon\_period}\right)\right]\ modulo\ 8$
4	$32 + \left[\text{DevAddr} + floor\left(\frac{beacon\_time}{beacon\_period}\right)\right]\ modulo\ 8$
5	$40 + \left[\text{DevAddr} + floor\left(\frac{beacon\_time}{beacon\_period}\right)\right]\ modulo\ 8$
6	$48 + \left[\text{DevAddr} + floor\left(\frac{beacon\_time}{beacon\_period}\right)\right]\ modulo\ 8$
7	$56 + \left[\text{DevAddr} + floor\left(\frac{beacon\_time}{beacon\_period}\right)\right]\ modulo\ 8$

Table 51: Ping-slot channel number for channel plan type A for 20 MHz antenna

Defaults for channel plan Type B are shown in the following table along with the downstream channel used for beacons, according to the common join channel the end-device used:

Common Join Channel Index	Beacon Channel Number
8	23
9	55

Table 52: Beacon channel number for channel plan type B for 20 MHz antenna

- where `beacon_time` is the integer value of the 4-byte `Time` field of the beacon frame
- where `beacon_period` is the periodicity of beacons, 128 seconds
- where `floor`*(x)* designates rounding to the integer immediately inferior or equal to x

The downstream channel used for a ping-slot channel is shown in the following table, according to the common join channel the end-device used:

Common Join Channel Index	**Ping-Slot Channel Number**
8	$\left[\text{DevAddr} + floor\left(\frac{beacon\_time}{beacon\_period}\right)\right]\ modulo\ 32$
9	$32 + \left[\text{DevAddr} + floor\left(\frac{beacon\_time}{beacon\_period}\right)\right]\ modulo\ 32$

Table 53: Ping-slot channel number for channel plan type B for 20MHz antenna

2.9.8.2 Default Beacon and Ping-Slot Frequencies for 26 MHz Antenna Systems

By default, beacons and downlink ping-slot messages are transmitted using the following frequencies:

For Channel Plan A: 494.9 MHz
For Channel Plan B: 504.9 MHz

2.9.9 CN470-510 Relay Parameters

The WOR default channels are:

Channel Index	0	1
Frequency WOR (MHz)	472.1	494.9
Frequency WOR ACK (MHz)	485.3	505.5
SF	SF9	
BW	BW125	

Table 54: CN470-510 WOR default channel

2.9.10 CN470-510 Default Settings

There are no specific default settings for the CN470-510 MHz band.

2.10 AS923 MHz Band

2.10.1 AS923 Preamble Format

Refer to Section 4, “Physical Layer”.

2.10.2 AS923 Band Channel Frequencies

This section was originally intended to apply to regions where the frequencies [915…928 MHz] are present in an unlicensed LPWAN band but MAY also apply to regions with available bands in frequencies up to 1.67 GHz.

In order to accommodate country specific sub-bands across 915 - 928 MHz band, a frequency offset parameter `AS923_FREQ_OFFSET` is defined. `AS923_FREQ_OFFSET` is a 32-bit signed integer, allowing both positive and negative frequency offsets.

The corresponding frequency offset in Hz is:

`AS923_FREQ_OFFSET_HZ` = 100 x `AS923_FREQ_OFFSET`.

`AS923_FREQ_OFFSET` only applies to end-device default settings. `AS923_FREQ_OFFSET` does not apply to any frequencies delivered to the end-device from the Network Server through MAC commands or the CFList.

AS923 end-devices operated in Japan SHALL perform Listen Before Talk (LBT) based on ARIB STD-T108 regulations. The ARIB STD-T108 regulation is available for free and should be consulted as needed by the user.

The end-device’s LBT requirement, maximum transmission time, duty cycle, or other parameters MAY be dependent on frequency of each transmission.

The network channels can be freely assigned by the network operator. However, the two following default channels SHALL be implemented in every AS923 end-device. Network gateways SHALL always be listening on one or more of these channels.

Modulation	Bandwidth [kHz]	Channel Frequency [Hz]	LoRa DR / Bitrate	Number of Channels	Duty Cycle
LoRa	125	923200000 + AS923_FREQ_OFFSET_HZ	DR0 to DR5 / 0.3-5 kbps	2	< 1%
		923400000 + AS923_FREQ_OFFSET_HZ			

Table 55: AS923 default channels

For devices compliant with [TS001-1.0.x], those default channels SHALL NOT be modified through the ***NewChannelReq*** command. For devices compliant with [TS001-1.1.x] and beyond, these channels MAY be modified through the ***NewChannelReq*** command but SHALL be reset during the back-off procedure defined in [TS001] to guarantee a minimal common channel set between end-devices and network gateways.

AS923 end-devices SHOULD use the following default parameter:

- Default EIRP: `16 dBm`

AS923 end-devices SHALL feature a channel data structure to store the parameters of at least 24 channels. A channel data structure corresponds to a frequency and a set of data rates usable on this frequency.

The following table gives the list of frequencies that SHALL be used by end-devices to broadcast the Join-Request message:

Modulation	Bandwidth [kHz]	Channel Frequency [Hz]	LoRa DR / Bitrate	Number of Channels	Duty Cycle
LoRa	125	923200000 + AS923_FREQ_OFFSET_HZ 923400000 + AS923_FREQ_OFFSET_HZ	DR2 to DR5 / 0.9-5 kbps	2	< 1%

Table 56: AS923 Join-Request channel list

The default Join-Request Data Rate utilizes the range `DR2-DR5` (SF10/125 kHz – SF7/125 kHz). This setting ensures that end-devices are compatible with the 400ms dwell time limitation until the actual dwell time limit is notified to the end-device by the Network Server via the MAC command ***TxParamSetupReq***.

The Join-Request message transmit duty-cycle SHALL follow the rules described in chapter "Retransmissions back-off" of the LoRaWAN [TS001] specification document.

2.10.3 AS923 Data Rate and End-Point Output Power Encoding

The ***TxParamSetupReq/Ans*** MAC command SHALL be implemented by the AS923 devices.

The following encoding is used for Data Rate (DR) in the AS923 band:

Data Rate	Configuration	Indicative Physical Bit Rate [bit/s]
0	LoRa: SF12 / 125 kHz	250
1	LoRa: SF11 / 125 kHz	440
2	LoRa: SF10 / 125 kHz	980
3	LoRa: SF9 / 125 kHz	1760
4	LoRa: SF8 / 125 kHz	3125
5	LoRa: SF7 / 125 kHz	5470
6	LoRa: SF7 / 250 kHz	11000
7	FSK: 50 kbps	50000
8..14	RFU	
15	Defined in [TS001][31]	

Table 57: AS923 data rate

AS923 end-devices SHALL support one of the two following data rate options:

1. DR0 to DR5 (minimum set supported for certification)
2. DR0 to DR7

For both options, all data rates in the range specified SHALL be implemented (meaning no intermediate DR may be left unimplemented).

When the device is using the Adaptive Data Rate mode and transmits using the `DRcurrent` data rate, the following table defines the next data rate (`DRnext`) the end-device SHALL use during data rate back-off:

UplinkDwellTime=0		UplinkDwellTime=1	
DRcurrent	**DRnext**	**DRcurrent**	**DRnext**
0	NA	NA	NA
1	0	NA	NA
2	1	2	NA
3	2	3	2
4	3	4	3
5	4	5	4
6	5	6	5
7	6	7	6

Table 58: AS923 data rate back-off

The TXPower table indicates power levels relative to the Max EIRP level of the end-device, as per the following table:

TXPower	Configuration (EIRP)
0	Max EIRP
1	Max EIRP – 2dB
2	Max EIRP – 4dB
3	Max EIRP – 6dB
4	Max EIRP – 8dB
5	Max EIRP – 10dB
6	Max EIRP – 12dB
7	Max EIRP – 14dB
8..14	RFU
15	Defined in [TS001][31]

Table 59: AS923 TXPower

EIRP refers to the Equivalent Isotropically Radiated Power, which is the radiated output power referenced to an isotropic antenna radiating power equally in all directions and whose gain is expressed in dBi.

By default, the Max EIRP of the end-device SHALL be 16 dBm. The Max EIRP of the end-device can be modified by the Network Server through the ***TxParamSetupReq*** MAC command and SHOULD be used by both the end-device and the Network Server as shown in Table 59 once ***TxParamSetupReq*** is acknowledged by the end-device via ***TxParamSetupAns***.

2.10.4 AS923 Join-Accept CFList

The AS923 LoRaWAN implements an OPTIONAL CFList of 16 octets in the Join-Accept message for both `CFListType` 0 and `CFListType 1`. When receiving a `CFListType` 1, it shall be interpreted according to the channel list definition in Section 2.3.2.2 (*900 MHz Fixed Channel List Definition*).

`AS923_FREQ_OFFSET` does not apply any frequencies delivered to the end-device from the Network Server through MAC commands or the CFList. Therefore, AS923 end-devices SHALL NOT apply `AS923_FREQ_OFFSET` to the channel frequencies defined in the CFList.

2.10.5 AS923 *LinkADRReq* Command

The AS923 channel plan of LoRaWAN supports a minimum of 24 and a maximum of 80 channels. The `ChMaskCntl` field of the ***LinkADRReq*** command has the following meaning:

ChMaskCntl	ChMask Applies To
0	Channels 0 to 15
1	Channels 16 to 31
2	Channels 32 to 47
3	Channels 48 to 63
4	Channels 64 to 79
5	10 LSBs control channel blocks 0 to 9, 6 MSBs are RFU
6	All channels ON: The device SHALL enable all currently defined channels independently of the `ChMask` field value.
7	RFU

Table 60: AS923 ChMaskCntl value

If `ChMaskCntl` = 5, the corresponding bits in the `ChMask` enable and disable a bank of eight channels defined by the following calculation: [`ChannelMaskBit` * 8, `ChannelMaskBit` * 8 +7].

If the `ChMask` field value is RFU, the end-device SHALL reject the command and unset the `Channel mask ACK` bit in its response.

2.10.6 AS923 Maximum Payload Size

The maximum `MACPayload` size length (*M)* is given by the following table for both `UplinkDwellTime` and `DownlinkDwellTime` configurations: *No Limit* and *400ms*. It is derived from the maximum allowed transmission time at the PHY layer, taking into account a possible repeater encapsulation layer. The maximum application payload length in the absence of the OPTIONAL `FOpts` MAC control field (*N*) is also given for information only. The value of *N* might be smaller if the `FOpts` field is not empty.

Data Rate	DwellTime=0 (No Limit)		DwellTime=1 (400 ms Limit)	
	M	N	M	N
0	59	51	N/A	N/A
1	59	51	N/A	N/A
2	123	115	19	11
3	123	115	61	53
4	230	222	133	125
5	230	222	230	222
6	230	222	230	222
7	230	222	230	222
8:15	Not defined		Not defined	

Table 61: AS923 maximum payload size (repeater compatible)

If the end-device will never operate with a repeater, the maximum application payload length in the absence of the OPTIONAL `FOpts` control field SHALL be:

Data Rate	DwellTime=0 (No Limit)		DwellTime=1 (400 ms Limit)	
	M	N	M	N
0	59	51	N/A	N/A
1	59	51	N/A	N/A
2	123	115	19	11
3	123	115	61	53
4	250	242	133	125
5	250	242	250	242
6	250	242	250	242
7	250	242	250	242
8:15	Not defined		Not defined	

Table 62: AS923 maximum payload size (not repeater compatible)

The end-device SHALL only enforce the maximum downlink `MACPayload` size defined for `DownlinkDwellTime` = 0 (no dwell time enforced) regardless of the actual setting. This prevents the end-device from discarding valid downlink messages that comply with the regulatory requirements that may be unknown to the device (for example, when the device is joining the network).

2.10.7 AS923 Receive Windows

By default, the RX1 receive window uses the same channel as the preceding uplink. The data rate is a function of the uplink data rate and the `RX1DROffset`, as given by the following table. The allowed values for `RX1DROffset` are in the [0:7] range.

Values in the [6:7] range allow setting the downstream RX1 data rate higher than the upstream data rate[32].

When `DownlinkDwellTime` is zero, the allowed values for `RX1DROffset` are in the [0:7] range, encoded as per the following table.

Upstream Data Rate	Downstream Data Rate							
RX1DROffset	0	1	2	3	4	5	6	7
DR0	DR0	DR0	DR0	DR0	DR0	DR0	DR1	DR2
DR1	DR1	DR0	DR0	DR0	DR0	DR0	DR2	DR3
DR2	DR2	DR1	DR0	DR0	DR0	DR0	DR3	DR4
DR3	DR3	DR2	DR1	DR0	DR0	DR0	DR4	DR5
DR4	DR4	DR3	DR2	DR1	DR0	DR0	DR5	DR6
DR5	DR5	DR4	DR3	DR2	DR1	DR0	DR6	DR7
DR6	DR6	DR5	DR4	DR3	DR2	DR1	DR7	DR7
DR7	DR7	DR6	DR5	DR4	DR3	DR2	DR7	DR7

Table 63: AS923 downlink RX1 data rate mapping for DownLinkDwellTime = 0

[32] DR6 and DR7 are allowed in RX1 for AS923 since version RP2 1.0.0, in previous versions downlink data rate was limited to DR5 in RX1.

When DownlinkDwellTime is one, the allowed values for RX1DROffset are in the [0:7] range, encoded as per the following table:

Upstream Data Rate	**Downstream Data Rate**							
RX1DROffset	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
DR0	DR2	DR2	DR2	DR2	DR2	DR2	DR2	DR2
DR1	DR2	DR2	DR2	DR2	DR2	DR2	DR2	DR3
DR2	DR2	DR2	DR2	DR2	DR2	DR2	DR3	DR4
DR3	DR3	DR2	DR2	DR2	DR2	DR2	DR4	DR5
DR4	DR4	DR3	DR2	DR2	DR2	DR2	DR5	DR6
DR5	DR5	DR4	DR3	DR2	DR2	DR2	DR6	DR7
DR6	DR6	DR5	DR4	DR3	DR2	DR2	DR7	DR7
DR7	DR7	DR6	DR5	DR4	DR3	DR2	DR7	DR7

Table 64: AS923 downlink RX1 data rate mapping for DownLinkDwellTime =1

The RX2 receive window uses a fixed frequency and data rate. The default parameters are 923.2 MHz + AS923_FREQ_OFFSET_HZ / DR2 (SF10/125 kHz).

2.10.8 AS923 Class B Beacon and Default Downlink Channel

The beacon frame content is defined in section 4.1.3.[17]

The default beacon data rate is DR3.

The default beacon broadcast frequency is 923.4 MHz + AS923_FREQ_OFFSET_HZ.

The default class B downlink ping-slot frequency is 923.4 MHz + AS923_FREQ_OFFSET_HZ.

2.10.9 AS923 Relay Parameters

The WOR default channels are:

Channel Index	**0**	**1**
Frequency WOR (MHz)	923.6 + AS923_FREQ_OFFSET_HZ	na
Frequency WOR ACK (MHz)	923.8 + AS923_FREQ_OFFSET_HZ	
SF	SF9	
BW	BW125	

Table 65: AS923 WOR default channel

2.10.10 AS923 Default Settings

Several default values of `AS923_FREQ_OFFSET` are defined to address all of the different AS923 countries. The default values of `AS923_FREQ_OFFSET` are chosen to minimize their total number and cover a large number of countries. Four different groups are defined below according to the `AS923_FREQ_OFFSET` default value.

Group AS923-1: `AS923_FREQ_OFFSET` default value = 0x00000000,
`AS923_FREQ_OFFSET_HZ = 0 .0 MHz`

> This group is comprised of countries having available frequencies in the 915 – 928 MHz range with common channels in the 923.0 – 923.5 MHz sub-band. These are the "historical" AS923 countries, compliant to the RP2-1.0.0 specification and previous versions.

Group AS923-2: `AS923_FREQ_OFFSET` default value = 0xFFFFB9B0,
`AS923_FREQ_OFFSET_HZ = -1.80 MHz`

> This group is comprised of countries having available frequencies in the 920 – 923 MHz range with common channels in the 921.4 – 922.0 MHz sub-band.

Group AS923-3: `AS923_FREQ_OFFSET` default value = 0xFFFEFE30,
`AS923_FREQ_OFFSET_HZ = -6.60 MHz`

> This group is comprised of countries having available frequencies in the 915 – 921 MHz range with common channels in the 916.5 – 917.0 MHz sub-band.

Group AS923-4: `AS923_FREQ_OFFSET` default value = 0xFFFF1988,
`AS923_FREQ_OFFSET_HZ = -5.90 MHz`

> This group is comprised of countries having available frequencies in the 917 – 920 MHz range with common channels in the 917.3 – 917.5 MHz sub-band.

There are no other specific default settings for the AS923 band.

2.11 KR920-923 MHz Band

2.11.1 KR920-923 Preamble Format

Refer to Section 4, “Physical Layer”.

2.11.2 KR920-923 Band Channel Frequencies

The center frequency, bandwidth, and maximum EIRP output power for the South Korea RFID/USN frequency band are defined by the Korean Government, which has allocated LPWA-based IoT networks the channel center frequencies from 920.9 to 923.3 MHz.

Center Frequency (MHz)	Bandwidth (kHz)	Maximum EIRP Output Power (dBm)	
		For End-Device	For Gateway
920.9	125	10	23
921.1	125	10	23
921.3	125	10	23
921.5	125	10	23
921.7	125	10	23
921.9	125	10	23
922.1	125	14	23
922.3	125	14	23
922.5	125	14	23
922.7	125	14	23
922.9	125	14	23
923.1	125	14	23
923.3	125	14	23

Table 66: KR920-923 center frequency, bandwidth, maximum EIRP output power

The three default channels correspond to 922.1, 922.3, and 922.5 MHz / DR0 to DR5 and SHALL be implemented in every KR920-923 end-device. For devices compliant with [TS001-1.0.x], those default channels SHALL NOT be modified through the ***NewChannelReq*** command. For devices compliant with [TS001-1.1.x] and beyond, these channels MAY be modified through the ***NewChannelReq*** command but SHALL be reset during the back-off procedure defined in [TS001] to guarantee a minimal common channel set between end-devices and network gateways.

The following table gives the list of frequencies that SHALL be used by end-devices to broadcast the Join-Request message. The Join-Request message transmit duty-cycle SHALL follow the rules described in chapter “Retransmissions back-off” of the LoRaWAN [TS001] specification document.

Modulation	Bandwidth [kHz]	Channel Frequency [MHz]	LoRa DR / Bitrate	Number of Channels
LoRa	125	922.10 922.30 922.50	DR0 to DR5 / 0.3-5 kbps	3

Table 67: KR920-923 default channels

In order to access the physical medium, the South Korea regulations impose several restrictions. The South Korea regulations allow the choice of using either a duty-cycle limitation or Listen Before Talk Adaptive Frequency Agility (LBT AFA) transmission management. The current LoRaWAN specification for the KR920-923 band exclusively uses the LBT channel access rule to maximize `MACPayload` size length and comply with the South Korea regulations.

KR920-923 MHz band end-devices SHALL use the following default parameters:

- Default EIRP output power for end-device (920.9~921.9 MHz): 10 dBm
- Default EIRP output power for end-device (922.1~923.3 MHz): 14 dBm
- Default EIRP output power for gateway: 23 dBm

KR920-923 MHz end-devices SHALL be capable of operating in the 920 to 923 MHz frequency band and SHALL feature a channel data structure to store the parameters of at least 24 channels. A channel data structure corresponds to a frequency and a set of data rates usable on this frequency.

The following table gives the list of frequencies that SHALL be used by end-devices to broadcast the Join-Request message:

Modulation	Bandwidth [kHz]	Channel Frequency [MHz]	LoRa DR / Bitrate	Number of Channels
LoRa	125	922.10 922.30 922.50	DR0 to DR5 / 0.3-5 kbps	3

Table 68: KR920-923 Join-Request channel list

2.11.3 KR920-923 Data Rate and End-Device Output Power Encoding

There is no dwell time limitation for the KR920-923 PHY layer. The ***TxParamSetupReq*** MAC command is not implemented by KR920-923 devices.

The following encoding is used for Data Rate (DR), and EIRP Output Power (TXPower) in the KR920-923 band:

Data Rate	Configuration	Indicative Physical Bit Rate [bit/s]
0	LoRa: SF12 / 125 kHz	250
1	LoRa: SF11 / 125 kHz	440
2	LoRa: SF10 / 125 kHz	980
3	LoRa: SF9 / 125 kHz	1760
4	LoRa: SF8 / 125 kHz	3125
5	LoRa: SF7 / 125 kHz	5470
6..14	RFU	
15	Defined in [TS001][31]	

Table 69: KR920-923 TX data rate

KR920-923 end-devices SHALL support the following data rates:

1. DR0 to DR5 (minimum set supported for certification)

All data rates in the range specified SHALL be implemented (meaning no intermediate DR may be left unimplemented).

When the device is using the Adaptive Data Rate mode and transmits using the DRcurrent data rate, the following table defines the next data rate (`DRnext`) the end-device SHALL use during data rate back-off:

DRcurrent	DRnext	Comment
0	NA	Already the lowest data rate
1	0	
2	1	
3	2	
4	3	
5	4	

Table 70: KR920-923 data rate back-off

TXPower	Configuration (EIRP)
0	Max EIRP
1	Max EIRP – 2dB
2	Max EIRP – 4dB
3	Max EIRP – 6dB
4	Max EIRP – 8dB
5	Max EIRP – 10dB
6	Max EIRP – 12dB
7	Max EIRP – 14dB
8..14	RFU
15	Defined in [TS001]**Error! Bookmark not defined.**

Table 71: KR920-923 TXPower

EIRP refers to the Equivalent Isotropically Radiated Power, which is the radiated output power referenced to an isotropic antenna radiating power equally in all directions and whose gain is expressed in dBi.

By default, the Max EIRP is considered to be +14 dBm. If the end-device cannot achieve 14 dBm EIRP, the Max EIRP SHOULD be communicated to the Network Server using an out-of-band channel during the end-device commissioning process.

When the device transmits in a channel whose frequency is <922 MHz, the transmit power SHALL be limited to +10 dBm EIRP even if the current transmit power level set by the Network Server is higher.

2.11.4 KR920-923 Join-Accept CFList

The KR920-923 band LoRaWAN implements an OPTIONAL CFList of 16 octets in the Join-Accept message for both `CFListType` 0 and `CFListType` 1. When receiving a `CFListType` 1, it shall be interpreted according to the channel list definition in Section 2.3.2.1 (*800 MHz Fixed Channel List Definition*).

2.11.5 KR920-923 *LinkADRReq* Command

The KR920-923 channel plan of LoRaWAN supports a minimum of 24 and a maximum of 80 channels. The `ChMaskCntl` field of the ***LinkADRReq*** command has the following meaning:

ChMaskCntl	ChMask Applies To
0	Channels 0 to 15
1	Channels 16 to 31
2	Channels 32 to 47
3	Channels 48 to 63
4	Channels 64 to 79
5	10 LSBs control channel blocks 0 to 9, 6 MSBs are RFU
6	All channels ON: The device SHALL enable all currently defined channels independently of the `ChMask` field value.
7	RFU

Table 72: KR920-923 ChMaskCntl value

If `ChMaskCntl` = 5, the corresponding bits in the `ChMask` enable and disable a bank of eight channels defined by the following calculation: [`ChannelMaskBit` * 8, `ChannelMaskBit` * 8 +7].

If the `ChMaskCntl` field value is RFU, the end-device SHALL[16] reject the command and unset the `Channel mask ACK` bit in its response.

2.11.6 KR920-923 Maximum Payload Size

The maximum `MACPayload` size length (*M*) is given by the following table for the regulation of dwell time; less than 4 seconds with LBT. It is derived from a limitation of the PHY layer, depending on the effective modulation rate used, taking into account a possible repeater encapsulation layer. The maximum application payload length in the absence of the OPTIONAL `FOpts` control field (*N*) is also given for information only. The value of *N* might be smaller if the `FOpts` field is not empty.

Data Rate	M	N
0	59	51
1	59	51
2	59	51
3	123	115
4	230	222
5	230	222
6:15	Not defined	

Table 73: KR920-923 maximum payload size (repeater compatible)

If the end-device will never operate with a repeater, the maximum application payload length in the absence of the OPTIONAL `FOpts` control field SHOULD be:

Data Rate	M	N
0	59	51
1	59	51
2	59	51
3	123	115
4	250	242
5	250	242
6:15	Not defined	

Table 74: KR920-923 maximum payload size (not repeater compatible)

2.11.7 KR920-923 Receive Windows

By default, the RX1 receive window uses the same channel as the preceding uplink. The data rate is a function of the uplink data rate and the `RX1DROffset`, as given by the following table. The allowed values for `RX1DROffset` are in the [0:5] range. Values in the [6:7] range are reserved for future use.

Upstream Data Rate	Downstream Data rate					
RX1DROffset	0	1	2	3	4	5
DR0	DR0	DR0	DR0	DR0	DR0	DR0
DR1	DR1	DR0	DR0	DR0	DR0	DR0
DR2	DR2	DR1	DR0	DR0	DR0	DR0
DR3	DR3	DR2	DR1	DR0	DR0	DR0
DR4	DR4	DR3	DR2	DR1	DR0	DR0
DR5	DR5	DR4	DR3	DR2	DR1	DR0

Table 75: KR920-923 downlink RX1 data rate mapping

The RX2 receive window uses a fixed frequency and data rate. The default parameters are `921.90 MHz / DR0` (SF12, 125 kHz).

2.11.8 KR920-923 Class B Beacon and Default Downlink Channel

The beacon frame content is defined in section 4.1.3.[17]

The default beacon data rate is `DR3`.

The default beacon broadcast frequency is `923.1 MHz`.

The default class B downlink ping-slot frequency is `923.1 MHz`

2.11.9 KR920-923 Relay Parameters

The WOR default channels are:

Channel Index	**0**	**1**
Frequency WOR (MHz)	922.7	923.1
Frequency WOR ACK (MHz)	922.9	923.1
SF	SF9	
BW	BW125	

Table 76: KR920-923 WOR default channel

2.11.10 KR920-923 Default Settings

There are no specific default settings for the KR920-923 MHz band.

2.12 IN865-867 MHz Band

2.12.1 IN865-867 Preamble Format

Refer to Section 4, “Physical Layer”.

2.12.2 IN865-867 Band Channel Frequencies

This section applies to the Indian sub-continent.

The network channels can be freely attributed by the network operator. However, the three following default channels SHALL be implemented in every India 865-867 MHz end-device. Network gateways SHALL be listening on one or more of these channels.

Modulation	Bandwidth [kHz]	Channel Frequency [MHz]	LoRa DR / Bitrate	Number of Channels
LoRa	125	865.0625 865.4025 865.985	DR0 to DR5 / 0.3-5 kbps	3

Table 77: IN865-867 default channels

End-devices SHALL be capable of operating in the 865 to 867 MHz frequency band and should feature a channel data structure to store the parameters of at least 24 channels. A channel data structure corresponds to a frequency and a set of data rates usable on this frequency.

The first three channels correspond to 865.0625, 865.4025, and 865.985 MHz / DR0 to DR5 and SHALL be implemented in every end-device. For devices compliant with [TS001-1.0.x], those default channels SHALL NOT be modified through the ***NewChannelReq*** command. For devices compliant with [TS001-1.1.x] and beyond, these channels MAY be modified through the ***NewChannelReq*** command but SHALL be reset during the back-off procedure defined in [TS001] to guarantee a minimal common channel set between end-devices and network gateways.

The following table gives the list of frequencies that SHALL be used by end-devices to broadcast the Join-Request message. The Join-Request message transmit duty-cycle SHALL follow the rules described in chapter “Retransmissions back-off” of the LoRaWAN [TS001] specification document.

Modulation	Bandwidth [kHz]	Channel Frequency [MHz]	LoRa DR / Bitrate	Number of Channels
LoRa	125	865.0625 865.4025 865.9850	DR0 – DR5 / 0.3-5 kbps	3

Table 78: IN865-867 Join-Request channel list

2.12.3 IN865-867 Data Rate and End-Device Output Power Encoding

There is no dwell time or duty-cycle limitation for the INDIA 865-867 PHY layer. The ***TxParamSetupReq*** MAC command is not implemented by INDIA 865-867 devices.

The following encoding is used for Data Rate (DR) and end-device output power (TXPower) in the INDIA 865-867 band:

Data Rate	Configuration	Indicative Physical Bit Rate [bit/s]
0	LoRa: SF12 / 125 kHz	250
1	LoRa: SF11 / 125 kHz	440
2	LoRa: SF10 / 125 kHz	980
3	LoRa: SF9 / 125 kHz	1760
4	LoRa: SF8 / 125 kHz	3125
5	LoRa: SF7 / 125 kHz	5470
6	RFU	RFU
7	FSK: 50 kbps	50000
8..14	RFU	
15	Defined in [TS001][33]	

Table 79: IN865-867 TX data rate

[33] DR15 and TXPower15 are defined in the ***LinkADRReq*** MAC command of the LoRaWAN1.0.4 and subsequent specifications and were previously RFU.

IN865-867 end-devices SHALL support one of the two following data rate options:

1. DR0 to DR5 (minimum set supported for certification)
2. DR0 to DR6 and DR7

For both options, all data rates in the range specified SHALL be implemented (meaning no intermediate DR may be left unimplemented).

When the device is using the Adaptive Data Rate mode and transmits using the `DRcurrent` data rate, the following table defines the next data rate (`DRnext`) the end-device SHALL use during data rate back-off:

DRcurrent	DRnext	Comment
0	NA	Already the lowest data rate
1	0	
2	1	
3	2	
4	3	
5	4	
7	5	

Table 80: IN865-867 data rate back-off

The `TXPower` table indicates power levels relative to the Max EIRP level of the end-device, as per the following table:

TXPower	Configuration (EIRP)
0	Max EIRP
1	Max EIRP – 2dB
2	Max EIRP – 4dB
3	Max EIRP – 6dB
4	Max EIRP – 8dB
5	Max EIRP – 10dB
6	Max EIRP – 12dB
7	Max EIRP – 14dB
8	Max EIRP – 16dB
9	Max EIRP – 18dB
10	Max EIRP – 20dB
11..14	RFU
15	Defined in [TS001][31]

Table 81: IN865-867 TXPower

EIRP refers to the Equivalent Isotropically Radiated Power, which is the radiated output power referenced to an isotropic antenna radiating power equally in all directions and whose gain is expressed in dBi.

By default, Max EIRP is considered to be 30 dBm. If the end-device cannot achieve 30 dBm EIRP, the Max EIRP SHOULD be communicated to the Network Server using an out-of-band channel during the end-device commissioning process.

2.12.4 IN865-867 Join-Accept CFList

The India 865-867 band LoRaWAN implements an OPTIONAL CFList of 16 octets in the Join-Accept message for both `CFListType` 0 and `CFListType` 1. When receiving a `CFListType` 1, it shall be interpreted according to the channel list definition in Section 2.3.2.1 (*800 MHz Fixed Channel List Definition*).

2.12.5 IN865-867 *LinkADRReq* Command

The INDIA 865-867 channel plan LoRaWAN supports a minimum of 24 and a maximum of 80 channels. The `ChMaskCntl` field of the ***LinkADRReq*** command has the following meaning:

ChMaskCntl	ChMask Applies To
0	Channels 0 to 15
1	Channels 16 to 31
2	Channels 32 to 47
3	Channels 48 to 63
4	Channels 64 to 79
5	10 LSBs control channel blocks 0 to 9, 6 MSBs are RFU
6	All channels ON: The device SHALL enable all currently defined channels independently of the `ChMask` field value.
7	RFU

Table 82: IN865-867 ChMaskCntl value

If `ChMaskCntl` = 5, the corresponding bits in the `ChMask` enable and disable a bank of eight channels defined by the following calculation: [`ChannelMaskBit` * 8, `ChannelMaskBit` * 8 +7].

If the `ChMaskCntl` field value is RFU, the end-device SHALL[16] reject the command and unset the `Channel mask ACK` bit in its response.

2.12.6 IN865-867 Maximum Payload Size

The maximum `MACPayload` size length (*M)* is given by the following table. It is derived from a limitation of the PHY layer, depending on the effective modulation rate used, taking into account a possible repeater encapsulation layer. The maximum application payload length in the absence of the OPTIONAL `FOpts` control field (*N*) is also given for information only. The value of *N* might be smaller if the `FOpts` field is not empty.

Data Rate	M	N
0	59	51
1	59	51
2	59	51
3	123	115
4	230	222
5	230	222
7	230	222
8:15	Not defined	

Table 83: IN865-867 maximum payload size (repeater compatible)

If the end-device will never operate with a repeater, the maximum application payload length in the absence of the OPTIONAL `FOpts` control field SHOULD be:

Data Rate	M	N
0	59	51
1	59	51
2	59	51
3	123	115
4	250	242
5	250	242
7	250	242
8:15	Not defined	

Table 84: IN865-867 maximum payload size (not repeater compatible)

2.12.7 IN865-867 Receive Windows

By default, the RX1 receive window uses the same channel as the preceding uplink. The data rate is a function of the uplink data rate and the `RX1DROffset`, as given by the following table. The allowed values for `RX1DROffset` are in the [0:7] range.

Values in the [6:7] range allow setting the downstream RX1 data rate higher than upstream data rate[34].

The allowed values for `RX1DROffset` are in the [0:7] range, encoded as per the following table:

Upstream Data Rate	**Downstream Data Rate**							
RX1DROffset	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
DR0	DR0	DR0	DR0	DR0	DR0	DR0	DR1	DR2
DR1	DR1	DR0	DR0	DR0	DR0	DR0	DR2	DR3
DR2	DR2	DR1	DR0	DR0	DR0	DR0	DR3	DR4
DR3	DR3	DR2	DR1	DR0	DR0	DR0	DR4	DR5
DR4	DR4	DR3	DR2	DR1	DR0	DR0	DR5	DR5
DR5	DR5	DR4	DR3	DR2	DR1	DR0	DR5	DR7
DR7	DR7	DR5	DR5	DR4	DR3	DR2	DR7	DR7

Table 85: IN865-867 downlink RX1 data rate mapping

The RX2 receive window uses a fixed frequency and data rate. The default parameters are `866.550 MHz / DR2` (SF10, 125 kHz).

2.12.8 IN865-867 Class B Beacon and Default Downlink Channel

The beacon frame content is defined in section 4.1.3.[17]

The default beacon data rate is `DR4`.

The default beacon broadcast frequency is `866.550 MHz`.

The default class B downlink ping-slot frequency is `866.550 MHz`.

2.12.9 IN865-867 Relay Parameters

The WOR default channels are:

Channel Index	**0**	**1**
Frequency WOR (MHz)	866.0	866.7
Frequency WOR ACK (MHz)	866.2	866.9
SF	SF9	
BW	BW125	

Table 86: IN865-867 WOR default channel

2.12.10 IN865-867 Default Settings

There are no specific default settings for the IN 865-867 MHz band.

[34] DR7 is allowed in RX1 for IN865 since version RP2 1.0.0, in previous versions downlink data rate was limited to DR5 in RX1.

2.13 RU864-870 MHz Band

2.13.1 RU864-870 Preamble Format

Refer to Section 4, "Physical Layer".

2.13.2 RU864-870 Band Channel Frequencies

The network channels can be freely attributed by the network operator in compliance with the allowed sub-bands defined by the Russian regulation. However, the two following default channels SHALL be implemented in every RU864-870 MHz end-device. Network gateways SHALL be listening on one or more of these channels.

Modulation	Bandwidth [kHz]	Channel Frequency [MHz]	LoRa DR / Bitrate	Number of Channels	Duty Cycle
LoRa	125	868.9 869.1	DR0 to DR5 / 0.3-5 kbps	2	<1%

Table 87: RU864-870 default channels

RU864-870 MHz end-devices SHALL be capable of operating in the 864 to 870 MHz frequency band and SHALL feature a channel data structure to store the parameters of at least 24 channels. A channel data structure corresponds to a frequency and a set of data rates usable on this frequency.

The first two channels correspond to 868.9 and 869.1 MHz / DR0 to DR5 and SHALL be implemented in every end-device. For devices compliant with [TS001-1.0.x], those default channels SHALL NOT be modified through the ***NewChannelReq*** command. For devices compliant with [TS001-1.1.x] and beyond, these channels MAY be modified through the ***NewChannelReq*** command but SHALL be reset during the back-off procedure defined in [TS001] to guarantee a minimal common channel set between end-devices and network gateways.

The following table gives the list of frequencies that SHALL be used by end-devices to broadcast the Join-Request message. The Join-Request message transmit duty-cycle SHALL follow the rules described in chapter "Retransmissions back-off" of the LoRaWAN [TS001] specification document.

Modulation	Bandwidth [kHz]	Channel Frequency [MHz]	LoRa DR / Bitrate	Number of Channels
LoRa	125	868.9 869.1	DR0 – DR5 / 0.3-5 kbps	2

Table 88: RU864-870 Join-Request channel list

2.13.3 RU864-870 Data Rate and End-Device Output Power Encoding

There is no dwell time limitation for the RU864-870 PHY layer. The ***TxParamSetupReq*** MAC command is not implemented in RU864-870 devices.

The following encoding is used for Data Rate (DR) and end-device EIRP (TXPower) in the RU864-870 band:

Data Rate	Configuration	Indicative Physical Bit Rate [bit/s]
0	LoRa: SF12 / 125 kHz	250
1	LoRa: SF11 / 125 kHz	440
2	LoRa: SF10 / 125 kHz	980
3	LoRa: SF9 / 125 kHz	1760

4	LoRa: SF8 / 125 kHz	3125
5	LoRa: SF7 / 125 kHz	5470
6	LoRa: SF7 / 250 kHz	11000
7	FSK: 50 kbps	50000
8..14	RFU	
15	Defined in [TS001][31]	

Table 89: RU864-870 TX Data rate

RU864-870 end-devices SHALL support one of the two following data rate options:

1. DR0 to DR5 (minimum set supported for certification)
2. DR0 to DR7

For both options, all data rates in the range specified SHALL be implemented (meaning no intermediate DR may be left unimplemented).

When the device is using the Adaptive Data Rate mode and transmits using the `DRcurrent` data rate, the following table defines the next data rate (`DRnext`) the end-device SHALL use during data rate back-off:

DRcurrent	DRnext	Comment
0	NA	Already the lowest data rate
1	0	
2	1	
3	2	
4	3	
5	4	
6	5	
7	6	

Table 90: RU864-870 data rate back-off

EIRP[35] refers to the Equivalent Isotropically Radiated Power, which is the radiated output power referenced to an isotropic antenna radiating power equally in all directions and whose gain is expressed in dBi.

TXPower	Configuration (EIRP)
0	Max EIRP
1	Max EIRP – 2dB
2	Max EIRP – 4dB
3	Max EIRP – 6dB
4	Max EIRP – 8dB
5	Max EIRP – 10dB
6	Max EIRP – 12dB
7	Max EIRP – 14dB
8..14	RFU
15	Defined in [TS001][31]

Table 91: RU864-870 TXPower

By default, the Max EIRP is considered to be +16 dBm. If the end-device cannot achieve +16 dBm EIRP, the Max EIRP SHOULD be communicated to the Network Server using an out-of-band channel during the end-device commissioning process.

[35] ERP = EIRP – 2.15dB; it is referenced to a half-wave dipole antenna whose gain is expressed in dBd.

2.13.4 RU864-870 Join-Accept CFList

The RU864-870 band LoRaWAN implements an OPTIONAL CFList of 16 octets in the Join-Accept message for both `CFListType` 0 and `CFListType` 1. When receiving a `CFListType` 1, it shall be interpreted according to the channel list definition in Section 2.3.2.1 (*800 MHz Fixed Channel List Definition*).

2.13.5 RU864-870 *LinkADRReq* Command

The RU864-870 channel plan of LoRaWAN supports a minimum of 24 and a maximum of 80 channels. The `ChMaskCntl` field of the ***LinkADRReq*** command has the following meaning:

ChMaskCntl	ChMask Applies To
0	Channels 0 to 15
1	Channels 16 to 31
2	Channels 32 to 47
3	Channels 48 to 63
4	Channels 64 to 79
5	10 LSBs control channel blocks 0 to 9, 6 MSBs are RFU
6	All channels ON: The device SHALL enable all currently defined channels independently of the `ChMask` field value.
7	RFU

Table 92: RU864-870 ChMaskCntl value

If `ChMaskCntl` = 5, the corresponding bits in the `ChMask` enable and disable a bank of eight channels defined by the following calculation: [`ChannelMaskBit` * 8, `ChannelMaskBit` * 8 +7].

If the `ChMaskCntl` field value is RFU, the end-device SHALL[16] reject the command and unset the `Channel mask ACK` bit in its response.

2.13.6 RU864-870 Maximum Payload Size

The maximum `MACPayload` size length (*M)* is given by the following table. It is derived from a limitation of the PHY layer, depending on the effective modulation rate used, taking into account a possible repeater encapsulation layer. The maximum application payload length in the absence of the OPTIONAL `FOpts` control field (*N*) is also given for information only. The value of *N* might be smaller if the `FOpts` field is not empty.

Data Rate	M	N
0	59	51
1	59	51
2	59	51
3	123	115
4	230	222
5	230	222
6	230	222
7	230	222
8:15	Not defined	

Table 93: RU864-870 maximum payload size (repeater compatible)

If the end-device will never operate with a repeater, the maximum application payload length in the absence of the OPTIONAL `FOpts` control field SHOULD be:

Data Rate	M	N
0	59	51
1	59	51
2	59	51
3	123	115
4	250	242
5	250	242
6	250	242
7	250	242
8:15	Not defined	

Table 94: RU864-870 maximum payload size (not repeater compatible)

2.13.7 RU864-870 Receive Windows

By default, the RX1 receive window uses the same channel as the preceding uplink. The data rate is a function of the uplink data rate and the `RX1DROffset`, as given by the following table. The allowed values for `RX1DROffset` are in the [0:5] range. Values in the [6:7] range are reserved for future use.

Upstream Data Rate	Downstream Data Rate					
RX1DROffset	**0**	**1**	**2**	**3**	**4**	**5**
DR0	DR0	DR0	DR0	DR0	DR0	DR0
DR1	DR1	DR0	DR0	DR0	DR0	DR0
DR2	DR2	DR1	DR0	DR0	DR0	DR0
DR3	DR3	DR2	DR1	DR0	DR0	DR0
DR4	DR4	DR3	DR2	DR1	DR0	DR0
DR5	DR5	DR4	DR3	DR2	DR1	DR0
DR6	DR6	DR5	DR4	DR3	DR2	DR1
DR7	DR7	DR6	DR5	DR4	DR3	DR2

Table 95: RU864-870 downlink RX1 data rate mapping

The RX2 receive window uses a fixed frequency and data rate. The default parameters are `869.1 MHz / DR0` (SF12, 125 kHz)

2.13.8 RU864-870 Class B Beacon and Default Downlink Channel

The beacon frame content is defined in section 4.1.3.[17]

The default beacon data rate is `DR3`.

The default beacon broadcast frequency is `869.1 MHz`.

The default class B downlink ping-slot frequency is `868.9 MHz`.

2.13.9 RU864-870 Relay Parameters

The WOR default channels are:

Channel Index	**0**	**1**
Frequency WOR (MHz)	866.1	866.5
Frequency WOR ACK (MHz)	866.3	866.9
SF	SF9	
BW	BW125	

Table 96: RU864-870 WOR default channel

2.13.10 RU864-870 Default Settings

There are no specific default settings for the RU864-870 MHz band.

3 Repeaters

Repeaters have not yet been specified by the LoRa Alliance; however, this specification does include references to repeaters and constraints that end-devices should follow to be compliant with them.

3.1 Repeater Compatible Maximum Payload Size

Repeaters, as referenced in this specification, were intended to fully encapsulate a `MACPayload` in the `ApplicationPayload` of another LoRaWAN data message. In addition to the original `MACPayload`, up to 20 bytes of metadata describing the original message were envisioned to be included with the encapsulated data message. In order to minimize impact on the end-device and its application, repeaters would communicate with the network (gateways) using only data rates that supported the maximum allowed `MACPayload` size of 250 bytes. Therefore, these data rates show a maximum payload size that is 20 bytes fewer when describing “Repeater Compatible” operation.

4 Physical Layer

The LoRaWAN uses a physical layer to communicate with other devices. Three physical layers are currently supported through the long range (LoRa), Long-Range Frequency Hopping Spread Spectrum (LR-FHSS), and Frequency shift keying (FSK) modulations.

4.1 LoRa Description

4.1.1 LoRa Packet Physical Structure

LoRa messages use the radio packet explicit header mode, in which the LoRa physical header (`PHDR`) plus a header CRC (`PHDR_CRC`) are included.[36] In explicit header mode, the `PHDR` specifies the payload length in bytes, the forward error correction rate, and the presence of an OPTIONAL CRC for the payload. The integrity of the payload is protected by a CRC for uplink messages. LoRaWAN beacons are transmitted using LoRa modulation in implicit header mode with no payload CRC. The size of the payload depends on the beacon's data rate. In implicit header mode, neither the `PHDR` nor `PHDR_CRC` are present.

The `PHDR` , `PHDR_CRC` and payload `CRC` fields are inserted by the radio transceiver.

PHY:

Size	8 Symbols	4.25 Symbols	8 Symbols		*L* bytes (from PHDR)	2 Bytes
Packet Structure	Preamble	Synchronization Word	PHDR	PHDR_CRC	PHYPayload	CRC (uplink only)

Table 97: LoRa PHY structure

4.1.2 LoRa Settings

In order to be fully compliant with LoRaWAN, an end-device SHALL configure the LoRa physical layer as described in Table 98 and Table 99:

Parameter	Uplink Value	Downlink Value	Class B Beacon
Preamble size	8 symbols		10 symbols
SyncWord	0x34 (Public)		
Header type	Explicit		Implicit
CRC presence	True	False	
Coding Rate	4/5		
Spreading Factor	Defined by the data rate, specified in each region		
Bandwidth			
IQ polarization	Not-inverted	Inverted	Not-inverted

Table 98: LoRa physical layer settings

The `LDRO` parameter stands for Low Data Rate Optimizer. If set, the modulation alphabet is reduced to allow better synchronization and tracking on the receiver. Since such synchronization is more difficult on low data rates, it is enabled only on the lowest data rates. It also increases the tolerance for multipath delays from simultaneous transmissions (that gain does not depend on data rate). This parameter is not signaled in the `PHDR`. Therefore, it needs to be set to a constant value for each data rate.

[36] See the LoRa radio transceiver datasheet for a description of LoRa radio packet implicit/explicit modes.

Data Rate	LDRO Parameter	Status
BW125, SF7 to SF10	0	Disabled
BW125, SF11 and SF12	1	Enabled
BW250, SF7 to SF11	0	Disabled
BW250, SF12	1	Enabled
BW500, SF7 to SF12	0	Disabled

Table 99: LoRa physical layer settings for LDRO

4.1.3 Class B Beacon Frame Content

The beacon payload `BCNPayload` consists of a network common part and an OPTIONAL gateway-specific part. The size of the RFU fields for each part depend on the LoRa spreading factor used to send the beacon. The length is adjusted to fit LoRa modulation interleaving blocks, so that the network common part and gateway-specific part are carried by different portions of the radio packet. In addition, each part has an independent CRC. As a result, it is possible to receive correctly and detect the correct reception of the network common part, even if several gateways transmit concurrently a beacon with different gateway-specific parts. In that situation, the gateway-specific part will likely not be received correctly, and this will be detected by the CRC.

	Size (Octets)						
`BCNPayload`	**Common**				**Gateway-Specific**		
	`RFU`	`Param`	`Time`	CRC	`GwSpecific`	`RFU`	CRC
SF 8 BW125/BW500		1	4	2	7	3	2
SF 9 BW125/BW500	1	1	4	2	7	0	2
SF 10 BW125/BW500	2	1	4	2	7	1	2
SF 11 BW500	3	1	4	2	7	2	2
SF 12 BW500	4	1	4	2	7	3	2

Table 100: Beacon frame content

	With Network Common Part Only	With Network Common + Gateway-Specific Parts
SF8 – 125KHz	55.8 ms	86.5 ms
SF9 – 125KHz	111.6 ms	152.6 ms
SF10 – 125KHz	223.2 ms	305.2 ms
SF8 – 500KHz	14.0 ms	21.6 ms
SF9 – 500KHz	27.9 ms	38.1 ms
SF10 – 500KHz	55.8 ms	76.3 ms
SF11 – 500KHz	111.6 ms	152.6 ms
SF12 – 500KHz	223.2 ms	305.2 ms

Table 101: Beacon time-on-air

Example: This is a valid EU868 beacon frame (SF9):

Field	RFU	Param	Time	**CRC**	InfoDesc	Lat	Lng	**CRC**
Value Hex	00	00	CC020000	**7EA2**	0	002001	038100	**55DE**

Table 102: Example of beacon CRC calculation (SF9)

Example: Over the air, the octets are sent in the following order:

`00 00 | 00 00 02 CC | A2 7E | 00 | 01 20 00 | 00 81 03 | DE 55`

The first CRC is calculated on [00 00 00 00 02 CC].

The OPTIONAL gateway-specific part provides additional information regarding the gateway sending a beacon and therefore can differ for each gateway. The OPTIONAL part is protected by a CRC-16 computed on the `GwSpecific` + `RFU` fields. The CRC-16 definition SHALL be the same as for the mandatory part.

Example: This is a valid US915 beacon (SF12):

Field	RFU	Param	Time	**CRC**	InfoDesc	Lat	Lng	**RFU**	**CRC**
Value Hex	0000	00	CC020000	**7EA2**	00	002001	038100	**00**	**D450**

Table 103: Example of beacon CRC calculation

Example: Over the air, the octets are sent in the following order:

`00 00 00 | 00 00 02 CC | A2 7E | 00 | 01 20 00 | 00 81 03 | 00 | 50 D4`

4.2 FSK Description

4.2.1 FSK Packet Physical Structure

FSK messages can be built either by the software stack or by the hardware transceiver, depending on the end-device architecture.

The *PHYPayload length* field contains the length in bytes of the *PHYPayload* field.
The *CRC* field is computed on *PHYPayload length* and *PHYPayload* fields, using the CRC-CCITT algorithm.

PHY:

Size (bytes)	5	3	1	*L bytes from PHYPayloadLength*	2
Packet Structure	Preamble	SyncWord	PHYPayloadLength	PHYPayload	CRC

Table 104: FSK PHY structure

4.2.2 FSK Settings

In order to be fully compliant with LoRaWAN, an end-device SHALL configure the FSK physical layer as follows:

Parameter	**Uplink Value**	**Downlink Value**
Preamble size	5 bytes	
SyncWord	0xC194C1	
Bitrate	50000 bit/sec	
Tx frequency deviation	25 kHz (SSB[37])	
Rx bandwidth	50 kHz (SSB)	
Rx bandwidth AFC	80 kHz (SSB)	
CRC presence	True (CRC-16-CCITT)	

[37] SSB: Single-Side Bandwidth

Gaussian filter	BT = 1,0
DC-Free Encoding	Whitening Encoding

Table 105: FSK physical layer settings

To avoid a non-uniform power distribution signal with the FSK modulation, a data whitening DC-free data mechanism is used as shown in the above table.

4.3 LR-FHSS Description

LR-FHSS modulation is only used on the uplink.

4.3.1 LR-FHSS Physical Layer Description

LR-FHSS is a fast frequency hopping spread spectrum (FHSS) modulation with bit rates ranging from 162bits/s to 325bits/s.

When a device transmits a packet using LR-FHSS on a given channel, the packet content is modulated across several pseudo-random frequencies that spans the interval:

$$F_{interval} = centrefreq \pm \; bw/2$$

For FCC 47 CFR Part 15 compliance, the end-device frequency hops across 60 physical channels on a 25.4 kHz frequency grid.

For ETSI based countries, the end-device frequency hops across 35 or 86 physical channels on a 3.9 kHz frequency grid.

All physical channels are statistically used equally.

The transmission starts on a random frequency inside the interval, and the following frequency hopping pattern is also randomly selected and announced in the LR-FHSS packet physical header. The transmission carrier frequency changes every 102.4 msec for each payload fragment, and 233.472 msec for each PHY header.

The instantaneous LR-FHSS modulation bandwidth is 488 Hz. Therefore, a single LR-FHSS channel actually corresponds to many physical frequency channels.

The LR-FHSS frequency hopping bandwidth is region-specific.

The LR-FHSS physical layer is described in the following table:

LR-FHSS Frequency Hopping BW (all hops)	**LR-FHSS** BW of a single hop	**Minimum Separation Between LR-FHSS Hopping Channels (grid)**	**Number of Physical Channels Usable for Frequency Hopping Per End-Device Transmission**	**Number of Physical Channels Available for Frequency Hopping**	**Coding Rate**	**Physical Bit Rate**
137 kHz	488 Hz	3.9 kHz	35	280 (8x35)	1/3	162bits/s
					2/3	325bits/s
336 kHz	488 Hz	3.9 kHz	86	688 (8x86)	1/3	162bits/s
					2/3	325bits/s
1.523 MHz	488 Hz	25.4 kHz	60	3120 (52x60)	1/3	162bits/s
					2/3	325bits/s

Table 106: LR-FHSS physical layer description

4.3.2 LR-FHSS Packet Physical Structure

LR-FHSS uses redundant physical headers on different frequencies to improve the modulation robustness to in-band interferers. The number (*N*) of PHY headers is selectable on a packet-per-packet basis, in the range 1 to 4.

A LR-FHSS packet has the following structure:

<table>
<tr><th>Repeated</th><td colspan="3">N (1 to 4) times on different frequencies</td><td colspan="2">once</td></tr>
<tr><th rowspan="2">Size</th><td colspan="3">114 bits with convolutional coding rate ½ on (PHDR + PHRD_CRC), 2bits preamble and interleaving</td><td rowspan="2">L Bytes (from PHDR)</td><td rowspan="2">2 Bytes</td></tr>
<tr><td>4 Bytes</td><td>4 Bytes</td><td>1 Byte</td></tr>
<tr><th>Packet Structure</th><td>SyncWord</td><td>PHDR</td><td>PHDR_CRC</td><td>PHYPayload</td><td>CRC</td></tr>
</table>

Table 107: LR-FHSS packet structure

A LR-FHSS packet time-on-air can be computed using the following table:

	PHY Header	Payload + CRC
Forward Error Correction	Conv ½	Conv 1/3 or 2/3
Bits per hop	114	16 info bits (CR=1/3) 32 (CR=2/3)
Time-on-air	N* 233.472 mSec	Ceil((L+3)/2)*102.4 msec (CR=1/3) ceil((L+3)/4)*102.4 msec (2/3)

Table 108: LR-FHSS time-on-air

4.3.3 LR-FHSS PHY Layer Settings

In order to be fully compliant with LoRaWAN, an end-device SHALL configure the LR-FHSS physical header as follows:

Parameter	Uplink Value
PHY header (SyncWord, PHDR, PHDR_CRC) repetition (*N*)	*N*=4: NOT USED *N*=3 when CR1/3 is used by the Payload *N*=2 when CR2/3 is used by the Payload *N*=1: NOT USED
SyncWord	0x2C0F7995
Payload CRC	Enabled
Data Rate	Specified in each region
Coding Rate	1/3 or 2/3 - Defined by the DR, specified in each region
Frequency Hopping Grid	25.4 kHz in FCC like regions 3.9 kHz in other regions Defined by the DR, specified in each region
Frequency hopping Bandwidth (OCW)	137 kHz, 336 kHz or 1.523 MHz Defined by the DR, specified in each region
Channel/hopping sequence	Randomly selected for each transmission

Table 109: LR-FHSS physical layer settings

4.4 Relay Mechanism [TS011] Regional Parameters

4.4.1 Wake On Radio - Physical Parameters

To send a WOR frame, an end-device SHALL configure the LoRa physical layer as follows:

Parameter	Value
Preamble size	At least 8 symbols
Sync Word	0x34 (public)
Header type	Explicit
CRC presence	True
Coding Rate	4/5
IQ polarization	Inverted

Table 110: WOR physical layer settings

Data rate and frequency are region dependent. Refer to each region section for more information.

The output power of the WOR frame SHALL be the default one.

Only LoRa modulation SHALL be used for the WOR protocol exchanges. FSK and LR-FHSS data rates SHALL NOT be used for the WOR protocol exchanges.

> **Note:** The WOR frame uses inverted chirp polarity to minimize false wake-ups of the relay by reception of standard LoRaWAN uplink preambles.

4.4.2 WOR ACK - Physical Parameters

To receive a WOR ACK frame, an end-device SHALL configure the LoRa physical layer as follows:

Parameter	Value
Preamble size	8 symbols
Sync Word	0x34 (public)
Header type	Explicit
CRC presence	True
Coding Rate	4/5
IQ polarization	Inverted
Frequency	For default channel: Refer to WOR parameter for each region. For second channel: The Network Server sets the frequency with a MAC command.
Data rate	Same as the WOR frame.

Table 111: WOR ACK physical layer settings

The output power of the WOR ACK frame SHALL be the default one.

4.4.3 End-Device LoRaWAN Uplink – Physical Parameters

The end-device uplink SHALL use the standard LoRaWAN data rate but SHALL NOT use the LR-FHSS data rate.

4.4.4 Relay Receive Window (RXR) – Physical Parameters

To receive a downlink on RX relay windows, an end-device SHALL configure the LoRa physical layer as follows:

Parameter	**Value**
Preamble size	8 symbols
Sync Word	0x34 (public)
Header type	Explicit
CRC presence	True
Coding Rate	4/5
IQ polarization	Inverted
Frequency	Same as WOR frame
Data rate	Same as LoRaWAN uplink

Table 112: RXR physical layer settings

4.4.5 Default Relay Settings

The following parameters are the values for all regions:

TRUSTED_ED_NUMBER	16
WOR_ATTEMPTS_WO_ACK	8
WOR_DATA_DELAY	50 milliseconds
WOR_ACK_DELAY	50 milliseconds
RELAY_FWD_DELAY	50 milliseconds
RXR_DELAY	18 seconds

> **Note:** These timings have been chosen to be compatible with Listen Before Talk.

The time-on-air of the WOR ACK is dependent on the SF and bandwidth. The following table**Error! Reference source not found.** represents the different possible values:

Time-On-Air [ms]	BW125	BW250	BW500
SF7	36.0	27.2	9.0
SF8	72.1	36.0	18.0
SF9	123.9	61.9	30.9
SF10	247.8	123.9	61.9
SF11	495.6	247.8	123.9
SF12	991.2	495.6	247.8

Table 113: Time-on-air of WOR ACK

5 Revisions

5.1 Revision RP002-1.0.4

- Added support for the following countries:
  - Kazakhstan (IN865)
  - Zimbabwe (E868)
- Revised Algeria channel plan support based on latest intelligence from the Regulatory Working Group, EU868 is supported.
- Added a note to encourage participation in the RPWG by member companies prior to inventing channel plans.
- Clarified MaxEIRP in AU915 and AS923.
- Created Revision-ID to clearly and concisely enumerate versions of this specification.
- Amended band reference for South Africa to 868-868MHz.
- Bolivia no longer supports AU915, now limited to AS923-1,2,3,4.
- Explicitly allowed single-channel gateways:
  - Add channel hopping as an explicit requirement for all regions.
  - Remove requirement for network gateways to be listening on all default channels (EU868, AS923, KR920, RU864).
- Aligned downlink channel selection with the ability to add downlink channels (not modulo 8, but modulo N) for US915 and AU915.
- Adapted minimum (24 or 72) and maximum (80) channel requirements to [TS001] (all regions).
- Deprecated CN779.
- Defined PHY parameter LDRO.
- Added global CFList definitions and addition of CFList Type1 for dynamic plan regions.
- Removed support for EU868 from Bonaire, Sint Eustatius, and Saba (not under ETSI jurisdiction).
- Added support for Relay Specification [TS011].
- Added a footnote on 915-928 MHz band use for countries in the Australia economic zone.
- Defined Class B beacon formats for all LoRa Modulation Spreading Factors.

5.2 Revision RP002-1.0.3

- Added AS923-4 to cover 917-920 MHz (Israel).
- Added a clarifying note regarding DR6/DR7 for AS923/IN865.
- Added LR-FHSS clarifications.

5.3 Revision RP002-1.0.2

- Added a summary table of the regional parameter for all regions except for CN470.
- “Repeater Compatible” rationale is described (Section 3) and US902-928, AU915-928 and CN470-520 maximum payload sizes for “repeater compatible” operation were amended (relaxed) for data rates that do not support encapsulation (this brings them into harmony with all other regions).
- LR-FHSS data rates added to EU868, US915, AU915. Data rate back-off progression explicitly documented for all regions. Data rate support requirements clarified for all regions.
- Aligned the language and descriptions of AS923 maximum payload size section with that of all the other regions.

- Added language to all regions to align with new applications of ***NewChannelReq*** commands as of [TS001-1.1+].
- Amended RU864-870 to indicate that 16 channels SHALL be supported. This was believed to have been an editorial oversight.
- Added Senegal (EU868), Montserrat (AU915), Mali (EU433), Guinea (EU433), Senegal (EU868), Syria (EU433, EU868, AS923-3), and Vanuatu (IN865 & AS923-3) to cross-reference table.
- Modified Israel and Morocco cross-reference table entries.
- Added a Channel Index ID to the Channel Plan Common Name Table.
- Added AS923-1,-2,-3 to the Channel Plan Common Name Table.
- Defined CLASS_B_RESP_TIMEOUT and CLASS_C_RESP_TIMEOUT (used in [TS001-1.0.4] and later).

5.4 Revision RP002-1.0.1

- Modified AS923 to support multiple groups of default/join channels. Each country/band supports a specific configuration based on an offset from the original AS923 default/join channels. Country summary table updated to indicate support.
- Defined Cuba, Indonesia, Philippines, and Vietnam channel plan use.
- Israel support for EU433 and AS923-3 was backed out as Israel MoC has deprecated their use for LoRaWAN as of November 2019. A new 900 MHz band is under discussion with the MoC.
- Increased `MaxPayload` size for AS923, Data Rate 2 from 59 to 123 for `UplinkDwellTime` = 0 and `DownlinkDwellTime` = 0.
- Modified CN470-510 to reflect most recent regulatory requirements. Specifically, SF12 is no longer available and maximum payload sizes for several other data rates were modified to comply with the 1 second dwell time. Further, a 500 kHz LoRa data rate and an FSK data rate were added.
- For dynamic channel plan regions, clarified that it is only by default that the RX1 frequency is the same as the uplink frequency.

5.5 Revision RP002-1.0.0

- Initial RP002-1.0.0 revision, the regional parameters were extracted from the released LoRaWAN v1.1 Regional Parameters.
- Added statement in Section 1 regarding non-authoritative source for regional regulatory information.
- Added Section 2.2 RegParamsRevision common names table.
- Added Regulatory Type Approval to quick reference table in Section 1.
- Added Section 3 (changing this section to section 4) to incorporate changes from CR 00010.001.CR_add_physical_layer_description_Kerlink.docx of the TC21 meeting.
- Clarified Physical Header Explicit Mode (section 3.1).
- Required end-devices in AS923 to accept `MaxPayload` size downlinks as defined for `DownlinkDwellTime`=0, regardless of its actual configuration.
- Fixed several `MaxPayload` tables when operating in “repeater compatible” mode, no `MACPayload` (M) may be larger than 230 bytes, regardless of dwell-time limitations.
- Updated and clarified section 3, Physical Layer.
- Normative language cleanup.
- Removed Beacon format definition and referred back to LoRaWAN specification.
- Fixed the footnote for the US plan in section 2.5.3.
- Added notes concerning the use of ARIB STD-T108 for AS923 end-devices in section 2.10.2.

- Migrated the CN470-510 channel plan from the RP 1.2rA draft.
- Clarified the wording of the footnotes regarding `ChMaskCntl`.
- Made AS923 use consistent in section 2.10.
- Changed SHOULD to SHALL in section 2.6.2.
- Changed footnote references to 1.0.2rC to 1.0.3rA.
- Changed table reference from 1.0.2rC to 1.0.2rB.
- Changed CN779 duty cycle from 0.1% to 1% as per the Regional Regulation Summary.
- Reduced number of default channels for CN779 plan to 3 to make consistent with other plans.
- Changed `RX1DROffset` tables in sections 2.10.7 and 2.12.7 to be direct lookup tables.
- Clarified/fixed errors in sections 2.10.7 and 2.12.7.
- Added default parameter definitions for Class B (referenced in LW).
- Modified as per CR ACK_TIMEOUT / RETRANSMIT_TIMEOUT.
- Modified suggested New Zealand channel plan from EU868 to IN865.
- Modified Bangladesh and Pakistan channel plans from EU868 to IN865.
- Modified Singapore channel plan from EU868 to “Other”.
- Updated Burma (Myanmar) channel plans from EU868 to “Other” and “Other” to AS923.
- Corrected typo error in channel plan for India Added and updated channel plans for Sri Lanka, Bhutan and Papua New Guinea.
- Updated Middle East country suggested channel plan.
- Added channel plans for Samoa, Tonga, and Vanuatu/
- Updated Bahrain and Kuwait channel plans.
- Corrected Qatar frequency range for EU868.
- Updated channel plans for UAE: 870-875.8 MHz band can be used with EU868 channel plan.
- Corrected frequency range for Lebanon from 862-870 MHz to 863-87 MHz.
- Updated Africa priority-one country suggested channel plan.
- Added channel plans for the following African countries: Botswana, Burundi, Cabo Verde, Cameroon, Ghana, Ivory Coast, Kenya, Lesotho, Niger, Rwanda, Tanzania, Togo, Zambia, and Zimbabwe.
- Corrected frequency range for Morocco from 867.6-869MHz to 868-869.65MHz.
- Updated frequency range for Tunisia (863-868MHz added).
- Added EU433 for Nigeria and corrected frequency range from 863-870 to 868-870MHz.
- Added IN865 channel plan for Uganda.
- Updated Belarus and Ukraine channel plans (EU863-870 can be used).
- Added EU433 channel plan for Costa Rica.
- Added channel plans for Suriname.
- Added or corrected bands for Albania, Denmark, Estonia, Hungary, Ireland, Liechtenstein, Luxembourg, Macedonia, Norway, Poland, Slovakia, Slovenia, Switzerland, UK: 918-921MHz changed to 915-918MHz.
- Added channel plans for Trinidad and Tobago, and Bahamas.
- Added channel plans for Aland Islands, Holy See, Monaco, and San Marino.
- Fixed the AU entry in the Quick Reference Table.
- Italicized countries in the country table to highlight those whose regulations may be changing soon.
- Finalized initial Regulatory Type Approval column with information based on LA survey of certified end-device manufacturers.

- Italicized Indonesia due to possible changes to regulatory environment there.
- Addressed inconsistencies in CN470.

6 Bibliography

6.1 References

[TS001] LoRaWAN® MAC Layer Specification, v1.0 through V1.1, the LoRa Alliance.
[TS011] LoRaWAN® Relay Mechanism Specification 1.0.0, the LoRa Alliance.
[EN300.220-2] Short Range Devices (SRD) operating in the frequency range 25 MHz to 1 000 MHz; Part 2: Harmonized Standard for access to radio spectrum for non-specific radio equipment, V.3.2.1, ETSI