

1 **RP002-1.0.2 LoRaWAN® Regional Parameters**

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## RP002-1.0.2 LoRaWAN® Regional Parameters

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**This document is a companion document to the LoRaWAN® protocol specification**

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319

## 320 **1 Introduction**

321

322 This document describes the LoRaWAN<sup>®</sup> regional parameters for different regulatory regions  
 323 worldwide. This document is a companion document to the various versions of the  
 324 LoRaWAN<sup>®</sup> MAC Layer Protocol Specification [TS001]. Separating the regional parameters  
 325 from the protocol specification allows addition of new regions to the former without impacting

326 the latter document.

327

328 This document combines regional parameters aspects defined in all LoRaWAN<sup>®</sup> protocol  
329 specifications, with differences arising from LoRaWAN<sup>®</sup> versions highlighted at each  
330 occurrence.

331

This document references TS001-1.0.4, which is in final draft form at the  
332 time of the publication of RP002-1.0.2 (this document). These  
333 references are clearly highlighted in the text of this document.

334

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

339

340 It must be noted here that, regardless of the specifications provided, at no time is any  
341 LoRaWAN<sup>®</sup> equipment allowed to operate in a manner contrary to the prevailing local rules  
342 and regulations where it is expected to operate. It is the responsibility of the LoRaWAN<sup>®</sup> end-  
343 device to ensure that compliant operation is maintained without any outside assistance from  
344 a LoRaWAN<sup>®</sup> network or any other mechanism.

## 345 **1.1 Conventions**

346

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

351

352 The tables in this document are normative. The figures in this document are informative. The  
353 notes in this document are informative.

## 354 **1.2 Country Cross Reference Table**

355 In order to support the identification of LoRaWAN<sup>®</sup> channel plans for a given country, the  
356 table below provides a quick reference of suggested channel plans available to implementors  
357 for each country.

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

360 The table also provides an indication of the existence of known end devices that are  
361 LoRaWAN<sup>®</sup> certified with Regulatory Type Approval in the given country.

362

363



ISO 3166-1 Country name (Code alpha-2)	Band / channels	Channel Plan	LoRaWAN <sup>®</sup> 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	
<i>Algeria (DZ)</i>	433.05 – 434.79 MHz	EU433	
	870-876MHz		
	880-885MHz		
	915 – 921 MHz	AS923-3	
	925 – 926 MHz		
American Samoa (AS)	902 - 928 MHz	US902-928 <sup>1</sup>	X
Andorra (AD)	433.05 – 434.79 MHz	EU433	
	863 – 870 MHz	EU863-870	
Angola (AO)			
Anguilla (AI)	915 - 928 MHz <sup>2</sup>	AU915-928 <sup>3</sup>	
Antarctica (AQ)			
Antigua and Barbuda (AG)			
Argentina (AR)	915 - 928 MHz <sup>2</sup>	AU915-928	
Armenia (AM)	863 – 870 MHz	EU863-870	
	433.05 – 434.79 MHz	EU433	
Aruba (AW)			
Australia (AU)	915 - 928 MHz	AS923-1	X
		AU915-928	X
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 <sup>1</sup>	
<i>Bahrain (BH)</i>	433 – 434 MHz	EU433	
	863 - 870MHz	EU863-870	
Bangladesh (BD)	433.05 - 434.79 MHz	EU433	
	866 - 868 MHz		

<sup>1</sup> AU915-928 also applies to this band

<sup>2</sup> Regulations imply 902-928 MHz, but only 915-928 MHz is available

<sup>3</sup> AS923-1 also applies to this band

	922 - 925.0 MHz	AS923-1	
Barbados (BB)	902 - 928 MHz	AU915-928 <sup>4</sup>	
Belarus (BY)	433.05 - 434.79 MHz	EU433	
	864.4 - 868.6 MHz	EU863-870	
	869-869.2MHz	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 <sup>4</sup>	
Benin (BJ)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	
Bermuda (BM)	902 - 928 MHz	US902-928 <sup>1</sup>	
Bhutan (BT)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	
Bolivia (BO)	915 - 930 MHz	AU915-928 <sup>3</sup>	
Bonaire, Sint Eustatius and Saba (BQ)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	
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	
	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	

<sup>4</sup> US902-928 also applies to this band

Cameroon (CM)	433.05 – 434.79 MHz	EU433	
Canada (CA)	902 - 928 MHz	US902-928 <sup>1</sup>	X
Central African Republic (CF)			
Chad (TD)			
Chile (CL)	433 – 434.79 MHz	EU433	
	915 - 928MHz <sup>2</sup>	AU915-928 <sup>3</sup>	
China (CN)	920.5 - 924.5 MHz	AS923-1	
	779 - 787 MHz <sup>5</sup>	CN779-787	
	470 - 510 MHz	CN470-510	
	314-316 MHz		
	430 - 432 MHz		
	840 - 845 MHz		
Christmas Island (CX)	915 - 928 MHz	AS923-1 AU915-928	
Cocos Islands (CC)	915 - 928 MHz	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	AS923-1 AU915-928	
Costa Rica (CR)	433.05 - 434.79 MHz	EU433	
	920.5 - 928 MHz	AS923-1	
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	

<sup>5</sup> 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.

	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 <sup>4</sup>	
Dominican Republic (DO)	915 - 928 MHz	AU915-928	
Ecuador (EC)	902 - 928 MHz	AU915-928 <sup>3 4</sup>	
<i>Egypt (EG)</i>	433.05 - 434.79 MHz	EU433	
	865 - 868 MHz	IN865-867	
	863 - 870 MHz	EU863-870	
El Salvador (SV)	915 - 928 MHz	AU915-928 <sup>3</sup>	
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 <sup>4</sup>	
Guadeloupe (GP)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	X
Guam (GU)	902 - 928 MHz	US902-928 <sup>1</sup>	X
Guatemala (GT)	915 – 928 MHz <sup>2</sup>	AU915-928 <sup>3</sup>	
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	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)	915 - 917 MHz <sup>6</sup>		
Italy (IT)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	X
Jamaica (JM)	915 - 928 MHz <sup>2</sup>	AU915-928	
Japan (JP)	920.6 - 928.0 MHz (steps of 200kHz & 600kHz)	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	
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 - 918 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	

<sup>6</sup> Israeli regulators have prohibited use of 915-917MHz, but are considering adding a new band



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 – 865 MHz		
Mayotte (YT)	433.05 - 434.79 MHz	EU433	
	863 – 870 MHz	EU863-870	X
Mexico (MX)	902 – 928 MHz	US902-928 <sup>1</sup>	
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 <sup>4</sup>	
Morocco (MA)	433.05 - 434.79 MHz	EU433	
	869 – 870 MHz		
Mozambique (MZ)			
Myanmar (MM)	433 - 435 MHz	EU433	
	866 - 869MHz		
	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	AS923-1 AU915-928	
	819 - 824 MHz		
	864 - 868MHz	IN865-867	
	433.05 - 434.79 MHz	EU433	
Nicaragua (NI)	915 - 928 MHz <sup>2</sup>	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	AS923-1 AU915-928	
Norfolk Island (NF)	915 - 928 MHz	AS923-1 AU915-928	
Northern Mariana Islands (MP)	902 – 928 MHz	US902-928 <sup>1</sup>	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 <sup>3 4</sup>	
Papua New Guinea (PG)	433.05 - 434.79 MHz	EU433	
	915 – 928 MHz	AU915-928 AS923-1	
Paraguay (PY)	433.05 - 434.79 MHz	EU433	
	915 - 928 MHz	AU915-928 <sup>3</sup>	

Peru (PE)	915 - 928 MHz	AU915-928 <sup>3</sup>	
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 <sup>1</sup>	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 <sup>4</sup>	
Saint Lucia (LC)	902 – 928 MHz	AU915-928 <sup>4</sup>	
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 <sup>4</sup>	
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	
	865 – 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 <sup>2</sup>	AU915-928 <sup>3</sup>	
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	AS923-1 AU915-928	
Tonga (TO)	433.05 – 434.79 MHz	EU433	
	915 – 928 MHz	AU915-928 <sup>3</sup>	
Trinidad and Tobago (TT)	902 – 928 MHz	AU915-928	
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 <sup>2</sup>	AU915-928 <sup>3</sup>	
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 <sup>1</sup>	X
United States of America (US)	902 - 928 MHz	US902-928 <sup>1</sup>	X
Uruguay (UY)	915 - 928 MHz <sup>2</sup>	AU915-928 <sup>3</sup>	
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	
Viet Nam (VN)	433.05 - 434.79 MHz	EU433	
	918 - 923 MHz <sup>7</sup>	AS923-2	
	920 - 922.5 MHz <sup>8</sup>	AS923-2	
Virgin Islands, UK (VG)	915 - 928 MHz <sup>2</sup>	AU915-928 <sup>3</sup>	
Virgin Islands, US (VI)	902 - 928 MHz	US902-928 <sup>1</sup>	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	
Zimbabwe (ZW)	433.05 - 434.79 MHz	EU433	

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Table 1: Channel Plan per ISO 3166-1 Country

<sup>7</sup> Band LIKELY available through 2021 – regulations in flux

<sup>8</sup> Newly proposed band which LIKELY becomes available in 2021 – regulations in flux



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### 1.3 Regional Parameters Summary Table

The following summary tables have been provided as a 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 channels are defined after the join process; and fixed channel plans, where the majority (or all channels in LoRaWAN® versions prior to 1.1.1) of channels are defined statically and known prior to the join process.

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#### 1.3.1 Dynamic Channel Plan Regions

Plan	EU868	CN779	EU433	IN865	KR920	AS923-1	AS923-2	AS923-3	RU864
<b>Default Freq band</b>	863 to 870 MHz	779 to 787 MHz	433 to 434	865 to 867 MHz	920.9 to 923.3 MHz	915 to 928 MHz	915 to 928 MHz	915 to 928 MHz	864 to 870 MHz
	868.10	779.5	433.175	865.0625	922.10	923.20	921.4	916.6	868.9
<b>Mandatory Channel Freq (Join Req)</b>	868.30	779.7	433.375	865.4025	922.30	923.40	921.6	916.8	869.1
	868.50	779.9	433.575	865.985	922.50				
<b>JoinReq DataRate [MinDR:MaxDR]</b>	[0:5]	[0:5]	[0:5]	[0:5]	[0:5]	[2:5]	[2:5]	[2:5]	[0:5]
<b>CFList Type Supported</b>	0	0	0	0	0	0	0	0	0
<b>Mandatory Data Rate [MinDR:MaxDR]</b>	[0:5]	[0:5]	[0:5]	[0:5]	[0:5]	[0:5]	[0:5]	[0:5]	[0:5]
<b>Optional Data Rate [MinDR:MaxDR]</b>	[6:7]   [6:11]	[6:7]	[6:7]	[7]		[6:7]	[6:7]	[6:7]	[6:7]
<b>Number of channels</b>	16	16	16	16	16	16	16	16	16
<b>ChMaskCtrl - ChMask</b>	0 -> Channels 0-15 6 -> All channels on	0 -> Channels 0-15 6 -> All channels on	0 -> Channels 0-15 6 -> All channels on	0 -> Channels 0-15 6 -> All channels on	0 -> Channels 0-15 6 -> All channels on	0 -> Channels 0-15 6 -> All channels on	0 -> Channels 0-15 6 -> All channels on	0 -> Channels 0-15 6 -> All channels on	0 -> Channels 0-15 6 -> All channels on
<b>Default channels</b>	[0:2]	[0:2]	[0:2]	[0:2]	[0:2]	[0:1]	[0:1]	[0:1]	[0:1]
<b>Default RX1DRoffset</b>	0	0	0	0	0	0	0	0	0
<b>Allowed RX1DRoffset</b>	[0:5]	[0:5]	[0:5]	[0:7]	[0:5]	[0:7]	[0:7]	[0:7]	[0:5]
<b>Duty Cycle</b>	< 1%	< 1%	< 10%		LBT	< 1%	< 1%	< 1%	< 1%
<b>Dwell time limitation</b>	No	No	No	No	No	Yes (400ms)	Yes (400ms)	Yes (400ms)	No
<b>TxParamSetupReq support</b>	No	No	No	No	No	Yes	Yes	Yes	No
<b>Max EIRP (default) - TXPower 0</b>	+16 dBm	+12.15 dBm	+12.15 dBm	+30 dBm	+14 dBm	+16 dBm	+16 dBm	+16 dBm	+16 dBm
<b>Default RX2DataRate</b>	DR0	DR0	DR0	DR2	DR0	DR2	DR2	DR2	DR0
<b>Default RX2 Frequency</b>	869.525 MHz	786.0 MHz	434.665 MHz	866.550 MHz	921.90 MHz	923.2 MHz	921.4 MHz	916.6 MHz	869.1 MHz
<b>Class B default Beacon Freq</b>	869.525 MHz	785.0 MHz	434.665 MHz	866.550 MHz	923.1 MHz	923.4 MHz	921.6 MHz	916.8 MHz	869.1 MHz
<b>Class B default downlink pingSlot Freq</b>	869.525 MHz	785.0 MHz	434.665 MHz	866.550 MHz	923.1 MHz	923.4 MHz	921.6 MHz	916.8 MHz	868.9 MHz

Table 2 - Dynamic Channel Plans Summary

374  
375

## 1.3.2 Fixed Channel Plan Regions

Plan	US915	AU915
<b>Default Freq band</b>	902 to 928 MHz	915 to 928 MHz
<b>Mandatory Channel Freq (Join Req)</b>	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])
<b>JoinReq DataRate [MinDR:MaxDR]</b>	64 (125kHz channels) using DR0 and 8 (500kHz channels) using DR4	64 (125kHz channels) using DR2 and 8 (500kHz channels) using DR6
<b>CFList Type Supported</b>	1	1
<b>Mandatory Data Rate [MinDR:MaxDR]</b>	[0:4],[8:13]	[0:6],[8:13]
<b>Optional Data Rate [MinDR:MaxDR]</b>	[5:6]	[7]
<b>Number of channels</b>	upstream: 64 (125 kHz) + 8 (500 kHz) downstream: 8 (500 kHz)	upstream: 64 (125 kHz) + 8 (500 kHz) downstream: 8 (500 kHz)
<b>ChMaskCtrl - ChMask</b>	0 -> Channels 0 to 15 1 -> Channels 16 to 31 ... 4 -> Channels 64 to 71 5 -> 8LSBs controls Channel Blocks 0 to 7, 8MSBs are RFU 6 -> All 125 kHz ON, ChMask applies to channels 64 to 71 7 -> All 125 kHz OFF, ChMask applies to channels 64 to 71	0 -> Channels 0 to 15 1 -> Channels 16 to 31 ... 4 -> Channels 64 to 71 5 -> 8LSBs controls Channel Blocks 0 to 7, 8MSBs are RFU 6 -> All 125 kHz ON, ChMask applies to channels 64 to 71 7 -> All 125 kHz OFF, ChMask applies to channels 64 to 71
<b>Default channels</b>	[0:71]	[0:71]
<b>Default RX1DROffset</b>	0	0
<b>Allowed RX1DROffset</b>	[0:3]	[0:5]
<b>Duty Cycle</b>	No Limit	No Limit
<b>Dwell time limitation</b>	[0:63] 400ms [64:71] No	[0:63] 400ms (regional dependence) [64:71] No
<b>TxParamSetupReq support</b>	No	Yes
<b>Max EIRP (default) - TXPower 0</b>	+30 dBm	+30 dBm
<b>Default RX2DataRate</b>	DR8	DR8
<b>Default RX2 Frequency</b>	923.3 MHz	923.3 MHz
<b>Class B default Beacon Freq</b>	Hops across all 8 downlink channels	Hops across all 8 downlink channels
<b>Class B default downlink pingSlot Freq</b>	Follows beacon channel	Follows beacon channel

[Table 3 - Fixed Channel Plans Summary](#)

379

## 380 2 LoRaWAN® Regional Parameters

381

### 382 2.1 Regional Parameter Channel Plan Common Names

383 In order to support the identification of LoRaWAN® channel plans referenced by other  
384 specification documents, the table below provides a quick reference of common channel plans  
385 listed for each formal plan name.  
386

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 <sup>9</sup>	AS923	7
AS923-2	AS923-2	8
AS923-3	AS923-3	9
KR920-923	KR920	10
IN865-867	IN865	11
RU864-870	RU864	12

387 **Table 4 Regional Parameter Common Names**

388

### 389 2.2 Regional Parameter Revision Names

390 In order to support the identification of Regional Parameter Specification versions referenced  
391 by other specification documents, the table below provides a quick reference of common  
392 revision strings listed for each formal revision number.  
393

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

394 **Table 5 Regional Parameter Revision Names**

### 395 2.3 Default Settings

396 The following parameters are RECOMMENDED 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

<sup>9</sup> AS923 has been renamed AS923-1 as of RP002-1.0.2, however, the common name remains the same

MAX_FCNT_GAP <sup>10</sup>	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 is the responsibly of the end-device to comply with
PING_SLOT_PERIODICITY	7 (2 <sup>7</sup> = 128s)
PING_SLOT_DATARATE	The value of the BEACON DR defined for each regional band
PING_SLOT_CHANNEL	Defined in each regional band
CLASS_B_RESP_TIMEOUT	8s <sup>11</sup>
CLASS_C_RESP_TIMEOUT	8s <sup>12</sup>

397

398 If the actual parameter values implemented in the end-device are different from those default  
 399 values (for example the end-device uses a longer JOIN\_ACCEPT\_DELAY1 and  
 400 JOIN\_ACCEPT\_DELAY2 latency), those parameters SHALL be communicated to the  
 401 network server using an out-of-band channel during the end-device commissioning process.  
 402 The network server may not accept parameters different from those default values.  
 403

403

404 RETRANSMIT\_TIMEOUT was known as ACK\_TIMEOUT in versions prior to 1.0.4 of  
 405 LoRaWAN® specification. It is renamed in version 1.0.4 and subsequent versions of the  
 406 LoRaWAN® specification to better reflect its intended use.  
 407

407

408 MAC commands exist in the LoRaWAN® specification to change the value of  
 409 RECEIVE\_DELAY1 (using *RXTimingSetupReq*, *RXTimingSetupAns*) as well as  
 410 ADR\_ACK\_LIMIT and ADR\_ACK\_DELAY (using *ADRParamSetupReq*,  
 411 *ADRParamSetupAns*). Also, *RXTimingSettings* are transmitted to the end device along with  
 412 the JOIN\_ACCEPT message in OTAA mode.  
 413

413

414 The default values for PING\_SLOT\_PERIODICITY, PING\_SLOT\_DATARATE, and  
 415 PING\_SLOT\_CHANNEL can be adjusted using Class B MAC commands.  
 416

416

---

<sup>10</sup> MAX\_FCNT\_GAP was deprecated and removed from LoRaWAN® 1.0.4 and subsequent versions

<sup>11</sup> 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

<sup>12</sup> 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

## 417 2.4 EU863-870MHz Band

### 418 2.4.1 EU863-870 Preamble Format

419 Please refer to Section 3.0 Physical Layer.

### 420 2.4.2 EU863-870 Band channel frequencies

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

423 The network channels can be freely attributed by the network operator. However, the three  
424 following default channels SHALL be implemented in every EU863-870 end-device. Those  
425 channels are the minimum set that all network gateways SHALL be listening on.

426

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

427

Table 6: EU863-870 default channels

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

434 EU868MHz end-devices SHALL be capable of operating in the 863 to 870 MHz frequency  
435 band and SHALL feature a channel data structure to store the parameters of at least 16  
436 channels. A channel data structure corresponds to a frequency and a set of data rates usable  
437 on this frequency.

438 The first three channels correspond to 868.1, 868.3, and 868.5 MHz / DR0 to DR5 and SHALL  
439 be implemented in every end-device. For devices compliant with TS001-1.0.x, those default  
440 channels SHALL NOT be modified through the **NewChannelReq** command. For devices  
441 compliant with TS001-1.1.x and beyond, these channels MAY be modified through the  
442 **NewChannelReq** but SHALL be reset during the backoff procedure defined in TS001-1.1.1  
443 to guarantee a minimal common channel set between end-devices and network gateways.

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

448

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

449

Table 7: EU863-870 Join-Request Channel List

450 **2.4.3 EU863-870 Data Rate and End-device Output Power encoding**

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

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

455

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 <sup>13</sup> CR1/3: 137kHz OCW <sup>14</sup>	162
9	LR-FHSS CR2/3: 137kHz OCW	325
10	LR-FHSS CR1/3: 336kHz OCW	162
11	LR-FHSS CR2/3: 336kHz OCW	325
12..14	RFU	
15	Defined in [TS001] <sup>15</sup>	

Table 8: EU863-870 TX DataRate table

456

457

458 EU863-870 end-devices SHALL support one of the 3 following data rate options:

459

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

460

461

462

 463 For each of the 3 options all data rates in the range specified SHALL be implemented  
 464 (meaning no intermediate DR may be left unimplemented)

464

465

 466 When the device is using the Adaptive Data Rate mode and transmits using the DR<sub>current</sub>  
 467 data rate, the following table defines the next data rate (DR<sub>next</sub>) the end-device SHALL use  
 during data rate back-off:

DR <sub>current</sub>	DR <sub>next</sub>	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	

<sup>13</sup> Long Range Frequency Hopping Spread Spectrum, see Section 4.3

<sup>14</sup> Occupied Channel Width

<sup>15</sup> DR<sub>15</sub> and TXPower<sub>15</sub> are defined in the LinkADRRReq MAC command of the LoRaWAN1.0.4 and subsequent specifications and were previously RFU



468  
469  
470  
471

**Table 9: EU868-870 Data Rate Backoff table**

EIRP<sup>16</sup> 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 TX power table**

472  
473  
474  
475  
476

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

#### 477 **2.4.4 EU863-870 Join-Accept CFList**

478

479 The EU863-870 band LoRaWAN® implements an OPTIONAL **channel frequency list**  
480 (CFList) of 16 octets in the Join-Accept message.

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

486

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

487 The actual channel frequency in Hz is 100 x frequency whereby values representing  
488 frequencies below 100 MHz are reserved for future use. This allows setting the frequency of  
489 a channel anywhere between 100 MHz to 1.67 GHz in 100 Hz steps. Unused channels have  
490 a frequency value of 0. The **CFList** is OPTIONAL and its presence can be detected by the  
491 length of the join-accept message. If present, the **CFList** SHALL replace all the previous  
492 channels stored in the end-device apart from the three default channels. The newly defined  
493 channels are immediately enabled and usable by the end-device for communication.

#### 494 **2.4.5 EU863-870 LinkAdrReq command**

495 The EU863-870 LoRaWAN® only supports a maximum of 16 channels. When **ChMaskCntl**  
496 field is 0 the ChMask field individually enables/disables each of the 16 channels.

497

ChMaskCntl	ChMask applies to
0	Channels 0 to 15

<sup>16</sup> ERP = EIRP – 2.15dB; it is referenced to a half-wave dipole antenna whose gain is expressed in dBd

ChMaskCntl	ChMask applies to
1	RFU
2	RFU
3	RFU
4	RFU
5	RFU
6	All channels ON : The device SHALL enable all currently defined channels independently of the ChMask field value.
7	RFU

498

Table 11: EU863-870 ChMaskCntl value table

499 If the ChMaskCntl field value is one of values meaning RFU, the end-device SHALL<sup>17</sup> reject  
 500 the command and unset the “**Channel mask ACK**” bit in its response.

### 501 2.4.6 EU863-870 Maximum payload size

502 The maximum **MACPayload** size length ( $M$ ) is given by the following table. It is derived from  
 503 limitation of the PHY layer depending on the effective modulation rate used taking into account  
 504 a possible repeater encapsulation layer. The maximum application payload length in the  
 505 absence of the OPTIONAL **FOpt** control field ( $N$ ) is also given for information only. The value  
 506 of  $N$  MAY be smaller if the **FOpt** field is not empty.  
 507

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	

508

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

509 If the end-device will never operate with a repeater then the maximum application payload  
 510 length in the absence of the OPTIONAL **FOpt** control field SHALL be:  
 511

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

<sup>17</sup> Made SHALL from SHOULD starting in LoRaWAN Regional Parameters Specification 1.0.3rA

11	123	115
12:15	Not defined	

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

 513 **2.4.7 EU863-870 Receive windows**

 514 By default, the RX1 receive window uses the same channel as the preceding uplink. The data  
 515 rate is a function of the uplink data rate and the RX1DROffset as given by the following table.  
 516 The allowed values for RX1DROffset are in the [0:5] range. Values in the [6:7] range are  
 517 reserved for future use.  
 518

Upstream data rate RX1DROffset	Downstream data rate in RX1 slot					
	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

 519 **Table 14: EU863-870 downlink RX1 data rate mapping**

 520 The RX2 receive window uses a fixed frequency and data rate. The default parameters are  
 521 869.525 MHz / DR0 (SF12, 125 kHz)

 522 **2.4.8 EU863-870 Class B beacon and default downlink channel**

523 The beacons SHALL be transmitted using the following settings

<b>DR</b>	3	Corresponds to SF9 spreading factor with 125 kHz BW
<b>CR</b>	1	Coding rate = 4/5
<b>Signal polarity</b>	Non-inverted	As opposed to normal downlink traffic which uses inverted signal polarity

 524 **Table 15: EU863-870 beacon settings**

525

 526 The beacon frame content is defined in [TS001].<sup>18</sup>

527 The beacon default broadcast frequency is 869.525 MHz.

528 The Class B default downlink pingSlot frequency is 869.525 MHz.

 529 **2.4.9 EU863-870 Default Settings**

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

531

<sup>18</sup> Prior to LoRaWAN<sup>®</sup> 1.0.4, the EU863-870 beacon format was defined here as:

<b>Size (bytes)</b>	2	4	2	7	2
<b>BCNPayload</b>	RFU	Time	CRC	GwSpecific	CRC

532 **2.5 US902-928MHz ISM Band**

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

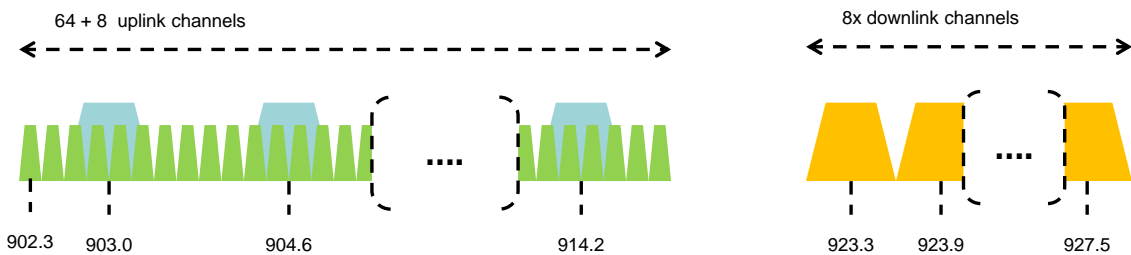
535 **2.5.1 US902-928 Preamble Format**

536 Please refer to Section 3.0 Physical Layer.

537 **2.5.2 US902-928 Channel Frequencies**

538 The 915 MHz ISM Band SHALL be divided into the following channel plans.

- 539 • Upstream – 64 channels numbered 0 to 63 utilizing LoRa 125 kHz BW varying from
- 540 DR0 to DR3, using coding rate 4/5, starting at 902.3 MHz and incrementing linearly
- 541 by 200 kHz to 914.9 MHz
- 542 • Upstream – 8 channels numbered 64 to 71 utilizing LoRa 500 kHz BW at DR4 or LR-
- 543 FHSS 1.523 MHz BW at DR5-DR6 starting at 903.0 MHz and incrementing linearly
- 544 by 1.6 MHz to 914.2 MHz
- 545 • Downstream – 8 channels numbered 0 to 7 utilizing LoRa 500 kHz BW at DR8 to
- 546 DR13, starting at 923.3 MHz and incrementing linearly by 600 kHz to 927.5 MHz
- 547



548 **Figure 1: US902-928 channel frequencies**

550 915 MHz ISM band end-devices are required to operate in compliance with the relevant  
 551 regulatory specifications, the following note summarizes some of the current (March 2017)  
 552 relevant regulations.

553 Frequency-Hopping, Spread-Spectrum (FHSS) mode, which requires  
 554 the device transmit at a measured conducted power level no greater  
 555 than +30 dBm, for a period of no more than 400 msec and over at least  
 556 50 channels, each of which occupy no greater than 250 kHz of  
 557 bandwidth and separated by a minimum of 25kHz or the 20 dB  
 558 bandwidth of the hopping channel, whichever is greater.

559 Digital Transmission System (DTS) mode, which requires that the  
 560 device use channels greater than or equal to 500 kHz and comply to a  
 561 conducted Power Spectral Density measurement of no more than +8  
 562 dBm per 3 kHz of spectrum. In practice, this limits the conducted output  
 563 power of an end-device to +26 dBm.

564 Hybrid mode, which requires that the device transmit over multiple  
 565 channels (this may be less than the 50 channels required for FHSS  
 566 mode but is recommended to be at least 4) while complying with the  
 567 Power Spectral Density requirements of DTS mode and the 400 msec  
 568 dwell time of FHSS mode. In practice this limits the measured  
 569 conducted power of the end-device to 21 dBm.

570  
571  
572  
573 US902-928 end-devices SHALL be capable of operating in the 902 to 928 MHz frequency  
574 band and SHALL feature a channel data structure to store the parameters for 72 channels.  
575 This channel data structure contains a list of frequencies and the set of data rates available  
576 for each frequency.

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

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

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

587 Example: First pass: Random channel from [0-7], followed by [8-15]... [56-63], then 64  
588 Second pass: Random channel from [0-7], followed by [8-15]... [56-63], then  
589 65  
590 Last pass: Random channel from [0-7], followed by [8-15]... [56-63], then 71

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

### 593 2.5.3 US902-928 Data Rate and End-device Output Power encoding

594 FCC regulation imposes for frequency hopping systems, a maximum dwell time of 400ms on  
595 uplinks, when the 20dB modulation bandwidth is less than 500KHz. The **TxParamSetupReq**  
596 MAC command is not implemented by US902-928 devices.

597 The following encoding is used for Data Rate (**DR**) and End-device conducted Power  
598 (**TXPower**) in the US902-928 band:

599

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: 1.523MHz OCW	162
6	LR-FHSS CR2/3: 1.523MHz OCW	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] <sup>19</sup>	

600

Table 16: US902-928 TX DataRate table

601

602

603

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

604

US902-928 devices SHALL support one of the 2 following data rate options:

605

1. [DR0 to DR4] and [DR8 to DR13] (minimum set supported for certification)

606

2. [DR0 to DR13] (all data rates implemented)

607

In both cases all data rates in the range specified SHALL be implemented (meaning no intermediate DR may be left unimplemented)

608

609

610

When the device is using the Adaptive Data Rate mode and transmits using the DR<sub>current</sub> data rate, the following table defines the next data rate (DR<sub>next</sub>) the end-device SHALL use during data rate back-off:

611

612

DR <sub>current</sub>	DR <sub>next</sub>	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		

613

Table 17: US902-928 Data Rate Backoff table

614

TXPower	Configuration (conducted power)
0	30 dBm – 2*TXPower
1	28 dBm
2	26 dBm
3 : 13	....
14	2 dBm
15	Defined in [TS001] <sup>20</sup>

615

Table 18: US902-928 TX power table

616

## 2.5.4 US902-928 Join-Accept CFList

617

618

For LoRaWAN<sup>®</sup> 1.0.1, the US902-928 does not support the use of the OPTIONAL **CFlist** appended to the Join-Accept message. If the **CFlist** is not empty it is ignored by the end-device.

620

621

622

The US902-928 LoRaWAN<sup>®</sup> supports the use of the OPTIONAL **CFlist** appended to the Join-Accept message. If the **CFlist** is not empty, then 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

623

624

625

<sup>19</sup> DR15 and TXPower15 are defined in the LinkADRRReq MAC command of the LoRaWAN<sup>®</sup> 1.0.4 and subsequent specifications and were previously RFU

<sup>20</sup> DR15 and TXPower15 are defined in the LinkADRRReq MAC command of the LoRaWAN<sup>®</sup> 1.0.4 and subsequent specifications and were previously RFU



626 zero (0) and increments for each ChMask field to a value of four (4). (The first 16 bits  
 627 controls the channels 0 to 15...)  
 628

Size (bytes)	[2]	[2]	[2]	[2]	[2]	[2]	[3]	[1]
CFList	<i>ChMask0</i>	<i>ChMask1</i>	<i>ChMask2</i>	<i>ChMask3</i>	<i>ChMask4</i>	<i>RFU</i>	<i>RFU</i>	<i>CFListType</i>

### 629 2.5.5 US902-928 LinkAdrReq command

630 For the US902-928 version the **ChMaskCntl** field of the *LinkADRReq* command has the  
 631 following meaning:  
 632

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 71
5	8LSBs controls Channel Blocks 0 to 7 (8MSBs are RFU)
6	All 125 kHz ON : ChMask applies to channels 64 to 71
7	All 125 kHz OFF : ChMask applies to channels 64 to 71

633 **Table 19: US902-928 ChMaskCntl value table**

634 If **ChMaskCntl** = 5<sup>21</sup> then the corresponding bits in the ChMask enable and disable a bank of  
 635 8 125kHz channels and the corresponding 500kHz channel defined by the following  
 636 calculation: [ChannelMaskBit \* 8, ChannelMaskBit \* 8 +7],64+ChannelMaskBit.

637 If **ChMaskCntl** = 6 then all 125 kHz channels are enabled, if **ChMaskCntl** = 7 then all 125  
 638 kHz channels are disabled. Simultaneously the channels 64 to 71 are set according to the  
 639 **ChMask** bit mask. The Data Rate specified in the command need not be valid for channels  
 640 specified in the ChMask, as it governs the global operational state of the end-device.

641

642 **Note:** FCC regulation requires hopping over at least 50 channels when  
 643 using maximum output power. This is achieved either when more than  
 644 50 LoRa/125kHz channels are enabled and/or when at least one LR-  
 645 FHSS channel is enabled. It is possible to have end-devices with less  
 646 channels when limiting the end-device conducted transmit power to 21  
 647 dBm.

648 **Note:** A common network server action may be to reconfigure a device  
 649 through multiple LinkAdrReq commands in a contiguous block of MAC  
 650 Commands. For example, to reconfigure a device from 64 channel  
 651 operation to the first 8 channels could contain two LinkAdrReq, the first  
 652 (ChMaskCntl = 7) to disable all 125 kHz channels and the second  
 653 (ChMaskCntl = 0) to enable a bank of 8 125 kHz channels. Alternatively,  
 654 using ChMaskCntl = 5 a device can be re-configured from 64 channel  
 655 operation to support the first 8 channels in a single LinkAdrReq.  
 656

<sup>21</sup> Added in LoRaWAN<sup>®</sup> Regional Parameters Specification version 1.0.3rA

657 **2.5.6 US902-928 Maximum payload size**

 658 The maximum **MACPayload** size length ( $M$ ) is given by the following table. It is derived from  
 659 the maximum allowed transmission time at the PHY layer taking into account a possible  
 660 repeater encapsulation. The maximum application payload length in the absence of the  
 661 OPTIONAL **FOpt** MAC control field ( $N$ ) is also given for information only. The value of  $N$  MAY  
 662 be smaller if the **FOpt** field is not empty:  
 663

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	

 664 **Table 20: US902-928 maximum payload size (repeater compatible)**

665

 666 If the end-device will never operate under a repeater then the maximum application payload  
 667 length in the absence of the OPTIONAL **FOpt** control field SHALL be:  
 668

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	

 669 **Table 21 : US902-928 maximum payload size (not repeater compatible)**

 670 **2.5.7 US902-928 Receive windows**

- 671
- 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 8
  - The RX1 window data rate depends on the transmit data rate (see Table 22 below).
  - The RX2 (second receive window) settings uses a fixed data rate and frequency.
- 672
- 
- 673
- 
- 674
- 
- 675

676 Default parameters are 923.3MHz / DR8  
 677

Upstream data rate RX1DROffset	Downstream data rate			
	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

678 **Table 22: US902-928 downlink RX1 data rate mapping**<sup>22</sup>

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

### 681 2.5.8 US902-928 Class B beacon<sup>23</sup>

682 The beacons SHALL be transmitted using the following settings:

683

<b>DR</b>	8	Corresponds to SF12 spreading factor with 500kHz bw
<b>CR</b>	1	Coding rate = 4/5
<b>Signal polarity</b>	Non-inverted	As opposed to normal downlink traffic which uses inverted signal polarity
<b>frequencies</b>	923.3 to 927.5MHz with 600kHz steps	Beaconing is performed on the same channel that normal downstream traffic as defined in the Class A specification

684 **Table 23: US902-928 beacon settings**

685 The downstream channel used for a given beacon is:

686

$$687 \text{ Channel} = \left[ \text{floor} \left( \frac{\text{beacon\_time}}{\text{beacon\_period}} \right) \right] \text{ modulo } 8$$

688

- 689 • whereby beacon\_time is the integer value of the 4 bytes “Time” field of the beacon
- 690 frame
- 691 • whereby beacon\_period is the periodicity of beacons, 128 seconds
- 692 • whereby floor(x) designates rounding to the integer immediately inferior or equal to x

693

694 **Example: the first beacon will be transmitted on 923.3MHz, the second**  
 695 **on 923.9MHz, the 9<sup>th</sup> beacon will be on 923.3MHz again.**

696

697

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

<sup>22</sup> Re-defined in the LoRaWAN<sup>®</sup> 1.0.1 specification to eliminate RX1DROffset values beyond DR4

<sup>23</sup> Class B beacon operation was first defined in the LoRaWAN<sup>®</sup> 1.0.3 specification

7	927.5
---	-------

**Table 24: US902-928 Beacon Channels**

698

699

700 The beacon frame content is defined in [TS001].<sup>24</sup>

701

702 The default Class B PING\_SLOT\_CHANNEL is defined in the LoRaWAN<sup>®</sup> specification.

### 703 **2.5.9 US902-928 Default Settings**

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

705

---

<sup>24</sup> Prior to LoRaWAN<sup>®</sup> 1.0.4, the beacon was defined here as:

<b>Size (bytes)</b>	<b>5</b>	4	2	7	<b>3</b>	2
<b>BCNPayload</b>	<b>RFU</b>	Time	CRC	GwSpecific	<b>RFU</b>	CRC

## 706 2.6 CN779-787 MHz Band<sup>25</sup>

### 707 2.6.1 CN779-787 Preamble Format

708 Please refer to Section 3.0 Physical Layer.

### 709 2.6.2 CN779-787 Band channel frequencies

710 CN779-787 devices may not be produced, imported or installed after 2021-  
 711 01-01; deployed devices may continue to operate through their normal end-  
 712 of-life.

713 The LoRaWAN<sup>®</sup> can be used in the Chinese 779-787MHz band as long as the radio device  
 714 EIRP is less than 12.15dBm.

715 The end-device transmit duty-cycle SHALL be lower than 1%.

716 The LoRaWAN<sup>®</sup> channels center frequency MAY be in the following range:

- 717 • Minimum frequency: 779.5MHz
- 718 • Maximum frequency: 786.5 MHz

719 CN780MHz end-devices SHALL be capable of operating in the 779 to 787 MHz frequency  
 720 band and SHALL feature a channel data structure to store the parameters of at least 16  
 721 channels. A channel data structure corresponds to a frequency and a set of data rates usable  
 722 on this frequency.

723 The first three channels correspond to 779.5, 779.7 and 779.9 MHz with DR0 to DR5 and  
 724 SHALL be implemented in every end-device. For devices compliant with TS001-1.0.x, those  
 725 default channels SHALL NOT be modified through the **NewChannelReq** command. For  
 726 devices compliant with TS001-1.1.x and beyond, these channels MAY be modified through  
 727 the **NewChannelReq** but SHALL be reset during the backoff procedure defined in TS001-  
 728 1.1.1 to guarantee a minimal common channel set between end-devices and gateways of all  
 729 networks. Other channels can be freely distributed across the allowed frequency range on a  
 730 network per network basis.

731 The following table gives the list of frequencies that SHALL be used by end-devices to  
 732 broadcast the Join-Request message The Join-Request message transmit duty-cycle SHALL  
 733 follow the rules described in chapter “Retransmissions back-off” of the LoRaWAN<sup>®</sup>  
 734 specification document. Those channels are the minimum set that all network gateways  
 735 SHALL be listening on.

736

Modulation	Bandwidth [kHz]	Channel Frequency [MHz]	LoRa DR / Bitrate	Nb Channels	Duty cycle
LoRa	125	779.5 779.7 779.9	DR0 – DR5 / 0.3-5 kbps	3	< 1%

737 **Table 25: CN779-787 Join-Request Channel List**

### 738 2.6.3 CN779-787 Data Rate and End-device Output Power encoding

739 There is no dwell time limitation for the CN779-787 PHY layer. The **TxParamSetupReq** MAC  
 740 command is not implemented by CN779-787 devices.

<sup>25</sup> Defined in the LoRaWAN<sup>®</sup> 1.0.1 specification

741 The following encoding is used for Data Rate (DR) and End-device EIRP (TXPower) in the  
 742 CN779-787 band:

743

Data Rate	Configuration	Indicative physical bit rate [bit/s]	TXPower	Configuration (EIRP)
0	LoRa: SF12 / 125 kHz	250	0	Max EIRP
1	LoRa: SF11 / 125 kHz	440	1	Max EIRP – 2dB
2	LoRa: SF10 / 125 kHz	980	2	Max EIRP – 4dB
3	LoRa: SF9 / 125 kHz	1760	3	Max EIRP – 6dB
4	LoRa: SF8 / 125 kHz	3125	4	Max EIRP – 8dB
5	LoRa: SF7 / 125 kHz	5470	5	Max EIRP – 10dB
6	LoRa: SF7 / 250 kHz	11000	6..14	RFU
7	FSK: 50 kbps	50000		
8..14	RFU			
15	Defined in [TS001] <sup>26</sup>		15	Defined in [TS001] <sup>26</sup>

Table 26: CN779-787 Data rate and TX power table

744

745

746 CN779-787 end-devices SHALL support one of the 2 following data rate options:

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

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

751

752 When the device is using the Adaptive Data Rate mode and transmits using the DR<sub>current</sub>  
 753 data rate, the following table defines the next data rate (DR<sub>next</sub>) the end-device SHALL use  
 754 during data rate back-off:

DR <sub>current</sub>	DR <sub>next</sub>	Comment
0	NA	Already the lowest data rate
1	0	
2	1	
3	2	
4	3	
5	4	
6	5	
7	6	

Table 27: CN779-787 Data Rate Backoff table

755

756

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

760 By default, Max EIRP is considered to be +12.15dBm. If the end-device cannot achieve  
 761 12.15dBm EIRP, the Max EIRP SHOULD be communicated to the network server using an  
 762 out-of-band channel during the end-device commissioning process.

## 763 2.6.4 CN779-787 Join-Accept CFList

764 The CN780 band LoRaWAN<sup>®</sup> implements an OPTIONAL **channel frequency list** (CFList) of  
 765 16 octets in the Join-Accept message.

<sup>26</sup> DR15 and TXPower15 are defined in the LinkADRRReq MAC command of the LoRaWAN<sup>®</sup> 1.0.4 and subsequent specifications and were previously RFU

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

771

<b>Size (bytes)</b>	3	3	3	3	3	1
<b>CFList</b>	Freq Ch3	Freq Ch4	Freq Ch5	Freq Ch6	Freq Ch7	CFListType

772

773 The actual channel frequency in Hz is 100 x frequency whereby values representing  
 774 frequencies below 100 MHz are reserved for future use. This allows setting the frequency of  
 775 a channel anywhere between 100 MHz to 1.67 GHz in 100 Hz steps. Unused channels have  
 776 a frequency value of 0. The **CFList** is OPTIONAL and its presence can be detected by the  
 777 length of the join-accept message. If present, the **CFList** SHALL replace all the previous  
 778 channels stored in the end-device apart from the three default channels.

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

### 781 2.6.5 CN779-787 LinkAdrReq command

782 The CN780 LoRaWAN<sup>®</sup> only supports a maximum of 16 channels. When **ChMaskCntl** field  
 783 is 0 the ChMask field individually enables/disables each of the 16 channels.

784

<b>ChMaskCntl</b>	<b>ChMask applies to</b>
0	Channels 0 to 15
1	RFU
..	..
4	RFU
5	RFU
6	All channels ON : The device SHALL enable all currently defined channels independently of the ChMask field value.
7	RFU

785 **Table 28: CN779-787 ChMaskCntl value table**

786

787

788 If the ChMask field value is one of values meaning RFU, then end-device SHALL<sup>27</sup> reject the command and unset the “**Channel mask ACK**” bit in its response.

### 789 2.6.6 CN779-787 Maximum payload size

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

795

<b>Data Rate</b>	<b>M</b>	<b>N</b>
0	59	51
1	59	51
2	59	51

<sup>27</sup> Made SHALL from SHOULD starting in LoRaWAN<sup>®</sup> Regional Parameters Specification 1.0.3rA



3	123	115
4	230	222
5	230	222
6	230	222
7	230	222
8:15	Not defined	

**Table 29: CN779-787 maximum payload size (repeater compatible)**

796  
797  
798  
799  
800

If the end-device will never operate with a repeater then the maximum application payload length in the absence of the OPTIONAL **FOpt** 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 30 : CN779-787 maximum payload size (not repeater compatible)**

801

### 802 2.6.7 CN779-787 Receive windows

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

807

Upstream data rate RX1DROffset	Downstream data rate					
	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 31: CN779-787 downlink RX1 data rate mapping**

808

809 The RX2 receive window uses a fixed frequency and data rate. The default parameters are  
810 786 MHz / DR0.

### 811 2.6.8 CN779-787 Class B beacon and default downlink channel

812 The beacons SHALL be transmitted using the following settings:

<b>DR</b>	3	Corresponds to SF9 spreading factor with 125 kHz BW
<b>CR</b>	1	Coding rate = 4/5
<b>Signal polarity</b>	Non-inverted	As opposed to normal downlink traffic which uses inverted signal polarity

**Table 32: CN779-787 beacon settings**

813

814 The beacon frame content is defined in [TS001].<sup>28</sup> The beacon default broadcast frequency is  
 815 785MHz.

816 The class B default downlink pingSlot frequency is 785MHz

817 **2.6.9 CN779-787 Default Settings**

818 There are no specific default settings for the CN779-787 MHz Band.

---

<sup>28</sup> Prior to LoRaWAN<sup>®</sup> 1.0.4, the beacon was defined here as:

<b>Size (bytes)</b>	<b>2</b>	<b>4</b>	<b>2</b>	<b>7</b>	<b>2</b>
<b>BCNPayload</b>	<b>RFU</b>	Time	CRC	GwSpecific	CRC

## 819 2.7 EU433MHz ISM Band

### 820 2.7.1 EU433 Preamble Format

821 Please refer to Section 3.0 Physical Layer.

### 822 2.7.2 EU433 ISM Band channel frequencies

823 The LoRaWAN® can be used in the 433.05 – 434.79 MHz ISM band in ITU Region 1 as long  
824 as the radio device EIRP is less than 12.15dBm.

825 The end-device transmit duty-cycle SHALL be lower than 10%<sup>29</sup>

826 The LoRaWAN® channels center frequency can be in the following range:

- 827 • Minimum frequency: 433.175 MHz
- 828 • Maximum frequency: 434.665 MHz

829 EU433 end-devices SHALL be capable of operating in the 433.05 to 434.79 MHz frequency  
830 band and SHALL feature a channel data structure to store the parameters of at least 16  
831 channels. A channel data structure corresponds to a frequency and a set of data rates usable  
832 on this frequency.

833 The first three channels correspond to 433.175, 433.375 and 433.575 MHz with DR0 to DR5  
834 and SHALL be implemented in every end-device. For devices compliant with TS001-1.0.x,  
835 those default channels SHALL NOT be modified through the **NewChannelReq** command. For  
836 devices compliant with TS001-1.1.x and beyond, these channels MAY be modified through  
837 the **NewChannelReq** but SHALL be reset during the backoff procedure defined in TS001-  
838 1.1.1 to guarantee a minimal common channel set between end-devices and gateways of all  
839 networks. Other channels can be freely distributed across the allowed frequency range on a  
840 network per network basis.

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

845

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

846 [Table 33: EU433 Join-Request Channel List](#)

847

### 848 2.7.3 EU433 Data Rate and End-device Output Power encoding

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

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

853

<sup>29</sup> Defined in the LoRaWAN® Regional Parameters 1.0.2 specification

Data Rate	Configuration	Indicative physical bit rate [bit/s]	TXPower	Configuration (EIRP)
0	LoRa: SF12 / 125 kHz	250	0	Max EIRP
1	LoRa: SF11 / 125 kHz	440	1	Max EIRP – 2dB
2	LoRa: SF10 / 125 kHz	980	2	Max EIRP – 4dB
3	LoRa: SF9 / 125 kHz	1760	3	Max EIRP – 6dB
4	LoRa: SF8 / 125 kHz	3125	4	Max EIRP – 8dB
5	LoRa: SF7 / 125 kHz	5470	5	Max EIRP – 10dB
6	LoRa: SF7 / 250 kHz	11000	6..14	RFU
7	FSK: 50 kbps	50000		
8..14	RFU			
15	Defined in [TS001] <sup>30</sup>		15	Defined in [TS001] <sup>30</sup>

Table 34: EU433 Data rate and TX power table

854

855

EU433 end-devices SHALL support one of the 2 following data rate options:

856

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

857

2. DR0 to DR7

858

For both of the options all data rates in the range specified SHALL be implemented

859

(meaning no intermediate DR may be left unimplemented)

860

861

When the device is using the Adaptive Data Rate mode and transmits using the DR<sub>current</sub> data rate, the following table defines the next data rate (DR<sub>next</sub>) the end-device SHALL use during data rate back-off:

862

863

864

DR <sub>current</sub>	DR <sub>next</sub>	Comment
0	NA	Already the lowest data rate
1	0	
2	1	
3	2	
4	3	
5	4	
6	5	
7	6	

Table 35: EU433 Data Rate Backoff table

865

866

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.

867

868

869

By default, the Max EIRP is considered to be +12.15dBm. If the end-device cannot achieve 12.15dBm EIRP, the Max EIRP SHALL be communicated to the network server using an out-of-band channel during the end-device commissioning process.

870

871

872

## 2.7.4 EU433 Join-Accept CFList

873

874

The EU433 ISM band LoRaWAN<sup>®</sup> implements an OPTIONAL **channel frequency list** (CFList) of 16 octets in the Join-Accept message.

875

876

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 bits unsigned integer (three octets). All these

877

878

<sup>30</sup> DR15 and TXPower15 are defined in the LinkADRRReq MAC command of the LoRaWAN<sup>®</sup> 1.0.4 and subsequent specifications and were previously RFU

879 channels are usable for DR0 to DR5 125 kHz LoRa modulation. The list of frequencies is  
 880 followed by a single CFListType octet for a total of 16 octets. The CFListType SHALL be equal  
 881 to zero (0) to indicate that the CFList contains a list of frequencies.

882

<b>Size (bytes) CFList</b>	3	3	3	3	3	1
	Freq Ch3	Freq Ch4	Freq Ch5	Freq Ch6	Freq Ch7	CFListType

883 The actual channel frequency in Hz is 100 x frequency whereby values representing  
 884 frequencies below 100 MHz are reserved for future use. This allows setting the frequency of  
 885 a channel anywhere between 100 MHz to 1.67 GHz in 100 Hz steps. Unused channels have  
 886 a frequency value of 0. The **CFList** is OPTIONAL and its presence can be detected by the  
 887 length of the join-accept message. If present, the **CFList** SHALL replace all the previous  
 888 channels stored in the end-device apart from the three default channels.

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

### 891 2.7.5 EU433 LinkAdrReq command

892 The EU433 LoRaWAN® only supports a maximum of 16 channels. When **ChMaskCntl** field  
 893 is 0 the ChMask field individually enables/disables each of the 16 channels.

894

ChMaskCntl	ChMask applies to
0	Channels 0 to 15
1	RFU
..	..
4	RFU
5	RFU
6	All channels ON : The device SHALL enable all currently defined channels regardless of the ChMask field value.
7	RFU

895

Table 36: EU433 ChMaskCntl value table

896 If the ChMask field value is one of the values meaning RFU, then end-device SHALL<sup>31</sup> reject  
 897 the command and unset the “**Channel mask ACK**” bit in its response.

### 898 2.7.6 EU433 Maximum payload size

899 The maximum **MACPayload** size length (*M*) is given by the following table. It is derived from  
 900 limitation of the PHY layer depending on the effective modulation rate used taking into account  
 901 a possible repeater encapsulation layer. The maximum application payload length in the  
 902 absence of the OPTIONAL **FOpt** control field (*N*) is also given for information only. The value  
 903 of *N* might be smaller if the **FOpt** field is not empty:  
 904

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

<sup>31</sup> Made SHALL from SHOULD starting in LoRaWAN® Regional Parameters Specification 1.0.3rA

7	230	222
8:15	Not defined	

**Table 37: EU433 maximum payload size (repeater compatible)**

905  
906  
907  
908  
909

If the end-device will never operate with a repeater then the maximum application payload length in the absence of the OPTIONAL **FOpt** 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 38 : EU433 maximum payload size (not repeater compatible)**

910

### 911 2.7.7 EU433 Receive windows

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

916

Upstream data rate RX1DROffset	Downstream data rate					
	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 39 : EU433 downlink RX1 data rate mapping**

917

918 The RX2 receive window uses a fixed frequency and data rate. The default parameters are  
919 434.665MHz / DR0 (SF12, 125 kHz).

### 920 2.7.8 EU433 Class B beacon and default downlink channel

921 The beacons SHALL be transmitted using the following settings

<b>DR</b>	3	Corresponds to SF9 spreading factor with 125 kHz BW
<b>CR</b>	1	Coding rate = 4/5
<b>Signal polarity</b>	Non-inverted	As opposed to normal downlink traffic which uses inverted signal polarity

**Table 40 : EU433 beacon settings**

922

- 923 The beacon frame content is defined in [TS001].<sup>32</sup>
- 924 The beacon default broadcast frequency is 434.665MHz.
- 925 The class B default downlink pingSlot frequency is 434.665MHz

926 **2.7.9 EU433 Default Settings**

- 927 There are no specific default settings for the EU 433 MHz ISM Band.
- 928

---

<sup>32</sup> Prior to LoRaWAN<sup>®</sup> 1.0.4, the beacon was defined here as:

<b>Size (bytes)</b>	<b>2</b>	<b>4</b>	<b>2</b>	<b>7</b>	<b>2</b>
<b>BCNPayload</b>	<b>RFU</b>	Time	CRC	GwSpecific	CRC



929 **2.8 AU915-928MHz Band<sup>33</sup>**

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

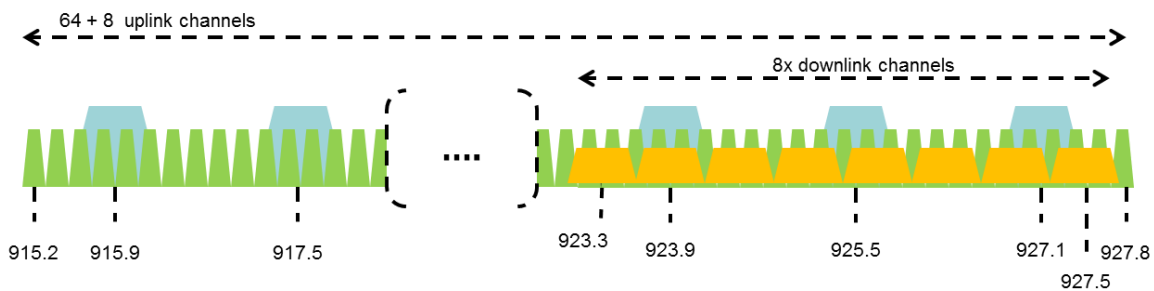
932 **2.8.1 AU915-928 Preamble Format**

933 Please refer to Section 3.0 Physical Layer.

934 **2.8.2 AU915-928 Channel Frequencies**

935 The AU915-928 Band SHALL be divided into the following channel plans.

- 936 • Upstream – 64 channels numbered 0 to 63 utilizing LoRa 125 kHz BW varying from  
937 DR0 to DR5, using coding rate 4/5, starting at 915.2 MHz and incrementing linearly  
938 by 200 kHz to 927.8 MHz
- 939 • Upstream – 8 channels numbered 64 to 71 utilizing LoRa 500 kHz BW at DR6 or LR-  
940 FHSS 1.523 MHz BW at DR7 starting at 915.9 MHz and incrementing linearly by 1.6  
941 MHz to 927.1 MHz
- 942 • Downstream – 8 channels numbered 0 to 7 utilizing LoRa 500 kHz BW at DR8 to  
943 DR13) starting at 923.3 MHz and incrementing linearly by 600 kHz to 927.5 MHz  
944



945 **Figure 2: AU915-928 channel frequencies**  
946

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

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

952 If using the over-the-air activation procedure, the end-device SHALL broadcast the Join-  
953 Request message alternatively on a random 125 kHz channel amongst the 64 channels  
954 defined using **DR2** and on a 500 kHz channel amongst the 8 channels defined using **DR6**.  
955 The end-device SHOULD change channel for every transmission.  
956

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

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

<sup>33</sup> Defined in the LoRaWAN® 1.0.1 specification

963 Example: First pass: Random channel from [0-7], followed by [8-15]... [56-63], then 64  
 964 Second pass: Random channel from [0-7], followed by [8-15]... [56-63], then  
 965 65  
 966 Last pass: Random channel from [0-7], followed by [8-15]... [56-63], then 71

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

969  
 970 The default Join-Request Data Rate SHALL be DR2 (SF10/125 kHz), this setting ensures  
 971 that end-devices are compatible with the 400ms dwell time limitation until the actual dwell  
 972 time limit is notified to the end-device by the network server via the MAC command  
 973 ***TxParamSetupReq***.

974  
 975 AU915-928 end-devices SHALL consider UplinkDwellTime = 1 during boot stage until  
 976 reception of the ***TxParamSetupReq*** command.

977  
 978 AU915-928 end-devices SHALL always consider DownlinkDwellTime = 0, since downlink  
 979 channels use 500 kHz bandwidth without any dwell time limit.

### 980 **2.8.3 AU915-928 Data Rate and End-point Output Power encoding**

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

983  
 984 If the field UplinkDwellTime is set to 1 by the network server in the ***TxParamSetupReq***  
 985 command, AU915-928 end-devices SHALL adjust the time between two consecutive uplink  
 986 transmissions to meet the local regulation. Twenty seconds (20s) are recommended  
 987 between 2 uplink transmissions when UplinkDwellTime = 1 but this value MAY be adjusted  
 988 depending on local regulation.

989  
 990 There is no such constraint on time between two consecutive transmissions when  
 991 UplinkDwellTime = 0.

992  
 993 The following encoding is used for Data Rate (**DR**) and end-point EIRP (**TXPower**) in the  
 994 AU915-928 band:

995

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 OCW	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] <sup>34</sup>	

Table 41: AU915-928 DataRate table

Note: DR6 is purposely identical to DR12, DR8...13 refer to data rates that are only used for downlink messages.

AU915-928 devices SHALL support one of the 2 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)

In both cases 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 DR<sub>current</sub> data rate, the following table defines the next data rate (DR<sub>next</sub>) the end-device SHALL use during data rate back-off:

UplinkDwellTime=0		UplinkDwellTime=1	
DR <sub>current</sub>	DR <sub>next</sub>	DR <sub>current</sub>	DR <sub>next</sub>
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 42: AU915-928 Data Rate Backoff table

TXPower	Configuration (EIRP)
0	Max EIRP
1:14	Max EIRP – 2*TXPower
15	Defined in [TS001] <sup>34</sup>

Table 43 : AU915-928 TX power table

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 +30dBm. The Max EIRP 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 once **TxParamSetupReq** is acknowledged by the device via **TxParamSetupAns**.

## 2.8.4 AU915-928 Join-Accept CFList

The AU915-928 LoRaWAN<sup>®</sup> supports the use of the OPTIONAL **CFList** appended to the Join-Accept message. If the **CFList** is not empty, then the CFListType field SHALL contain

<sup>34</sup> DR15 and TXPower15 are defined in the LinkADRRReq MAC command of the LoRaWAN<sup>®</sup> 1.0.4 and subsequent specifications and were previously RFU

1026 the value one (0x01) to indicate the CFList contains a series of ChMask fields. The ChMask  
 1027 fields are interpreted as being controlled by a virtual ChMaskCntl that initializes to a value of  
 1028 zero (0) and increments for each ChMask field to a value of four (4). (The first 16 bits  
 1029 controls the channels 0 to 15...)  
 1030

<b>Size (bytes)</b>	[2]	[2]	[2]	[2]	[2]	[2]	[3]	[1]
<b>CFList</b>	ChMask0	ChMask1	ChMask2	ChMask3	ChMask4	RFU	RFU	CFListType

### 1031 2.8.5 AU915-928 LinkAdrReq command

1032 For the AU915-928 version the **ChMaskCntl** field of the *LinkADRReq* command has the  
 1033 following meaning:

1034

<b>ChMaskCntl</b>	<b>ChMask applies to</b>
0	Channels 0 to 15
1	Channels 16 to 31
..	..
4	Channels 64 to 71
5	8LSBs control Channel Blocks 0 to 7 (8MSBs are RFU)
6	All 125 kHz ON : ChMask applies to channels 64 to 71
7	All 125 kHz OFF : ChMask applies to channels 64 to 71

1035

Table 44: AU915-928 ChMaskCntl value table

1036 If **ChMaskCntl** = 5<sup>35</sup> then the corresponding bits in the ChMask enable and disable a bank of  
 1037 8 125kHz channels and the corresponding 500kHz channel defined by the following  
 1038 calculation: [ChannelMaskBit \* 8, ChannelMaskBit \* 8 +7],64+ChannelMaskBit.

1039 If **ChMaskCntl** = 6 then 125 kHz channels are enabled, if **ChMaskCntl** = 7 then 125 kHz  
 1040 channels are disabled. Simultaneously the channels 64 to 71 are set according to the **ChMask**  
 1041 bit mask. The Data Rate specified in the command need not be valid for channels specified in  
 1042 the ChMask, as it governs the global operational state of the end-device.

### 1043 2.8.6 AU915-928 Maximum payload size

1044 The maximum **MACPayload** size length (*M*) is given by the following table for both uplink  
 1045 dwell time configurations: No Limit and 400ms. It is derived from the maximum allowed  
 1046 transmission time at the PHY layer taking into account a possible repeater encapsulation. The  
 1047 maximum application payload length in the absence of the OPTIONAL **FOpt** MAC control field  
 1048 (*M*) is also given for information only. The value of *N* might be smaller if the **FOpt** field is not  
 1049 empty:

1050

<b>Data Rate</b>	<b>UplinkDwellTime=0</b>		<b>UplinkDwellTime=1</b>	
	<b>M</b>	<b>N</b>	<b>M</b>	<b>N</b>
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

<sup>35</sup> Added in LoRaWAN<sup>®</sup> Regional Parameters Specification version 1.0.3rA

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 45: AU915-928 maximum payload size (repeater compatible)

1051

 1052 For AU915-928, **DownlinkDwellTime** SHALL be set to 0 (no limit). The 400ms dwell time  
 1053 MAY apply to uplink channels depending on the local regulations.

 1054 If the end-device will never operate with a repeater then the maximum application payload  
 1055 length in the absence of the OPTIONAL **Fopt** control field SHALL be:

1056

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 46: AU915-928 Maximum repeater payload size

1057

1058

 1059 **2.8.7 AU915-928 Receive windows**

 1060 • The RX1 receive channel is a function of the upstream channel used to initiate the  
 1061 data exchange. The RX1 receive channel can be determined as follows.

1062 ○ RX1 Channel Number = Transmit Channel Number modulo 8

1063 • The RX1 window data rate depends on the transmit data rate (see Table 22 below).

 1064 • The RX2 (second receive window) settings uses a fixed data rate and frequency.  
 1065 Default parameters are 923.3MHz / DR8

1066

Upstream data rate RX1DROffset	Downstream data rate					
	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 47 : AU915-928 downlink RX1 data rate mapping

1067

1068

 1069 The allowed values for RX1DROffset are in the [0:5] range. Values in the range [6:7] are  
 1070 reserved for future use.

 1071 **2.8.8 AU915-928 Class B beacon**

1072 The beacons are transmitted using the following settings:

<b>DR</b>	8	Corresponds to SF12 spreading factor with 500kHz bw
<b>CR</b>	1	Coding rate = 4/5
<b>Signal polarity</b>	Non-inverted	As opposed to normal downlink traffic which uses inverted signal polarity
<b>frequencies</b>	923.3 to 927.5MHz with 600kHz steps	Beaconing is performed on the same channel that normal downstream traffic as defined in the Class A specification

1073

**Table 48 : AU915-928 beacon settings**

1074 The downstream channel used for a given beacon is:

1075

$$1076 \text{ Channel} = \left[ \text{floor} \left( \frac{\text{beacon\_time}}{\text{beacon\_period}} \right) \right] \text{ modulo } 8$$

1077

- 1078 • whereby beacon\_time is the integer value of the 4 bytes “Time” field of the beacon
- 1079 frame
- 1080 • whereby beacon\_period is the periodicity of beacons, 128 seconds
- 1081 • whereby  $\text{floor}(x)$  designates rounding to the integer immediately inferior or equal to  $x$

1082 | Example: the first beacon will be transmitted on 923.3 MHz, the second  
 1083 | on 923.9MHz, the 9<sup>th</sup> beacon will be on 923.3MHz again.

1084

Beacon channel nb	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

1085

 1086 The beacon frame content is defined in [TS001].<sup>36</sup>

1087 The default Class B PING\_SLOT\_CHANNEL is defined in the LoRaWAN® specification.

 1088 **2.8.9 AU915-928 Default Settings**

1089 There are no specific default settings for AU 915-928 MHz Band.

<sup>36</sup> Prior to LoRaWAN® 1.0.4, the beacon was defined here as:

Size (bytes)	3	4	2	7	1	2
<b>BCNPayload</b>	<b>RFU</b>	Time	CRC	GwSpecific	<b>RFU</b>	CRC

1090 **2.9 CN470-510MHz Band<sup>37</sup>**

 1091 

Note: The CN470-510 channel plan has been significantly changed from

 1092 

prior revisions and should be considered experimental pending

 1093 

published documents confirming plan compliant devices have been

 1094 

granted local regulatory approval.

 1095 **2.9.1 CN470-510 Preamble Format**

1096 Please refer to Section 3.0 Physical Layer.

 1097 **2.9.2 CN470-510 Channel Frequencies**

1098
 1099 In China, this band is defined by SRRC to be used for small scale networks covering civil
 1100 metering applications in buildings, residential areas and villages. The transmission time shall
 1101 not exceed one second and is limited to one channel at a time. For interferences mitigation,
 1102 access to the physical medium requires a Listen Before Talk Adaptive Frequency Agility
 1103 (LBT AFA) transmission management or other similar mechanisms like channels
 1104 blacklisting.

 1105 

**Note:** The limitation of scope to small scale networks enters into effect

 1106 

after November 2021. Gateways and end-devices deployed prior to

 1107 

December 1, 2021 are not required to comply with this restriction.

 1108

1109 In the areas where channels are used by China Broadcasting Services, they SHALL be
 1110 disabled.

1111
 1112 For the CN470-510MHz band, the bandwidth is the biggest and the frequency is the lowest
 1113 compared to all the countries and areas in this document. The bandwidth and the frequency
 1114 affect the design of antennas. There are several different antenna solutions for CN470-
 1115 510MHz band.

1116
 1117 The CN470-510MHz SRD Band shall be divided into the channel plans as follows:

- 1118
- The channel plan for 20MHz antenna (type A and B)
  - The channel plan for 26MHz antenna (type A and B)
- 1119

1120
 1121 20 common join channels are defined for all the channel plans mentioned above.
 1122

Common Join Channel Index	UL (MHz)	DL (MHz)	Activate 20MHz plan A	Activate 20MHz plan B	Activate 26MHz plan A	Activate 26MHz 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	

<sup>37</sup> 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 49: Common join channels for CN470-510 channel frequencies

1123  
1124  
1125  
1126  
1127  
1128

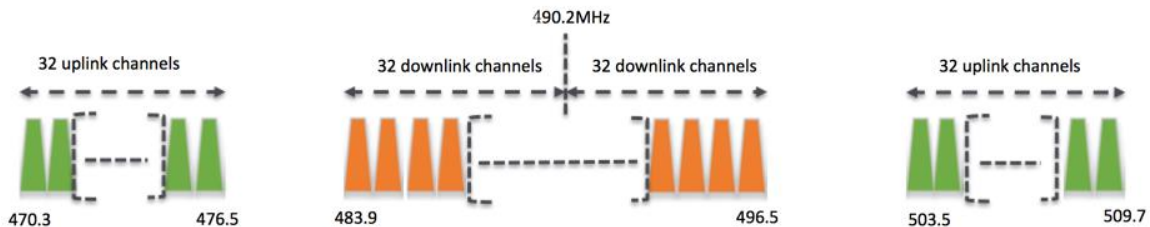
All the above channel plans SHALL be implemented in the CN470 end-devices. End devices SHALL scan all the common join channels. If the end-device receives the join-accept message from one of the above DL common join channel, the end-device SHALL use the corresponding channel plan<sup>38</sup> in the above table.

1129 **2.9.2.1 Channel Plan for 20MHz Antenna**

1130 For 20MHz Antennas, the CN470-510MHz Band shall be divided into two channel plans: plan  
1131 Type A and plan Type B.

1132 For channel plan Type A:

- 1133 • Upstream (Group 1) – 32 channels numbered 0 to 31 utilizing LoRa 125 kHz BW  
1134 varying from DR0 to DR5, using coding rate 4/5, starting at 470.3 MHz and  
1135 incrementing linearly by 200 kHz to 476.5 MHz
- 1136 • Downstream (Group 1) – 32 channels numbered 0 to 31 utilizing LoRa 125 kHz BW  
1137 varying from DR0 to DR5, using coding rate 4/5, starting at 483.9 MHz and  
1138 incrementing linearly by 200 kHz to 490.1 MHz
- 1139 • Downstream (Group 2) – 32 channels numbered 32 to 63 utilizing LoRa 125 kHz BW  
1140 varying from DR0 to DR5, using coding rate 4/5, starting at 490.3 MHz and  
1141 incrementing linearly by 200 kHz to 496.5 MHz
- 1142 • Upstream (Group 2) – 32 channels numbered 32 to 63 utilizing LoRa 125 kHz BW  
1143 varying from DR0 to DR5, using coding rate 4/5, starting at 503.5 MHz and  
1144 incrementing linearly by 200 kHz to 509.7 MHz



1145

Table 50: channel plan type A for 20MHz antenna channel frequencies

1146  
1147  
1148

For channel plan Type B:

- 1149 • Upstream (Group 1) – 32 channels numbered 0 to 31 utilizing LoRa 125 kHz BW  
1150 varying from DR0 to DR5, using coding rate 4/5, starting at 476.9 MHz and  
1151 incrementing linearly by 200 kHz to 483.1 MHz.
- 1152 • Downstream (Group 1) – 32 channels numbered 0 to 31 utilizing LoRa 125 kHz BW  
1153 varying from DR0 to DR5, using coding rate 4/5, starting at 476.9 MHz and  
1154 incrementing linearly by 200 kHz to 483.1 MHz.
- 1155 • Upstream (Group 2) – 32 channels numbered 32 to 63 utilizing LoRa 125 kHz BW  
1156 varying from DR0 to DR5, using coding rate 4/5, starting at 496.9 MHz and

<sup>38</sup> 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.

- 1157 incrementing linearly by 200 kHz to 503.1 MHz.  
 1158 • Downstream (Group 2) – 32 channels numbered 32 to 63 utilizing LoRa 125 kHz BW  
 1159 varying from DR0 to DR5, using coding rate 4/5, starting at 496.9 MHz and  
 1160 incrementing linearly by 200 kHz to 503.1 MHz.



Table 51: channel plan type B for 20MHz antenna channel frequencies

1163 **2.9.2.2 Channel Plan for 26MHz antenna**

1164 For 26MHz Antennas, the CN470-510MHz Band shall be divided into two channel plans: plan  
 1165 Type A and plan Type B.

1166 For channel plan Type A:

- 1167 • Upstream – 48 channels numbered 0 to 47 utilizing LoRa 125 kHz BW varying from  
 1168 DR0 to DR5, using coding rate 4/5, starting at 470.3 MHz and incrementing linearly by  
 1169 200 kHz to 479.7 MHz  
 1170 • Downstream – 24 channels numbered 0 to 23 utilizing LoRa 125 kHz BW at DR0 to  
 1171 DR5, starting at 490.1 MHz and incrementing linearly by 200 kHz to 494.7 MHz.  
 1172 Additional frequencies from 494.9 to 495.9 MHz are available for configurable downlink  
 1173 parameters (beacon frequency, ping-slot frequency and RX2 frequency).

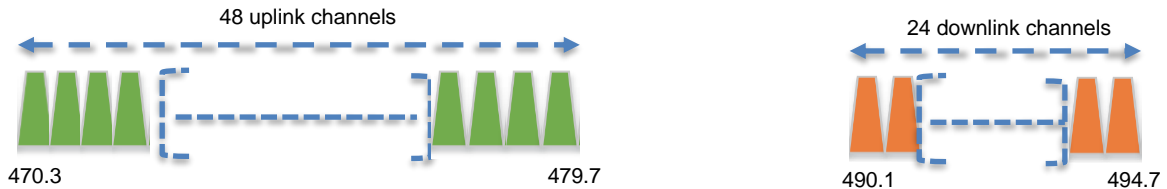


Table 52: channel plan type A for 26MHz antenna channel frequencies

1176 For channel plan Type B:

- 1177 • Upstream – 48 channels numbered 0 to 47 utilizing LoRa 125 kHz BW varying from  
 1178 DR0 to DR5, using coding rate 4/5, starting at 480.3 MHz and incrementing linearly by  
 1179 200 kHz to 489.7 MHz  
 1180 • Downstream – 24 channels numbered 0 to 23 utilizing LoRa 125 kHz BW at DR0 to  
 1181 DR5, starting at 500.1 MHz and incrementing linearly by 200 kHz to 504.7 MHz.  
 1182 Additional frequencies from 504.9 to 505.9 MHz are available for configurable downlink  
 1183 parameters (beacon frequency, ping-slot frequency and RX2 frequency).

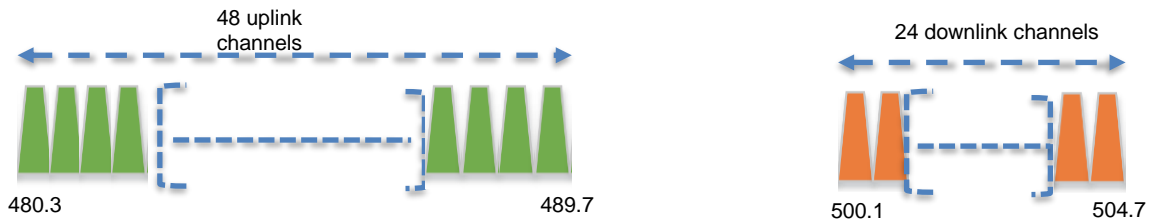


Table 53: channel plan type B for 26MHz antenna channel frequencies

1184  
 1185  
 1186

1187 If using the over-the-air activation procedure, the end-device SHALL broadcast the Join-  
 1188 Request message on a random 125 kHz channel amongst the 20 uplink channels defined  
 1189 previously in this section using **DR5 to DR0**.

1190 Personalized devices SHALL have all channels enabled corresponding to activation plan  
 1191 following a reset.

### 1192 2.9.3 CN470-510 Data Rate and End-point Output Power encoding

1193 The *TxParamSetupReq* MAC command is not implemented by CN470-510 devices.

1194 The following encoding is used for Data Rate (DR) and end-point EIRP (TXPower) in the  
 1195 CN470-510 band:

1196

Data Rate	Configuration	Indicative physical bit rate [bit/sec]	TXPower	Configuration (EIRP)
0 <sup>39</sup>	LoRa: SF12/ 125 kHz	250	0	Max EIRP
1	LoRa: SF11 / 125 kHz	440	1	Max EIRP – 2dB
2	LoRa: SF10 / 125 kHz	980	2	Max EIRP – 4dB
3	LoRa: SF9 / 125 kHz	1760	3	Max EIRP – 6dB
4	LoRa: SF8 / 125 kHz	3125	4	Max EIRP – 8dB
5	LoRa:SF7 / 125 kHz	5470	5	Max EIRP – 10dB
6	LoRa:SF7 / 500 kHz	21900	6	Max EIRP – 12dB
7	FSK: 50 Kbps	50000	7	Max EIRP – 14dB
8:14	RFU		8...14	RFU
15	Defined in [TS001] <sup>40</sup>		15	Defined in [TS001] <sup>40</sup>

Table 54: CN470-510 Data rate and TX power table

1197

1198

1199 CN470-510 end-devices SHALL support one of the 2 following data rate options:

- 1200 1. DR0 to DR5 (minimum set supported for certification)
- 1201 2. DR0 to DR7

1202 For both of the options all data rates in the range specified SHALL be implemented  
 1203 (meaning no intermediate DR may be left unimplemented)

1204

1205 When the device is using the Adaptive Data Rate mode and transmits using the DR<sub>current</sub>  
 1206 data rate, the following table defines the next data rate (DR<sub>next</sub>) the end-device SHALL use  
 1207 during data rate back-off:

DR <sub>current</sub>	DR <sub>next</sub>	Comment
0	NA	Already the lowest data rate
1	0	
2	1	
3	2	
4	3	
5	4	
6	5	
7	6	

Table 55: CN470-510 Data Rate Backoff table

1208

<sup>39</sup> As of RP002-1.0.1, DR0 is unavailable for devices implementing CN470-510, but remains defined to better support existing implementations.

<sup>40</sup> DR15 and TXPower15 are defined in the LinkADRRReq MAC command of the LoRaWAN<sup>®</sup> 1.0.4 and subsequent specifications and were previously RFU

1209

1210 EIRP refers to the Equivalent Isotropically Radiated Power, which is the radiated output  
 1211 power referenced to an isotropic antenna radiating power equally in all directions and whose  
 1212 gain is expressed in dBi.

1213 By default, the Max EIRP is considered to be +19.15dBm. If the end-device cannot achieve  
 1214 19.15dBm EIRP, the Max EIRP SHOULD be communicated to the network server using an  
 1215 out-of-band channel during the end-device commissioning process.

## 1216 2.9.4 CN470-510 Join-Accept CFList

1217

1218 The CN470 LoRaWAN<sup>®</sup> supports the use of the OPTIONAL CFList appended to the Join-  
 1219 Accept message. If the CFList is not empty, then the CFListType field SHALL contain the  
 1220 value one (0x01) to indicate the CFList contains a series of ChMask fields. The ChMask  
 1221 fields are interpreted as being controlled by a virtual ChMaskCntl that initializes to a value of  
 1222 zero (0) and increments for each ChMask field to a value of four (3) for 20 MHz plans A or B  
 1223 and three (2) for 26 MHz plans A or B. (The first 16 bits controls the channels 0 to 15...)  
 1224

1225 For 20MHz Antenna Systems:

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

1226

1227 For 26MHz Antenna Systems:

1228

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

1229

## 1230 2.9.5 CN470-510 LinkAdrReq command

### 1231 2.9.5.1 Channel Plan for 20MHz antenna

1232

1233 For 20MHz antenna the ChMaskCntl field of the *LinkADRReq* command has the following  
 1234 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 <sup>41</sup>

1235

Table 56:CH470 ChMaskCntl value table for 20M Antenna

<sup>41</sup> This command must be followed by another LinkADRReq command enabling at least one channel.

1236

1237 If the ChMask field value is one of the values indicating RFU, then end-device SHALL reject  
 1238 the command and unset the “**Channel mask ACK**” bit in its response.

### 1239 2.9.5.2 Channel Plan for 26MHz antenna

1240

1241 The ChMaskCntl field of the *LinkADRReq* command has the following meaning:  
 1242

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 <sup>42</sup>
5	RFU
6	RFU
7	RFU

1243 **Table 57: CH470 ChMaskCntl value table for 26M Antenna**

1244

1245 If the ChMask field value is one of the values indicating RFU, the end-device SHALL reject  
 1246 the command and unset the “**Channel mask ACK**” bit in its response.

### 1247 2.9.6 CN470-510 Maximum payload size

1248 The maximum **MACPayload** size length (*M*) is given by the following table. It is derived from  
 1249 the maximum allowed transmission time at the PHY layer taking into account a possible  
 1250 repeater encapsulation. The maximum application payload length in the absence of the  
 1251 OPTIONAL **FOpt** MAC control field (*N*) is also given for information only. The value of *N* might  
 1252 be smaller if the **FOpt** field is not empty:

1253

Data Rate	M	N
0 <sup>39</sup>	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	

1254 **Table 58: CN470-510 maximum payload size (repeater compatible)**

1255

1256 If the end-device will never operate with a repeater then the maximum application payload  
 1257 length in the absence of the OPTIONAL **FOpt** control field SHALL be:

Data Rate	M	N
0 <sup>39</sup>	N/A	N/A
1	31	23
2	94	86
3	192	184
4	250	242

<sup>42</sup> This command must be followed by another *LinkADRReq* command enabling at least one channel

5	250	242
6	250	242
7	250	242
8:15	Not defined	

Table 59: CN470-510 maximum payload size (not repeater compatible)

 1258  
1259

## 1260 2.9.7 CN470-510 Receive windows

1261 The RX1 data rate depends on the transmit data rate (see Table 60 below).  
1262 The RX2 default data rate is DR1.

1263

Upstream data rate RX1DROffset	Downstream data rate					
	0	1	2	3	4	5
DR0 <sup>39</sup>	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 60: CN470-510 downlink RX1 data rate mapping

 1264  
1265

1266 The allowed values for RX1DROffset are in the [0:5] range. Values in the range [6:7] are  
1267 reserved for future use.

### 1268 2.9.7.1 Channel Plan for 20MHz Antenna Systems

1269 For channel plan Type A:

- 1270 ○ The RX1 downlink channel is the same as the uplink channel number
- 1271 ○ The RX2 channel number for OTAA devices is defined in Table 61
- 1272 ○ The RX2 channel number for ABP devices is 486.9 MHz

1273

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 61: RX2 Default Frequency for channel plan type A for 20MHz antenna

1274

1275 For channel plan Type B:

- 1276 ○ The RX1 downlink channel is the same as the uplink channel number
- 1277 ○ The RX2 channel number for OTAA devices is defined in Table 62
- 1278 ○ The RX2 channel number for ABP devices is 498.3 MHz

1279

Common Join Channel Index used in OTAA	RX2 Default Frequency
8	478.3 MHz



9	498.3 MHz
---	-----------

 1280 **Table 62: RX2 Default Frequency for channel plan type B for 20MHz antenna**

 1281 **2.9.7.2 Channel Plan for 26MHz Antenna Systems**

- 1282 • For both plans, the RX1 receive channel is a function of the upstream channel used to
- 1283 initiate the data exchange. The RX1 receive channel can be determined as follows.
- 1284 ○ RX1 Channel Number = Transmit Channel Number modulo 24
- 1285 • The RX2 default frequency is:
- 1286 ○ For Channel plan A: 492.5MHz
- 1287 ○ For Channel plan B: 502.5MHz

 1288 **2.9.8 CN470-510 Class B beacon**

 1289 The beacon frame content is defined in [TS001].<sup>43</sup>

1291 The beacons are transmitted using the following settings:

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

 1293 **Table 63 : CN470-510 beacon settings**

 1294 **2.9.8.1 Default Beacon and Ping-Slot Channel Numbers and Ping-Slots for 20MHz**  
 1295 **Antenna Systems**

1296 By default, for channel plan Type A:

 1297 The downstream channel used for beacon is as the following table according to the common  
 1298 join channel the end-device used:

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

 1300 **Table 64: Beacon Channel Number for channel plan type A for 20MHz antenna**

<sup>43</sup> Prior to LoRaWAN® 1.0.4, the beacon was defined here as:

Size (bytes)	3	4	2	7	1	2
<b>BCNPayload</b>	RFU	Time	CRC	GwSpecific	RFU	CRC



1301  
1302  
1303  
1304  
1305  
1306  
1307  
1308  
1309  
1310

- whereby beacon\_time is the integer value of the 4 bytes “Time” field of the beacon frame
- whereby beacon\_period is the periodicity of beacons, 128 seconds
- whereby  $\text{floor}(x)$  designates rounding to the integer immediately inferior or equal to  $x$

The downstream channel used for a Ping-slot channel is as the following table according to the common join channel the end-device used:

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

Table 65: Ping-slot Channel Number for channel plan type A for 20MHz antenna

1311  
1312  
1313  
1314  
1315  
1316

By default, for channel plan Type B:

The downstream channel used for beacon is as the following table according to the common join channel the end-device used:

Common Join Channel Index	Beacon Channel Number
8	23
9	55

Table 66: Beacon Channel Number for channel plan type B for 20MHz antenna

1317  
1318  
1319  
1320  
1321  
1322  
1323  
1324  
1325  
1326  
1327

- whereby beacon\_time is the integer value of the 4 bytes “Time” field of the beacon frame
- whereby beacon\_period is the periodicity of beacons, 128 seconds
- whereby  $\text{floor}(x)$  designates rounding to the integer immediately inferior or equal to  $x$

The downstream channel used for a Ping-slot channel is as the following table according to the common join channel the end-device used:

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

1328  
1329

Table 67: Ping-slot Channel Number for channel plan type B for 20MHz antenna

1330 **2.9.8.2 Default Beacon and Ping-Slot Frequencies for 26MHz antenna Systems**

1331 By default, beacons and downlink ping-slot messages are transmitted using the following  
1332 frequencies:

1333 For Channel Plan A: 494.9MHz

1334 For Channel Plan B: 504.9MHz

1335 **2.9.9 CN470-510 Default Settings**

1336 There are no specific default settings for the CN470-510 MHz Band.

1337 **2.10 AS923MHz Band**

 1338 **2.10.1 AS923 Preamble Format**

1339 Please refer to Section 3.0 Physical Layer.

 1340 **2.10.2 AS923 Band channel frequencies**

 1341 This section was originally intended to apply to regions where the frequencies [915...928MHz]  
 1342 are present in an unlicensed LPWAN band but MAY also apply to regions with available bands  
 1343 in frequencies up to 1.67GHz.

 1344 In order to accommodate country specific sub-bands across 915 - 928 MHz band, a frequency  
 1345 offset parameter **AS923\_FREQ\_OFFSET** is defined. **AS923\_FREQ\_OFFSET** is a 32-bit  
 1346 signed integer, allowing both positive and negative frequency offsets.

1347 The corresponding frequency offset in Hz is:

1348 
$$\mathbf{AS923\_FREQ\_OFFSET\_HZ} = 100 \times \mathbf{AS923\_FREQ\_OFFSET}.$$

 1349 **AS923\_FREQ\_OFFSET** only applies to end-device default settings. **AS923\_FREQ\_OFFSET**  
 1350 does not apply any frequencies delivered to end-device from network server through MAC  
 1351 commands or the CFList.

 1352 AS923 end-devices operated in Japan SHALL perform Listen Before Talk (LBT) based on  
 1353 ARIB STD-T108 regulations. The ARIB STD-T108 regulation is available for free and should  
 1354 be consulted as needed by the user.

 1355 The end-device's LBT requirement, maximum transmission time, duty cycle or other  
 1356 parameters MAY be dependent on frequency of each transmission.

 1357 The network channels can be freely assigned by the network operator. However, the two  
 1358 following default channels SHALL be implemented in every AS923 end-device. Those  
 1359 channels are the minimum set that all network gateways SHALL always be listening on.

1360

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

1361

**Table 68: AS923 default channels**

 1362 For devices compliant with TS001-1.0.x, those default channels SHALL NOT be modified  
 1363 through the **NewChannelReq** command. For devices compliant with TS001-1.1.x and  
 1364 beyond, these channels MAY be modified through the **NewChannelReq** but SHALL be reset  
 1365 during the backoff procedure defined in TS001-1.1.1 to guarantee a minimal common channel  
 1366 set between end-devices and network gateways.

1367 AS923 end-devices SHOULD use the following default parameters

- 1368
- Default EIRP: 16 dBm

 1369 AS923 end-devices SHALL feature a channel data structure to store the parameters of at least  
 1370 16 channels. A channel data structure corresponds to a frequency and a set of data rates  
 1371 usable on this frequency.

 1372 The following table gives the list of frequencies that SHALL be used by end-devices to  
 1373 broadcast the Join-Request message.

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

Table 69: AS923 Join-Request Channel List

1374

1375

1376 The default Join-Request Data Rate utilizes the range DR2-DR5 (SF10/125 kHz – SF7/125  
1377 kHz), this setting ensures that end-devices are compatible with the 400ms dwell time limitation  
1378 until the actual dwell time limit is notified to the end-device by the network server via the MAC  
1379 command **TxParamSetupReq**.

1380

1381 The Join-Request message transmit duty-cycle SHALL follow the rules described in chapter  
1382 “Retransmissions back-off” of the LoRaWAN® specification document.

### 1383 2.10.3 AS923 Data Rate and End-point Output Power encoding

1384 The “TxParamSetupReq/Ans” MAC command SHALL be implemented by the AS923 devices.

1385 The following encoding is used for Data Rate (DR) in the AS923 band:

1386

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] <sup>44</sup>	

Table 70: AS923 Data rate table

1387

1388

1389 AS923 end-devices SHALL support one of the 2 following data rate options:

- 1390 1. DR0 to DR5 (minimum set supported for certification)
- 1391 2. DR0 to DR7

1392 For both of the options all data rates in the range specified SHALL be implemented  
1393 (meaning no intermediate DR may be left unimplemented)

1394

1395 When the device is using the Adaptive Data Rate mode and transmits using the DR<sub>current</sub>  
1396 data rate, the following table defines the next data rate (DR<sub>next</sub>) the end-device SHALL use  
1397 during data rate back-off:

UplinkDwellTime=0		UplinkDwellTime=1	
DR <sub>current</sub>	DR <sub>next</sub>	DR <sub>current</sub>	DR <sub>next</sub>
0	NA	NA	NA
1	0	NA	NA

<sup>44</sup> DR15 and TXPower15 are defined in the LinkADRRReq MAC command of the LoRaWAN® 1.0.4 and subsequent specifications and were previously RFU

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 71: AS923 Data Rate Backoff table

1398

1399

1400 The TXPower table indicates power levels relative to the Max EIRP level of the end-device,  
1401 as per the following table:

1402

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] <sup>44</sup>

Table 72: AS923 TXPower table

1403

1404

1405 EIRP refers to the Equivalent Isotropically Radiated Power, which is the radiated output  
1406 power referenced to an isotropic antenna radiating power equally in all directions and whose  
1407 gain is expressed in dBi.

1408 By default, the Max EIRP SHALL be 16dBm. The Max EIRP can be modified by the network  
1409 server through the ***TxParamSetupReq*** MAC command and SHOULD be used by both the  
1410 end-device and the network server once ***TxParamSetupReq*** is acknowledged by the device  
1411 via ***TxParamSetupAns***,

#### 1412 2.10.4 AS923 Join-Accept CFList

1413 The AS923 LoRaWAN<sup>®</sup> implements an OPTIONAL channel frequency list (CFList) of 16 octets  
1414 in the Join-Accept message.

1415 In this case the CFList is a list of five channel frequencies for the channels two to six whereby  
1416 each frequency is encoded as a 24 bits unsigned integer (three octets). All these channels are  
1417 usable for DR0 to DR5 125 KHz LoRa modulation subject to local regulatory dwell-time  
1418 limitations. The list of frequencies is followed by a single CFListType octet for a total of 16  
1419 octets. The CFListType SHALL be equal to zero (0) to indicate that the CFList contains a list  
1420 of frequencies.

1421

Size (bytes) CFList	3	3	3	3	3	1
	Freq Ch2	Freq Ch3	Freq Ch4	Freq Ch5	Freq Ch6	CFListType

1422

1423 The actual channel frequency in Hz is 100 x frequency whereby values representing  
1424 frequencies below 100 MHz are reserved for future use. This allows setting the frequency of

1425 a channel anywhere between 915 and 928MHz in 100 Hz steps. Unused channels have a  
 1426 frequency value of 0. The CFList is OPTIONAL and its presence can be detected by the length  
 1427 of the join-accept message. If present, the CFList replaces all the previous channels stored in  
 1428 the end-device apart from the two default channels. The newly defined channels are  
 1429 immediately enabled and usable by the end-device for communication.

1430 **AS923\_FREQ\_OFFSET** does not apply any frequencies delivered to end-device from network  
 1431 server through MAC commands or the CFList. Therefore, AS923 end-devices SHALL NOT  
 1432 apply **AS923\_FREQ\_OFFSET** to the channel frequencies defined in the CFList

### 1433 2.10.5 AS923 LinkAdrReq command

1434 The AS923 LoRaWAN<sup>®</sup> only supports a maximum of 16 channels. When **ChMaskCntl** field  
 1435 is 0 the ChMask field individually enables/disables each of the 16 channels.  
 1436

ChMaskCntl	ChMask applies to
0	Channels 0 to 15
1	RFU
2	RFU
3	RFU
4	RFU
5	RFU
6	All channels ON - The device SHOULD enable all currently defined channels independently of the ChMask field value.
7	RFU

1437 **Table 73: AS923 ChMaskCntl value table**

1438 If the ChMask field value is one of values meaning RFU, the end-device SHALL reject the  
 1439 command and unset the “**Channel mask ACK**” bit in its response.

### 1440 2.10.6 AS923 Maximum payload size

1441 The maximum **MACPayload** size length (*M*) is given by the following table for both  
 1442 **UplinkDwellTime** and **DownlinkDwellTime** configurations: No Limit and 400ms. It is derived  
 1443 from the maximum allowed transmission time at the PHY layer taking into account a possible  
 1444 repeater encapsulation layer. The maximum application payload length in the absence of the  
 1445 OPTIONAL **FOpt** MAC control field (*N*) is also given for information only. The value of *N* might  
 1446 be smaller if the **FOpt** 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	

1448 **Table 74: AS923 maximum payload size (repeater compatible)**

1449 If the end-device will never operate with a repeater then the maximum application payload  
 1450 length in the absence of the OPTIONAL **FOpt** control field SHALL be:

1451

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	

1452

**Table 75: AS923 maximum payload size (not repeater compatible)**

1453 The end-device SHALL only enforce the maximum Downlink MAC Payload Size defined for  
 1454 DownlinkDwellTime = 0 (no dwell time enforced) regardless of the actual setting. This  
 1455 prevents the end-device from discarding valid downlink messages which comply with the  
 1456 regulatory requirements which may be unknown to the device (for example, when the device  
 1457 is joining the network).

### 1458 2.10.7 AS923 Receive windows

1459 By default, the RX1 receive window uses the same channel as the preceding uplink. The data  
 1460 rate is a function of the uplink data rate and the RX1DROffset as given by the following table.  
 1461 The allowed values for RX1DROffset are in the [0:7] range.

1462 Values in the [6:7] range allow setting the Downstream RX1 data rate higher than upstream  
 1463 data rate.

1464 When **DownlinkDwellTime** is zero, the allowed values for RX1DROffset are in the [0:7] range,  
 1465 encoded as per the below table.

1466

Upstream data rate RX1DROffset	Downstream data rate							
	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

1467

**Table 76: AS923 downlink RX1 data rate mapping for DownLinkDwellTime = 0**

1468

1469 When **DownlinkDwellTime** is one, the allowed values for RX1DROffset are in the [0:7] range,  
 1470 encoded as per the below table.

1471



Upstream data rate RX1DROffset	Downstream data rate							
	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 67: AS923 downlink RX1 data rate mapping for DownLinkDwellTime =1

1472

1473 The RX2 receive window uses a fixed frequency and data rate. The default parameters are  
1474 923.2 MHz + **AS923\_FREQ\_OFFSET\_HZ** / DR2 (SF10/125KHz).

### 1475 2.10.8 AS923 Class B beacon and default downlink channel

1476 The beacons SHALL be transmitted using the following settings

<b>DR</b>	3	Corresponds to SF9 spreading factor with 125 kHz BW
<b>CR</b>	1	Coding rate = 4/5
<b>Signal polarity</b>	Non-inverted	As opposed to normal downlink traffic which uses inverted signal polarity

1477

Table 77 : AS923 beacon settings

1478 The beacon frame content is defined in [TS001].<sup>45</sup>

1479 The beacon default broadcast frequency is 923.4MHz + **AS923\_FREQ\_OFFSET\_HZ**.

1480 The class B default downlink pingSlot frequency is 923.4MHz + **AS923\_FREQ\_OFFSET\_HZ**.

### 1481 2.10.9 AS923 Default Settings

1482 Several default values of **AS923\_FREQ\_OFFSET** are defined to address all the different  
1483 AS923 countries. The default values of **AS923\_FREQ\_OFFSET** are chosen to minimize their  
1484 total number and cover a large number of countries. Three different groups are defined below  
1485 according to **AS923\_FREQ\_OFFSET** default value.

1486 **Group AS923-1: AS923\_FREQ\_OFFSET default value = 0x00000000,**

1487 **AS923\_FREQ\_OFFSET\_HZ = 0.0 MHz**

1488 This group is composed of countries having available frequencies in the 915 – 928  
1489 MHz range with common channels in the 923.0 – 923.5 MHz sub-band. These are the  
1490 “historical” AS923 countries, compliant to RP2-1.0.0 specification and previous  
1491 versions.

1492 **Group AS923-2: AS923\_FREQ\_OFFSET default value = 0xFFFFB9B0,**

1493 **AS923\_FREQ\_OFFSET\_HZ = -1.80 MHz**

1494 This group is composed of countries having available frequencies in the 920 – 923  
1495 MHz range with common channels in the 921.4 – 922.0 MHz sub-band.

<sup>45</sup> Prior to LoRaWAN<sup>®</sup> 1.0.4, the beacon was defined here as:

<b>Size (bytes)</b>	2	4	2	7	2
<b>BCNPayload</b>	RFU	Time	CRC	GwSpecific	CRC

1496 **Group AS923-3: AS923\_FREQ\_OFFSET default value = 0xFFFEFE30,**  
1497 **AS923\_FREQ\_OFFSET\_HZ = -6.60 MHz**

1498 This group is composed of countries having available frequencies in the 915 – 921  
1499 MHz range with common channels in the 916.5 – 917.0 MHz sub-band.

1500

1501 There are no other specific default settings for the AS923 Band.

1502 **2.11 KR920-923MHz Band**

 1503 **2.11.1 KR920-923 Preamble Format**

1504 Please refer to Section 3.0 Physical Layer.

 1505 **2.11.2 KR920-923 Band channel frequencies**

 1506 The center frequency, bandwidth and maximum EIRP output power for the South Korea  
 1507 RFID/USN frequency band are defined by Korean Government, which has allocated LPWA  
 1508 based IoT networks the channel center frequencies from 920.9 to 923.3MHz.

1509

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

1510

**Table 78: KR920-923 Center frequency, bandwidth, maximum EIRP output power table**

 1511 The three default channels correspond to 922.1, 922.3 and 922.5MHz / DR0 to DR5 and  
 1512 SHALL be implemented in every KR920-923 end-device. For devices compliant with TS001-  
 1513 1.0.x, those default channels SHALL NOT be modified through the **NewChannelReq**  
 1514 command. For devices compliant with TS001-1.1.x and beyond, these channels MAY be  
 1515 modified through the **NewChannelReq** but SHALL be reset during the backoff procedure  
 1516 defined in TS001-1.1.1 to guarantee a minimal common channel set between end-devices  
 1517 and network gateways.

 1518 The following table gives the list of frequencies that SHALL be used by end-devices to  
 1519 broadcast the Join-Request message. The Join-Request message transmit duty-cycle SHALL  
 1520 follow the rules described in chapter “Retransmissions back-off” of the LoRaWAN®  
 1521 specification document.

1522

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

1523

**Table 79: KR920-923 default channels**

 1524 In order to access the physical medium, the South Korea regulations impose several  
 1525 restrictions. The South Korea regulations allow the choice of using either a duty-cycle  
 1526 limitation or Listen Before Talk Adaptive Frequency Agility (LBT AFA) transmission  
 1527 management. The current LoRaWAN® specification for the KR920-923 band exclusively uses

1528 LBT channel access rule to maximize MACPayload size length and comply with the South  
1529 Korea regulations.

1530 KR920-923MHz band end-devices SHALL use the following default parameters

- 1531 • Default EIRP output power for end-device(920.9~921.9MHz): 10 dBm
- 1532 • Default EIRP output power for end-device(922.1~923.3MHz): 14 dBm
- 1533 • Default EIRP output power for gateway: 23 dBm

1534 KR920-923MHz end-devices SHALL be capable of operating in the 920 to 923MHz frequency  
1535 band and SHALL feature a channel data structure to store the parameters of at least 16  
1536 channels. A channel data structure corresponds to a frequency and a set of data rates usable  
1537 on this frequency.

1538 The following table gives the list of frequencies that SHALL be used by end-devices to  
1539 broadcast the Join-Request message.

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

1540 **Table 80: KR920-923 Join-Request Channel List**

### 1541 2.11.3 KR920-923 Data Rate and End-device Output Power encoding

1542 There is no dwell time limitation for the KR920-923 PHY layer. The *TxParamSetupReq* MAC  
1543 command is not implemented by KR920-923 devices.

1544 The following encoding is used for Data Rate (DR), and EIRP Output Power (TXPower) in the  
1545 KR920-923 band:

1546

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] <sup>46</sup>	

1547 **Table 81: KR920-923 TX Data rate table**

1548 KR920-923 end-devices SHALL support the following data rates:

- 1550 1. DR0 to DR5 (minimum set supported for certification)

1551 All data rates in the range specified SHALL be implemented (meaning no intermediate DR  
1552 may be left unimplemented)

1553

1554 When the device is using the Adaptive Data Rate mode and transmits using the DR<sub>current</sub>  
1555 data rate, the following table defines the next data rate (DR<sub>next</sub>) the end-device SHALL use  
1556 during data rate back-off:

<sup>46</sup> DR15 and TXPower15 are defined in the LinkADRRReq MAC command of the LoRaWAN1.0.4 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	

Table 82: KR920-923 Data Rate Backoff table

 1557  
1558

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] <sup>46</sup>

Table 83: KR920-923 TX power table

 1559  
1560

1561 EIRP refers to the Equivalent Isotropically Radiated Power, which is the radiated output  
1562 power referenced to an isotropic antenna radiating power equally in all directions and whose  
1563 gain is expressed in dBi.

1564 By default, the Max EIRP is considered to be +14dBm. If the end-device cannot achieve  
1565 14dBm EIRP, the Max EIRP SHOULD be communicated to the network server using an out-  
1566 of-band channel during the end-device commissioning process.

1567  
1568 When the device transmits in a channel whose frequency is <922MHz, the transmit power  
1569 SHALL be limited to +10dBm EIRP even if the current transmit power level set by the  
1570 network server is higher.

#### 1571 2.11.4 KR920-923 Join-Accept CFList

1572 The KR920-923 band LoRaWAN<sup>®</sup> implements an OPTIONAL **channel frequency list**  
1573 (CFList) of 16 octets in the Join-Accept message.

1574 In this case the CFList is a list of five channel frequencies for the channels three to seven  
1575 whereby each frequency is encoded as a 24 bits unsigned integer (three octets). All these  
1576 channels are usable for DR0 to DR5 125 kHz LoRa modulation. The list of frequencies is  
1577 followed by a single CFListType octet for a total of 16 octets. The CFListType SHALL be equal  
1578 to zero (0) to indicate that the CFList contains a list of frequencies.

1579

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

1580 The actual channel frequency in Hz is 100 x frequency whereby values representing  
1581 frequencies below 100 MHz are reserved for future use. This allows setting the frequency of  
1582 a channel anywhere between 100 MHz to 1.67 GHz in 100 Hz steps. Unused channels have  
1583 a frequency value of 0. The **CFList** is OPTIONAL and its presence can be detected by the

1584 length of the join-accept message. If present, the **CFList** replaces all the previous channels  
 1585 stored in the end-device apart from the three default channels. The newly defined channels  
 1586 are immediately enabled and usable by the end-device for communication.

### 1587 2.11.5 KR920-923 LinkAdrReq command

1588 The KR920-923 LoRaWAN® only supports a maximum of 16 channels. When **ChMaskCntl**  
 1589 field is 0 the ChMask field individually enables/disables each of the 16 channels.

1590

ChMaskCntl	ChMask applies to
0	Channels 0 to 15
1	RFU
2	RFU
3	RFU
4	RFU
5	RFU
6	All channels ON - The device SHOULD enable all currently defined channels independently of the ChMask field value.
7	RFU

Table 84: KR920-923 ChMaskCntl value table

1591

1592

1593 If the ChMaskCntl field value is one of values meaning RFU, the end-device SHALL<sup>47</sup> reject  
 1594 the command and unset the “**Channel mask ACK**” bit in its response.

### 1595 2.11.6 KR920-923 Maximum payload size

1596 The maximum **MACPayload** size length (*M*) is given by the following table for the regulation  
 1597 of dwell time; less than 4 sec with LBT. It is derived from limitation of the PHY layer depending  
 1598 on the effective modulation rate used taking into account a possible repeater encapsulation  
 1599 layer. The maximum application payload length in the absence of the OPTIONAL **FOpt** control  
 1600 field (*M*) is also given for information only. The value of *N* might be smaller if the **FOpt** field is  
 1601 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 85: KR920-923 maximum payload size (repeater compatible)

1602

1603 If the end-device will never operate with a repeater then the maximum application payload  
 1604 length in the absence of the OPTIONAL **FOpt** control field SHOULD be:

1605

Data Rate	M	N
0	59	51
1	59	51
2	59	51
3	123	115
4	250	242
5	250	242

<sup>47</sup> Made SHALL from SHOULD starting in LoRaWAN Regional Parameters Specification 1.0.3rA

6:15	Not defined
------	-------------

Table 86 : KR920-923 maximum payload size (not repeater compatible)

1606  
1607

### 1608 2.11.7 KR920-923 Receive windows

1609 By default, the RX1 receive window uses the same channel as the preceding uplink. The data  
1610 rate is a function of the uplink data rate and the RX1DROffset as given by the following table.  
1611 The allowed values for RX1DROffset are in the [0:5] range. Values in the [6:7] range are  
1612 reserved for future use.

1613

Upstream data rate RX1DROffset	Downstream data rate					
	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

1614

Table 87 : KR920-923 downlink RX1 data rate mapping

1615 The RX2 receive window uses a fixed frequency and data rate. The default parameters are  
1616 921.90MHz / DR0 (SF12, 125 kHz).

### 1617 2.11.8 KR920-923 Class B beacon and default downlink channel

1618 The beacons SHALL be transmitted using the following settings

<b>DR</b>	3	Corresponds to SF9 spreading factor with 125 kHz BW
<b>CR</b>	1	
<b>Signal polarity</b>	Non-inverted	As opposed to normal downlink traffic which uses inverted signal polarity

1619

Table 88 : KR920-923 beacon settings

1620

1621 The beacon frame content is defined in [TS001].<sup>48</sup>

1622 The beacon default broadcast frequency is 923.1MHz.

1623 The class B default downlink pingSlot frequency is 923.1MHz

### 1624 2.11.9 KR920-923 Default Settings

1625 There are no specific default settings for the KR920-923 MHz Band.

<sup>48</sup> Prior to LoRaWAN 1.0.4, the beacon was defined here as:

<b>Size (bytes)</b>	2	4	2	7	2
<b>BCNPayload</b>	RFU	Time	CRC	GwSpecific	CRC



1626 **2.12 IN865-867 MHz Band**

 1627 **2.12.1 IN865-867 Preamble Format**

1628 Please refer to Section 3.0 Physical Layer.

 1629 **2.12.2 IN865-867 Band channel frequencies**

1630 This section applies to the Indian sub-continent.

 1631 The network channels can be freely attributed by the network operator. However, the three  
 1632 following default channels SHALL be implemented in every India 865-867MHz end-device.  
 1633 Those channels are the minimum set that all network gateways SHALL be listening on.

1634

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

1635

Table 89: IN865-867 default channels

 1636 End-devices SHALL be capable of operating in the 865 to 867 MHz frequency band and  
 1637 should feature a channel data structure to store the parameters of at least 16 channels. A  
 1638 channel data structure corresponds to a frequency and a set of data rates usable on this  
 1639 frequency.

 1640 The first three channels correspond to 865.0625, 865.4025, and 865.985 MHz / DR0 to DR5  
 1641 and SHALL be implemented in every end-device. For devices compliant with TS001-1.0.x,  
 1642 those default channels SHALL NOT be modified through the **NewChannelReq** command. For  
 1643 devices compliant with TS001-1.1.x and beyond, these channels MAY be modified through  
 1644 the **NewChannelReq** but SHALL be reset during the backoff procedure defined in TS001-  
 1645 1.1.1 to guarantee a minimal common channel set between end-devices and network  
 1646 gateways.

 1647 The following table gives the list of frequencies that SHALL be used by end-devices to  
 1648 broadcast the Join-Request message. The Join-Request message transmit duty-cycle SHALL  
 1649 follow the rules described in chapter "Retransmissions back-off" of the LoRaWAN<sup>®</sup>  
 1650 specification document.

1651

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

1652

Table 90: IN865-867 Join-Request Channel List

 1653 **2.12.3 IN865-867 Data Rate and End-device Output Power Encoding**

 1654 There is no dwell time or duty-cycle limitation for the INDIA 865-867 PHY layer. The  
 1655 **TxParamSetupReq** MAC command is not implemented by INDIA 865-867 devices.

 1656 The following encoding is used for Data Rate (DR) and End-device Output Power (TXPower)  
 1657 in the INDIA 865-867 band:

1658

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] <sup>49</sup>	

**Table 91: IN865-867 TX Data rate table**

1659  
1660  
1661  
1662  
1663  
1664  
1665  
1666  
1667  
1668  
1669

IN865-867 end-devices SHALL support one of the 2 following data rate options:

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

For both of the 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 DR<sub>current</sub> data rate, the following table defines the next data rate (DR<sub>next</sub>) the end-device SHALL use during data rate back-off:

DR <sub>current</sub>	DR <sub>next</sub>	Comment
0	NA	Already the lowest data rate
1	0	
2	1	
3	2	
4	3	
5	4	
7	5	

**Table 92: IN865-867 DataRate Backoff table**

1670  
1671  
1672  
1673  
1674

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] <sup>49</sup>

**Table 93: IN865-867 TXPower table**

1675  
1676

<sup>49</sup> DR15 and TXPower15 are defined in the LinkADRRReq MAC command of the LoRaWAN1.0.4 and subsequent specifications and were previously RFU

1677 EIRP refers to the Equivalent Isotropically Radiated Power, which is the radiated output power  
 1678 referenced to an isotropic antenna radiating power equally in all directions and whose gain is  
 1679 expressed in dBi.

1680 By default, Max EIRP is considered to be 30dBm. If the end-device cannot achieve 30dBm  
 1681 EIRP, the Max EIRP SHOULD be communicated to the network server using an out-of-band  
 1682 channel during the end-device commissioning process.

#### 1683 2.12.4 IN865-867 Join-Accept CFList

1684 The India 865-867 band LoRaWAN<sup>®</sup> implements an OPTIONAL **channel frequency list**  
 1685 (CFList) of 16 octets in the Join-Accept message.

1686 In this case the CFList is a list of five channel frequencies for the channels three to seven  
 1687 whereby each frequency is encoded as a 24 bits unsigned integer (three octets). All these  
 1688 channels are usable for DR0 to DR5 125 kHz LoRa modulation.

1689 The list of frequencies is followed by a single CFListType octet for a total of 16 octets. The  
 1690 CFListType SHALL be equal to zero (0) to indicate that the CFList contains a list of  
 1691 frequencies.

1692

<b>Size (bytes)</b>	3	3	3	3	3	1
<b>CFList</b>	Freq Ch3	Freq Ch4	Freq Ch5	Freq Ch6	Freq Ch7	CFListType

1693

1694 The actual channel frequency in Hz is 100 x frequency whereby values representing  
 1695 frequencies below 100 MHz are reserved for future use. This allows setting the frequency of  
 1696 a channel anywhere between 100 MHz to 1.67 GHz in 100 Hz steps. Unused channels have  
 1697 a frequency value of 0. The **CFList** is OPTIONAL and its presence can be detected by the  
 1698 length of the join-accept message. If present, the **CFList** replaces all the previous channels  
 1699 stored in the end-device apart from the three default channels. The newly defined channels  
 1700 are immediately enabled and usable by the end-device for communication.

#### 1701 2.12.5 IN865-867 LinkAdrReq command

1702 The INDIA 865-867 LoRaWAN<sup>®</sup> only supports a maximum of 16 channels. When  
 1703 **ChMaskCntl** field is 0 the ChMask field individually enables/disables each of the 16 channels.  
 1704

<b>ChMaskCntl</b>	<b>ChMask applies to</b>
0	Channels 0 to 15
1	RFU
2	RFU
3	RFU
4	RFU
5	RFU
6	All channels ON - The device SHOULD enable all currently defined channels independently of the ChMask field value.
7	RFU

1705

[Table 94: IN865-867 ChMaskCntl value table](#)

1706 If the ChMaskCntl field value is one of values meaning RFU, the end-device SHALL<sup>50</sup> reject  
 1707 the command and unset the “**Channel mask ACK**” bit in its response.

<sup>50</sup> Made SHALL from SHOULD starting in LoRaWAN<sup>®</sup> Regional Parameters Specification 1.0.3rA

1708 **2.12.6 IN865-867 Maximum payload size**

 1709 The maximum **MACPayload** size length ( $M$ ) is given by the following table. It is derived from  
 1710 limitation of the PHY layer depending on the effective modulation rate used taking into account  
 1711 a possible repeater encapsulation layer. The maximum application payload length in the  
 1712 absence of the OPTIONAL **FOpt** control field ( $N$ ) is also given for information only. The value  
 1713 of  $N$  might be smaller if the **FOpt** field is not empty:  
 1714

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	

 1715 **Table 95: IN865-867 maximum payload size (repeater compatible)**

 1716 If the end-device will never operate with a repeater then the maximum application payload  
 1717 length in the absence of the OPTIONAL **FOpt** control field SHOULD be:  
 1718

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	

 1719 **Table 96 : IN865-867 maximum payload size (not repeater compatible)**

 1720 **2.12.7 IN865-867 Receive windows**

 1721 By default, the RX1 receive window uses the same channel as the preceding uplink. The data  
 1722 rate is a function of the uplink data rate and the RX1DROffset as given by the following table.  
 1723 The allowed values for RX1DROffset are in the [0:7] range.

 1724 Values in the [6:7] range allow setting the Downstream RX1 data rate higher than upstream  
 1725 data rate.

1726 The allowed values for RX1DROffset are in the [0:7] range, encoded as per the below table:

Upstream data rate RX1DROffset	Downstream data rate							
	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

 1727 **Table 97: IN865-867 downlink RX1 data rate mapping**

 1728 The RX2 receive window uses a fixed frequency and data rate. The default parameters are  
 1729 866.550 MHz / DR2 (SF10, 125 kHz).

1730 **2.12.8 IN865-867 Class B beacon and default downlink channel**

1731 The beacons are transmitted using the following settings

DR	4	Corresponds to SF8 spreading factor with 125 kHz BW
CR	1	Coding rate = 4/5
<b>Signal polarity</b>	Non-inverted	As opposed to normal downlink traffic which uses inverted signal polarity

1732

 1733 The beacon frame content is defined in [TS001].<sup>51</sup>

1734 The beacon default broadcast frequency is 866.550MHz.

1735 The class B default downlink pingSlot frequency is 866.550MHz

 1736 **2.12.9 IN865-867 Default Settings**

1737 There are no specific default settings for the IN 865-867 MHz Band.

---

<sup>51</sup> Prior to LoRaWAN<sup>®</sup> 1.0.4, the beacon was defined here as:

<b>Size (bytes)</b>	1	4	2	7	3	2
<b>BCNPayload</b>	RFU	Time	<b>CRC</b>	GwSpecific	<b>RFU</b>	<b>CRC</b>

1738 **2.13 RU864-870 MHz Band**

 1739 **2.13.1 RU864-870 Preamble Format**

1740 Please refer to Section 3.0 Physical Layer.

 1741 **2.13.2 RU864-870 Band channel frequencies**

 1742 The network channels can be freely attributed by the network operator in compliance with the  
 1743 allowed sub-bands defined by the Russian regulation. However, the two following default  
 1744 channels SHALL be implemented in every RU864-870 MHz end-device. Those channels are  
 1745 the minimum set that all network gateways SHALL be listening on.

1746

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

1747

Table 98: RU864-870 default channels

 1748 RU864-870 MHz end-devices SHALL be capable of operating in the 864 to 870 MHz  
 1749 frequency band and SHALL feature a channel data structure to store the parameters of at  
 1750 least 16 channels. A channel data structure corresponds to a frequency and a set of data rates  
 1751 usable on this frequency.

 1752 The first two channels correspond to 868.9 and 869.1 MHz / DR0 to DR5 and SHALL be  
 1753 implemented in every end-device. For devices compliant with TS001-1.0.x, those default  
 1754 channels SHALL NOT be modified through the **NewChannelReq** command. For devices  
 1755 compliant with TS001-1.1.x and beyond, these channels MAY be modified through the  
 1756 **NewChannelReq** but SHALL be reset during the backoff procedure defined in TS001-1.1.1  
 1757 to guarantee a minimal common channel set between end-devices and network gateways.

 1758 The following table gives the list of frequencies that SHALL be used by end-devices to  
 1759 broadcast the Join-Request message. The Join-Request message transmit duty-cycle SHALL  
 1760 follow the rules described in chapter "Retransmissions back-off" of the LoRaWAN®  
 1761 specification document.

1762

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

1763

Table 99: RU864-870 Join-Request Channel List

 1764 **2.13.3 RU864-870 Data Rate and End-device Output Power encoding**

 1765 There is no dwell time limitation for the RU864-870 PHY layer. The **TxParamSetupReq** MAC  
 1766 command is not implemented in RU864-870 devices.

 1767 The following encoding is used for Data Rate (DR) and End-device EIRP (TXPower) in the  
 1768 RU864-870 band:

1769

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] <sup>52</sup>	

**Table 100: RU864-870 TX Data rate table**

1770  
1771  
1772  
1773  
1774  
1775  
1776  
1777  
1778  
1779  
1780

RU864-870 end-devices SHALL support one of the 2 following data rate options:

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

For both of the 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 DR<sub>current</sub> data rate, the following table defines the next data rate (DR<sub>next</sub>) the end-device SHALL use during data rate back-off:

DR <sub>current</sub>	DR <sub>next</sub>	Comment
0	NA	Already the lowest data rate
1	0	
2	1	
3	2	
4	3	
5	4	
6	5	
7	6	

**Table 101: RU864-870 Data Rate Backoff table**

1781  
1782

EIRP<sup>53</sup> 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] <sup>52</sup>

**Table 102: RU864-870 TX power table**

1786  
1787

<sup>52</sup> DR15 and TXPower15 are defined in the LinkADRRReq MAC command of the LoRaWAN<sup>®</sup> 1.0.4 and subsequent specifications and were previously RFU

<sup>53</sup> ERP = EIRP – 2.15dB; it is referenced to a half-wave dipole antenna whose gain is expressed in dBd



1788 By default, the Max EIRP is considered to be +16dBm. If the end-device cannot achieve  
 1789 +16dBm EIRP, the Max EIRP SHOULD be communicated to the network server using an  
 1790 out-of-band channel during the end-device commissioning process.

### 1791 2.13.4 RU864-870 Join-Accept CFList

1792 The RU864-870 band LoRaWAN<sup>®</sup> implements an OPTIONAL **channel frequency list**  
 1793 (CFList) of 16 octets in the Join-Accept message.

1794 In this case the CFList is a list of five channel frequencies for the channels two to six whereby  
 1795 each frequency is encoded as a 24 bits unsigned integer (three octets). All these channels are  
 1796 usable for DR0 to DR5 125 kHz LoRa modulation. The list of frequencies is followed by a  
 1797 single CFListType octet for a total of 16 octets. The CFListType SHALL be equal to zero (0)  
 1798 to indicate that the CFList contains a list of frequencies.

1799

Size (bytes) CFList	3	3	3	3	3	1
	Freq Ch2	Freq Ch3	Freq Ch4	Freq Ch5	Freq Ch6	CFListType

1800

1801 The actual channel frequency in Hz is 100 x frequency whereby values representing  
 1802 frequencies below 100 MHz are reserved for future use. This allows setting the frequency of  
 1803 a channel anywhere between 100 MHz to 1.67 GHz in 100 Hz steps. Unused channels have  
 1804 a frequency value of 0. The **CFList** is OPTIONAL and its presence can be detected by the  
 1805 length of the join-accept message. If present, the **CFList** replaces all the previous channels  
 1806 stored in the end-device apart from the two default channels. The newly defined channels are  
 1807 immediately enabled and usable by the end-device for communication.

### 1808 2.13.5 RU864-870 LinkAdrReq command

1809 The RU864-870 LoRaWAN<sup>®</sup> only supports a maximum of 16 channels. When **ChMaskCntl**  
 1810 field is 0 the ChMask field individually enables/disables each of the 16 channels.  
 1811

ChMaskCntl	ChMask applies to
0	Channels 0 to 15
1	RFU
2	RFU
3	RFU
4	RFU
5	RFU
6	All channels ON - The device SHOULD enable all currently defined channels independently of the ChMask field value.
7	RFU

1812

**Table 103: RU864-870 ChMaskCntl value table**

1813 If the ChMaskCntl field value is one of values meaning RFU, the end-device SHALL<sup>54</sup> reject  
 1814 the command and unset the “**Channel mask ACK**” bit in its response.

### 1815 2.13.6 RU864-870 Maximum payload size

1816 The maximum **MACPayload** size length (*M*) is given by the following table. It is derived from  
 1817 limitation of the PHY layer depending on the effective modulation rate used taking into account

<sup>54</sup> Made SHALL from SHOULD starting in LoRaWAN<sup>®</sup> Regional Parameters Specification 1.0.3rA

1818 a possible repeater encapsulation layer. The maximum application payload length in the  
 1819 absence of the OPTIONAL **FOpt** control field (*M*) is also given for information only. The value  
 1820 of *N* might be smaller if the **FOpt** field is not empty:  
 1821

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	

1822 **Table 104: RU864-870 maximum payload size (repeater compatible)**

1823 If the end-device will never operate with a repeater then the maximum application payload  
 1824 length in the absence of the OPTIONAL **FOpt** control field SHOULD be:  
 1825

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	

1826 **Table 105 : RU864-870 maximum payload size (not repeater compatible)**

### 1827 2.13.7 RU864-870 Receive windows

1828 By default, the RX1 receive window uses the same channel as the preceding uplink. The data  
 1829 rate is a function of the uplink data rate and the RX1DROffset as given by the following table.  
 1830 The allowed values for RX1DROffset are in the [0:5] range. Values in the [6:7] range are  
 1831 reserved for future use.  
 1832

Upstream data rate RX1DROffset	Downstream data rate					
	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

1833 **Table 106: RU864-870 downlink RX1 data rate mapping**

1834  
 1835 The RX2 receive window uses a fixed frequency and data rate. The default parameters are  
 1836 869.1MHz / DR0 (SF12, 125 kHz)

1837 **2.13.8 RU864-870 Class B beacon and default downlink channel**

1838 The beacons SHALL be transmitted using the following settings

<b>DR</b>	3	Corresponds to SF9 spreading factor with 125 kHz BW
<b>CR</b>	1	Coding rate = 4/5
<b>Signal polarity</b>	Non-inverted	As opposed to normal downlink traffic which uses inverted signal polarity

 1839 [Table 107: RU864-870 beacon settings](#)

1840

 1841 The beacon frame content is defined in [TS001].<sup>55</sup>The beacon default broadcast frequency is  
 1842 869.1 MHz.

1843 The class B default downlink pingSlot frequency is 868.9 MHz.

 1844 **2.13.9 RU864-870 Default Settings**

1845 There are no specific default settings for the RU864-870 MHz Band.

---

<sup>55</sup> Prior to LoRaWAN 1.0.4, the beacon was defined here as:

<b>Size (bytes)</b>	2	4	2	7	2
<b>BCNPayload</b>	RFU	Time	CRC	GwSpecific	CRC

**1846 3 Repeaters**

1847 Repeaters have not yet been specified by the LoRa Alliance; however, the Regional  
1848 Parameters specification does include references to repeaters and constraints which end-  
1849 devices should follow to be compliant with them.

**1850 3.1 Repeater Compatible Maximum Payload Size**

1851 Repeaters, as referenced in this specification, were intended to fully encapsulate a  
1852 MACPayload in the ApplicationPayload of another LoRaWAN<sup>®</sup> data message. In addition to  
1853 the original MACPayload, up to 20 bytes of meta-data describing the original message were  
1854 envisioned to be included with the encapsulated data message. In order to minimize impact  
1855 on the end-device and its application, repeaters would communicate with the network  
1856 (gateways) using only data rates that supported the maximum allowed MAC Payload Size of  
1857 250 bytes. Thus, these data rates show a maximum payload size which is 20 bytes fewer  
1858 when describing “Repeater Compatible” operation.  
1859

1860

## 1861 4 Physical layer

1862 The LoRaWAN® uses a physical layer to communicate with other devices. Three physical  
1863 layers are currently supported through the LoRa™, LR-FHSS and FSK modulations.

### 1864 4.1 LoRa™ description

#### 1865 4.1.1 LoRa™ packet physical structure

1866 LoRa™ messages use the radio packet explicit header mode in which the LoRa™ physical  
1867 header (**PHDR**) plus a header CRC (**PHDR\_CRC**) are included.<sup>56</sup> In explicit header mode the  
1868 **PHDR** specifies: the payload length in bytes, the forward error correction rate, and the  
1869 presence of an OPTIONAL **CRC** for the payload. The integrity of the payload is protected by  
1870 a **CRC** for uplink messages. LoRaWAN® beacons are transmitted using LoRa™ modulation  
1871 in implicit header mode with a fixed length. In implicit header mode neither the **PHDR** nor  
1872 **PHDR\_CRC** are present.

1873 The **PHDR**, **PHDR\_CRC** and payload **CRC** fields are inserted by the radio transceiver.

1874 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)

1875

Figure 3: LoRa PHY structure

#### 1876 4.1.2 LoRa™ settings

1877 In order to be fully compliant with LoRaWAN®, an end device SHALL configure the LoRa™  
1878 physical layer as follows:

1879

Parameter	Uplink value	Downlink value
Preamble size	8 symbols	
SyncWord	0x34 (Public)	
Header type	Explicit	
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

1880

Table 108 : LoRa physical layer settings

## 1881 4.2 FSK description

### 1882 4.2.1 FSK packet physical structure

1883 FSK messages can be built either by the software stack or by the hardware transceiver,  
1884 depending on the end-device architecture.

1885 The **PHYPayload length** field contains the length in bytes of the **PHYPayload** field.

1886 The **CRC** field is computed on **PHYPayload length** and **PHYPayload** fields, using the CRC-  
1887 CCITT algorithm.

<sup>56</sup> See the LoRa radio transceiver datasheet for a description of LoRa radio packet implicit/explicit modes.

1888 PHY:

1889

Size (bytes)	5	3	1	<i>L bytes from PHYPayloadLength</i>	2
<b>Packet Structure</b>	Preamble	SyncWord	PHYPayloadLength	PHYPayload	CRC

1890

Figure 4: FSK PHY structure

 1891 **4.2.2 FSK settings**

 1892 In order to be fully compliant with LoRaWAN®, an end device SHALL configure the FSK  
 1893 physical layer as follows:

1894

Parameter	Uplink value	Downlink value
Preamble size	5 bytes	
SyncWord	0xC194C1	
Bitrate	50000 bit/sec	
Tx frequency deviation	25kHz (SSB <sup>57</sup> )	
Rx bandwidth	50kHz (SSB)	
Rx bandwidth AFC	80kHz (SSB)	
CRC presence	True (CRC-16-CCITT)	
Gaussian filter	BT = 1,0	
DC Free Encoding	Whitening Encoding	

1895

Table 109 : FSK physical layer settings

1896

 1897 To avoid a non-uniform power distribution signal with the FSK modulation, a Data Whitening  
 1898 DC-Free data mechanism is used as shown in the above table.

 1899 **4.3 LR-FHSS description**

 1900 The Long Range Frequency Hopping Spread Spectrum (LR-FHSS) modulation is only used  
 1901 on the uplink.

 1902 **4.3.1 LR-FHSS physical layer description**

1903

 1904 LR-FHSS is a fast frequency hopping spread spectrum (FHSS) modulation with bit rates  
 1905 ranging from 162bits/s to 7.8kbits/s. Only the two lowest data rates (162bits/s and 325bits/s)  
 1906 are currently implemented.

1907

 1908 When a device transmits a packet using LR-FHSS on a given channel, the packet content is  
 1909 modulated across several pseudo-random frequencies than span the interval:

1910

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

1911

 1912 For FCC 47 CFR Part 15 compliance, the end-device frequency hops across 60 physical  
 1913 channels on a 25.4kHz frequency grid.

 1914 For ETSI based countries, the end-device frequency hops across 35 or 86 physical channels  
 1915 on a 3.9kHz frequency grid.

1916 All physical channels are statistically used equally.

1917

 1918 The transmission starts on a random frequency inside the interval, and the following  
 1919 frequency hopping pattern is also randomly selected and announced in the LR-FHSS packet  
 1920 physical header. The transmission carrier frequency changes every ~50mSec

57 SSB : Single Side Bandwidth

- 1921  
 1922 The instantaneous LR-FHSS modulation bandwidth (Occupied Band Width - OBW) is  
 1923 488Hz. Therefore, a single LR-FHSS channel actually corresponds to lots of physical  
 1924 frequency channels.  
 1925  
 1926 The LR-FHSS frequency hopping bandwidth (Operating Channel Width – OCW) is region  
 1927 specific.  
 1928  
 1929 The LR-FHSS physical layer is described in the following table:  
 1930

LR-FHSS OCW	LR-FHSS OBW	Minimum separation between LR-FHSS hopping channels (grid)	Nb of physical channels usable for frequency hopping per end-device transmission	Nb of physical channels available for frequency hopping	Coding Rate	Physical bit rate
137kHz	488Hz	3.9kHz	35	280 (8x35)	1/3	162bits/s
					2/3	325bits/s
336kHz	488Hz	3.9kHz	86	688 (8x86)	1/3	162bits/s
					2/3	325bits/s
1.523MHz	488Hz	25.4kHz	60	3120 (52x60)	1/3	162bits/s
					2/3	325bits/s

1931 **Table 110 : LR-FHSS physical layer description**

1932

### 1933 4.3.2 LR-FHSS packet physical structure

1934

1935 LR-FHSS uses redundant physical headers on different frequencies to improve the  
 1936 modulation robustness to in-band interferers. The number (N) of PHY header is selectable  
 1937 on a packet per packet basis in the range 1 to 4.  
 1938

1938

1939 A LR-FHSS packet has the following structure:  
 1940

Repeated	N (1 to 4) times on different frequencies			once	
<b>Size</b>	114 bits with convolutional coding rate ½ on (PHDR + PHDR_CRC), 2bits preamble and interleaving			L Bytes (from PHDR)	2 Bytes
	4 Bytes	4 Bytes	1 Byte		
<b>Packet Structure</b>	SyncWord	PHDR	PHDR_CRC	PHYPayload	CRC

1941 **Figure 5: LR-FHSS Packet Structure**

1941

1942

1943 A LR-FHSS packet time-on-air can be computed using the following table:  
 1944

	PHY header	Payload + CRC
FEC	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* 233mSec	Ceil((L+2)/2)*102 msec (CR=1/3) ceil((L+2)/4)*102 msec (2/3)

1945 **Figure 6 : LR-FHSS time-on-air**

1945



1946 **4.3.3 LR-FHSS PHY layer settings**

1947

 1948 In order to be fully compliant with LoRaWAN<sup>®</sup>, an end device SHALL configure the LR-  
 1949 FHSS physical header as follows:

1950

Parameter	Uplink value
PHY header (SyncWord, PHDR, PHDR_CRC) repetition ( <i>N</i> )	<i>N</i> =4: NOT USED <i>N</i> =3 when CR1/3 is used by the Payload <i>N</i> =2 when CR2/3 is used by the Payload <i>N</i> =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	25.4kHz in FCC like regions 3.9kHz in other regions Defined by the DR, specified in each region
Frequency hopping Bandwidth (OCW)	137kHz, 336kHz or 1.523MHz Defined by the DR, specified in each region
Channel/hopping sequence	Randomly selected for each transmission

Table 111 : LR-FHSS physical layer settings

1951

1952

1953

 1954 **5 Revisions**

 1955 **5.1 Revision RP002-1.0.2**

- 1956 • Added a summary table of the regional parameter for all regions except for CN470.
- 1957 • “Repeater Compatible” rationale is described (Section 3) and US902-928, AU915-
- 1958 928 and CN470-520 maximum payload sizes for “repeater compatible” operation
- 1959 were amended (relaxed) for data rates which do not support encapsulation (this
- 1960 brings them into harmony with all other regions).
- 1961 • LR-FHSS data rates added to EU868, US915, AU915. Data rate backoff progression
- 1962 explicitly documented for all regions. Data rate support requirements clarified for all
- 1963 regions.
- 1964 • Align the language and descriptions of AS923 Maximum payload size section with
- 1965 that of all the other regions.
- 1966 • Added language to all regions to align with new applications of NewChannelReq
- 1967 commands as of TS001-1.1.1.
- 1968 • RU864-870 amended to indicate that 16 channels SHALL be supported. This was
- 1969 believed to have been an editorial oversight.
- 1970 • Senegal (EU868), Montserrat (AU915), Mali (EU433), Guinea (EU433), Senegal
- 1971 (EU868), Syria (EU433, EU868, AS923-3) and Vanuatu (IN865 & AS923-3) added to
- 1972 cross-reference table
- 1973 • Israel and Morocco cross-reference table entries modified
- 1974 • Added a Channel Index ID to the Channel Plan Common Name Table
- 1975 • Added AS923-1,-2,-3 to the Channel Plan Common Name Table
- 1976 • Defined CLASS\_B\_RESP\_TIMEOUT and CLASS\_C\_RESP\_TIMEOUT (used in
- 1977 TS001-1.0.4 and later)

 1978 **5.2 Revision RP002-1.0.1**

- 1979 • AS923 modified to support multiple groups of default/join channels. Each
- 1980 country/band supports a specific configuration based on an offset from the original
- 1981 AS923 default/join channels. Country summary table updated to indicate support.
- 1982 • Cuba, Indonesia, Philippines, and Viet Nam channel plan use defined.
- 1983 • Israel support for EU433 and AS923-3 were backed out as Israel MoC has
- 1984 deprecated their use for LoRaWAN® as of November 2019. A new 900MHz band is
- 1985 under discussion with the MoC.
- 1986 • Maximum Payload Size for AS923, Data Rate 2 was increased from 59 to 123 for
- 1987 UplinkDwellTime = 0 and DownlinkDwellTime = 0.
- 1988 • CN470-510 modified to reflect most recent regulatory requirements. Specifically,
- 1989 SF12 is no longer available and maximum payload sizes for several other data rates
- 1990 were modified to comply with the 1 second dwell time. Further, a 500kHz LoRa data
- 1991 rate and an FSK data rate were added.
- 1992 • For dynamic channel plan regions, clarified that it is only by default that the RX1
- 1993 frequency is the same as the uplink frequency.

 1994 **5.3 Revision RP002-1.0.0**

- 1995 • Initial RP002-1.0.0 revision, the regional parameters were extracted from the
- 1996 released LoRaWAN® v1.1 Regional Parameters
- 1997 • Added statement in Section 1 regarding non-authoritative source for regional
- 1998 regulatory information

- 1999 • Added Section 2.2 RegParamsRevision common names table
- 2000 • Added Regulatory Type Approval to quick reference table in Section 1
- 2001 • Added Section 3 (changing this section to section 4) to incorporate changes from CR
- 2002 00010.001.CR\_add\_physical\_layer\_description\_Kerlink.docx of the TC21 meeting.
- 2003 • Clarified Physical Header Explicit Mode (section 3.1)
- 2004 • Require end-devices in AS923 to accept MaxPayload size downlinks as defined for
- 2005 DownlinkDwellTime=0, regardless of its actual configuration.
- 2006 • Fixed several maxpayload tables when operating in “repeater compatible” mode, no
- 2007 MACPayload (M) may be larger than 230 bytes, regardless of dwell-time limitations
- 2008 • Updated and clarified section 3, Physical Layer
- 2009 • Normative language cleanup
- 2010 • Removed Beacon format definition and referred back to LoRaWAN® specification
- 2011 • Fixed the footnote for the US plan in section 2.5.3
- 2012 • Added notes concerning the use of ARIB STD-T108 for AS923 end-devices in
- 2013 section 2.10.2
- 2014 • Migrated the CN470-510 channel plan from the RP 1.2rA draft
- 2015 • Clarified the wording of the footnotes regarding ChMaskCntl
- 2016 • Made AS923 use consistent in section 2.10
- 2017 • Changed SHOULD to SHALL in section 2.6.2
- 2018 • Changed footnote references to 1.0.2rC to 1.0.3rA
- 2019 • Changed table reference from 1.0.2rC to 1.0.2rB
- 2020 • Changed CN779 duty cycle from 0.1% to 1% as per Regional Regulation Summary
- 2021 • Reduced number of default channels for CN779 plan to 3 to make consistent with
- 2022 other plans
- 2023 • Changed RX1DROffset tables in sections 2.10.7 and 2.12.7 to be direct lookup
- 2024 tables.
- 2025 • Clarified/fixed errors in sections 2.10.7 and 2.12.7
- 2026 • Added default parameter definitions for Class B (referenced in LW)
- 2027 • Modified as per CR ACK\_TIMEOUT / RETRANSMIT\_TIMEOUT
- 2028 • Modified suggest New Zealand channel plan from EU868 to IN865
- 2029 • Modified Bangladesh and Pakistan channel plans from EU868 to IN865
- 2030 • Modified Singapore channel plan from EU868 to “Other”
- 2031 • Updated Burma (Myanmar) channel plans from EU868 to “Other” and “Other” to
- 2032 AS923
- 2033 • Corrected typo error in channel plan for India Added and updated channel plans for
- 2034 Sri Lanka, Bhutan and Papua New Guinea,
- 2035 • Updated Middle East country suggested channel plan
- 2036 • Added channel plans for Samoa, Tonga and Vanuatu
- 2037 • Updated Bahrain and Kuwait channel plans
- 2038 • Corrected Qatar frequency range for EU868
- 2039 • Updated channel plans for UAE: 870-875.8MHz band can be used withEU868
- 2040 channel plan
- 2041 • Corrected frequency range for Lebanon from 862-870MHz to 863-87MHz
- 2042 • Updated Africa priority one country suggested channel plan
- 2043 • Added channel plans for the following African countries: Botswana, Burundi, Cabo
- 2044 Verde, Cameroon, Ghana, Ivory Coast, Kenya, Lesotho, Niger, Rwanda, Tanzania,
- 2045 Togo, Zambia, Zimbabwe
- 2046 • Corrected frequency range for Morocco from 867.6-869MHz to 868-869.65MHz
- 2047 • Updated frequency range for Tunisia (863-868MHz added)
- 2048 • Added EU433 for Nigeria and corrected frequency range from 863-870 to 868-
- 2049 870MHz

- 2050 • Added IN865 channel plan for Uganda
- 2051 • Updated Belarus and Ukraine channel plans (EU863-870 can be used)
- 2052 • Added EU433 channel plan for Costa Rica
- 2053 • Added channel plans for Suriname
- 2054 • Added or corrected bands for Albania, Denmark, Estonia, Hungary, Ireland,
- 2055 Liechtenstein, Luxembourg, Macedonia, Norway, Poland, Slovakia, Slovenia,
- 2056 Switzerland, UK: 918-921MHz changed to 915-918MHz!
- 2057 • Added channel plans for Trinidad and Tobago, Bahamas
- 2058 • Added channel plans for Aland Islands, Holy See, Monaco and San Marino
- 2059 • Fixed the AU entry in the Quick Reference Table
- 2060 • Italicized countries in the country table to highlight those whose regulations may be
- 2061 changing soon.
- 2062 • Finalized initial Regulatory Type Approval column with information based on LA
- 2063 survey of certified end device manufacturers.
- 2064 • Italicized Indonesia due to possible changes to regulatory environment there
- 2065 • Addressed inconsistencies in CN470
- 2066

2067

2068 **6 Bibliography**2069 **6.1 References**

2070

2071 [TS001] LoRaWAN<sup>®</sup> MAC Layer Specification, v1.0 through V1.1, the LoRa Alliance.

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