NOTICE OF USE AND DISCLOSURE

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RP002-1.0.3 LoRaWAN® Regional Parameters

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

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1 Introduction

This document describes the LoRaWAN® regional parameters for different regulatory regions worldwide. This document is a companion document to the various versions of the

LoRaWAN® MAC Layer Protocol Specification [TS001]. Separating the regional parameters from the protocol specification allows addition of new regions to the former without impacting the latter document.

This document combines regional parameters aspects defined in all LoRaWAN® protocol specifications, with differences arising from LoRaWAN® versions highlighted at each occurrence.

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

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

1.1 Conventions

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

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

1.2 Country Cross Reference Table

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

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

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

ISO 3166-1 Country name (Code alpha-2)	Band / channels	Channel Plan	LoRaWAN® Certified devices with Regulatory Type Approval
Afghanistan (AF)			
Aland Islands (AX)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	
Albania (AL)	433.05 - 434.79 MHz	EU433	
	863 - 873 MHz	EU863-870	
	915 - 918 MHz	AS923-3	
Algeria (DZ)	433.05 – 434.79 MHz	EU433	
	870-876 MHz		
	880-885 MHz		
	915 – 921 MHz	AS923-3	
	925 – 926 MHz		
American Samoa (AS)	902 - 928 MHz	US902-928[1]	X
Andorra (AD)	433.05 – 434.79 MHz	EU433	
	863 – 870 MHz	EU863-870	
Angola (AO)			
Anguilla (AI)	915 - 928 MHz[2]	AU915-928[3]	
Antarctica (AQ)			
Antigua and Barbuda (AG)			
Argentina (AR)	915 - 928 MHz[2]	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[1]	
Bahrain (BH)	433 – 434 MHz	EU433	
	863 - 870 MHz	EU863-870	
Bangladesh (BD)	433.05 - 434.79 MHz	EU433	
	866 - 868 MHz		

[1] AU915-928 also applies to this band
[2] Regulations imply 902-928 MHz, but only 915-928 MHz is available
[3] AS923-1 also applies to this band

	922 - 925.0 MHz	AS923-1	
Barbados (BB)	902 - 928 MHz	AU915-928[4]	
Belarus (BY)	433.05 - 434.79 MHz	EU433	
	864.4 - 868.6 MHz	EU863-870	
	869-869.2 MHz	EU863-870	
	869.4 – 869.65 MHz	EU863-870	
	869.7 – 870 MHz	EU863-870	
Belgium (BE)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	X
Belize (BZ)	902 - 928 MHz	AU915-928[4]	
Benin (BJ)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	
Bermuda (BM)	902 - 928 MHz	US902-928[1]	
Bhutan (BT)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	
Bolivia (BO)	915 - 930 MHz	AU915-928[3]	
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	

[4] US902-928 also applies to this band

Cameroon (CM)	433.05 – 434.79 MHz	EU433	
Canada (CA)	902 - 928 MHz	US902-928[1]	X
Central African Republic (CF)			
Chad (TD)			
Chile (CL)	433 – 434.79 MHz	EU433	
	915 - 928MHz[2]	AU915-928[3]	
China (CN)	920.5 - 924.5 MHz		
	779 - 787 MHz[5]	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	
	863 - 870 MHz	EU863-870	X

[5] 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.

Denmark (DK)	433.05 - 434.79 MHz	EU433	
	863 - 873 MHz	EU863-870	X
	915 - 918 MHz	AS923-3	
Djibouti (DJ)			
Dominica (DM)	902 - 928 MHz	AU915-928[4]	
Dominican Republic (DO)	915 - 928 MHz	AU915-928	
Ecuador (EC)	902 - 928 MHz	AU915-928[3] [4]	
Egypt (EG)	433.05 - 434.79 MHz	EU433	
	865 – 868 MHz	IN865-867	
	863 - 870 MHz	EU863-870	
El Salvador (SV)	915 – 928 MHz	AU915-928[3]	
Equatorial Guinea (GQ)	433.05 - 434.79 MHz	EU433	
	868 - 870 MHz	EU863-870	
Eritrea (ER)			
Estonia (EE)	433.05 - 434.79 MHz	EU433	
	863 - 873 MHz	EU863-870	X
	915 - 918 MHz	AS923-3	
Eswatini (SZ)			
Ethiopia (ET)			
Falkland Islands (FK)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	
Faroe Islands (FO)	433.05 - 434.79 MHz	EU433	
	863 - 873 MHz	EU863-870	
Fiji (FJ)			
Finland (FI)	433.05 - 434.79 MHz	EU433	
	863 - 873 MHz	EU863-870	X
France (FR)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	X
French Guiana (GF)	433.05 - 434.79 MHz	EU433	
	863 - 873 MHz	EU863-870	X
French Polynesia (PF)	433.05 - 434.79 MHz	EU433	
	863 - 873 MHz	EU863-870	X
French Southern Territories (TF)	433.05 - 434.79 MHz	EU433	
	863 - 873 MHz	EU863-870	X
Gabon (GA)			
Gambia (GM)	433.05 - 434.79 MHz	EU433	
Georgia (GE)	433.05 - 434.79 MHz	EU433	
	863 - 873 MHz	EU863-870	
Germany (DE)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	X
Ghana (GH)	430 - 435 MHz	EU433	
	830 - 850 MHz		
Gibraltar (GI)	433.05 - 434.79 MHz	EU433	

	863 - 873 MHz	EU863-870	X
Greece (GR)	433.05 - 434.79 MHz	EU433	
	868 - 870 MHz	EU863-870	X
Greenland (GL)	433.05 - 434.79 MHz	EU433	
	863 - 873 MHz	EU863-870	X
	915 - 918 MHz	AS923-3	
Grenada (GD)	902 - 928 MHz	AU915-928[4]	
Guadeloupe (GP)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	X
Guam (GU)	902 - 928 MHz	US902-928[1]	X
Guatemala (GT)	915 – 928 MHz[2]	AU915-928[3]	
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)	917 - 920 MHz	AS923-4	
Italy (IT)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	X
Jamaica (JM)	915 - 928 MHz[2]	AU915-928	
Japan (JP)	920.6 - 928.0 MHz (steps of 200 kHz & 600 kHz)	AS923-1	X
Jersey (JE)	433.05 - 434.79 MHz	EU433	
	863 - 873 MHz	EU863-870	
	915 – 918 MHz	AS923-3	
Jordan (JO)	433.05 – 434.79 MHz	EU433	
	865 - 868 MHz	IN865-867	
	915 – 921 MHz	AS923-3	
Kazakhstan (KZ)	433.05 - 434.79 MHz	EU433	
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	
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[1]	
Micronesia (FM)			
Moldova (MD)	433.05 - 434.79 MHz	EU433	
	862 - 873 MHz	EU863-870	
	915 - 918 MHz	AS923-3	
Monaco (MC)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	
Mongolia (MN)	216 – 217 MHz		
	312 – 316 MHz		
	1427 – 1432 MHz		
Montenegro (ME)	433.05 – 434.79 MHz	EU433	
	863 – 870 MHz	EU863-870	
Montserrat (MS)	902 - 928 MHz	AU915-928[4]	
Morocco (MA)	433.05 - 434.79 MHz	EU433	
	869 – 870 MHz		
Mozambique (MZ)			
Myanmar (MM)	433 - 435 MHz	EU433	
	866 - 869 MHz		
	919 - 924 MHz	AS923-1	
Namibia (NA)	433.05 – 434.79 MHz	EU433	
	868 – 870 MHz	EU863-870	

Nauru (NR)			
Nepal (NP)			
Netherlands (NL)	433.05 – 434.79 MHz	EU433	
	863 – 870 MHz	EU863-870	X
New Caledonia (NC)	433.05 – 434.79 MHz	EU433	
	863 – 870 MHz	EU863-870	X
New-Zealand (NZ)	915 - 928 MHz	AS923-1 AU915-928	
	819 - 824 MHz		
	864 868 MHz	IN865-867	
	433.05 - 434.79 MHz	EU433	
Nicaragua (NI)	915 - 928 MHz[2]	AU915-928	
Niger (NE)	865 – 865.6 MHz	IN865-867	
	865.6 – 867.6 MHz	IN865-867	
	867.6 – 868 MHz	IN865-867	
Nigeria (NG)	433.05 - 434.79 MHz	EU433	
	868 - 870 MHz	EU863-870	
Niue (NU)	433.05 - 434.79 MHz	EU433	
	819 - 824 MHz		
	864 - 868 MHz	IN865-867	
	915 - 928 MHz	AS923-1 AU915-928	
Norfolk Island (NF)	915 - 928 MHz	AS923-1 AU915-928	
Northern Mariana Islands (MP)	902 – 928 MHz	US902-928[1]	X
Norway (NO)	433.05 - 434.79 MHz	EU433	
	863 - 873 MHz	EU863-870	
	915 - 918 MHz	AS923-3	
Oman (OM)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	
Pakistan (PK)	433.05 - 434.79 MHz	EU433	
	865 - 869 MHz	IN865-867	
	920 - 925 MHz	AS923-1	
Palau (PW)			
Palestine (PS)			
Panama (PA)	902 - 928 MHz	AU915-928[3] [4]	
Papua New Guinea (PG)	433.05 - 434.79 MHz	EU433	
	915 – 928 MHz	AU915-928 AS923-1	
Paraguay (PY)	433.05 - 434.79 MHz	EU433	
	915 - 928 MHz	AU915-928[3]	
Peru (PE)	915 - 928 MHz	AU915-928[3]	
Philippines (PH)	915 – 918 MHz	AS923-3	

	868 – 869.2 MHz	EU863-870	
	869.7 – 870 MHz	EU863-870	
	433.05 – 434.79 MHz	EU433	
Pitcairn (PN)			
Poland (PL)	433.05 - 434.79 MHz	EU433	
	863 - 873 MHz	EU863-870	X
	915 - 918 MHz	AS923-3	
Portugal (PT)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	X
Puerto Rico (PR)	902 – 928 MHz	US902-928[1]	X
Qatar (QA)	433.05 – 434.79 MHz	EU433	
	863 – 870 MHz	EU863-870	
	915 – 921 MHz	AS923-3	
Reunion (RE)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	X
Romania (RO)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	X
Russian Federation (RU)	866 - 868 MHz	RU864-870	
	864 - 865 MHz	RU864-870	
	868.7 - 869.2 MHz	RU864-870	
	433.075 - 434.75 MHz	EU433	
	916 - 921 MHz (Licensed)	AS923-3	
Rwanda (RW)	433.05 - 434.79 MHz	EU433	
	868 - 870 MHz	EU863-870	
Saint Barthelemy (BL)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	X
Saint Helena, Ascension and Tristan da Cunha (SH)			
Saint Kitts and Nevis (KN)	902 – 928 MHz	AU915-928[4]	
Saint Lucia (LC)	902 – 928 MHz	AU915-928[4]	
Saint Martin (MF)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	X
Saint Pierre and Miquelon (PM)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	X
Saint Vincent and the Grenadines (VC)	902 – 928 MHz	AU915-928[4]	
Samoa (WS)	433.05 - 434.79 MHz	EU433	
	868 - 870 MHz	EU863-870	
San Marino (SM)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	
Sao Tome and Principe (ST)			
Saudi Arabia (SA)	863 – 875.8 MHz	EU863-870	
	433.05 - 434.79 MHz	EU433	
	915 – 921 MHz	AS923-3	

Senegal (SN)	868 – 870 MHz	EU863-870	
Serbia (RS)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	
Seychelles (SC)	433.05 - 434.79 MHz	EU433	
Sierra Leone (SL)			
Singapore (SG)	920 - 925 MHz	AS923-1	
	433.05 - 434.79 MHz	EU433	
	866 - 869 MHz		
Sint Maarten (SX)			
Slovakia (SK)	433.05 - 434.79 MHz	EU433	
	863 - 873 MHz	EU863-870	X
	915 - 918 MHz	AS923-3	
Slovenia (SI)	433.05 - 434.79 MHz	EU433	
	863 - 873 MHz	EU863-870	X
	915 - 918 MHz	AS923-3	
Solomon Islands (SB)	918 - 926 MHz	AS923-1	
Somalia (SO)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	
	915 - 918 MHz	AS923-3	
South Africa (ZA)	433.05 - 434.79 MHz	EU433	
	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[2]	AU915-928[3]	
Svalbard and Jan Mayen (SJ)	433.05 - 434.79 MHz	EU433	
	863 - 873 MHz	EU863-870	
	915 - 918 MHz	AS923-3	
Sweden (SE)	433.05 - 434.79 MHz	EU433	
	868 - 870 MHz	EU863-870	X
Switzerland (CH)	433.05 - 434.79 MHz	EU433	
	863 - 873 MHz	EU863-870	X
	915 – 918 MHz	AS923-3	
Syrian Arab Republic (SY)	433.05 – 434.79 MHz	EU433	

	863 – 870 MHz	EU863-870	
	870 – 876 MHz	EU863-870	
	915 – 921 MHz	AS923-3	
Taiwan, Province of China (TW)	920 - 925 MHz	AS923-1	X
Tajikistan (TJ)			
Tanzania (TZ)	433.05 - 434.79 MHz	EU433	
	866 - 869 MHz		
	920 - 925 MHz	AS923-1	
Thailand (TH)	433.05 – 434.79 MHz	EU433	
	920 – 925 MHz	AS923-1	X
Timor-Leste (TL)			
Togo (TG)	433.05 - 434.79 MHz	EU433	
Tokelau (TK)	433.05 - 434.79 MHz	EU433	
	819 - 824 MHz		
	864 - 868 MHz	IN865-867	
	915 - 928 MHz	AS923-1 AU915-928	
Tonga (TO)	433.05 – 434.79 MHz	EU433	
	915 – 928 MHz	AU915-928[3]	
Trinidad and Tobago (TT)	902 – 928 MHz	AU915-928	
Tunisia (TN)	433.05 - 434.79 MHz	EU433	
	863 - 868 MHz	EU863-870	
	868 – 868.6 MHz	EU863-870	
	868.7 – 869.2 MHz	EU863-870	
	869.4 – 869.65 MHz	EU863-870	
	869.7 – 870 MHz	EU863-870	
Turkey (TR)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	
Turkmenistan (TM)			
Turks and Caicos Islands (TC)	915 – 928 MHz[2]	AU915-928[3]	
Tuvalu (TV)			
Uganda (UG)	433.05 - 434.79 MHz	EU433	
	863 - 865 MHz	IN865-867	
	865 - 867.6 MHz	IN865-867	
	869.25 - 869.7 MHz		
	923 - 925 MHz	AS923-1	
Ukraine (UA)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	
United Arab Emirates (AE)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	
	870 - 875.8 MHz	EU863-870	
	915 - 921 MHz	AS923-3	
	433.05 - 434.79 MHz	EU433	

United Kingdom of Great Britain and Northern Ireland (GB)	863 - 873 MHz	EU863-870	X
	915 - 918 MHz	AS923-3	
United States Minor Outlying Islands (UM)	902 - 928 MHz	US902-928[1]	X
United States of America (US)	902 - 928 MHz	US902-928[1]	X
Uruguay (UY)	915 - 928 MHz[2]	AU915-928[3]	
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[6]	AS923-2	
	920 - 922.5 MHz[7]	AS923-2	
Virgin Islands, UK (VG)	915 - 928 MHz[2]	AU915-928[3]	
Virgin Islands, US (VI)	902 - 928 MHz	US902-928[1]	X
Wallis and Futuna (WF)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	X
Western Sahara (EH)			
Yemen (YE)			
Zambia (ZM)	433.05 - 434.79 MHz	EU433	
	868 - 870 MHz	EU863-870	
Zimbabwe (ZW)	433.05 - 434.79 MHz	EU433	

Table 1: Channel Plan per ISO 3166-1 Country

[6] Band LIKELY available through 2021 – regulations in flux
[7] Newly proposed band which LIKELY becomes available in 2021 – regulations in flux

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.

1.3.1 Dynamic Channel Plan Regions

Plan	***EU868***	***CN779***	***EU433***	***IN865***	***KR920***	***AS923-1***	***AS923-2***	***AS923-3***	***AS923-4***	***RU864***
Default Freq band	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	917 to 920 MHz	864 to 870 MHz
Mandatory Channel Freq (Join Req)	868.10 MHz 868.30 MHz 868.50 MHz	779.5 MHz 779.7 MHz 779.9 MHz	433.175 MHz 433.375 MHz 433.575 MHz	865.0625 MHz 865.4025 MHz 865.985 MHz	922.10 MHz 922.30 MHz 922.50 MHz	923.20 MHz 923.40 MHz	921.4 MHz 921.6 MHz	916.6 MHz 916.8 MHz	917.3 MHz 917.5 MHz	868.9 MHz 869.1 MHz
JoinReq DataRate [MinDR:MaxDR]	[0:5]	[0:5]	[0:5]	[0:5]	[0:5]	[2:5]	[2:5]	[2:5]	[2:5]	[0:5]
CFList Type Supported	0	0	0	0	0	0	0	0	0	0
Mandatory Data Rate [MinDR:MaxDR]	[0:5]	[0:5]	[0:5]	[0:5]	[0:5]	[0:5]	[0:5]	[0:5]	[0:5]	[0:5]
Optional Data Rate [MinDR:MaxDR]	[6:7] | [6:11]	[6:7]	[6:7]	[7]		[6:7]	[6:7]	[6:7]	[6:7]	[6:7]
Number of channels	16	16	16	16	16	16	16	16	16	16
ChMaskCtrl - ChMask	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	0 -> Channels 0-15 6 -> All channels on
Default channels	[0:2]	[0:2]	[0:2]	[0:2]	[0:2]	[0:1]	[0:1]	[0:1]	[0:1]	[0:1]
Default RX1DRoffset	0	0	0	0	0	0	0	0	0	0
Allowed RX1DRoffset	[0:5]	[0:5]	[0:5]	[0:7]	[0:5]	[0:7]	[0:7]	[0:7]	[0:7]	[0:5]
Duty Cycle	< 1%	< 1%	< 10%		LBT	< 1%	< 1%	< 1%	< 1%	< 1%
Dwell time limitation	No	No	No	No	No	Yes (400ms)	Yes (400ms)	Yes (400ms)	Yes (400ms)	No
TxParamSetupReq support	No	No	No	No	No	Yes	Yes	Yes	Yes	No
Max EIRP (default) - TXPower 0	+16 dBm	+12 dBm	+12dBm	+30 dBm	+14 dBm	+16 dBm	+16 dBm	+16 dBm	+16 dBm	+16 dBm
Default RX2DataRate	DR0	DR0	DR0	DR2	DR0	DR2	DR2	DR2	DR2	DR0
Default RX2 Frequency	869.525 MHz	786.0 MHz	434.665 MHz	866.550 MHz	921.90 MHz	923.2 MHz	921.4 MHz	916.6 MHz	917.3 MHz	869.1 MHz
Class B default Beacon Freq	869.525 MHz	785.0 MHz	434.665 MHz	866.550 MHz	923.1 MHz	923.4 MHz	921.6 MHz	916.8 MHz	917.5 MHz	869.1 MHz
Class B default downlink pingSlot Freq	869.525 MHz	785.0 MHz	434.665 MHz	866.550 MHz	923.1 MHz	923.4 MHz	921.6 MHz	916.8 MHz	917.5 MHz	868.9 MHz

Table 2 - Dynamic Channel Plans Summary

1.3.2 Fixed Channel Plan Regions

Plan	***US915***	***AU915***
Default Freq band	902 to 928 MHz	915 to 928 MHz
Mandatory Channel Freq (Join Req)	upstream: 64 (902.3 to 914.9 [+ by 0.2]) + 8 (903.0 to 914.2 [+ by 1.6]) downstream: 8 (923.3 to 927.5 [+ by 0.6])	upstream: 64 (915.2 to 927.8 [+ by 0.2]) + 8 (915.9 to 927.1 [+ by 1.6]) downstream: 8 (923.3 to 927.5 [+ by 0.6])
JoinReq DataRate [MinDR:MaxDR]	64 (125 kHz channels) using DR0 and 8 (500 kHz channels) using DR4	64 (125 kHz channels) using DR2 and 8 (500 kHz channels) using DR6
CFList Type Supported	1	1
Mandatory Data Rate [MinDR:MaxDR]	[0:4],[8:13]	[0:6],[8:13]
Optional Data Rate [MinDR:MaxDR]	[5:6]	[7]
Number of channels	upstream: 64 (125 kHz) + 8 (500 kHz) downstream: 8 (500 kHz)	upstream: 64 (125 kHz) + 8 (500 kHz) downstream: 8 (500 kHz)
ChMaskCtrl - ChMask	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
Default channels	[0:71]	[0:71]
Default RX1DRoffset	0	0
Allowed RX1DRoffset	[0:3]	[0:5]
Duty Cycle	No Limit	No Limit
Dwell time limitation	[0:63] 400ms [64:71] No	[0:63] 400ms (regional dependence) [64:71] No
TxParamSetupReq support	No	Yes
Max EIRP (default) - TXPower 0	+30 dBm	+30 dBm
Default RX2DataRate	DR8	DR8
Default RX2 Frequency	923.3 MHz	923.3 MHz
Class B default Beacon Freq	Hops across all 8 downlink channels	Hops across all 8 downlink channels
Class B default downlink pingSlot Freq	Follows beacon channel	Follows beacon channel

Table 3 - Fixed Channel Plans Summary

2 LoRaWAN® Regional Parameters

2.1 Regional Parameter Channel Plan Common Names

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

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

Table 4 Regional Parameter Common Names

2.2 Regional Parameter Revision Names

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

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
RP002-1.0.3	Supports both LoRaWAN® 1.0.x and 1.1.x

Table 5 Regional Parameter Revision Names

2.3 Default Settings

The following parameters are RECOMMENDED values for all regions.

RECEIVE_DELAY1	1s
RECEIVE_DELAY2	2s (SHALL be RECEIVE_DELAY1 + 1s)
RX1DROffset	0 (table index)

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

JOIN_ACCEPT_DELAY1	5s
JOIN_ACCEPT_DELAY2	6s
MAX_FCNT_GAP[9]	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 (2^7 = 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[10]
CLASS_C_RESP_TIMEOUT	8s[11]

If the actual parameter values implemented in the end-device are different from those default values (for example the end-device uses a longer JOIN_ACCEPT_DELAY1 and JOIN_ACCEPT_DELAY2 latency), those parameters SHALL be communicated to the network server using an out-of-band channel during the end-device commissioning process. The network server may not accept parameters different from those default values.

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

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

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

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

2.4 EU863-870 MHz Band

2.4.1 EU863-870 Preamble Format

Please refer to Section 3.0 Physical Layer.

2.4.2 EU863-870 Band Channel Frequencies

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

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

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%

Table 6: EU863-870 default channels

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

EU868 end-devices SHALL be capable of operating in the 863 to 870 MHz frequency band and SHALL feature a channel data structure to store the parameters of at least 16 channels. A channel data structure corresponds to a frequency and a set of data rates usable on this frequency.

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

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

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

Table 7: EU863-870 Join-Request Channel List

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

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

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

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

Table 8: EU863-870 TX DataRate table

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

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

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

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

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

Table 9: EU863-870 Data Rate Backoff table

12 Long Range Frequency Hopping Spread Spectrum, see Section 4.3

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

EIRP[14] 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

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

2.4.4 EU863-870 Join-Accept CFList

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

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

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

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

2.4.5 EU863-870 LinkAdrReq command

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

ChMaskCntl	ChMask applies to
0	Channels 0 to 15

[14] *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

Table 11: EU863-870 ChMaskCntl value table

If the ChMaskCntl field value is one of values meaning RFU, the end-device SHALL[15] reject the command and unset the "**Channel mask ACK**" bit in its response.

2.4.6 EU863-870 Maximum payload size

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

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

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

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

Data Rate	M	N
0	59	51
1	59	51
2	59	51
3	123	115
4	250	242
5	250	242
6	250	242
7	250	242
8	58	50
9	123	115
10	58	50

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

11	123	115
12:15	Not defined	

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

2.4.7 EU863-870 Receive windows

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

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

Table 14: EU863-870 downlink RX1 data rate mapping

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

2.4.8 EU863-870 Class B beacon and default downlink channel

The beacons SHALL be transmitted using the following settings

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

Table 15: EU863-870 beacon settings

The beacon frame content is defined in [TS001].[16]

The beacon default broadcast frequency is 869.525 MHz.

The Class B default downlink pingSlot frequency is 869.525 MHz.

2.4.9 EU863-870 Default Settings

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

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

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

2.5 US902-928 MHz ISM Band

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

2.5.1 US902-928 Preamble Format

Please refer to Section 3.0 Physical Layer.

2.5.2 US902-928 Band Channel Frequencies

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

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

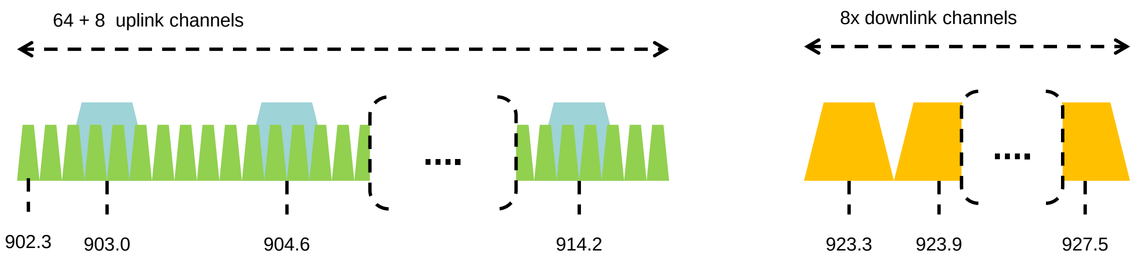

Figure 1: US902-928 channel frequencies

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

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

> Devices 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.

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

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

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

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

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

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

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

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

Data Rate	Configuration	Indicative physical bit rate [bit/sec]
0	LoRa: SF10 / 125 kHz	980
1	LoRa: SF9 / 125 kHz	1760
2	LoRa: SF8 / 125 kHz	3125
3	LoRa: SF7 / 125 kHz	5470
4	LoRa: SF8 / 500 kHz	12500
5	LR-FHSS CR1/3: 1.523 MHz BW	162
6	LR-FHSS CR2/3: 1.523 MHz BW	325
7	RFU	
8	LoRa: SF12 / 500 kHz	980
9	LoRa: SF11 / 500 kHz	1760
10	LoRa: SF10 / 500 kHz	3900
11	LoRa: SF9 / 500 kHz	7000
12	LoRa: SF8 / 500 kHz	12500
13	LoRa: SF7 / 500 kHz	21900

14	RFU	
15	Defined in [TS001][17]	

Table 16: US902-928 TX DataRate table

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

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

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

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 DRcurrent data rate, the following table defines the next data rate (DRnext) the end-device SHALL use during data rate back-off:

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

Table 17: US902-928 Data Rate Backoff table

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

Table 18: US902-928 TX power table

2.5.4 US902-928 Join-Accept CFList

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

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

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

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

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

Size (bytes)	[2]	[2]	[2]	[2]	[2]	[2]	[3]	[1]
CFList	*ChMask0*	*ChMask1*	*ChMask2*	*ChMask3*	*ChMask4*	*RFU*	*RFU*	*CFListType*

2.5.5 US902-928 LinkAdrReq command

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

ChMaskCntl	ChMask applies to
0	Channels 0 to 15
1	Channels 16 to 31
2	Channels 32 to 47
3	Channels 48 to 63
4	Channels 64 to 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

Table 19: US902-928 ChMaskCntl value table

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

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

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

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

2.5.6 US902-928 Maximum payload size

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

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

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

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

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

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

2.5.7 US902-928 Receive windows

- The RX1 receive channel is a function of the upstream channel used to initiate the data exchange. The RX1 receive channel can be determined as follows.
    - RX1 Channel Number = Transmit Channel Number modulo 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.

Default parameters are 923.3 MHz / DR8

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

Table 22: US902-928 downlink RX1 data rate mapping[20]

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

2.5.8 US902-928 Class B beacon[21]

The beacons SHALL be transmitted using the following settings:

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

Table 23: US902-928 beacon settings

The downstream channel used for a given beacon is:

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

- 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 *floor(x)* designates rounding to the integer immediately inferior or equal to x

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

Beacon channel number	Frequency [MHz]
0	923.3
1	923.9
2	924.5
3	925.1
4	925.7
5	926.3
6	926.9

[20] *Re-defined in the LoRaWAN® 1.0.1 specification to eliminate RX1DROffset values beyond DR4*
[21] *Class B beacon operation was first defined in the LoRaWAN® 1.0.3 specification*

7	927.5

Table 24: US902-928 Beacon Channels

The beacon frame content is defined in [TS001].[22]

The default Class B PING_SLOT_CHANNEL is defined in the LoRaWAN® specification.

2.5.9 US902-928 Default Settings

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

[22] *Prior to LoRaWAN® 1.0.4, the beacon was defined here as:*

Size (bytes)	**5**	4	2	7	**3**	2
BCNPayload	**RFU**	Time	CRC	GwSpecific	**RFU**	CRC

2.6 CN779-787 MHz Band[23]

2.6.1 CN779-787 Preamble Format

Please refer to Section 3.0 Physical Layer.

2.6.2 CN779-787 Band Channel Frequencies

> 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.

The LoRaWAN® can be used in the Chinese 779-787 MHz band as long as the radio device EIRP is less than 12 dBm.

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

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

- Minimum frequency: 779.5 MHz
- Maximum frequency: 786.5 MHz

CN780 end-devices SHALL be capable of operating in the 779 to 787 MHz frequency band and SHALL feature a channel data structure to store the parameters of at least 16 channels. A channel data structure corresponds to a frequency and a set of data rates usable on this frequency.

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

The following table gives the list of frequencies that SHALL be used by end-devices to broadcast the Join-Request message The Join-Request message transmit duty-cycle SHALL follow the rules described in chapter "Retransmissions back-off" of the LoRaWAN® specification document. Those channels are the minimum set that all network gateways SHALL be listening on.

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%

Table 25: CN779-787 Join-Request Channel List

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

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

[23] *Defined in the LoRaWAN® 1.0.1 specification*

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

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

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

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

CN779-787 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 DRcurrent data rate, the following table defines the next data rate (DRnext) the end-device SHALL use during data rate back-off:

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

Table 27: CN779-787 Data Rate Backoff 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, Max EIRP is considered to be +12 dBm. If the end-device cannot achieve 12 dBm EIRP, the Max EIRP SHOULD be communicated to the network server using an out-of-band channel during the end-device commissioning process.

2.6.4 CN779-787 Join-Accept CFList

The CN780 band LoRaWAN® implements an OPTIONAL **channel frequency list** (CFlist) of 16 octets in the Join-Accept message.

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

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

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

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

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

2.6.5 CN779-787 LinkAdrReq command

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

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 independently of the ChMask field value.
7	RFU

Table 28: CN779-787 ChMaskCntl value table

If the ChMask field value is one of values meaning RFU, then end-device SHALL[25] reject the command and unset the "**Channel mask ACK**" bit in its response.

2.6.6 CN779-787 Maximum payload size

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

Data Rate	M	N
0	59	51
1	59	51
2	59	51

[25] Made SHALL from SHOULD starting in LoRaWAN® 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)

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

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

Table 30 : CN779-787 maximum payload size (not repeater compatible)

2.6.7 CN779-787 Receive windows

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

Upstream data rate	Downstream data rate					
RX1DROffset	0	1	2	3	4	5
DR0	DR0	DR0	DR0	DR0	DR0	DR0
DR1	DR1	DR0	DR0	DR0	DR0	DR0
DR2	DR2	DR1	DR0	DR0	DR0	DR0
DR3	DR3	DR2	DR1	DR0	DR0	DR0
DR4	DR4	DR3	DR2	DR1	DR0	DR0
DR5	DR5	DR4	DR3	DR2	DR1	DR0
DR6	DR6	DR5	DR4	DR3	DR2	DR1
DR7	DR7	DR6	DR5	DR4	DR3	DR2

Table 31: CN779-787 downlink RX1 data rate mapping

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

2.6.8 CN779-787 Class B beacon and default downlink channel

The beacons SHALL be transmitted using the following settings:

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

Table 32: CN779-787 beacon settings

The beacon frame content is defined in [TS001].[26] The beacon default broadcast frequency is 785 MHz.

The class B default downlink pingSlot frequency is 785 MHz

2.6.9 CN779-787 Default Settings

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

[26] *Prior to LoRaWAN® 1.0.4, the beacon was defined here as:*

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

2.7 EU433 MHz ISM Band

2.7.1 EU433 Preamble Format

Please refer to Section 3.0 Physical Layer.

2.7.2 EU433 ISM Band Channel Frequencies

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

The end-device transmit duty-cycle SHALL be lower than 10%.[27]

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

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

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

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

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

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%

Table 33: EU433 Join-Request Channel List

2.7.3 EU433 Data Rate and End-device Output Power encoding

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

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

[27] *Defined in the LoRaWAN® Regional Parameters 1.0.2 specification*

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][28]	

TXPower	Configuration (EIRP)
0	Max EIRP
1	Max EIRP – 2dB
2	Max EIRP – 4dB
3	Max EIRP – 6dB
4	Max EIRP – 8dB
5	Max EIRP – 10dB
6..14	RFU
15	Defined in [TS001][28]

Table 34: EU433 Data rate and TX power table

EU433 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 DRcurrent data rate, the following table defines the next data rate (DRnext) the end-device SHALL use during data rate back-off:

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

Table 35: EU433 Data Rate Backoff 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 +12 dBm. If the end-device cannot achieve 12 dBm EIRP, the Max EIRP SHALL be communicated to the network server using an out-of-band channel during the end-device commissioning process.

2.7.4 EU433 Join-Accept CFList

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

In this case the CFList is a list of five channel frequencies for the channels three to seven whereby each frequency is encoded as a 24 bits unsigned integer (three octets). All these

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

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

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

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

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

2.7.5 EU433 LinkAdrReq command

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

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

Table 36: EU433 ChMaskCntl value table

If the ChMask field value is one of the values meaning RFU, then end-device SHALL[29] reject the command and unset the "**Channel mask ACK**" bit in its response.

2.7.6 EU433 Maximum payload size

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

Data Rate	M	N
0	59	51
1	59	51
2	59	51
3	123	115
4	230	222
5	230	222
6	230	222

[29] 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)

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

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

Table 38 : EU433 maximum payload size (not repeater compatible)

2.7.7 EU433 Receive windows

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

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

Table 39 : EU433 downlink RX1 data rate mapping

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

2.7.8 EU433 Class B beacon and default downlink channel

The beacons SHALL be transmitted using the following settings

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

Table 40 : EU433 beacon settings

The beacon frame content is defined in [TS001].[30]

The beacon default broadcast frequency is 434.665 MHz.

The class B default downlink pingSlot frequency is 434.665 MHz

2.7.9 EU433 Default Settings

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

[30] *Prior to LoRaWAN® 1.0.4, the beacon was defined here as:*

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

2.8 AU915-928 MHz Band[31]

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

2.8.1 AU915-928 Preamble Format

Please refer to Section 3.0 Physical Layer.

2.8.2 AU915-928 Band Channel Frequencies

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

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

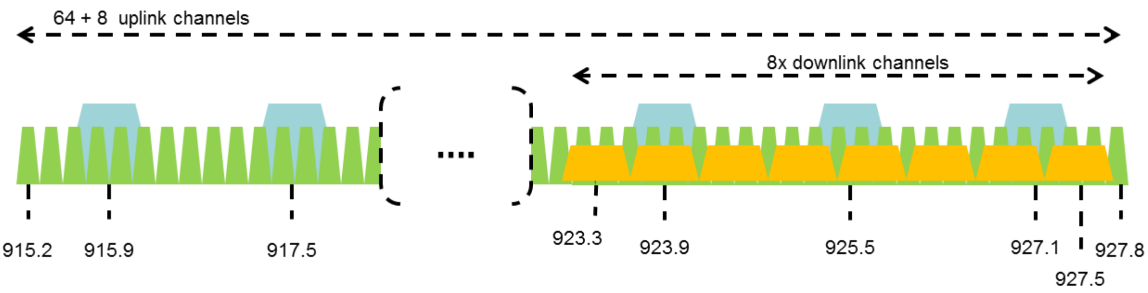

Figure 2: AU915-928 channel frequencies

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

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

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

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

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

[31] *Defined in the LoRaWAN® 1.0.1 specification*

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

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

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

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

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

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

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

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

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

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

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

13	LoRa: SF7 / 500 kHz	21900
14	RFU	
15	Defined in [TS001][32]	

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 DRcurrent data rate, the following table defines the next data rate (DRnext) the end-device SHALL use during data rate back-off:

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

Table 42: AU915-928 Data Rate Backoff table

TXPower	Configuration (EIRP)
0	Max EIRP
1:14	Max EIRP – 2*TXPower
15	Defined in [TS001][32]

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® 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

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

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

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

2.8.5 AU915-928 LinkAdrReq command

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

ChMaskCntl	ChMask applies to
0	Channels 0 to 15
1	Channels 16 to 31
..	..
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

Table 44: AU915-928 ChMaskCntl value table

If **ChMaskCntl** = 5[33] then the corresponding bits in the ChMask enable and disable a bank of 8 125 kHz channels and the corresponding 500 kHz channel defined by the following calculation: [ChannelMaskBit * 8, ChannelMaskBit * 8 +7],64+ChannelMaskBit.

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

2.8.6 AU915-928 Maximum payload size

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

Data Rate	UplinkDwellTime=0		UplinkDwellTime=1	
	M	N	M	N
0	59	51	N/A	N/A
1	59	51	N/A	N/A
2	59	51	19	11
3	123	115	61	53
4	230	222	133	125
5	230	222	230	222
6	230	222	230	222
7	58	50	58	50

[33] Added in LoRaWAN® 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)

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

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

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

Table 46: AU915-928 Maximum repeater payload size

2.8.7 AU915-928 Receive windows

- The RX1 receive channel is a function of the upstream channel used to initiate the data exchange. The RX1 receive channel can be determined as follows.
    - RX1 Channel Number = Transmit Channel Number modulo 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. Default parameters are 923.3 MHz / DR8

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

Table 47 : AU915-928 downlink RX1 data rate mapping

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

2.8.8 AU915-928 Class B beacon

The beacons are transmitted using the following settings:

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

Table 48 : AU915-928 beacon settings

The downstream channel used for a given beacon is:

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

- 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 *floor(x)* designates rounding to the integer immediately inferior or equal to x

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

Beacon channel 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

The beacon frame content is defined in [TS001].[34]

The default Class B PING_SLOT_CHANNEL is defined in the LoRaWAN® specification.

2.8.9 AU915-928 Default Settings

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

[34] *Prior to LoRaWAN® 1.0.4, the beacon was defined here as:*

Size (bytes)	**3**	4	2	7	**1**	2
BCNPayload	**RFU**	Time	CRC	GwSpecific	**RFU**	CRC

2.9 CN470-510 MHz Band[35]

> Note: The CN470-510 channel plan has been significantly changed from prior revisions and should be considered experimental pending published documents confirming plan compliant devices have been granted local regulatory approval.

2.9.1 CN470-510 Preamble Format

Please refer to Section 3.0 Physical Layer.

2.9.2 CN470-510 Band Channel Frequencies

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

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

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

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

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

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

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

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

[35] 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

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[36] in the above table.

2.9.2.1 Channel Plan for 20 MHz Antenna

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

For channel plan Type A:

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

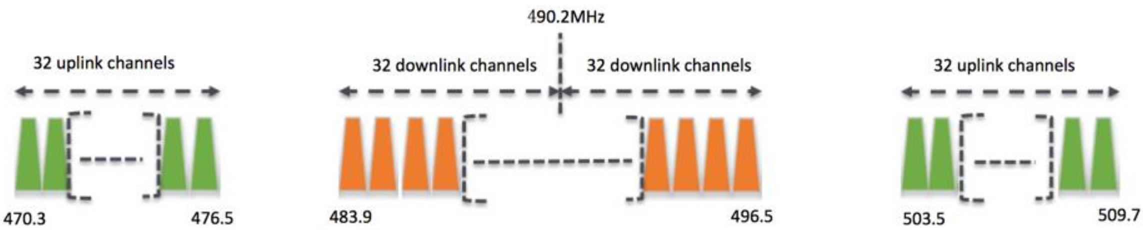

Table 50: channel plan type A for 20MHz antenna channel frequencies

For channel plan Type B:

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

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

incrementing linearly by 200 kHz to 503.1 MHz.

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

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

2.9.2.2 Channel Plan for 26 MHz antenna

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

For channel plan Type A:

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

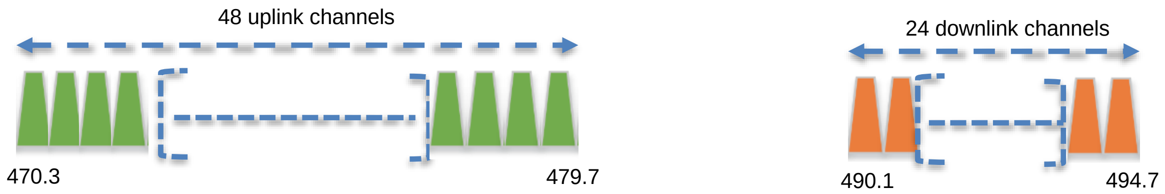

Table 52: channel plan type A for 26MHz antenna channel frequencies

For channel plan Type B:

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

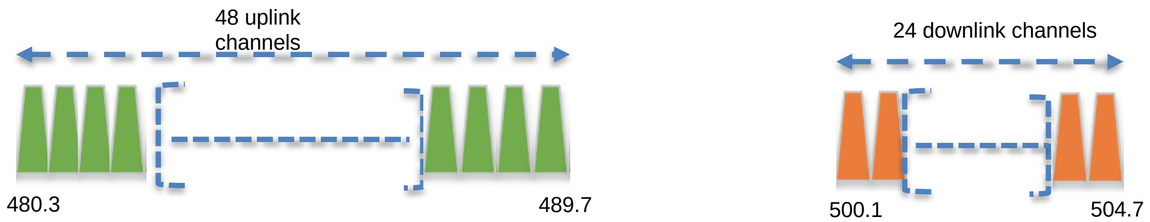

Table 53: channel plan type B for 26MHz antenna channel frequencies

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

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

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

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

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

Data Rate	Configuration	Indicative physical bit rate [bit/sec]
0[37]	LoRa: SF12/ 125 kHz	250
1	LoRa: SF11 / 125 kHz	440
2	LoRa: SF10 / 125 kHz	980
3	LoRa: SF9 / 125 kHz	1760
4	LoRa: SF8 / 125 kHz	3125
5	LoRa:SF7 / 125 kHz	5470
6	LoRa:SF7 / 500 kHz	21900
7	FSK: 50 Kbps	50000
8:14	RFU	
15	Defined in [TS001][38]	

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][38]

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

CN470-510 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 DRcurrent data rate, the following table defines the next data rate (DRnext) the end-device SHALL use during data rate back-off:

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

Table 55: CN470-510 Data Rate Backoff table

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

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

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

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

2.9.4 CN470-510 Join-Accept CFList

The CN470 LoRaWAN® supports the use of the OPTIONAL CFlist appended to the Join-Accept message. If the CFlist is not empty, 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 zero (0) and increments for each ChMask field to a value of four (3) for 20 MHz plans A or B and three (2) for 26 MHz plans A or B. (The first 16 bits controls the channels 0 to 15...)

For 20 MHz Antenna Systems:

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

For 26 MHz Antenna Systems:

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

2.9.5 CN470-510 LinkAdrReq command

2.9.5.1 Channel Plan for 20 MHz antenna

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

ChMaskCntl	ChMask applies to
0	Channels 0 to 15
1	Channels 16 to 31
2	Channels 32 to 47
3	Channels 48 to 63
4	RFU
5	RFU
6	All Channels Enabled
7	All Channels Disabled[39]

Table 56:CH470 ChMaskCntl value table for 20M Antenna

[39] *This command must be followed by another LinkADRReq command enabling at least one channel.*

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

2.9.5.2 Channel Plan for 26 MHz antenna

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

ChMaskCntl	ChMask applies to
0	Channels 0 to 15
1	Channels 16 to 31
2	Channels 32 to 47
3	All channels Enabled
4	All channels Disabled[40]
5	RFU
6	RFU
7	RFU

Table 57: CH470 ChMaskCntl value table for 26M Antenna

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

2.9.6 CN470-510 Maximum payload size

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

Data Rate	M	N
0[37]	N/A	N/A
1	31	23
2	94	86
3	192	184
4	230	222
5	230	222
6	230	222
7	230	222
8:15	Not defined	

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

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

Data Rate	M	N
0[37]	N/A	N/A
1	31	23
2	94	86
3	192	184
4	250	242

[40] *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)

2.9.7 CN470-510 Receive windows

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

Upstream data rate	Downstream data rate					
RX1DROffset	**0**	**1**	**2**	**3**	**4**	**5**
DR0[37]	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

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

2.9.7.1 Channel Plan for 20 MHz Antenna Systems

For channel plan Type A:

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

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

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

For channel plan Type B:

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

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

9	498.3 MHz

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

2.9.7.2 Channel Plan for 26 MHz Antenna Systems

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

2.9.8 CN470-510 Class B beacon

The beacon frame content is defined in [TS001].[41]
The beacons are transmitted using the following settings:

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

Table 63 : CN470-510 beacon settings

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

By default, for channel plan Type A:

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

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

[41] *Prior to LoRaWAN® 1.0.4, the beacon was defined here as:*

Size (bytes)	**3**	4	2	7	**1**	2
BCNPayload	**RFU**	Time	CRC	GwSpecific	**RFU**	CRC

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

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

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 20 MHz antenna

- 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 *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	$\left[\mathrm{DevAddr} + floor\left(\frac{beacon\_time}{beacon\_period}\right)\right]\ modulo\ 32$
9	$32 + \left[\mathrm{DevAddr} + floor\left(\frac{beacon\_time}{beacon\_period}\right)\right]\ modulo\ 32$

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

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

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

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

2.9.9 CN470-510 Default Settings

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

2.10 AS923 MHz Band

2.10.1 AS923 Preamble Format

Please refer to Section 3.0 Physical Layer.

2.10.2 AS923 Band Channel Frequencies

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

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

The corresponding frequency offset in Hz is:

AS923_FREQ_OFFSET_HZ = 100 x **AS923_FREQ_OFFSET**.

AS923_FREQ_OFFSET only applies to end-device default settings. **AS923_FREQ_OFFSET** does not apply any frequencies delivered to end-device from network server through MAC commands or the CFList.

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

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

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

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

Table 68: AS923 default channels

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

AS923 end-devices SHOULD use the following default parameters

- Default EIRP: 16 dBm

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

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

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

Table 69: AS923 Join-Request Channel List

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

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

2.10.3 AS923 Data Rate and End-point Output Power encoding

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

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

Data Rate	Configuration	Indicative physical bit rate [bit/s]
0	LoRa: SF12 / 125 kHz	250
1	LoRa: SF11 / 125 kHz	440
2	LoRa: SF10 / 125 kHz	980
3	LoRa: SF9 / 125 kHz	1760
4	LoRa: SF8 / 125 kHz	3125
5	LoRa: SF7 / 125 kHz	5470
6	LoRa: SF7 / 250 kHz	11000
7	FSK: 50 kbps	50000
8..14	RFU	
15	Defined in [TS001][42]	

Table 70: AS923 Data rate table

AS923 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 DRcurrent data rate, the following table defines the next data rate (DRnext) the end-device SHALL use during data rate back-off:

UplinkDwellTime=0		UplinkDwellTime=1	
DRcurrent	**DRnext**	**DRcurrent**	**DRnext**
0	NA	NA	NA
1	0	NA	NA

[42] *DR15 and TXPower15 are defined in the LinkADRReq 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

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

TXPower	Configuration (EIRP)
0	Max EIRP
1	Max EIRP – 2dB
2	Max EIRP – 4dB
3	Max EIRP – 6dB
4	Max EIRP – 8dB
5	Max EIRP – 10dB
6	Max EIRP – 12dB
7	Max EIRP – 14dB
8..14	RFU
15	Defined in [TS001][42]

Table 72: AS923 TXPower 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 SHALL be 16 dBm.The Max EIRP can be modified by the network server through the ***TxParamSetupReq*** MAC command and SHOULD be used by both the end-device and the network server once ***TxParamSetupReq*** is acknowledged by the device via ***TxParamSetupAns***,

2.10.4 AS923 Join-Accept CFList

The AS923 LoRaWAN® implements an OPTIONAL channel frequency list (CFlist) of 16 octets in the Join-Accept message.

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

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

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

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

2.10.5 AS923 LinkAdrReq command

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

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 73: AS923 ChMaskCntl value table

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

2.10.6 AS923 Maximum payload size

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

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

Table 74: AS923 maximum payload size (repeater compatible)

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

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

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

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

2.10.7 AS923 Receive windows

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

Values in the [6:7] range allow setting the Downstream RX1 data rate higher than upstream data rate[43].

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

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

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

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

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

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

Table 77: AS923 downlink RX1 data rate mapping for DownLinkDwellTime =1

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

2.10.8 AS923 Class B beacon and default downlink channel

The beacons SHALL be transmitted using the following settings

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

Table 78 : AS923 beacon settings

The beacon frame content is defined in [TS001].[44]

The beacon default broadcast frequency is 923.4 MHz + **AS923_FREQ_OFFSET_HZ**.

The class B default downlink pingSlot frequency is 923.4 MHz + **AS923_FREQ_OFFSET_HZ.**

2.10.9 AS923 Default Settings

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

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

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

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

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

[44] *Prior to LoRaWAN® 1.0.4, the beacon was defined here as:*

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

<u>Group AS923-3</u>: AS923_FREQ_OFFSET default value = 0xFFFEFE30, AS923_FREQ_OFFSET_HZ = -6.60 MHz

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

<u>Group AS923-4</u>: AS923_FREQ_OFFSET default value = 0xFFFF1988, AS923_FREQ_OFFSET_HZ = -5.90 MHz

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

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

2.11 KR920-923 MHz Band

2.11.1 KR920-923 Preamble Format

Please refer to Section 3.0 Physical Layer.

2.11.2 KR920-923 Band Channel Frequencies

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

Center frequency (MHz)	Bandwidth (kHz)	Maximum EIRP output power (dBm)	
		For end-device	For gateway
920.9	125	10	23
921.1	125	10	23
921.3	125	10	23
921.5	125	10	23
921.7	125	10	23
921.9	125	10	23
922.1	125	14	23
922.3	125	14	23
922.5	125	14	23
922.7	125	14	23
922.9	125	14	23
923.1	125	14	23
923.3	125	14	23

Table 79: KR920-923 Center frequency, bandwidth, maximum EIRP output power table

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

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

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

Table 80: KR920-923 default channels

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

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

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

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

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

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

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

Table 81: KR920-923 Join-Request Channel List

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

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

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

Data Rate	Configuration	Indicative physical bit rate [bit/s]
0	LoRa: SF12 / 125 kHz	250
1	LoRa: SF11 / 125 kHz	440
2	LoRa: SF10 / 125 kHz	980
3	LoRa: SF9 / 125 kHz	1760
4	LoRa: SF8 / 125 kHz	3125
5	LoRa: SF7 / 125 kHz	5470
6..14	RFU	
15	Defined in [TS001][45]	

Table 82: KR920-923 TX Data rate table

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

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

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

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

[45] *DR15 and TXPower15 are defined in the LinkADRReq 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 83: KR920-923 Data Rate Backoff table

TXPower	Configuration (EIRP)
0	Max EIRP
1	Max EIRP – 2dB
2	Max EIRP – 4dB
3	Max EIRP – 6dB
4	Max EIRP – 8dB
5	Max EIRP – 10dB
6	Max EIRP – 12dB
7	Max EIRP – 14dB
8..14	RFU
15	Defined in [TS001][45]

Table 84: KR920-923 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 +14 dBm. If the end-device cannot achieve 14 dBm EIRP, the Max EIRP SHOULD be communicated to the network server using an out-of-band channel during the end-device commissioning process.

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

2.11.4 KR920-923 Join-Accept CFList

The KR920-923 band LoRaWAN® implements an OPTIONAL **channel frequency list** (CFlist) of 16 octets in the Join-Accept message.

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

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

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

2.11.5 KR920-923 LinkAdrReq command

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

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 85: KR920-923 ChMaskCntl value table

If the ChMaskCntl field value is one of values meaning RFU, the end-device SHALL[46] reject the command and unset the "**Channel mask ACK**" bit in its response.

2.11.6 KR920-923 Maximum payload size

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

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

Table 86: KR920-923 maximum payload size (repeater compatible)

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

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

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

6:15	Not defined

Table 87 : KR920-923 maximum payload size (not repeater compatible)

2.11.7 KR920-923 Receive windows

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

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

Table 88 : KR920-923 downlink RX1 data rate mapping

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

2.11.8 KR920-923 Class B beacon and default downlink channel

The beacons SHALL be transmitted using the following settings

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

Table 89 : KR920-923 beacon settings

The beacon frame content is defined in [TS001].[47]

The beacon default broadcast frequency is 923.1 MHz.

The class B default downlink pingSlot frequency is 923.1 MHz

2.11.9 KR920-923 Default Settings

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

[47] *Prior to LoRaWAN 1.0.4, the beacon was defined here as:*

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

2.12 IN865-867 MHz Band

2.12.1 IN865-867 Preamble Format

Please refer to Section 3.0 Physical Layer.

2.12.2 IN865-867 Band Channel Frequencies

This section applies to the Indian sub-continent.

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

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

Table 90: IN865-867 default channels

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

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

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

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

Table 91: IN865-867 Join-Request Channel List

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

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

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

Data Rate	Configuration	Indicative physical bit rate [bit/s]

0	LoRa: SF12 / 125 kHz	250
1	LoRa: SF11 / 125 kHz	440
2	LoRa: SF10 / 125 kHz	980
3	LoRa: SF9 / 125 kHz	1760
4	LoRa: SF8 / 125 kHz	3125
5	LoRa: SF7 / 125 kHz	5470
6	RFU	RFU
7	FSK: 50 kbps	50000
8..14	RFU	
15	Defined in [TS001][48]	

Table 92: IN865-867 TX Data rate table

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 DRcurrent data rate, the following table defines the next data rate (DRnext) the end-device SHALL use during data rate back-off:

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

Table 93: IN865-867 DataRate Backoff table

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][48]

Table 94: IN865-867 TXPower table

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

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

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

2.12.4 IN865-867 Join-Accept CFList

The India 865-867 band LoRaWAN® implements an OPTIONAL **channel frequency list** (CFlist) of 16 octets in the Join-Accept message.

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

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

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

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

2.12.5 IN865-867 LinkAdrReq command

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

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 95: IN865-867 ChMaskCntl value table

If the ChMaskCntl field value is one of values meaning RFU, the end-device SHALL[49] reject the command and unset the "**Channel mask ACK**" bit in its response.

[49] Made SHALL from SHOULD starting in LoRaWAN® Regional Parameters Specification 1.0.3rA

2.12.6 IN865-867 Maximum payload size

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

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

Table 96: IN865-867 maximum payload size (repeater compatible)

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

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

Table 97 : IN865-867 maximum payload size (not repeater compatible)

2.12.7 IN865-867 Receive windows

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

Values in the [6:7] range allow setting the Downstream RX1 data rate higher than upstream data rate[50].

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

Upstream data rate	Downstream data rate							
RX1DROffset	0	1	2	3	4	5	6	7
DR0	DR0	DR0	DR0	DR0	DR0	DR0	DR1	DR2
DR1	DR1	DR0	DR0	DR0	DR0	DR0	DR2	DR3
DR2	DR2	DR1	DR0	DR0	DR0	DR0	DR3	DR4
DR3	DR3	DR2	DR1	DR0	DR0	DR0	DR4	DR5
DR4	DR4	DR3	DR2	DR1	DR0	DR0	DR5	DR5
DR5	DR5	DR4	DR3	DR2	DR1	DR0	DR5	DR7
DR7	DR7	DR5	DR5	DR4	DR3	DR2	DR7	DR7

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

Table 98: IN865-867 downlink RX1 data rate mapping

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

2.12.8 IN865-867 Class B beacon and default downlink channel

The beacons are transmitted using the following settings

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

The beacon frame content is defined in [TS001].[51]

The beacon default broadcast frequency is 866.550 MHz.

The class B default downlink pingSlot frequency is 866.550 MHz

2.12.9 IN865-867 Default Settings

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

[51] *Prior to LoRaWAN® 1.0.4, the beacon was defined here as:*

Size (bytes)	1	4	**2**	7	**3**	**2**
BCNPayload	RFU	Time	**CRC**	GwSpecific	**RFU**	**CRC**

2.13 RU864-870 MHz Band

2.13.1 RU864-870 Preamble Format

Please refer to Section 3.0 Physical Layer.

2.13.2 RU864-870 Band Channel Frequencies

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

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%

Table 99: RU864-870 default channels

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

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

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

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

Table 100: RU864-870 Join-Request Channel List

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

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

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

Data Rate	Configuration	Indicative physical bit rate [bit/s]
0	LoRa: SF12 / 125 kHz	250
1	LoRa: SF11 / 125 kHz	440

2	LoRa: SF10 / 125 kHz	980
3	LoRa: SF9 / 125 kHz	1760
4	LoRa: SF8 / 125 kHz	3125
5	LoRa: SF7 / 125 kHz	5470
6	LoRa: SF7 / 250 kHz	11000
7	FSK: 50 kbps	50000
8..14	RFU	
15	Defined in [TS001][52]	

Table 101: RU864-870 TX Data rate table

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 DRcurrent data rate, the following table defines the next data rate (DRnext) the end-device SHALL use during data rate back-off:

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

Table 102: RU864-870 Data Rate Backoff table

EIRP[53] 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][52]

Table 103: RU864-870 TX power table

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

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

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

2.13.4 RU864-870 Join-Accept CFList

The RU864-870 band LoRaWAN® implements an OPTIONAL **channel frequency list** (CFlist) of 16 octets in the Join-Accept message.

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

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

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

2.13.5 RU864-870 LinkAdrReq command

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

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 104: RU864-870 ChMaskCntl value table

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

2.13.6 RU864-870 Maximum payload size

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

[54] Made SHALL from SHOULD starting in LoRaWAN® Regional Parameters Specification 1.0.3rA

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

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

Table 105: RU864-870 maximum payload size (repeater compatible)

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

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

Table 106 : RU864-870 maximum payload size (not repeater compatible)

2.13.7 RU864-870 Receive windows

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

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

Table 107: RU864-870 downlink RX1 data rate mapping

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

2.13.8 RU864-870 Class B beacon and default downlink channel

The beacons SHALL be transmitted using the following settings

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

Table 108: RU864-870 beacon settings

The beacon frame content is defined in [TS001].[55]The beacon default broadcast frequency is 869.1 MHz.

The class B default downlink pingSlot frequency is 868.9 MHz.

2.13.9 RU864-870 Default Settings

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

[55] *Prior to LoRaWAN 1.0.4, the beacon was defined here as:*

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

3 Repeaters

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

3.1 Repeater Compatible Maximum Payload Size

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

4 Physical layer

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

4.1 LoRa™ description

4.1.1 LoRa™ packet physical structure

LoRa™ messages use the radio packet explicit header mode in which the LoRa™ physical header (**PHDR**) plus a header CRC (**PHDR_CRC**) are included.[56] In explicit header mode the **PHDR** specifies: the payload length in bytes, the forward error correction rate, and the presence of an OPTIONAL **CRC** for the payload. The integrity of the payload is protected by a **CRC** for uplink messages. LoRaWAN® beacons are transmitted using LoRa™ modulation in implicit header mode with a fixed length. In implicit header mode neither the **PHDR** nor **PHDR_CRC** are present.

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

PHY:

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

Figure 3: LoRa PHY structure

4.1.2 LoRa™ settings

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

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

Table 109 : LoRa physical layer settings

4.2 FSK description

4.2.1 FSK packet physical structure

FSK messages can be built either by the software stack or by the hardware transceiver, depending on the end-device architecture.
The ***PHYPayload length*** field contains the length in bytes of the ***PHYPayload*** field.
The ***CRC*** field is computed on ***PHYPayload length*** and ***PHYPayload*** fields, using the CRC-CCITT algorithm.

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

PHY:

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

Figure 4: FSK PHY structure

4.2.2 FSK settings

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

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

Table 110 : FSK physical layer settings

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

4.3 LR-FHSS description

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

4.3.1 LR-FHSS physical layer description

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

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

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

For FCC 47 CFR Part 15 compliance, the end-device frequency hops across 60 physical channels on a 25.4 kHz frequency grid.
For ETSI based countries, the end-device frequency hops across 35 or 86 physical channels on a 3.9 kHz frequency grid.
All physical channels are statistically used equally.

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

[57] SSB : Single Side Bandwidth

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

The LR-FHSS frequency hopping bandwidth is region specific.

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

LR-FHSS Frequency Hopping BW (all hops)	**LR-FHSS** BW of a single hop	**Minimum separation between LR-FHSS hopping channels (grid)**	**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**
137 kHz	488 Hz	3.9 kHz	35	280 (8x35)	1/3	162bits/s
					2/3	325bits/s
336 kHz	488 Hz	3.9 kHz	86	688 (8x86)	1/3	162bits/s
					2/3	325bits/s
1.523 MHz	488 Hz	25.4 kHz	60	3120 (52x60)	1/3	162bits/s
					2/3	325bits/s

Table 111 : LR-FHSS physical layer description

4.3.2 LR-FHSS packet physical structure

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

A LR-FHSS packet has the following structure:

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

Figure 5: LR-FHSS Packet Structure

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

	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* 233.472 mSec	Ceil((L+3)/2)*102.4 msec (CR=1/3) ceil((L+3)/4)*102.4 msec (2/3)

Figure 6 : LR-FHSS time-on-air

4.3.3 LR-FHSS PHY layer settings

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

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

Table 112 : LR-FHSS physical layer settings

5 Revisions

5.1 Revision RP002-1.0.3

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

5.2 Revision RP002-1.0.2

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

5.3 Revision RP002-1.0.1

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

5.4 Revision RP002-1.0.0

- Initial RP002-1.0.0 revision, the regional parameters were extracted from the released LoRaWAN® v1.1 Regional Parameters
- Added statement in Section 1 regarding non-authoritative source for regional regulatory information
- Added Section 2.2 RegParamsRevision common names table
- Added Regulatory Type Approval to quick reference table in Section 1
- Added Section 3 (changing this section to section 4) to incorporate changes from CR 00010.001.CR_add_physical_layer_description_Kerlink.docx of the TC21 meeting.
- Clarified Physical Header Explicit Mode (section 3.1)
- Require end-devices in AS923 to accept MaxPayload size downlinks as defined for DownlinkDwellTime=0, regardless of its actual configuration.
- Fixed several maxpayload tables when operating in “repeater compatible” mode, no MACPayload (M) may be larger than 230 bytes, regardless of dwell-time limitations
- Updated and clarified section 3, Physical Layer
- Normative language cleanup
- Removed Beacon format definition and referred back to LoRaWAN® specification
- Fixed the footnote for the US plan in section 2.5.3
- Added notes concerning the use of ARIB STD-T108 for AS923 end-devices in section 2.10.2
- Migrated the CN470-510 channel plan from the RP 1.2rA draft
- Clarified the wording of the footnotes regarding ChMaskCntl
- Made AS923 use consistent in section 2.10
- Changed SHOULD to SHALL in section 2.6.2
- Changed footnote references to 1.0.2rC to 1.0.3rA
- Changed table reference from 1.0.2rC to 1.0.2rB
- Changed CN779 duty cycle from 0.1% to 1% as per Regional Regulation Summary
- Reduced number of default channels for CN779 plan to 3 to make consistent with other plans
- Changed RX1DROffset tables in sections 2.10.7 and 2.12.7 to be direct lookup tables.
- Clarified/fixed errors in sections 2.10.7 and 2.12.7
- Added default parameter definitions for Class B (referenced in LW)
- Modified as per CR ACK_TIMEOUT / RETRANSMIT_TIMEOUT
- Modified suggest New Zealand channel plan from EU868 to IN865
- Modified Bangladesh and Pakistan channel plans from EU868 to IN865
- Modified Singapore channel plan from EU868 to “Other”
- Updated Burma (Myanmar) channel plans from EU868 to “Other” and “Other” to AS923
- Corrected typo error in channel plan for India Added and updated channel plans for Sri Lanka, Bhutan and Papua New Guinea,
- Updated Middle East country suggested channel plan
- Added channel plans for Samoa, Tonga and Vanuatu
- Updated Bahrain and Kuwait channel plans
- Corrected Qatar frequency range for EU868
- Updated channel plans for UAE: 870-875.8 MHz band can be used withEU868 channel plan
- Corrected frequency range for Lebanon from 862-870 MHz to 863-87 MHz
- Updated Africa priority one country suggested channel plan

- Added channel plans for the following African countries: Botswana, Burundi, Cabo Verde, Cameroon, Ghana, Ivory Coast, Kenya, Lesotho, Niger, Rwanda, Tanzania, Togo, Zambia, Zimbabwe
- Corrected frequency range for Morocco from 867.6-869MHz to 868-869.65MHz
- Updated frequency range for Tunisia (863-868MHz added)
- Added EU433 for Nigeria and corrected frequency range from 863-870 to 868-870MHz
- Added IN865 channel plan for Uganda
- Updated Belarus and Ukraine channel plans (EU863-870 can be used)
- Added EU433 channel plan for Costa Rica
- Added channel plans for Suriname
- Added or corrected bands for Albania, Denmark, Estonia, Hungary, Ireland, Liechtenstein, Luxembourg, Macedonia, Norway, Poland, Slovakia, Slovenia, Switzerland, UK: 918-921MHz changed to 915-918MHz!
- Added channel plans for Trinidad and Tobago, Bahamas
- Added channel plans for Aland Islands, Holy See, Monaco and San Marino
- Fixed the AU entry in the Quick Reference Table
- Italicized countries in the country table to highlight those whose regulations may be changing soon.
- Finalized initial Regulatory Type Approval column with information based on LA survey of certified end device manufacturers.
- Italicized Indonesia due to possible changes to regulatory environment there
- Addressed inconsistencies in CN470

6 Bibliography

6.1 References

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

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