

1 **RP002-1.0.3 LoRaWAN® Regional Parameters**  
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## RP002-1.0.3 LoRaWAN® Regional Parameters

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

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324

## 325 **1 Introduction**

326

327 This document describes the LoRaWAN<sup>®</sup> regional parameters for different regulatory regions  
 328 worldwide. This document is a companion document to the various versions of the

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

332  
333 This document combines regional parameters aspects defined in all LoRaWAN<sup>®</sup> protocol  
334 specifications, with differences arising from LoRaWAN<sup>®</sup> versions highlighted at each  
335 occurrence.

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

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

## 347 **1.1 Conventions**

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

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

## 356 **1.2 Country Cross Reference Table**

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

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

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

364  
365



| ISO 3166-1 Country name<br>(Code alpha-2) | Band / channels            | Channel Plan           | LoRaWAN <sup>®</sup><br>Certified<br>devices with<br>Regulatory<br>Type<br>Approval |
|---|----------------------------|------------------------|---|
| Afghanistan (AF)                          |                            |                        |   |
| Aland Islands (AX)                        | 433.05 - 434.79 MHz        | EU433                  |   |
|   | 863 - 870 MHz              | EU863-870              |   |
| Albania (AL)                              | 433.05 - 434.79 MHz        | EU433                  |   |
|   | 863 - 873 MHz              | EU863-870              |   |
|   | 915 - 918 MHz              | AS923-3                |   |
| <i>Algeria (DZ)</i>                       | 433.05 – 434.79 MHz        | EU433                  |   |
|   | 870-876 MHz                |                        |   |
|   | 880-885 MHz                |                        |   |
|   | 915 – 921 MHz              | AS923-3                |   |
|   | 925 – 926 MHz              |                        |   |
| American Samoa (AS)                       | 902 - 928 MHz              | US902-928 <sup>1</sup> | X   |
| Andorra (AD)                              | 433.05 – 434.79 MHz        | EU433                  |   |
|   | 863 – 870 MHz              | EU863-870              |   |
| Angola (AO)                               |                            |                        |   |
| Anguilla (AI)                             | 915 - 928 MHz <sup>2</sup> | AU915-928 <sup>3</sup> |   |
| Antarctica (AQ)                           |                            |                        |   |
| Antigua and Barbuda (AG)                  |                            |                        |   |
| Argentina (AR)                            | 915 - 928 MHz <sup>2</sup> | AU915-928              |   |
| Armenia (AM)                              | 863 – 870 MHz              | EU863-870              |   |
|   | 433.05 – 434.79 MHz        | EU433                  |   |
| Aruba (AW)                                |                            |                        |   |
| Australia (AU)                            | 915 - 928 MHz              | AS923-1                | X   |
|   |                            | AU915-928              | X   |
| Austria (AT)                              | 433.05 - 434.79 MHz        | EU433                  |   |
|   | 863 - 870 MHz              | EU863-870              | X   |
| Azerbaijan (AZ)                           | 433.05 – 434.79 MHz        | EU433                  |   |
|   | 868 – 868.6 MHz            |                        |   |
|   | 868.7 – 869.2 MHz          |                        |   |
| Bahamas (BS)                              | 902 – 928 MHz              | US902-928 <sup>1</sup> |   |
| <i>Bahrain (BH)</i>                       | 433 – 434 MHz              | EU433                  |   |
|   | 863 - 870 MHz              | EU863-870              |   |
| Bangladesh (BD)                           | 433.05 - 434.79 MHz        | EU433                  |   |
|   | 866 - 868 MHz              |                        |   |

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

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

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

|                                       |                     |                        |   |
|---------------------------------------|---------------------|------------------------|---|
|                                       | 922 - 925.0 MHz     | AS923-1                |   |
| Barbados (BB)                         | 902 - 928 MHz       | AU915-928 <sup>4</sup> |   |
| Belarus (BY)                          | 433.05 - 434.79 MHz | EU433                  |   |
|                                       | 864.4 - 868.6 MHz   | EU863-870              |   |
|                                       | 869-869.2 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 <sup>4</sup> |   |
| Benin (BJ)                            | 433.05 - 434.79 MHz | EU433                  |   |
|                                       | 863 - 870 MHz       | EU863-870              |   |
| Bermuda (BM)                          | 902 - 928 MHz       | US902-928 <sup>1</sup> |   |
| Bhutan (BT)                           | 433.05 - 434.79 MHz | EU433                  |   |
|                                       | 863 - 870 MHz       | EU863-870              |   |
| Bolivia (BO)                          | 915 - 930 MHz       | AU915-928 <sup>3</sup> |   |
| Bonaire, Sint Eustatius and Saba (BQ) | 433.05 - 434.79 MHz | EU433                  |   |
|                                       | 863 - 870 MHz       | EU863-870              |   |
| Bosnia and Herzegovina (BA)           | 433.05 - 434.79 MHz | EU433                  |   |
|                                       | 863 - 870 MHz       | EU863-870              |   |
| Botswana (BW)                         | 433.05 – 434.79 MHz | EU433                  |   |
|                                       | 862 – 870 MHz       | EU863-870              |   |
| Bouvet Island (BV)                    | 433.05 - 434.79 MHz | EU433                  |   |
|                                       | 863 - 870 MHz       | EU863-870              |   |
|                                       | 915 - 918 MHz       | AS923-3                |   |
| Brazil (BR)                           | 902 - 907.5 MHz     |                        |   |
|                                       | 915 - 928 MHz       | AU915-928              |   |
|                                       | 433 - 435 MHz       | EU433                  |   |
| British Indian Ocean Territory (IO)   |                     |                        |   |
| Brunei Darussalam (BN)                | 866 - 870 MHz       | EU863-870              |   |
|                                       | 920 - 925 MHz       | AS923-1                |   |
|                                       | 433 - 435 MHz       | EU433                  |   |
| Bulgaria (BG)                         | 433.05 - 434.79 MHz | EU433                  |   |
|                                       | 863 - 870 MHz       | EU863-870              | X |
| Burundi (BI)                          | 433.05 - 434.79 MHz | EU433                  |   |
|                                       | 868 - 870 MHz       | EU863-870              |   |
| Burkina Faso (BF)                     |                     |                        |   |
| Cabo Verde (CV)                       | 433.05 - 434.79 MHz | EU433                  |   |
|                                       | 863 - 870 MHz       | EU863-870              |   |
| Cambodia (KH)                         | 866 - 869 MHz       | EU863-870              |   |
|                                       | 923 - 925 MHz       | AS923-1                |   |

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

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

<sup>5</sup> CN779-787 devices may not be produced, imported or installed after 2021-01-01; deployed devices may continue to operate through their normal end-of-life.

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

|  |                            |                        |   |
|--|----------------------------|------------------------|---|
|  | 863 - 873 MHz              | EU863-870              | X |
| Greece (GR)                            | 433.05 - 434.79 MHz        | EU433                  |   |
|  | 868 - 870 MHz              | EU863-870              | X |
| Greenland (GL)                         | 433.05 - 434.79 MHz        | EU433                  |   |
|  | 863 - 873 MHz              | EU863-870              | X |
|  | 915 - 918 MHz              | AS923-3                |   |
| Grenada (GD)                           | 902 - 928 MHz              | AU915-928 <sup>4</sup> |   |
| Guadeloupe (GP)                        | 433.05 - 434.79 MHz        | EU433                  |   |
|  | 863 - 870 MHz              | EU863-870              | X |
| Guam (GU)                              | 902 - 928 MHz              | US902-928 <sup>1</sup> | X |
| Guatemala (GT)                         | 915 - 928 MHz <sup>2</sup> | AU915-928 <sup>3</sup> |   |
| Guernsey (GG)                          | 433.05 - 434.79 MHz        | EU433                  |   |
|  | 863 - 873 MHz              | EU863-870              |   |
|  | 915 - 918 MHz              | AS923-3                |   |
| Guinea (GN)                            | 433.05 - 434.79 MHz        | EU433                  |   |
| Guinea-Bissau (GW)                     |                            |                        |   |
| Guyana (GY)                            |                            |                        |   |
| Haiti (HT)                             |                            |                        |   |
| Heard Island and McDonald Islands (HM) | 915 - 928 MHz              | AU915-928<br>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 <sup>2</sup>                        | AU915-928 |   |
| Japan (JP)                                  | 920.6 - 928.0 MHz<br>(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   |   |
| <i>Jordan (JO)</i>                          | 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 |
| <i>Kuwait (KW)</i>                          | 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 <sup>1</sup> |   |
| Micronesia (FM)       |                     |                        |   |
| Moldova (MD)          | 433.05 - 434.79 MHz | EU433                  |   |
|                       | 862 - 873 MHz       | EU863-870              |   |
|                       | 915 - 918 MHz       | AS923-3                |   |
| Monaco (MC)           | 433.05 - 434.79 MHz | EU433                  |   |
|                       | 863 - 870 MHz       | EU863-870              |   |
| Mongolia (MN)         | 216 – 217 MHz       |                        |   |
|                       | 312 – 316 MHz       |                        |   |
|                       | 1427 – 1432 MHz     |                        |   |
| Montenegro (ME)       | 433.05 – 434.79 MHz | EU433                  |   |
|                       | 863 – 870 MHz       | EU863-870              |   |
| Montserrat (MS)       | 902 - 928 MHz       | AU915-928 <sup>4</sup> |   |
| Morocco (MA)          | 433.05 - 434.79 MHz | EU433                  |   |
|                       | 869 – 870 MHz       |                        |   |
| Mozambique (MZ)       |                     |                        |   |
| Myanmar (MM)          | 433 - 435 MHz       | EU433                  |   |
|                       | 866 - 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<br>AU915-928     |   |
|                               | 819 - 824 MHz              |                          |   |
|                               | 864 868 MHz                | IN865-867                |   |
|                               | 433.05 - 434.79 MHz        | EU433                    |   |
| Nicaragua (NI)                | 915 - 928 MHz <sup>2</sup> | AU915-928                |   |
| Niger (NE)                    | 865 – 865.6 MHz            | IN865-867                |   |
|                               | 865.6 – 867.6 MHz          | IN865-867                |   |
|                               | 867.6 – 868 MHz            | IN865-867                |   |
| Nigeria (NG)                  | 433.05 - 434.79 MHz        | EU433                    |   |
|                               | 868 - 870 MHz              | EU863-870                |   |
| Niue (NU)                     | 433.05 - 434.79 MHz        | EU433                    |   |
|                               | 819 - 824 MHz              |                          |   |
|                               | 864 - 868 MHz              | IN865-867                |   |
|                               | 915 - 928 MHz              | AS923-1<br>AU915-928     |   |
| Norfolk Island (NF)           | 915 - 928 MHz              | AS923-1<br>AU915-928     |   |
| Northern Mariana Islands (MP) | 902 – 928 MHz              | US902-928 <sup>1</sup>   | X |
| Norway (NO)                   | 433.05 - 434.79 MHz        | EU433                    |   |
|                               | 863 - 873 MHz              | EU863-870                |   |
|                               | 915 - 918 MHz              | AS923-3                  |   |
| Oman (OM)                     | 433.05 - 434.79 MHz        | EU433                    |   |
|                               | 863 - 870 MHz              | EU863-870                |   |
| Pakistan (PK)                 | 433.05 - 434.79 MHz        | EU433                    |   |
|                               | 865 - 869 MHz              | IN865-867                |   |
|                               | 920 - 925 MHz              | AS923-1                  |   |
| Palau (PW)                    |                            |                          |   |
| Palestine (PS)                |                            |                          |   |
| Panama (PA)                   | 902 - 928 MHz              | AU915-928 <sup>3 4</sup> |   |
| Papua New Guinea (PG)         | 433.05 - 434.79 MHz        | EU433                    |   |
|                               | 915 – 928 MHz              | AU915-928<br>AS923-1     |   |
| Paraguay (PY)                 | 433.05 - 434.79 MHz        | EU433                    |   |
|                               | 915 - 928 MHz              | AU915-928 <sup>3</sup>   |   |
| Peru (PE)                     | 915 - 928 MHz              | AU915-928 <sup>3</sup>   |   |
| Philippines (PH)              | 915 – 918 MHz              | AS923-3                  |   |

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

|   |                            |                        |   |
|---|----------------------------|------------------------|---|
| Senegal (SN)                                      | 868 – 870 MHz              | EU863-870              |   |
| Serbia (RS)                                       | 433.05 - 434.79 MHz        | EU433                  |   |
|   | 863 - 870 MHz              | EU863-870              |   |
| Seychelles (SC)                                   | 433.05 - 434.79 MHz        | EU433                  |   |
| Sierra Leone (SL)                                 |                            |                        |   |
| Singapore (SG)                                    | 920 - 925 MHz              | AS923-1                |   |
|   | 433.05 - 434.79 MHz        | EU433                  |   |
|   | 866 - 869 MHz              |                        |   |
| Sint Maarten (SX)                                 |                            |                        |   |
| Slovakia (SK)                                     | 433.05 - 434.79 MHz        | EU433                  |   |
|   | 863 - 873 MHz              | EU863-870              | X |
|   | 915 - 918 MHz              | AS923-3                |   |
| Slovenia (SI)                                     | 433.05 - 434.79 MHz        | EU433                  |   |
|   | 863 - 873 MHz              | EU863-870              | X |
|   | 915 - 918 MHz              | AS923-3                |   |
| Solomon Islands (SB)                              | 918 - 926 MHz              | AS923-1                |   |
| Somalia (SO)                                      | 433.05 - 434.79 MHz        | EU433                  |   |
|   | 863 - 870 MHz              | EU863-870              |   |
|   | 915 - 918 MHz              | AS923-3                |   |
| South Africa (ZA)                                 | 433.05 - 434.79 MHz        | EU433                  |   |
|   | 865 – 868.6 MHz            | EU863-870              |   |
|   | 868.7 – 869.2 MHz          | EU863-870              |   |
|   | 869.4 – 869.65 MHz         | EU863-870              |   |
|   | 869.7 – 870 MHz            | EU863-870              |   |
| South Georgia and the South Sandwich Islands (GS) | 433.05 - 434.79 MHz        | EU433                  |   |
|   | 863 - 873 MHz              | EU863-870              |   |
|   | 915 - 918 MHz              | AS923-3                |   |
| South Sudan (SS)                                  |                            |                        |   |
| Spain (ES)  | 433.05 - 434.79 MHz        | EU433                  |   |
|   | 863 - 870 MHz              | EU863-870              | X |
| Sri Lanka (LK)                                    | 433.05 - 434.79 MHz        | EU433                  |   |
|   | 868 – 869 MHz              |                        |   |
|   | 920 – 924 MHz              | AS923-1                |   |
| Sudan (SD)  |                            |                        |   |
| Suriname (SR)                                     | 915 – 928 MHz <sup>2</sup> | AU915-928 <sup>3</sup> |   |
| Svalbard and Jan Mayen (SJ)                       | 433.05 - 434.79 MHz        | EU433                  |   |
|   | 863 - 873 MHz              | EU863-870              |   |
|   | 915 - 918 MHz              | AS923-3                |   |
| Sweden (SE)                                       | 433.05 - 434.79 MHz        | EU433                  |   |
|   | 868 - 870 MHz              | EU863-870              | X |
| Switzerland (CH)                                  | 433.05 - 434.79 MHz        | EU433                  |   |
|   | 863 - 873 MHz              | EU863-870              | X |
|   | 915 – 918 MHz              | AS923-3                |   |
| Syrian Arab Republic (SY)                         | 433.05 – 434.79 MHz        | EU433                  |   |

|                                |                            |                        |   |
|--------------------------------|----------------------------|------------------------|---|
|                                | 863 – 870 MHz              | EU863-870              |   |
|                                | 870 – 876 MHz              | EU863-870              |   |
|                                | 915 – 921 MHz              | AS923-3                |   |
| Taiwan, Province of China (TW) | 920 - 925 MHz              | AS923-1                | X |
| Tajikistan (TJ)                |                            |                        |   |
| Tanzania (TZ)                  | 433.05 - 434.79 MHz        | EU433                  |   |
|                                | 866 - 869 MHz              |                        |   |
|                                | 920 - 925 MHz              | AS923-1                |   |
| Thailand (TH)                  | 433.05 – 434.79 MHz        | EU433                  |   |
|                                | 920 – 925 MHz              | AS923-1                | X |
| Timor-Leste (TL)               |                            |                        |   |
| Togo (TG)                      | 433.05 - 434.79 MHz        | EU433                  |   |
| Tokelau (TK)                   | 433.05 - 434.79 MHz        | EU433                  |   |
|                                | 819 - 824 MHz              |                        |   |
|                                | 864 - 868 MHz              | IN865-867              |   |
|                                | 915 - 928 MHz              | AS923-1<br>AU915-928   |   |
| Tonga (TO)                     | 433.05 – 434.79 MHz        | EU433                  |   |
|                                | 915 – 928 MHz              | AU915-928 <sup>3</sup> |   |
| Trinidad and Tobago (TT)       | 902 – 928 MHz              | AU915-928              |   |
| Tunisia (TN)                   | 433.05 - 434.79 MHz        | EU433                  |   |
|                                | 863 - 868 MHz              | EU863-870              |   |
|                                | 868 – 868.6 MHz            | EU863-870              |   |
|                                | 868.7 – 869.2 MHz          | EU863-870              |   |
|                                | 869.4 – 869.65 MHz         | EU863-870              |   |
|                                | 869.7 – 870 MHz            | EU863-870              |   |
| Turkey (TR)                    | 433.05 - 434.79 MHz        | EU433                  |   |
|                                | 863 - 870 MHz              | EU863-870              |   |
| Turkmenistan (TM)              |                            |                        |   |
| Turks and Caicos Islands (TC)  | 915 – 928 MHz <sup>2</sup> | AU915-928 <sup>3</sup> |   |
| Tuvalu (TV)                    |                            |                        |   |
| Uganda (UG)                    | 433.05 - 434.79 MHz        | EU433                  |   |
|                                | 863 - 865 MHz              | IN865-867              |   |
|                                | 865 - 867.6 MHz            | IN865-867              |   |
|                                | 869.25 - 869.7 MHz         |                        |   |
|                                | 923 - 925 MHz              | AS923-1                |   |
| Ukraine (UA)                   | 433.05 - 434.79 MHz        | EU433                  |   |
|                                | 863 - 870 MHz              | EU863-870              |   |
| United Arab Emirates (AE)      | 433.05 - 434.79 MHz        | EU433                  |   |
|                                | 863 - 870 MHz              | EU863-870              |   |
|                                | 870 - 875.8 MHz            | EU863-870              |   |
|                                | 915 - 921 MHz              | AS923-3                |   |
|                                | 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 <sup>1</sup> | X |
| United States of America (US)                             | 902 - 928 MHz                | US902-928 <sup>1</sup> | X |
| Uruguay (UY)  | 915 - 928 MHz <sup>2</sup>   | AU915-928 <sup>3</sup> |   |
| Uzbekistan (UZ)   | 433.05 – 434.79 MHz          | EU433                  |   |
| Vanuatu (VU)  | 433.05 - 434.79 MHz          | EU433                  |   |
|   | 863 – 869 MHz                | IN865-867              |   |
|   | 915 - 918 MHz                | AS923-3                |   |
| Venezuela (VE)  | 922 - 928 MHz                | AS923-1                |   |
| Viet Nam (VN)   | 433.05 - 434.79 MHz          | EU433                  |   |
|   | 918 - 923 MHz <sup>6</sup>   | AS923-2                |   |
|   | 920 - 922.5 MHz <sup>7</sup> | AS923-2                |   |
| Virgin Islands, UK (VG)                                   | 915 - 928 MHz <sup>2</sup>   | AU915-928 <sup>3</sup> |   |
| Virgin Islands, US (VI)                                   | 902 - 928 MHz                | US902-928 <sup>1</sup> | X |
| Wallis and Futuna (WF)                                    | 433.05 - 434.79 MHz          | EU433                  |   |
|   | 863 - 870 MHz                | EU863-870              | X |
| Western Sahara (EH)                                       |                              |                        |   |
| Yemen (YE)  |                              |                        |   |
| Zambia (ZM)   | 433.05 - 434.79 MHz          | EU433                  |   |
|   | 868 - 870 MHz                | EU863-870              |   |
| Zimbabwe (ZW)   | 433.05 - 434.79 MHz          | EU433                  |   |

Table 1: Channel Plan per ISO 3166-1 Country

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<sup>6</sup> Band LIKELY available through 2021 – regulations in flux

<sup>7</sup> Newly proposed band which LIKELY becomes available in 2021 – regulations in flux



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### 1.3 Regional Parameters Summary Table

The following summary tables have been provided as a quick reference to the various parameters described and defined, by channel plan region, in this document. These tables do not replace the full text in Section 2 and in the event of conflict, Section 2 is to be understood as the authoritative and normative text. The information is further broken down by channel plan type: dynamic channel plans, in which the majority of channels are defined after the join process; and fixed channel plans, where the majority (or all channels in LoRaWAN® versions prior to 1.1.1) of channels are defined statically and known prior to the join process.

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#### 1.3.1 Dynamic Channel Plan Regions

| <i>Plan</i>                                   | <i>EU868</i>         | <i>CN779</i>         | <i>EU433</i>         | <i>IN865</i>         | <i>KR920</i>         | <i>AS923-1</i>       | <i>AS923-2</i>       | <i>AS923-3</i>       | <i>AS923-4</i>       | <i>RU864</i>         |
|---|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
| <b>Default Freq band</b>                      | 863 to 870 MHz       | 779 to 787 MHz       | 433 to 434           | 865 to 867 MHz       | 920.9 to 923.3 MHz   | 915 to 928 MHz       | 915 to 928 MHz       | 915 to 928 MHz       | 917 to 920 MHz       | 864 to 870 MHz       |
| <b>Mandatory Channel Freq (Join Req)</b>      | 868.10 MHz           | 779.5 MHz            | 433.175 MHz          | 865.0625 MHz         | 922.10 MHz           | 923.20 MHz           | 921.4 MHz            | 916.6 MHz            | 917.3 MHz            | 868.9 MHz            |
|   | 868.30 MHz           | 779.7 MHz            | 433.375 MHz          | 865.4025 MHz         | 922.30 MHz           | 923.40 MHz           | 921.6 MHz            | 916.8 MHz            | 917.5 MHz            | 869.1 MHz            |
|   | 868.50 MHz           | 779.9 MHz            | 433.575 MHz          | 865.985 MHz          | 922.50 MHz           |                      |                      |                      |                      |                      |
| <b>JoinReq DataRate [MinDR:MaxDR]</b>         | [0:5]                | [0:5]                | [0:5]                | [0:5]                | [0:5]                | [2:5]                | [2:5]                | [2:5]                | [2:5]                | [0:5]                |
| <b>CFList Type Supported</b>                  | 0                    | 0                    | 0                    | 0                    | 0                    | 0                    | 0                    | 0                    | 0                    | 0                    |
| <b>Mandatory Data Rate [MinDR:MaxDR]</b>      | [0:5]                | [0:5]                | [0:5]                | [0:5]                | [0:5]                | [0:5]                | [0:5]                | [0:5]                | [0:5]                | [0:5]                |
| <b>Optional Data Rate [MinDR:MaxDR]</b>       | [6:7]   [6:11]       | [6:7]                | [6:7]                | [7]                  |                      | [6:7]                | [6:7]                | [6:7]                | [6:7]                | [6:7]                |
| <b>Number of channels</b>                     | 16                   | 16                   | 16                   | 16                   | 16                   | 16                   | 16                   | 16                   | 16                   | 16                   |
| <b>ChMaskCtrl - ChMask</b>                    | 0 -> Channels 0-15   | 0 -> Channels 0-15   | 0 -> Channels 0-15   | 0 -> Channels 0-15   | 0 -> Channels 0-15   | 0 -> Channels 0-15   | 0 -> Channels 0-15   | 0 -> Channels 0-15   | 0 -> Channels 0-15   | 0 -> Channels 0-15   |
|   | 6 -> All channels on | 6 -> All channels on | 6 -> All channels on | 6 -> All channels on | 6 -> All channels on | 6 -> All channels on | 6 -> All channels on | 6 -> All channels on | 6 -> All channels on | 6 -> All channels on |
| <b>Default channels</b>                       | [0:2]                | [0:2]                | [0:2]                | [0:2]                | [0:2]                | [0:1]                | [0:1]                | [0:1]                | [0:1]                | [0:1]                |
| <b>Default RX1DRoffset</b>                    | 0                    | 0                    | 0                    | 0                    | 0                    | 0                    | 0                    | 0                    | 0                    | 0                    |
| <b>Allowed RX1DRoffset</b>                    | [0:5]                | [0:5]                | [0:5]                | [0:7]                | [0:5]                | [0:7]                | [0:7]                | [0:7]                | [0:7]                | [0:5]                |
| <b>Duty Cycle</b>                             | < 1%                 | < 1%                 | < 10%                |                      | LBT                  | < 1%                 | < 1%                 | < 1%                 | < 1%                 | < 1%                 |
| <b>Dwell time limitation</b>                  | No                   | No                   | No                   | No                   | No                   | Yes (400ms)          | Yes (400ms)          | Yes (400ms)          | Yes (400ms)          | No                   |
| <b>TxParamSetupReq support</b>                | No                   | No                   | No                   | No                   | No                   | Yes                  | Yes                  | Yes                  | Yes                  | No                   |
| <b>Max EIRP (default) - TXPower 0</b>         | +16 dBm              | +12 dBm              | +12dBm               | +30 dBm              | +14 dBm              | +16 dBm              | +16 dBm              | +16 dBm              | +16 dBm              | +16 dBm              |
| <b>Default RX2DataRate</b>                    | DR0                  | DR0                  | DR0                  | DR2                  | DR0                  | DR2                  | DR2                  | DR2                  | DR2                  | DR0                  |
| <b>Default RX2 Frequency</b>                  | 869.525 MHz          | 786.0 MHz            | 434.665 MHz          | 866.550 MHz          | 921.90 MHz           | 923.2 MHz            | 921.4 MHz            | 916.6 MHz            | 917.3 MHz            | 869.1 MHz            |
| <b>Class B default Beacon Freq</b>            | 869.525 MHz          | 785.0 MHz            | 434.665 MHz          | 866.550 MHz          | 923.1 MHz            | 923.4 MHz            | 921.6 MHz            | 916.8 MHz            | 917.5 MHz            | 869.1 MHz            |
| <b>Class B default downlink pingSlot Freq</b> | 869.525 MHz          | 785.0 MHz            | 434.665 MHz          | 866.550 MHz          | 923.1 MHz            | 923.4 MHz            | 921.6 MHz            | 916.8 MHz            | 917.5 MHz            | 868.9 MHz            |

Table 2 - Dynamic Channel Plans Summary

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375 1.3.2 Fixed Channel Plan Regions  
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| Plan  | US915   | AU915   |
|---|---|---|
| <b>Default Freq band</b>                      | 902 to 928 MHz  | 915 to 928 MHz  |
| <b>Mandatory Channel Freq (Join Req)</b>      | upstream: 64 (902.3 to 914.9 [+ by 0.2]) + 8 (903.0 to 914.2 [+ by 1.6])<br>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])<br>downstream: 8 (923.3 to 927.5 [+ by 0.6])   |
| <b>JoinReq DataRate [MinDR:MaxDR]</b>         | 64 (125 kHz channels) using DR0 and<br>8 (500 kHz channels) using DR4   | 64 (125 kHz channels) using DR2 and<br>8 (500 kHz channels) using DR6   |
| <b>CFList Type Supported</b>                  | 1   | 1   |
| <b>Mandatory Data Rate [MinDR:MaxDR]</b>      | [0:4],[8:13]  | [0:6],[8:13]  |
| <b>Optional Data Rate [MinDR:MaxDR]</b>       | [5:6]   | [7]   |
| <b>Number of channels</b>                     | upstream: 64 (125 kHz) + 8 (500 kHz)<br>downstream: 8 (500 kHz)<br>0 -> Channels 0 to 15<br>1 -> Channels 16 to 31<br>...   | upstream: 64 (125 kHz) + 8 (500 kHz)<br>downstream: 8 (500 kHz)<br>0 -> Channels 0 to 15<br>1 -> Channels 16 to 31<br>...   |
| <b>ChMaskCtrl - ChMask</b>                    | 4 -> Channels 64 to 71<br>5 -> 8LSBs controls Channel Blocks 0 to 7, 8MSBs are RFU<br>6 -> All 125 kHz ON, ChMask applies to channels 64 to 71<br>7 -> All 125 kHz OFF, ChMask applies to channels 64 to 71 | 4 -> Channels 64 to 71<br>5 -> 8LSBs controls Channel Blocks 0 to 7, 8MSBs are RFU<br>6 -> All 125 kHz ON, ChMask applies to channels 64 to 71<br>7 -> All 125 kHz OFF, ChMask applies to channels 64 to 71 |
| <b>Default channels</b>                       | [0:71]  | [0:71]  |
| <b>Default RX1DROffset</b>                    | 0   | 0   |
| <b>Allowed RX1DROffset</b>                    | [0:3]   | [0:5]   |
| <b>Duty Cycle</b>                             | No Limit  | No Limit  |
| <b>Dwell time limitation</b>                  | [0:63] 400ms<br>[64:71] No  | [0:63] 400ms (regional dependence)<br>[64:71] No  |
| <b>TxParamSetupReq support</b>                | No  | Yes   |
| <b>Max EIRP (default) - TXPower 0</b>         | +30 dBm   | +30 dBm   |
| <b>Default RX2DataRate</b>                    | DR8   | DR8   |
| <b>Default RX2 Frequency</b>                  | 923.3 MHz   | 923.3 MHz   |
| <b>Class B default Beacon Freq</b>            | Hops across all 8 downlink channels   | Hops across all 8 downlink channels   |
| <b>Class B default downlink pingSlot Freq</b> | Follows beacon channel  | Follows beacon channel  |

Table 3 - Fixed Channel Plans Summary

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378

## 379 2 LoRaWAN® Regional Parameters

380

### 381 2.1 Regional Parameter Channel Plan Common Names

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

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

386 **Table 4 Regional Parameter Common Names**

387

### 388 2.2 Regional Parameter Revision Names

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

| 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     |

393 **Table 5 Regional Parameter Revision Names**

394

### 394 2.3 Default Settings

395 The following parameters are RECOMMENDED values for all regions.

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

<sup>8</sup> 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 <sup>9</sup> | 16384   |
| ADR_ACK_LIMIT             | 64  |
| ADR_ACK_DELAY             | 32  |
| RETRANSMIT_TIMEOUT        | 2s +/- 1s (random delay between 1 and 3 seconds)  |
| DownlinkDwellTime         | 0 (No downlink dwell time enforced, impacts data rate Offset calculations)                    |
| UplinkDwellTime           | Uplink dwell time is country specific and is the responsibly of the end-device to comply with |
| PING_SLOT_PERIODICITY     | 7 (2 <sup>7</sup> = 128s)   |
| PING_SLOT_DATARATE        | The value of the BEACON DR defined for each regional band                                     |
| PING_SLOT_CHANNEL         | Defined in each regional band   |
| CLASS_B_RESP_TIMEOUT      | 8s <sup>10</sup>  |
| CLASS_C_RESP_TIMEOUT      | 8s <sup>11</sup>  |

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

402

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

406

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

412

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

415

---

<sup>9</sup> MAX\_FCNT\_GAP was deprecated and removed from LoRaWAN<sup>®</sup> 1.0.4 and subsequent versions

<sup>10</sup> CLASS\_B\_RESP\_TIMEOUT must always be greater than the largest possible value of RETRANSMIT\_TIMEOUT plus the maximum possible time-on-air of an uplink frame

<sup>11</sup> CLASS\_C\_RESP\_TIMEOUT must always be greater than the largest possible value of RETRANSMIT\_TIMEOUT plus the maximum possible time-on-air of an uplink frame

## 416 2.4 EU863-870 MHz Band

### 417 2.4.1 EU863-870 Preamble Format

418 Please refer to Section 3.0 Physical Layer.

### 419 2.4.2 EU863-870 Band Channel Frequencies

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

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

425

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

426

Table 6: EU863-870 default channels

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

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

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

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

447

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

448

Table 7: EU863-870 Join-Request Channel List

449 **2.4.3 EU863-870 Data Rate and End-device Output Power encoding**

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

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

454

| Data Rate | Configuration                           | Indicative physical bit rate [bit/s] |
|-----------|---|--------------------------------------|
| 0         | LoRa: SF12 / 125 kHz                    | 250                                  |
| 1         | LoRa: SF11 / 125 kHz                    | 440                                  |
| 2         | LoRa: SF10 / 125 kHz                    | 980                                  |
| 3         | LoRa: SF9 / 125 kHz                     | 1760                                 |
| 4         | LoRa: SF8 / 125 kHz                     | 3125                                 |
| 5         | LoRa: SF7 / 125 kHz                     | 5470                                 |
| 6         | LoRa: SF7 / 250 kHz                     | 11000                                |
| 7         | FSK: 50 kbps                            | 50000                                |
| 8         | LR-FHSS <sup>12</sup> 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] <sup>13</sup>        |                                      |

Table 8: EU863-870 TX DataRate table

455

456

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

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

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

463

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

| DR <sub>current</sub> | DR <sub>next</sub> | Comment                      |
|-----------------------|--------------------|------------------------------|
| 0                     | NA                 | Already the lowest data rate |
| 1                     | 0                  |                              |
| 2                     | 1                  |                              |
| 3                     | 2                  |                              |
| 4                     | 3                  |                              |
| 5                     | 4                  |                              |
| 6                     | 5                  |                              |
| 7                     | 6                  |                              |
| 8                     | 0                  |                              |
| 9                     | 8                  |                              |
| 10                    | 0                  |                              |
| 11                    | 10                 |                              |

Table 9: EU863-870 Data Rate Backoff table

467

<sup>12</sup> Long Range Frequency Hopping Spread Spectrum, see Section 4.3

<sup>13</sup> DR<sub>15</sub> and TXPower<sub>15</sub> are defined in the LinkADRRReq MAC command of the LoRaWAN1.0.4 and subsequent specifications and were previously RFU



468 EIRP<sup>14</sup> refers to the Equivalent Isotropically Radiated Power, which is the radiated output  
 469 power referenced to an isotropic antenna radiating power equally in all directions and whose  
 470 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

471  
 472  
 473  
 474  
 475

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.

#### 476 2.4.4 EU863-870 Join-Accept CFList

477

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

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

485

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

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

#### 493 2.4.5 EU863-870 LinkAdrReq command

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

| ChMaskCntl | ChMask applies to |
|------------|-------------------|
| 0          | Channels 0 to 15  |

<sup>14</sup> ERP = EIRP – 2.15dB; it is referenced to a half-wave dipole antenna whose gain is expressed in dBd

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

497

Table 11: EU863-870 ChMaskCntl value table

498 If the ChMaskCntl field value is one of values meaning RFU, the end-device SHALL<sup>15</sup> reject  
 499 the command and unset the “**Channel mask ACK**” bit in its response.

### 500 2.4.6 EU863-870 Maximum payload size

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

| 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 |     |

507

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

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

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

<sup>15</sup> Made SHALL from SHOULD starting in LoRaWAN Regional Parameters Specification 1.0.3rA

|       |             |     |
|-------|-------------|-----|
| 11    | 123         | 115 |
| 12:15 | Not defined |     |

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

 512 **2.4.7 EU863-870 Receive windows**

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

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

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

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

 521 **2.4.8 EU863-870 Class B beacon and default downlink channel**

522 The beacons SHALL be transmitted using the following settings

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

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

524

 525 The beacon frame content is defined in [TS001].<sup>16</sup>

526 The beacon default broadcast frequency is 869.525 MHz.

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

 528 **2.4.9 EU863-870 Default Settings**

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

530

<sup>16</sup> Prior to LoRaWAN<sup>®</sup> 1.0.4, the EU863-870 beacon format was defined here as:

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

531 **2.5 US902-928 MHz ISM Band**

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

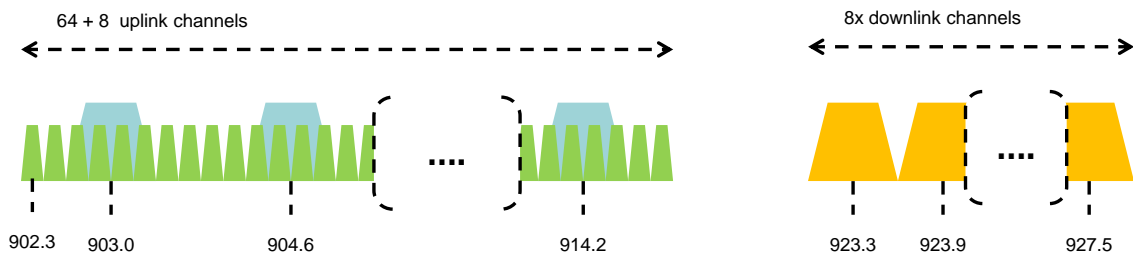
534 **2.5.1 US902-928 Preamble Format**

535 Please refer to Section 3.0 Physical Layer.

536 **2.5.2 US902-928 Band Channel Frequencies**

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

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



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

548  
 549 915 MHz ISM band end-devices are required to operate in compliance with the relevant  
 550 regulatory specifications, the following note summarizes some of the current (March 2017)  
 551 relevant regulations.

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

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

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

569  
570  
571  
572 US902-928 end-devices SHALL be capable of operating in the 902 to 928 MHz frequency  
573 band and SHALL feature a channel data structure to store the parameters for 72 channels.  
574 This channel data structure contains a list of frequencies and the set of data rates available  
575 for each frequency.

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

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

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

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

### 592 2.5.3 US902-928 Data Rate and End-device Output Power encoding

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

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

598

| 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] <sup>17</sup> |  |

599

Table 16: US902-928 TX DataRate table

600

601

602

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

603

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

604

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

605

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

606

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

608

609

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

610

611

| DR <sub>current</sub>  | DR <sub>next</sub> | comment                              |
|--|--------------------|--------------------------------------|
| 0  | NA                 | Already the default lowest data rate |
| 1  | 0                  |                                      |
| 2  | 1                  |                                      |
| 3  | 2                  |                                      |
| 4  | 3                  |                                      |
| 5  | 0                  |                                      |
| 6  | 5                  |                                      |
| DR 7 to DR15 are either RFU, reserved or only used in downlink |                    |                                      |

612

Table 17: US902-928 Data Rate Backoff table

613

| TXPower | Configuration (conducted power)  |
|---------|----------------------------------|
| 0       | 30 dBm – 2*TXPower               |
| 1       | 28 dBm                           |
| 2       | 26 dBm                           |
| 3 : 13  | ....                             |
| 14      | 2 dBm                            |
| 15      | Defined in [TS001] <sup>18</sup> |

614

Table 18: US902-928 TX power table

615

## 2.5.4 US902-928 Join-Accept CFList

616

617

For LoRaWAN<sup>®</sup> 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.

618

619

620

621

The US902-928 LoRaWAN<sup>®</sup> supports the use of the OPTIONAL **CFList** appended to the Join-Accept message. If the **CFList** is not empty, then the **CFListType** field SHALL contain the value one (0x01) to indicate the **CFList** contains a series of ChMask fields. The ChMask fields are interpreted as being controlled by a virtual ChMaskCntl that initializes to a value of

622

623

624

<sup>17</sup> DR15 and TXPower15 are defined in the LinkADRRReq MAC command of the LoRaWAN<sup>®</sup> 1.0.4 and subsequent specifications and were previously RFU

<sup>18</sup> DR15 and TXPower15 are defined in the LinkADRRReq MAC command of the LoRaWAN<sup>®</sup> 1.0.4 and subsequent specifications and were previously RFU



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

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

## 628 2.5.5 US902-928 LinkAdrReq command

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

| 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 |

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

633 If **ChMaskCntl** = 5<sup>19</sup> then the corresponding bits in the ChMask enable and disable a bank of  
 634 8 125 kHz channels and the corresponding 500 kHz channel defined by the following  
 635 calculation: [ChannelMaskBit \* 8, ChannelMaskBit \* 8 +7],64+ChannelMaskBit.

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

640

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

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

<sup>19</sup> Added in LoRaWAN<sup>®</sup> Regional Parameters Specification version 1.0.3rA

656 **2.5.6 US902-928 Maximum payload size**

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

| Data Rate | <i>M</i>    | <i>N</i> |
|-----------|-------------|----------|
| 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 |          |

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

664

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

| Data Rate | <i>M</i>    | <i>N</i> |
|-----------|-------------|----------|
| 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 |          |

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

 669 **2.5.7 US902-928 Receive windows**

- 670 • The RX1 receive channel is a function of the upstream channel used to initiate the  
 671 data exchange. The RX1 receive channel can be determined as follows.  
 672 ○ RX1 Channel Number = Transmit Channel Number modulo 8
- 673 • The RX1 window data rate depends on the transmit data rate (see Table 22 below).
- 674 • The RX2 (second receive window) settings uses a fixed data rate and frequency.

675 Default parameters are 923.3 MHz / DR8  
676

| Upstream data rate<br>RX1DROffset | Downstream data rate |      |      |      |
|-----------------------------------|----------------------|------|------|------|
|                                   | 0                    | 1    | 2    | 3    |
| DR0                               | DR10                 | DR9  | DR8  | DR8  |
| DR1                               | DR11                 | DR10 | DR9  | DR8  |
| DR2                               | DR12                 | DR11 | DR10 | DR9  |
| DR3                               | DR13                 | DR12 | DR11 | DR10 |
| DR4                               | DR13                 | DR13 | DR12 | DR11 |
| DR5                               | DR10                 | DR9  | DR8  | DR8  |
| DR6                               | DR11                 | DR10 | DR9  | DR8  |

677 **Table 22: US902-928 downlink RX1 data rate mapping<sup>20</sup>**

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

## 680 2.5.8 US902-928 Class B beacon<sup>21</sup>

681 The beacons SHALL be transmitted using the following settings:

682

|                        |                                       |   |
|------------------------|---------------------------------------|---|
| <b>DR</b>              | 8                                     | Corresponds to SF12 spreading factor with 500 kHz bw  |
| <b>CR</b>              | 1                                     | Coding rate = 4/5   |
| <b>Signal polarity</b> | Non-inverted                          | As opposed to normal downlink traffic which uses inverted signal polarity   |
| <b>frequencies</b>     | 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 |

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

684 The downstream channel used for a given beacon is:

685

$$686 \text{ Channel} = \left[ \text{floor} \left( \frac{\text{beacon\_time}}{\text{beacon\_period}} \right) \right] \text{ modulo } 8$$

687

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

692

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

695

696

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

<sup>20</sup> Re-defined in the LoRaWAN<sup>®</sup> 1.0.1 specification to eliminate RX1DROffset values beyond DR4

<sup>21</sup> Class B beacon operation was first defined in the LoRaWAN<sup>®</sup> 1.0.3 specification

|   |       |
|---|-------|
| 7 | 927.5 |
|---|-------|

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

697

698

699 The beacon frame content is defined in [TS001].<sup>22</sup>

700

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

## 702 **2.5.9 US902-928 Default Settings**

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

704

---

<sup>22</sup> Prior to LoRaWAN<sup>®</sup> 1.0.4, the beacon was defined here as:

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

705 **2.6 CN779-787 MHz Band<sup>23</sup>**

 706 **2.6.1 CN779-787 Preamble Format**

707 Please refer to Section 3.0 Physical Layer.

 708 **2.6.2 CN779-787 Band Channel Frequencies**

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

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

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

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

- 716
- Minimum frequency: 779.5 MHz
- 717
- Maximum frequency: 786.5 MHz

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

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

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

735

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

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

 737 **2.6.3 CN779-787 Data Rate and End-device Output Power encoding**

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

---

<sup>23</sup> Defined in the LoRaWAN® 1.0.1 specification

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

742

| Data Rate | Configuration                    | Indicative physical bit rate [bit/s] | TXPower | Configuration (EIRP)             |
|-----------|----------------------------------|--------------------------------------|---------|----------------------------------|
| 0         | LoRa: SF12 / 125 kHz             | 250                                  | 0       | Max EIRP                         |
| 1         | LoRa: SF11 / 125 kHz             | 440                                  | 1       | Max EIRP – 2dB                   |
| 2         | LoRa: SF10 / 125 kHz             | 980                                  | 2       | Max EIRP – 4dB                   |
| 3         | LoRa: SF9 / 125 kHz              | 1760                                 | 3       | Max EIRP – 6dB                   |
| 4         | LoRa: SF8 / 125 kHz              | 3125                                 | 4       | Max EIRP – 8dB                   |
| 5         | LoRa: SF7 / 125 kHz              | 5470                                 | 5       | Max EIRP – 10dB                  |
| 6         | LoRa: SF7 / 250 kHz              | 11000                                | 6..14   | RFU                              |
| 7         | FSK: 50 kbps                     | 50000                                |         |                                  |
| 8..14     | RFU                              |                                      |         |                                  |
| 15        | Defined in [TS001] <sup>24</sup> |                                      | 15      | Defined in [TS001] <sup>24</sup> |

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

743

744

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

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

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

750

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

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

Table 27: CN779-787 Data Rate Backoff table

754

755

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

759 By default, Max EIRP is considered to be +12 dBm. If the end-device cannot achieve 12  
760 dBm EIRP, the Max EIRP SHOULD be communicated to the network server using an out-of-  
761 band channel during the end-device commissioning process.

## 762 2.6.4 CN779-787 Join-Accept CFList

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

<sup>24</sup> DR15 and TXPower15 are defined in the LinkADRRReq MAC command of the LoRaWAN® 1.0.4 and subsequent specifications and were previously RFU

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

770

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

771

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

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

### 780 2.6.5 CN779-787 LinkAdrReq command

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

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

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

785

786

786 If the ChMask field value is one of values meaning RFU, then end-device SHALL<sup>25</sup> reject the  
 787 command and unset the “**Channel mask ACK**” bit in its response.

### 788 2.6.6 CN779-787 Maximum payload size

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

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

<sup>25</sup> Made SHALL from SHOULD starting in LoRaWAN<sup>®</sup> Regional Parameters Specification 1.0.3rA



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

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

795  
796  
797  
798  
799

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)**

800

### 801 2.6.7 CN779-787 Receive windows

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

806

| Upstream data rate<br>RX1DROffset | Downstream data rate |     |     |     |     |     |
|-----------------------------------|----------------------|-----|-----|-----|-----|-----|
|                                   | 0                    | 1   | 2   | 3   | 4   | 5   |
| DR0                               | DR0                  | DR0 | DR0 | DR0 | DR0 | DR0 |
| DR1                               | DR1                  | DR0 | DR0 | DR0 | DR0 | DR0 |
| DR2                               | DR2                  | DR1 | DR0 | DR0 | DR0 | DR0 |
| DR3                               | DR3                  | DR2 | DR1 | DR0 | DR0 | DR0 |
| DR4                               | DR4                  | DR3 | DR2 | DR1 | DR0 | DR0 |
| DR5                               | DR5                  | DR4 | DR3 | DR2 | DR1 | DR0 |
| DR6                               | DR6                  | DR5 | DR4 | DR3 | DR2 | DR1 |
| DR7                               | DR7                  | DR6 | DR5 | DR4 | DR3 | DR2 |

**Table 31: CN779-787 downlink RX1 data rate mapping**

807

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

### 810 2.6.8 CN779-787 Class B beacon and default downlink channel

811 The beacons SHALL be transmitted using the following settings:

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

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

812



813 The beacon frame content is defined in [TS001].<sup>26</sup> The beacon default broadcast frequency is  
 814 785 MHz.

815 The class B default downlink pingSlot frequency is 785 MHz

816 **2.6.9 CN779-787 Default Settings**

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

---

<sup>26</sup> Prior to LoRaWAN<sup>®</sup> 1.0.4, the beacon was defined here as:

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

## 818 2.7 EU433 MHz ISM Band

### 819 2.7.1 EU433 Preamble Format

820 Please refer to Section 3.0 Physical Layer.

### 821 2.7.2 EU433 ISM Band Channel Frequencies

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

824 The end-device transmit duty-cycle SHALL be lower than 10%.<sup>27</sup>

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

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

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

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

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

844

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

Table 33: EU433 Join-Request Channel List

845

846

### 847 2.7.3 EU433 Data Rate and End-device Output Power encoding

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

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

852

<sup>27</sup> Defined in the LoRaWAN® Regional Parameters 1.0.2 specification

| Data Rate | Configuration                    | Indicative physical bit rate [bit/s] | TXPower | Configuration (EIRP)             |
|-----------|----------------------------------|--------------------------------------|---------|----------------------------------|
| 0         | LoRa: SF12 / 125 kHz             | 250                                  | 0       | Max EIRP                         |
| 1         | LoRa: SF11 / 125 kHz             | 440                                  | 1       | Max EIRP – 2dB                   |
| 2         | LoRa: SF10 / 125 kHz             | 980                                  | 2       | Max EIRP – 4dB                   |
| 3         | LoRa: SF9 / 125 kHz              | 1760                                 | 3       | Max EIRP – 6dB                   |
| 4         | LoRa: SF8 / 125 kHz              | 3125                                 | 4       | Max EIRP – 8dB                   |
| 5         | LoRa: SF7 / 125 kHz              | 5470                                 | 5       | Max EIRP – 10dB                  |
| 6         | LoRa: SF7 / 250 kHz              | 11000                                | 6..14   | RFU                              |
| 7         | FSK: 50 kbps                     | 50000                                |         |                                  |
| 8..14     | RFU                              |                                      |         |                                  |
| 15        | Defined in [TS001] <sup>28</sup> |                                      | 15      | Defined in [TS001] <sup>28</sup> |

Table 34: EU433 Data rate and TX power table

853

854

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

855

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

856

2. DR0 to DR7

857

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

858

859

860

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

861

862

863

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

Table 35: EU433 Data Rate Backoff table

864

865

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.

866

867

868

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.

869

870

871

## 2.7.4 EU433 Join-Accept CFList

872

873

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

874

875

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

876

877

<sup>28</sup> DR15 and TXPower15 are defined in the LinkADRRReq MAC command of the LoRaWAN<sup>®</sup> 1.0.4 and subsequent specifications and were previously RFU

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

881

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

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

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

### 890 2.7.5 EU433 LinkAdrReq command

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

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

894

Table 36: EU433 ChMaskCntl value table

895 If the ChMask field value is one of the values meaning RFU, then end-device SHALL<sup>29</sup> reject  
 896 the command and unset the “**Channel mask ACK**” bit in its response.

### 897 2.7.6 EU433 Maximum payload size

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

| <b>Data Rate</b> | <b>M</b> | <b>N</b> |
|------------------|----------|----------|
| 0                | 59       | 51       |
| 1                | 59       | 51       |
| 2                | 59       | 51       |
| 3                | 123      | 115      |
| 4                | 230      | 222      |
| 5                | 230      | 222      |
| 6                | 230      | 222      |

<sup>29</sup> Made SHALL from SHOULD starting in LoRaWAN® Regional Parameters Specification 1.0.3rA

|      |             |     |
|------|-------------|-----|
| 7    | 230         | 222 |
| 8:15 | Not defined |     |

Table 37: EU433 maximum payload size (repeater compatible)

 904  
 905  
 906  
 907  
 908

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)

909

### 910 2.7.7 EU433 Receive windows

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

915

| Upstream data rate<br>RX1DROffset | Downstream data rate |     |     |     |     |     |
|-----------------------------------|----------------------|-----|-----|-----|-----|-----|
|                                   | 0                    | 1   | 2   | 3   | 4   | 5   |
| DR0                               | DR0                  | DR0 | DR0 | DR0 | DR0 | DR0 |
| DR1                               | DR1                  | DR0 | DR0 | DR0 | DR0 | DR0 |
| DR2                               | DR2                  | DR1 | DR0 | DR0 | DR0 | DR0 |
| DR3                               | DR3                  | DR2 | DR1 | DR0 | DR0 | DR0 |
| DR4                               | DR4                  | DR3 | DR2 | DR1 | DR0 | DR0 |
| DR5                               | DR5                  | DR4 | DR3 | DR2 | DR1 | DR0 |
| DR6                               | DR6                  | DR5 | DR4 | DR3 | DR2 | DR1 |
| DR7                               | DR7                  | DR6 | DR5 | DR4 | DR3 | DR2 |

Table 39 : EU433 downlink RX1 data rate mapping

916

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

### 919 2.7.8 EU433 Class B beacon and default downlink channel

920 The beacons SHALL be transmitted using the following settings

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

Table 40 : EU433 beacon settings

921

- 922 The beacon frame content is defined in [TS001].<sup>30</sup>
- 923 The beacon default broadcast frequency is 434.665 MHz.
- 924 The class B default downlink pingSlot frequency is 434.665 MHz

925 **2.7.9 EU433 Default Settings**

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

---

<sup>30</sup> Prior to LoRaWAN<sup>®</sup> 1.0.4, the beacon was defined here as:

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

928 **2.8 AU915-928 MHz Band<sup>31</sup>**

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

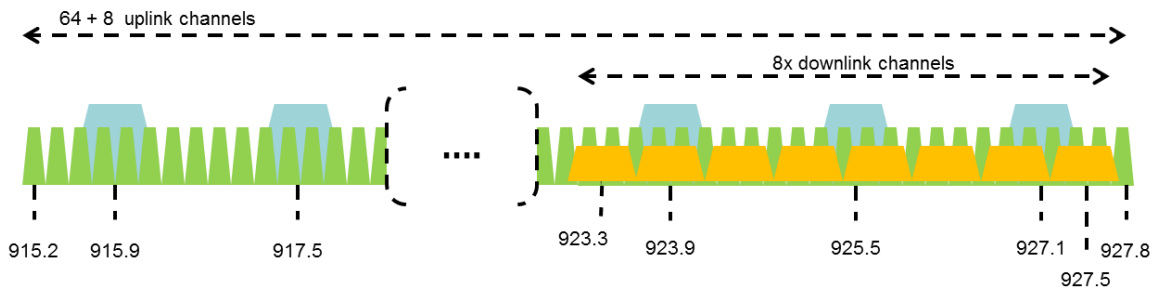
931 **2.8.1 AU915-928 Preamble Format**

932 Please refer to Section 3.0 Physical Layer.

933 **2.8.2 AU915-928 Band Channel Frequencies**

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

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



944  
 945

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

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

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

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

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

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

<sup>31</sup> Defined in the LoRaWAN® 1.0.1 specification

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

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

968  
 969 The default Join-Request Data Rate SHALL be DR2 (SF10/125 kHz), this setting ensures  
 970 that end-devices are compatible with the 400ms dwell time limitation until the actual dwell  
 971 time limit is notified to the end-device by the network server via the MAC command  
 972 ***TxParamSetupReq***.

973  
 974 AU915-928 end-devices SHALL consider UplinkDwellTime = 1 during boot stage until  
 975 reception of the ***TxParamSetupReq*** command.

976  
 977 AU915-928 end-devices SHALL always consider DownlinkDwellTime = 0, since downlink  
 978 channels use 500 kHz bandwidth without any dwell time limit.

### 979 **2.8.3 AU915-928 Data Rate and End-point Output Power encoding**

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

982  
 983 If the field UplinkDwellTime is set to 1 by the network server in the ***TxParamSetupReq***  
 984 command, AU915-928 end-devices SHALL adjust the time between two consecutive uplink  
 985 transmissions to meet the local regulation. Twenty seconds (20s) are recommended  
 986 between 2 uplink transmissions when UplinkDwellTime = 1 but this value MAY be adjusted  
 987 depending on local regulation.

988  
 989 There is no such constraint on time between two consecutive transmissions when  
 990 UplinkDwellTime = 0.

991  
 992 The following encoding is used for Data Rate (**DR**) and end-point EIRP (**TXPower**) in the  
 993 AU915-928 band:

994

| 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] <sup>32</sup> |       |

Table 41: AU915-928 DataRate table

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

AU915-928 devices SHALL support one of the 2 following data rate options:

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

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

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

| UplinkDwellTime=0     |                    | UplinkDwellTime=1     |                    |
|-----------------------|--------------------|-----------------------|--------------------|
| DR <sub>current</sub> | DR <sub>next</sub> | DR <sub>current</sub> | DR <sub>next</sub> |
| 0                     | NA                 | NA                    | NA                 |
| 1                     | 0                  | NA                    | NA                 |
| 2                     | 1                  | 2                     | NA                 |
| 3                     | 2                  | 3                     | 2                  |
| 4                     | 3                  | 4                     | 3                  |
| 5                     | 4                  | 5                     | 4                  |
| 6                     | 5                  | 6                     | 5                  |
| 7                     | 0                  | 7                     | 2                  |

DR 8 to DR15 are either RFU, reserved or only used in downlink

Table 42: AU915-928 Data Rate Backoff table

| TXPower | Configuration (EIRP)             |
|---------|----------------------------------|
| 0       | Max EIRP                         |
| 1:14    | Max EIRP – 2*TXPower             |
| 15      | Defined in [TS001] <sup>32</sup> |

Table 43 : AU915-928 TX power table

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

By default, the Max EIRP is considered to be +30dBm. The Max EIRP can be modified by the network server through the **TxParamSetupReq** MAC command and SHALL be used by both the end-device and the network server once **TxParamSetupReq** is acknowledged by the device via **TxParamSetupAns**.

#### 2.8.4 AU915-928 Join-Accept CFList

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

<sup>32</sup> DR15 and TXPower15 are defined in the LinkADRRReq MAC command of the LoRaWAN<sup>®</sup> 1.0.4 and subsequent specifications and were previously RFU

1025 the value one (0x01) to indicate the CFList contains a series of ChMask fields. The ChMask  
 1026 fields are interpreted as being controlled by a virtual ChMaskCntl that initializes to a value of  
 1027 zero (0) and increments for each ChMask field to a value of four (4). (The first 16 bits  
 1028 controls the channels 0 to 15...)  
 1029

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

### 1030 2.8.5 AU915-928 LinkAdrReq command

1031 For the AU915-928 version the **ChMaskCntl** field of the *LinkADRReq* command has the  
 1032 following meaning:

1033

| 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 |

1034

Table 44: AU915-928 ChMaskCntl value table

1035 If **ChMaskCntl** = 5<sup>33</sup> then the corresponding bits in the ChMask enable and disable a bank of  
 1036 8 125 kHz channels and the corresponding 500 kHz channel defined by the following  
 1037 calculation: [ChannelMaskBit \* 8, ChannelMaskBit \* 8 +7],64+ChannelMaskBit.

1038 If **ChMaskCntl** = 6 then 125 kHz channels are enabled, if **ChMaskCntl** = 7 then 125 kHz  
 1039 channels are disabled. Simultaneously the channels 64 to 71 are set according to the **ChMask**  
 1040 bit mask. The Data Rate specified in the command need not be valid for channels specified in  
 1041 the ChMask, as it governs the global operational state of the end-device.

### 1042 2.8.6 AU915-928 Maximum payload size

1043 The maximum **MACPayload** size length (*M*) is given by the following table for both uplink  
 1044 dwell time configurations: No Limit and 400ms. It is derived from the maximum allowed  
 1045 transmission time at the PHY layer taking into account a possible repeater encapsulation. The  
 1046 maximum application payload length in the absence of the OPTIONAL **FOpts** MAC control  
 1047 field (*N*) is also given for information only. The value of *N* might be smaller if the **FOpts** field  
 1048 is not empty:

1049

| 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  |

<sup>33</sup> Added in LoRaWAN<sup>®</sup> Regional Parameters Specification version 1.0.3rA

|       |             |     |             |     |
|-------|-------------|-----|-------------|-----|
| 8     | 61          | 53  | 61          | 53  |
| 9     | 137         | 129 | 137         | 129 |
| 10    | 230         | 222 | 230         | 222 |
| 11    | 230         | 222 | 230         | 222 |
| 12    | 230         | 222 | 230         | 222 |
| 13    | 230         | 222 | 230         | 222 |
| 14:15 | Not defined |     | Not defined |     |

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

1050

 1051 For AU915-928, **DownlinkDwellTime** SHALL be set to 0 (no limit). The 400ms dwell time  
 1052 MAY apply to uplink channels depending on the local regulations.

 1053 If the end-device will never operate with a repeater then the maximum application payload  
 1054 length in the absence of the OPTIONAL **FOpts** control field SHALL be:

1055

| 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**

1056

1057

**1058 2.8.7 AU915-928 Receive windows**

- 1059 • The RX1 receive channel is a function of the upstream channel used to initiate the  
 1060 data exchange. The RX1 receive channel can be determined as follows.
  - 1061 ○ RX1 Channel Number = Transmit Channel Number modulo 8
- 1062 • The RX1 window data rate depends on the transmit data rate (see Table 22 below).
- 1063 • The RX2 (second receive window) settings uses a fixed data rate and frequency.  
 1064 Default parameters are 923.3 MHz / DR8  
 1065

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

**Table 47 : AU915-928 downlink RX1 data rate mapping**

1066

1067

 1068 The allowed values for RX1DROffset are in the [0:5] range. Values in the range [6:7] are  
 1069 reserved for future use.

 1070 **2.8.8 AU915-928 Class B beacon**

1071 The beacons are transmitted using the following settings:

|                        |                                      |   |
|------------------------|--------------------------------------|---|
| <b>DR</b>              | 8                                    | Corresponds to SF12 spreading factor with 500 kHz bw  |
| <b>CR</b>              | 1                                    | Coding rate = 4/5   |
| <b>Signal polarity</b> | Non-inverted                         | As opposed to normal downlink traffic which uses inverted signal polarity   |
| <b>frequencies</b>     | 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 |

1072

Table 48 : AU915-928 beacon settings

1073 The downstream channel used for a given beacon is:

1074

$$1075 \text{ Channel} = \left[ \text{floor} \left( \frac{\text{beacon\_time}}{\text{beacon\_period}} \right) \right] \text{ modulo } 8$$

1076

- 1077 • whereby beacon\_time is the integer value of the 4 bytes “Time” field of the beacon
- 1078 frame
- 1079 • whereby beacon\_period is the periodicity of beacons, 128 seconds
- 1080 • whereby  $\text{floor}(x)$  designates rounding to the integer immediately inferior or equal to  $x$

1081

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

1084

 1085 The beacon frame content is defined in [TS001].<sup>34</sup>

1086

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

 1087 **2.8.9 AU915-928 Default Settings**

1088

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

<sup>34</sup> Prior to LoRaWAN® 1.0.4, the beacon was defined here as:

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

1089 **2.9 CN470-510 MHz Band<sup>35</sup>**

 1090 

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

 1091 

prior revisions and should be considered experimental pending

 1092 

published documents confirming plan compliant devices have been

 1093 

granted local regulatory approval.

 1094 **2.9.1 CN470-510 Preamble Format**

1095 Please refer to Section 3.0 Physical Layer.

 1096 **2.9.2 CN470-510 Band Channel Frequencies**

 1097
 1098 In China, this band is defined by SRRC to be used for small scale networks covering civil
 1099 

metering applications in buildings, residential areas and villages. The transmission time shall

 1100 

not exceed one second and is limited to one channel at a time. For interferences mitigation,

 1101 

access to the physical medium requires a Listen Before Talk Adaptive Frequency Agility

 1102 

(LBT AFA) transmission management or other similar mechanisms like channels

 1103 

blacklisting.

 1104 

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

 1105 

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

 1106 

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

 1107

 1108 In the areas where channels are used by China Broadcasting Services, they SHALL be
 1109 

disabled.

 1110

 1111 For the CN470-510 MHz band, the bandwidth is the biggest and the frequency is the lowest
 1112 

compared to all the countries and areas in this document. The bandwidth and the frequency

 1113 

affect the design of antennas. There are several different antenna solutions for CN470-510

 1114 

MHz band.

 1115

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

- 1117
- The channel plan for 20 MHz antenna (type A and B)
  - The channel plan for 26 MHz antenna (type A and B)
- 1118

1119
 1120 20 common join channels are defined for all the channel plans mentioned above.
 1121

| 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                      |                        |

<sup>35</sup> Heavily modified, and not backwardly compatible with, CN470-510 as previously defined in v1.0

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

Table 49: Common join channels for CN470-510 channel frequencies

1122  
1123  
1124  
1125  
1126  
1127

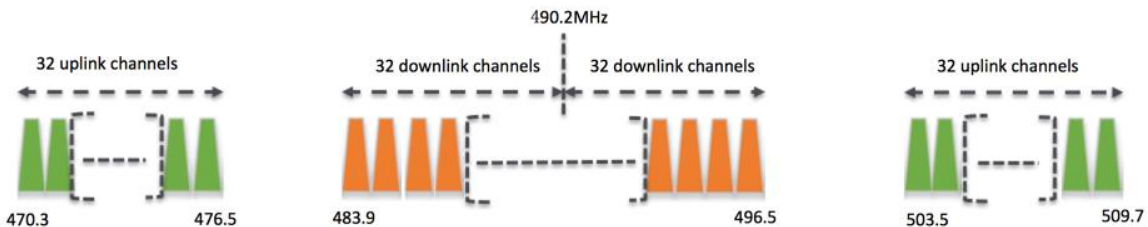
All the above channel plans SHALL be implemented in the CN470 end-devices. End devices SHALL scan all the common join channels. If the end-device receives the join-accept message from one of the above DL common join channel, the end-device SHALL use the corresponding channel plan<sup>36</sup> in the above table.

1128 **2.9.2.1 Channel Plan for 20 MHz Antenna**

1129 For 20 MHz Antennas, the CN470-510 MHz Band shall be divided into two channel plans:  
1130 plan Type A and plan Type B.

1131 For channel plan Type A:

- 1132 • Upstream (Group 1) – 32 channels numbered 0 to 31 utilizing LoRa 125 kHz BW  
1133 varying from DR0 to DR5, using coding rate 4/5, starting at 470.3 MHz and  
1134 incrementing linearly by 200 kHz to 476.5 MHz
- 1135 • Downstream (Group 1) – 32 channels numbered 0 to 31 utilizing LoRa 125 kHz BW  
1136 varying from DR0 to DR5, using coding rate 4/5, starting at 483.9 MHz and  
1137 incrementing linearly by 200 kHz to 490.1 MHz
- 1138 • Downstream (Group 2) – 32 channels numbered 32 to 63 utilizing LoRa 125 kHz BW  
1139 varying from DR0 to DR5, using coding rate 4/5, starting at 490.3 MHz and  
1140 incrementing linearly by 200 kHz to 496.5 MHz
- 1141 • Upstream (Group 2) – 32 channels numbered 32 to 63 utilizing LoRa 125 kHz BW  
1142 varying from DR0 to DR5, using coding rate 4/5, starting at 503.5 MHz and  
1143 incrementing linearly by 200 kHz to 509.7 MHz



1144

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

1146

1147 For channel plan Type B:

- 1148 • Upstream (Group 1) – 32 channels numbered 0 to 31 utilizing LoRa 125 kHz BW  
1149 varying from DR0 to DR5, using coding rate 4/5, starting at 476.9 MHz and  
1150 incrementing linearly by 200 kHz to 483.1 MHz.
- 1151 • Downstream (Group 1) – 32 channels numbered 0 to 31 utilizing LoRa 125 kHz BW  
1152 varying from DR0 to DR5, using coding rate 4/5, starting at 476.9 MHz and  
1153 incrementing linearly by 200 kHz to 483.1 MHz.
- 1154 • Upstream (Group 2) – 32 channels numbered 32 to 63 utilizing LoRa 125 kHz BW  
1155 varying from DR0 to DR5, using coding rate 4/5, starting at 496.9 MHz and

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



- 1156 incrementing linearly by 200 kHz to 503.1 MHz.  
 1157 • Downstream (Group 2) – 32 channels numbered 32 to 63 utilizing LoRa 125 kHz BW  
 1158 varying from DR0 to DR5, using coding rate 4/5, starting at 496.9 MHz and  
 1159 incrementing linearly by 200 kHz to 503.1 MHz.



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

1162 **2.9.2.2 Channel Plan for 26 MHz antenna**

1163 For 26 MHz Antennas, the CN470-510 MHz Band shall be divided into two channel plans:  
 1164 plan Type A and plan Type B.

1165 For channel plan Type A:

- 1166 • Upstream – 48 channels numbered 0 to 47 utilizing LoRa 125 kHz BW varying from  
 1167 DR0 to DR5, using coding rate 4/5, starting at 470.3 MHz and incrementing linearly by  
 1168 200 kHz to 479.7 MHz  
 1169 • Downstream – 24 channels numbered 0 to 23 utilizing LoRa 125 kHz BW at DR0 to  
 1170 DR5, starting at 490.1 MHz and incrementing linearly by 200 kHz to 494.7 MHz.  
 1171 Additional frequencies from 494.9 to 495.9 MHz are available for configurable downlink  
 1172 parameters (beacon frequency, ping-slot frequency and RX2 frequency).

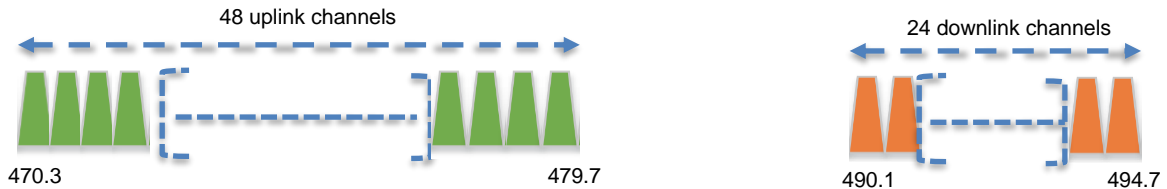


Table 52: channel plan type A for 26MHz antenna channel frequencies

1175 For channel plan Type B:

- 1176 • Upstream – 48 channels numbered 0 to 47 utilizing LoRa 125 kHz BW varying from  
 1177 DR0 to DR5, using coding rate 4/5, starting at 480.3 MHz and incrementing linearly by  
 1178 200 kHz to 489.7 MHz  
 1179 • Downstream – 24 channels numbered 0 to 23 utilizing LoRa 125 kHz BW at DR0 to  
 1180 DR5, starting at 500.1 MHz and incrementing linearly by 200 kHz to 504.7 MHz.  
 1181 Additional frequencies from 504.9 to 505.9 MHz are available for configurable downlink  
 1182 parameters (beacon frequency, ping-slot frequency and RX2 frequency).

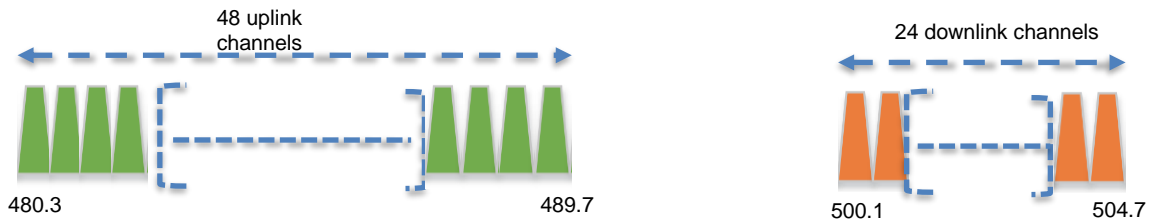


Table 53: channel plan type B for 26MHz antenna channel frequencies

1183  
 1184  
 1185



1186 If using the over-the-air activation procedure, the end-device SHALL broadcast the Join-  
 1187 Request message on a random 125 kHz channel amongst the 20 uplink channels defined  
 1188 previously in this section using **DR5 to DR0**.

1189 Personalized devices SHALL have all channels enabled corresponding to activation plan  
 1190 following a reset.

### 1191 2.9.3 CN470-510 Data Rate and End-point Output Power encoding

1192 The *TxParamSetupReq* MAC command is not implemented by CN470-510 devices.

1193 The following encoding is used for Data Rate (DR) and end-point EIRP (TXPower) in the  
 1194 CN470-510 band:

1195

| Data Rate       | Configuration                    | Indicative physical bit rate [bit/sec] | TXPower | Configuration (EIRP)             |
|-----------------|----------------------------------|--|---------|----------------------------------|
| 0 <sup>37</sup> | LoRa: SF12/ 125 kHz              | 250                                    | 0       | Max EIRP                         |
| 1               | LoRa: SF11 / 125 kHz             | 440                                    | 1       | Max EIRP – 2dB                   |
| 2               | LoRa: SF10 / 125 kHz             | 980                                    | 2       | Max EIRP – 4dB                   |
| 3               | LoRa: SF9 / 125 kHz              | 1760                                   | 3       | Max EIRP – 6dB                   |
| 4               | LoRa: SF8 / 125 kHz              | 3125                                   | 4       | Max EIRP – 8dB                   |
| 5               | LoRa:SF7 / 125 kHz               | 5470                                   | 5       | Max EIRP – 10dB                  |
| 6               | LoRa:SF7 / 500 kHz               | 21900                                  | 6       | Max EIRP – 12dB                  |
| 7               | FSK: 50 Kbps                     | 50000                                  | 7       | Max EIRP – 14dB                  |
| 8:14            | RFU                              |  | 8...14  | RFU                              |
| 15              | Defined in [TS001] <sup>38</sup> |  | 15      | Defined in [TS001] <sup>38</sup> |

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

1196

1197

1198 CN470-510 end-devices SHALL support one of the 2 following data rate options:

- 1199 1. DR0 to DR5 (minimum set supported for certification)
- 1200 2. DR0 to DR7

1201 For both of the options all data rates in the range specified SHALL be implemented  
 1202 (meaning no intermediate DR may be left unimplemented)

1203

1204 When the device is using the Adaptive Data Rate mode and transmits using the DR<sub>current</sub>  
 1205 data rate, the following table defines the next data rate (DR<sub>next</sub>) the end-device SHALL use  
 1206 during data rate back-off:

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

Table 55: CN470-510 Data Rate Backoff table

1207

<sup>37</sup> As of RP002-1.0.1, DR0 is unavailable for devices implementing CN470-510, but remains defined to better support existing implementations.

<sup>38</sup> DR15 and TXPower15 are defined in the LinkADRRReq MAC command of the LoRaWAN® 1.0.4 and subsequent specifications and were previously RFU

1208

1209 EIRP refers to the Equivalent Isotropically Radiated Power, which is the radiated output  
 1210 power referenced to an isotropic antenna radiating power equally in all directions and whose  
 1211 gain is expressed in dBi.

1212 By default, the Max EIRP is considered to be +19 dBm. If the end-device cannot achieve 19  
 1213 dBm EIRP, the Max EIRP SHOULD be communicated to the network server using an out-of-  
 1214 band channel during the end-device commissioning process.

## 1215 2.9.4 CN470-510 Join-Accept CFList

1216

1217 The CN470 LoRaWAN® supports the use of the OPTIONAL CFList appended to the Join-  
 1218 Accept message. If the CFList is not empty, then the CFListType field SHALL contain the  
 1219 value one (0x01) to indicate the CFList contains a series of ChMask fields. The ChMask  
 1220 fields are interpreted as being controlled by a virtual ChMaskCntl that initializes to a value of  
 1221 zero (0) and increments for each ChMask field to a value of four (3) for 20 MHz plans A or B  
 1222 and three (2) for 26 MHz plans A or B. (The first 16 bits controls the channels 0 to 15...)  
 1223

1224

For 20 MHz Antenna Systems:

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

1225

1226

For 26 MHz Antenna Systems:

1227

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

1228

## 1229 2.9.5 CN470-510 LinkAdrReq command

### 1230 2.9.5.1 Channel Plan for 20 MHz antenna

1231

1232 For 20 MHz antenna the ChMaskCntl field of the *LinkADRReq* command has the following  
 1233 meaning:

| ChMaskCntl | ChMask applies to                   |
|------------|-------------------------------------|
| 0          | Channels 0 to 15                    |
| 1          | Channels 16 to 31                   |
| 2          | Channels 32 to 47                   |
| 3          | Channels 48 to 63                   |
| 4          | RFU                                 |
| 5          | RFU                                 |
| 6          | All Channels Enabled                |
| 7          | All Channels Disabled <sup>39</sup> |

1234

Table 56:CH470 ChMaskCntl value table for 20M Antenna

<sup>39</sup> This command must be followed by another LinkADRReq command enabling at least one channel.

1235

1236 If the ChMask field value is one of the values indicating RFU, then end-device SHALL reject  
 1237 the command and unset the “**Channel mask ACK**” bit in its response.

### 1238 2.9.5.2 Channel Plan for 26 MHz antenna

1239

1240 The ChMaskCntl field of the *LinkADRReq* command has the following meaning:

1241

| ChMaskCntl | ChMask applies to                   |
|------------|-------------------------------------|
| 0          | Channels 0 to 15                    |
| 1          | Channels 16 to 31                   |
| 2          | Channels 32 to 47                   |
| 3          | All channels Enabled                |
| 4          | All channels Disabled <sup>40</sup> |
| 5          | RFU                                 |
| 6          | RFU                                 |
| 7          | RFU                                 |

Table 57: CH470 ChMaskCntl value table for 26M Antenna

1242

1243

1244 If the ChMask field value is one of the values indicating RFU, the end-device SHALL reject  
 1245 the command and unset the “**Channel mask ACK**” bit in its response.

### 1246 2.9.6 CN470-510 Maximum payload size

1247 The maximum **MACPayload** size length (*M*) is given by the following table. It is derived from  
 1248 the maximum allowed transmission time at the PHY layer taking into account a possible  
 1249 repeater encapsulation. The maximum application payload length in the absence of the  
 1250 OPTIONAL **FOpts** MAC control field (*N*) is also given for information only. The value of *N*  
 1251 might be smaller if the **FOpts** field is not empty:

1252

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

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

1253

1254 If the end-device will never operate with a repeater then the maximum application payload  
 1255 length in the absence of the OPTIONAL **FOpts** control field SHALL be:

1256

| Data Rate       | M   | N   |
|-----------------|-----|-----|
| 0 <sup>37</sup> | N/A | N/A |
| 1               | 31  | 23  |
| 2               | 94  | 86  |
| 3               | 192 | 184 |
| 4               | 250 | 242 |

<sup>40</sup> This command must be followed by another *LinkADRReq* command enabling at least one channel

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

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

 1257  
1258

### 1259 2.9.7 CN470-510 Receive windows

1260 The RX1 data rate depends on the transmit data rate (see Table 60 below).

1261 The RX2 default data rate is DR1.

1262

| Upstream data rate<br>RX1DROffset | Downstream data rate |     |     |     |     |     |
|-----------------------------------|----------------------|-----|-----|-----|-----|-----|
|                                   | 0                    | 1   | 2   | 3   | 4   | 5   |
| DR0 <sup>37</sup>                 | DR0                  | DR0 | DR0 | DR0 | DR0 | DR0 |
| DR1                               | DR1                  | DR1 | DR1 | DR1 | DR1 | DR1 |
| DR2                               | DR2                  | DR1 | DR1 | DR1 | DR1 | DR1 |
| DR3                               | DR3                  | DR2 | DR1 | DR1 | DR1 | DR1 |
| DR4                               | DR4                  | DR3 | DR2 | DR1 | DR1 | DR1 |
| DR5                               | DR5                  | DR4 | DR3 | DR2 | DR1 | DR1 |
| DR6                               | DR6                  | DR5 | DR4 | DR3 | DR2 | DR1 |
| DR7                               | DR7                  | DR6 | DR5 | DR4 | DR3 | DR2 |

Table 60: CN470-510 downlink RX1 data rate mapping

 1263  
1264

 1265 The allowed values for RX1DROffset are in the [0:5] range. Values in the range [6:7] are  
1266 reserved for future use.

#### 1267 2.9.7.1 Channel Plan for 20 MHz Antenna Systems

1268 For channel plan Type A:

- 1269 ○ The RX1 downlink channel is the same as the uplink channel number
- 1270 ○ The RX2 channel number for OTAA devices is defined in Table 61
- 1271 ○ The RX2 channel number for ABP devices is 486.9 MHz

1272

| 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

1273

1274 For channel plan Type B:

- 1275 ○ The RX1 downlink channel is the same as the uplink channel number
- 1276 ○ The RX2 channel number for OTAA devices is defined in Table 62
- 1277 ○ The RX2 channel number for ABP devices is 498.3 MHz

1278

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

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

 1279 **Table 62: RX2 Default Frequency for channel plan type B for 20 MHz antenna**

 1280 **2.9.7.2 Channel Plan for 26 MHz Antenna Systems**

- 1281 • For both plans, the RX1 receive channel is a function of the upstream channel used to
- 1282 initiate the data exchange. The RX1 receive channel can be determined as follows.
- 1283 ○ RX1 Channel Number = Transmit Channel Number modulo 24
- 1284 • The RX2 default frequency is:
- 1285 ○ For Channel plan A: 492.5 MHz
- 1286 ○ For Channel plan B: 502.5 MHz

 1287 **2.9.8 CN470-510 Class B beacon**

 1288 The beacon frame content is defined in [TS001].<sup>41</sup>

1289 The beacons are transmitted using the following settings:

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

 1292 **Table 63 : CN470-510 beacon settings**

 1293 **2.9.8.1 Default Beacon and Ping-Slot Channel Numbers and Ping-Slots for 20 MHz**  
 1294 **Antenna Systems**

1295 By default, for channel plan Type A:

 1296 The downstream channel used for beacon is as the following table according to the common  
 1297 join channel the end-device used:

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

 1299 **Table 64: Beacon Channel Number for channel plan type A for 20 MHz antenna**

<sup>41</sup> Prior to LoRaWAN<sup>®</sup> 1.0.4, the beacon was defined here as:

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

1300  
1301  
1302  
1303  
1304  
1305  
1306  
1307  
1308  
1309

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

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

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

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

1310  
1311  
1312  
1313  
1314  
1315

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

1316  
1317  
1318  
1319  
1320  
1321  
1322  
1323  
1324  
1325  
1326

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

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

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

1327  
1328

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

1329 **2.9.8.2 Default Beacon and Ping-Slot Frequencies for 26 MHz antenna Systems**

1330 By default, beacons and downlink ping-slot messages are transmitted using the following  
1331 frequencies:

1332 For Channel Plan A: 494.9 MHz

1333 For Channel Plan B: 504.9 MHz

1334 **2.9.9 CN470-510 Default Settings**

1335 There are no specific default settings for the CN470-510 MHz Band.



1336 **2.10 AS923 MHz Band**

 1337 **2.10.1 AS923 Preamble Format**

1338 Please refer to Section 3.0 Physical Layer.

 1339 **2.10.2 AS923 Band Channel Frequencies**

 1340 This section was originally intended to apply to regions where the frequencies [915...928 MHz]  
 1341 are present in an unlicensed LPWAN band but MAY also apply to regions with available bands  
 1342 in frequencies up to 1.67 GHz.

 1343 In order to accommodate country specific sub-bands across 915 - 928 MHz band, a frequency  
 1344 offset parameter **AS923\_FREQ\_OFFSET** is defined. **AS923\_FREQ\_OFFSET** is a 32-bit  
 1345 signed integer, allowing both positive and negative frequency offsets.

1346 The corresponding frequency offset in Hz is:

1347 
$$\mathbf{AS923\_FREQ\_OFFSET\_HZ} = 100 \times \mathbf{AS923\_FREQ\_OFFSET}.$$

 1348 **AS923\_FREQ\_OFFSET** only applies to end-device default settings. **AS923\_FREQ\_OFFSET**  
 1349 does not apply any frequencies delivered to end-device from network server through MAC  
 1350 commands or the CFList.

 1351 AS923 end-devices operated in Japan SHALL perform Listen Before Talk (LBT) based on  
 1352 ARIB STD-T108 regulations. The ARIB STD-T108 regulation is available for free and should  
 1353 be consulted as needed by the user.

 1354 The end-device's LBT requirement, maximum transmission time, duty cycle or other  
 1355 parameters MAY be dependent on frequency of each transmission.

 1356 The network channels can be freely assigned by the network operator. However, the two  
 1357 following default channels SHALL be implemented in every AS923 end-device. Those  
 1358 channels are the minimum set that all network gateways SHALL always be listening on.  
 1359

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

 1360 **Table 68: AS923 default channels**

 1361 For devices compliant with TS001-1.0.x, those default channels SHALL NOT be modified  
 1362 through the **NewChannelReq** command. For devices compliant with TS001-1.1.x and  
 1363 beyond, these channels MAY be modified through the **NewChannelReq** but SHALL be reset  
 1364 during the backoff procedure defined in TS001-1.1.1 to guarantee a minimal common channel  
 1365 set between end-devices and network gateways.

1366 AS923 end-devices SHOULD use the following default parameters

- 1367
- Default EIRP: 16 dBm

 1368 AS923 end-devices SHALL feature a channel data structure to store the parameters of at least  
 1369 16 channels. A channel data structure corresponds to a frequency and a set of data rates  
 1370 usable on this frequency.

 1371 The following table gives the list of frequencies that SHALL be used by end-devices to  
 1372 broadcast the Join-Request message.

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

Table 69: AS923 Join-Request Channel List

1373

1374

1375 The default Join-Request Data Rate utilizes the range DR2-DR5 (SF10/125 kHz – SF7/125  
1376 kHz), this setting ensures that end-devices are compatible with the 400ms dwell time limitation  
1377 until the actual dwell time limit is notified to the end-device by the network server via the MAC  
1378 command **TxParamSetupReq**.

1379

1380 The Join-Request message transmit duty-cycle SHALL follow the rules described in chapter  
1381 “Retransmissions back-off” of the LoRaWAN® specification document.

### 1382 2.10.3 AS923 Data Rate and End-point Output Power encoding

1383 The “TxParamSetupReq/Ans” MAC command SHALL be implemented by the AS923 devices.

1384 The following encoding is used for Data Rate (DR) in the AS923 band:

1385

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

Table 70: AS923 Data rate table

1386

1387

1388 AS923 end-devices SHALL support one of the 2 following data rate options:

- 1389 1. DR0 to DR5 (minimum set supported for certification)
- 1390 2. DR0 to DR7

1391 For both of the options all data rates in the range specified SHALL be implemented  
1392 (meaning no intermediate DR may be left unimplemented)

1393

1394 When the device is using the Adaptive Data Rate mode and transmits using the DR<sub>current</sub>  
1395 data rate, the following table defines the next data rate (DR<sub>next</sub>) the end-device SHALL use  
1396 during data rate back-off:

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

<sup>42</sup> DR15 and TXPower15 are defined in the LinkADRRReq MAC command of the LoRaWAN® 1.0.4 and subsequent specifications and were previously RFU

|   |   |   |    |
|---|---|---|----|
| 2 | 1 | 2 | NA |
| 3 | 2 | 3 | 2  |
| 4 | 3 | 4 | 3  |
| 5 | 4 | 5 | 4  |
| 6 | 5 | 6 | 5  |
| 7 | 6 | 7 | 6  |

Table 71: AS923 Data Rate Backoff table

1397

1398

 1399 The TXPower table indicates power levels relative to the Max EIRP level of the end-device,  
 1400 as per the following table:

1401

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

Table 72: AS923 TXPower table

1402

1403

 1404 EIRP refers to the Equivalent Isotropically Radiated Power, which is the radiated output  
 1405 power referenced to an isotropic antenna radiating power equally in all directions and whose  
 1406 gain is expressed in dBi.

 1407 By default, the Max EIRP SHALL be 16 dBm. The Max EIRP can be modified by the network  
 1408 server through the ***TxParamSetupReq*** MAC command and SHOULD be used by both the  
 1409 end-device and the network server once ***TxParamSetupReq*** is acknowledged by the device  
 1410 via ***TxParamSetupAns***,

#### 1411 2.10.4 AS923 Join-Accept CFList

 1412 The AS923 LoRaWAN® implements an OPTIONAL channel frequency list (CFList) of 16 octets  
 1413 in the Join-Accept message.

 1414 In this case the CFList is a list of five channel frequencies for the channels two to six whereby  
 1415 each frequency is encoded as a 24 bits unsigned integer (three octets). All these channels are  
 1416 usable for DR0 to DR5 125 KHz LoRa modulation subject to local regulatory dwell-time  
 1417 limitations. The list of frequencies is followed by a single CFListType octet for a total of 16  
 1418 octets. The CFListType SHALL be equal to zero (0) to indicate that the CFList contains a list  
 1419 of frequencies.

1420

|                     |          |          |          |          |          |            |
|---------------------|----------|----------|----------|----------|----------|------------|
| <b>Size (bytes)</b> | 3        | 3        | 3        | 3        | 3        | 1          |
| <b>CFList</b>       | Freq Ch2 | Freq Ch3 | Freq Ch4 | Freq Ch5 | Freq Ch6 | CFListType |

1421

 1422 The actual channel frequency in Hz is 100 x frequency whereby values representing  
 1423 frequencies below 100 MHz are reserved for future use. This allows setting the frequency of

1424 a channel anywhere between 100 MHz and 1.678 GHz in 100 Hz steps. Unused channels  
 1425 have a frequency value of 0. The CFList is OPTIONAL and its presence can be detected by  
 1426 the length of the join-accept message. If present, the CFList replaces all the previous channels  
 1427 stored in the end-device apart from the two default channels. The newly defined channels are  
 1428 immediately enabled and usable by the end-device for communication.

1429 **AS923\_FREQ\_OFFSET** does not apply any frequencies delivered to end-device from network  
 1430 server through MAC commands or the CFList. Therefore, AS923 end-devices SHALL NOT  
 1431 apply **AS923\_FREQ\_OFFSET** to the channel frequencies defined in the CFList

### 1432 2.10.5 AS923 LinkAdrReq command

1433 The AS923 LoRaWAN<sup>®</sup> only supports a maximum of 16 channels. When **ChMaskCntl** field  
 1434 is 0 the ChMask field individually enables/disables each of the 16 channels.  
 1435

| 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  |

1436 **Table 73: AS923 ChMaskCntl value table**

1437 If the ChMask field value is one of values meaning RFU, the end-device SHALL reject the  
 1438 command and unset the “**Channel mask ACK**” bit in its response.

### 1439 2.10.6 AS923 Maximum payload size

1440 The maximum **MACPayload** size length ( $M$ ) is given by the following table for both  
 1441 **UplinkDwellTime** and **DownlinkDwellTime** configurations: No Limit and 400ms. It is derived  
 1442 from the maximum allowed transmission time at the PHY layer taking into account a possible  
 1443 repeater encapsulation layer. The maximum application payload length in the absence of the  
 1444 OPTIONAL **FOpts** MAC control field ( $N$ ) is also given for information only. The value of  $N$   
 1445 might be smaller if the **FOpts** field is not empty:

| Data Rate | DwellTime=0<br>(No limit) |     | DwellTime=1<br>(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                   |     |

1446 **Table 74: AS923 maximum payload size (repeater compatible)**

1448 If the end-device will never operate with a repeater then the maximum application payload  
 1449 length in the absence of the OPTIONAL **FOpts** control field SHALL be:

1450

| Data Rate | DwellTime=0<br>(No limit) |     | DwellTime=1<br>(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                   |     |

1451

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

1452 The end-device SHALL only enforce the maximum Downlink MAC Payload Size defined for  
 1453 DownlinkDwellTime = 0 (no dwell time enforced) regardless of the actual setting. This  
 1454 prevents the end-device from discarding valid downlink messages which comply with the  
 1455 regulatory requirements which may be unknown to the device (for example, when the device  
 1456 is joining the network).

### 1457 2.10.7 AS923 Receive windows

1458 By default, the RX1 receive window uses the same channel as the preceding uplink. The data  
 1459 rate is a function of the uplink data rate and the RX1DROffset as given by the following table.  
 1460 The allowed values for RX1DROffset are in the [0:7] range.

1461 Values in the [6:7] range allow setting the Downstream RX1 data rate higher than upstream  
 1462 data rate<sup>43</sup>.

1463 When **DownlinkDwellTime** is zero, the allowed values for RX1DROffset are in the [0:7] range,  
 1464 encoded as per the below table.

1465

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

1466

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

1467

1468 When **DownlinkDwellTime** is one, the allowed values for RX1DROffset are in the [0:7] range,  
 1469 encoded as per the below table.

1470

<sup>43</sup> 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<br>RX1DROffset | Downstream data rate |     |     |     |     |     |     |     |
|-----------------------------------|----------------------|-----|-----|-----|-----|-----|-----|-----|
|                                   | 0                    | 1   | 2   | 3   | 4   | 5   | 6   | 7   |
| DR0                               | DR2                  | DR2 | DR2 | DR2 | DR2 | DR2 | DR2 | DR2 |
| DR1                               | DR2                  | DR2 | DR2 | DR2 | DR2 | DR2 | DR2 | DR3 |
| DR2                               | DR2                  | DR2 | DR2 | DR2 | DR2 | DR2 | DR3 | DR4 |
| DR3                               | DR3                  | DR2 | DR2 | DR2 | DR2 | DR2 | DR4 | DR5 |
| DR4                               | DR4                  | DR3 | DR2 | DR2 | DR2 | DR2 | DR5 | DR6 |
| DR5                               | DR5                  | DR4 | DR3 | DR2 | DR2 | DR2 | DR6 | DR7 |
| DR6                               | DR6                  | DR5 | DR4 | DR3 | DR2 | DR2 | DR7 | DR7 |
| DR7                               | DR7                  | DR6 | DR5 | DR4 | DR3 | DR2 | DR7 | DR7 |

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

1471

1472 The RX2 receive window uses a fixed frequency and data rate. The default parameters are  
1473 923.2 MHz + **AS923\_FREQ\_OFFSET\_HZ** / DR2 (SF10/125 kHz).

### 1474 2.10.8 AS923 Class B beacon and default downlink channel

1475 The beacons SHALL be transmitted using the following settings

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

1476

Table 78 : AS923 beacon settings

1477 The beacon frame content is defined in [TS001].<sup>44</sup>

1478 The beacon default broadcast frequency is 923.4 MHz + **AS923\_FREQ\_OFFSET\_HZ**.

1479 The class B default downlink pingSlot frequency is 923.4 MHz + **AS923\_FREQ\_OFFSET\_HZ**.

### 1480 2.10.9 AS923 Default Settings

1481 Several default values of **AS923\_FREQ\_OFFSET** are defined to address all the different  
1482 AS923 countries. The default values of **AS923\_FREQ\_OFFSET** are chosen to minimize their  
1483 total number and cover a large number of countries. Four different groups are defined below  
1484 according to **AS923\_FREQ\_OFFSET** default value.

1485 **Group AS923-1: AS923\_FREQ\_OFFSET default value = 0x00000000,**

1486 **AS923\_FREQ\_OFFSET\_HZ = 0.0 MHz**

1487 This group is composed of countries having available frequencies in the 915 – 928  
1488 MHz range with common channels in the 923.0 – 923.5 MHz sub-band. These are the  
1489 “historical” AS923 countries, compliant to RP2-1.0.0 specification and previous  
1490 versions.

1491 **Group AS923-2: AS923\_FREQ\_OFFSET default value = 0xFFFFB9B0,**

1492 **AS923\_FREQ\_OFFSET\_HZ = -1.80 MHz**

1493 This group is composed of countries having available frequencies in the 920 – 923  
1494 MHz range with common channels in the 921.4 – 922.0 MHz sub-band.

<sup>44</sup> Prior to LoRaWAN<sup>®</sup> 1.0.4, the beacon was defined here as:

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

- 1495 **Group AS923-3: AS923\_FREQ\_OFFSET default value = 0xFFFEFE30,**  
1496 **AS923\_FREQ\_OFFSET\_HZ = -6.60 MHz**
- 1497           This group is composed of countries having available frequencies in the 915 – 921  
1498           MHz range with common channels in the 916.5 – 917.0 MHz sub-band.
- 1499 **Group AS923-4: AS923\_FREQ\_OFFSET default value = 0xFFFF1988,**  
1500 **AS923\_FREQ\_OFFSET\_HZ = -5.90 MHz**
- 1501           This group is composed of countries having available frequencies in the 917 – 920  
1502           MHz range with common channels in the 917.3 – 917.5 MHz sub-band.
- 1503
- 1504 There are no other specific default settings for the AS923 Band.



1505 **2.11 KR920-923 MHz Band**

 1506 **2.11.1 KR920-923 Preamble Format**

1507 Please refer to Section 3.0 Physical Layer.

 1508 **2.11.2 KR920-923 Band Channel Frequencies**

 1509 The center frequency, bandwidth and maximum EIRP output power for the South Korea  
 1510 RFID/USN frequency band are defined by Korean Government, which has allocated LPWA  
 1511 based IoT networks the channel center frequencies from 920.9 to 923.3 MHz.

1512

| 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          |

1513

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

 1514 The three default channels correspond to 922.1, 922.3 and 922.5 MHz / DR0 to DR5 and  
 1515 SHALL be implemented in every KR920-923 end-device. For devices compliant with TS001-  
 1516 1.0.x, those default channels SHALL NOT be modified through the **NewChannelReq**  
 1517 command. For devices compliant with TS001-1.1.x and beyond, these channels MAY be  
 1518 modified through the **NewChannelReq** but SHALL be reset during the backoff procedure  
 1519 defined in TS001-1.1.1 to guarantee a minimal common channel set between end-devices  
 1520 and network gateways.

 1521 The following table gives the list of frequencies that SHALL be used by end-devices to  
 1522 broadcast the Join-Request message. The Join-Request message transmit duty-cycle SHALL  
 1523 follow the rules described in chapter “Retransmissions back-off” of the LoRaWAN®  
 1524 specification document.

1525

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

1526

**Table 80: KR920-923 default channels**

 1527 In order to access the physical medium, the South Korea regulations impose several  
 1528 restrictions. The South Korea regulations allow the choice of using either a duty-cycle  
 1529 limitation or Listen Before Talk Adaptive Frequency Agility (LBT AFA) transmission  
 1530 management. The current LoRaWAN® specification for the KR920-923 band exclusively uses

1531 LBT channel access rule to maximize MACPayload size length and comply with the South  
1532 Korea regulations.

1533 KR920-923 MHz band end-devices SHALL use the following default parameters

- 1534 • Default EIRP output power for end-device(920.9~921.9 MHz): 10 dBm
- 1535 • Default EIRP output power for end-device(922.1~923.3 MHz): 14 dBm
- 1536 • Default EIRP output power for gateway: 23 dBm

1537 KR920-923 MHz end-devices SHALL be capable of operating in the 920 to 923 MHz frequency  
1538 band and SHALL feature a channel data structure to store the parameters of at least 16  
1539 channels. A channel data structure corresponds to a frequency and a set of data rates usable  
1540 on this frequency.

1541 The following table gives the list of frequencies that SHALL be used by end-devices to  
1542 broadcast the Join-Request message.

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

1543 **Table 81: KR920-923 Join-Request Channel List**

### 1544 2.11.3 KR920-923 Data Rate and End-device Output Power encoding

1545 There is no dwell time limitation for the KR920-923 PHY layer. The *TxParamSetupReq* MAC  
1546 command is not implemented by KR920-923 devices.

1547 The following encoding is used for Data Rate (DR), and EIRP Output Power (TXPower) in the  
1548 KR920-923 band:

1549

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

**Table 82: KR920-923 TX Data rate table**

1550

1551

1552 KR920-923 end-devices SHALL support the following data rates:

- 1553 1. DR0 to DR5 (minimum set supported for certification)

1554 All data rates in the range specified SHALL be implemented (meaning no intermediate DR  
1555 may be left unimplemented)

1556

1557 When the device is using the Adaptive Data Rate mode and transmits using the DR<sub>current</sub>  
1558 data rate, the following table defines the next data rate (DR<sub>next</sub>) the end-device SHALL use  
1559 during data rate back-off:

<sup>45</sup> DR15 and TXPower15 are defined in the LinkADRRReq MAC command of the LoRaWAN1.0.4 and subsequent specifications and were previously RFU

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

Table 83: KR920-923 Data Rate Backoff table

 1560  
1561

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

Table 84: KR920-923 TX power table

 1562  
1563

1564 EIRP refers to the Equivalent Isotropically Radiated Power, which is the radiated output  
1565 power referenced to an isotropic antenna radiating power equally in all directions and whose  
1566 gain is expressed in dBi.

1567 By default, the Max EIRP is considered to be +14 dBm. If the end-device cannot achieve 14  
1568 dBm EIRP, the Max EIRP SHOULD be communicated to the network server using an out-of-  
1569 band channel during the end-device commissioning process.

1570

1571 When the device transmits in a channel whose frequency is <922 MHz, the transmit power  
1572 SHALL be limited to +10 dBm EIRP even if the current transmit power level set by the  
1573 network server is higher.

#### 1574 2.11.4 KR920-923 Join-Accept CFList

1575 The KR920-923 band LoRaWAN® implements an OPTIONAL **channel frequency list**  
1576 (CFList) of 16 octets in the Join-Accept message.

1577 In this case the CFList is a list of five channel frequencies for the channels three to seven  
1578 whereby each frequency is encoded as a 24 bits unsigned integer (three octets). All these  
1579 channels are usable for DR0 to DR5 125 kHz LoRa modulation. The list of frequencies is  
1580 followed by a single CFListType octet for a total of 16 octets. The CFListType SHALL be equal  
1581 to zero (0) to indicate that the CFList contains a list of frequencies.

1582

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

1583 The actual channel frequency in Hz is 100 x frequency whereby values representing  
1584 frequencies below 100 MHz are reserved for future use. This allows setting the frequency of  
1585 a channel anywhere between 100 MHz to 1.678 GHz in 100 Hz steps. Unused channels have  
1586 a frequency value of 0. The **CFList** is OPTIONAL and its presence can be detected by the

1587 length of the join-accept message. If present, the **CFList** replaces all the previous channels  
 1588 stored in the end-device apart from the three default channels. The newly defined channels  
 1589 are immediately enabled and usable by the end-device for communication.

### 1590 2.11.5 KR920-923 LinkAdrReq command

1591 The KR920-923 LoRaWAN® only supports a maximum of 16 channels. When **ChMaskCntl**  
 1592 field is 0 the ChMask field individually enables/disables each of the 16 channels.

1593

| 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

1594  
 1595

1596 If the ChMaskCntl field value is one of values meaning RFU, the end-device SHALL<sup>46</sup> reject  
 1597 the command and unset the “**Channel mask ACK**” bit in its response.

### 1598 2.11.6 KR920-923 Maximum payload size

1599 The maximum **MACPayload** size length (*M*) is given by the following table for the regulation  
 1600 of dwell time; less than 4 sec with LBT. It is derived from limitation of the PHY layer depending  
 1601 on the effective modulation rate used taking into account a possible repeater encapsulation  
 1602 layer. The maximum application payload length in the absence of the OPTIONAL **FOpts**  
 1603 control field (*N*) is also given for information only. The value of N might be smaller if the **FOpts**  
 1604 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)

1605

1606 If the end-device will never operate with a repeater then the maximum application payload  
 1607 length in the absence of the OPTIONAL **FOpts** control field SHOULD be:

1608

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

<sup>46</sup> 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)

1609  
1610

### 1611 2.11.7 KR920-923 Receive windows

1612 By default, the RX1 receive window uses the same channel as the preceding uplink. The data  
1613 rate is a function of the uplink data rate and the RX1DROffset as given by the following table.  
1614 The allowed values for RX1DROffset are in the [0:5] range. Values in the [6:7] range are  
1615 reserved for future use.

1616

| Upstream data rate<br>RX1DROffset | Downstream data rate |     |     |     |     |     |
|-----------------------------------|----------------------|-----|-----|-----|-----|-----|
|                                   | 0                    | 1   | 2   | 3   | 4   | 5   |
| DR0                               | DR0                  | DR0 | DR0 | DR0 | DR0 | DR0 |
| DR1                               | DR1                  | DR0 | DR0 | DR0 | DR0 | DR0 |
| DR2                               | DR2                  | DR1 | DR0 | DR0 | DR0 | DR0 |
| DR3                               | DR3                  | DR2 | DR1 | DR0 | DR0 | DR0 |
| DR4                               | DR4                  | DR3 | DR2 | DR1 | DR0 | DR0 |
| DR5                               | DR5                  | DR4 | DR3 | DR2 | DR1 | DR0 |

1617

Table 88 : KR920-923 downlink RX1 data rate mapping

1618 The RX2 receive window uses a fixed frequency and data rate. The default parameters are  
1619 921.90 MHz / DR0 (SF12, 125 kHz).

### 1620 2.11.8 KR920-923 Class B beacon and default downlink channel

1621 The beacons SHALL be transmitted using the following settings

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

1622

Table 89 : KR920-923 beacon settings

1623

1624 The beacon frame content is defined in [TS001].<sup>47</sup>

1625 The beacon default broadcast frequency is 923.1 MHz.

1626 The class B default downlink pingSlot frequency is 923.1 MHz

### 1627 2.11.9 KR920-923 Default Settings

1628 There are no specific default settings for the KR920-923 MHz Band.

<sup>47</sup> Prior to LoRaWAN 1.0.4, the beacon was defined here as:

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

1629 **2.12 IN865-867 MHz Band**

 1630 **2.12.1 IN865-867 Preamble Format**

1631 Please refer to Section 3.0 Physical Layer.

 1632 **2.12.2 IN865-867 Band Channel Frequencies**

1633 This section applies to the Indian sub-continent.

 1634 The network channels can be freely attributed by the network operator. However, the three  
 1635 following default channels SHALL be implemented in every India 865-867 MHz end-device.  
 1636 Those channels are the minimum set that all network gateways SHALL be listening on.

1637

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

1638

Table 90: IN865-867 default channels

 1639 End-devices SHALL be capable of operating in the 865 to 867 MHz frequency band and  
 1640 should feature a channel data structure to store the parameters of at least 16 channels. A  
 1641 channel data structure corresponds to a frequency and a set of data rates usable on this  
 1642 frequency.

 1643 The first three channels correspond to 865.0625, 865.4025, and 865.985 MHz / DR0 to DR5  
 1644 and SHALL be implemented in every end-device. For devices compliant with TS001-1.0.x,  
 1645 those default channels SHALL NOT be modified through the **NewChannelReq** command. For  
 1646 devices compliant with TS001-1.1.x and beyond, these channels MAY be modified through  
 1647 the **NewChannelReq** but SHALL be reset during the backoff procedure defined in TS001-  
 1648 1.1.1 to guarantee a minimal common channel set between end-devices and network  
 1649 gateways.

 1650 The following table gives the list of frequencies that SHALL be used by end-devices to  
 1651 broadcast the Join-Request message. The Join-Request message transmit duty-cycle SHALL  
 1652 follow the rules described in chapter "Retransmissions back-off" of the LoRaWAN®  
 1653 specification document.

1654

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

1655

Table 91: IN865-867 Join-Request Channel List

 1656 **2.12.3 IN865-867 Data Rate and End-device Output Power Encoding**

 1657 There is no dwell time or duty-cycle limitation for the INDIA 865-867 PHY layer. The  
 1658 **TxParamSetupReq** MAC command is not implemented by INDIA 865-867 devices.

 1659 The following encoding is used for Data Rate (DR) and End-device Output Power (TXPower)  
 1660 in the INDIA 865-867 band:

1661

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

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

**Table 92: IN865-867 TX Data rate table**

1662  
1663  
1664  
1665  
1666  
1667  
1668  
1669  
1670  
1671  
1672

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

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

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

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

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

**Table 93: IN865-867 DataRate Backoff table**

1673  
1674  
1675  
1676  
1677

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

| TXPower | Configuration (EIRP)             |
|---------|----------------------------------|
| 0       | Max EIRP                         |
| 1       | Max EIRP – 2dB                   |
| 2       | Max EIRP – 4dB                   |
| 3       | Max EIRP – 6dB                   |
| 4       | Max EIRP – 8dB                   |
| 5       | Max EIRP – 10dB                  |
| 6       | Max EIRP – 12dB                  |
| 7       | Max EIRP – 14dB                  |
| 8       | Max EIRP – 16dB                  |
| 9       | Max EIRP – 18dB                  |
| 10      | Max EIRP – 20dB                  |
| 11..14  | RFU                              |
| 15      | Defined in [TS001] <sup>48</sup> |

**Table 94: IN865-867 TXPower table**

1678  
1679

<sup>48</sup> DR15 and TXPower15 are defined in the LinkADRRReq MAC command of the LoRaWAN1.0.4 and subsequent specifications and were previously RFU



1680 EIRP refers to the Equivalent Isotropically Radiated Power, which is the radiated output power  
 1681 referenced to an isotropic antenna radiating power equally in all directions and whose gain is  
 1682 expressed in dBi.

1683 By default, Max EIRP is considered to be 30 dBm. If the end-device cannot achieve 30 dBm  
 1684 EIRP, the Max EIRP SHOULD be communicated to the network server using an out-of-band  
 1685 channel during the end-device commissioning process.

#### 1686 2.12.4 IN865-867 Join-Accept CFList

1687 The India 865-867 band LoRaWAN<sup>®</sup> implements an OPTIONAL **channel frequency list**  
 1688 (CFList) of 16 octets in the Join-Accept message.

1689 In this case the CFList is a list of five channel frequencies for the channels three to seven  
 1690 whereby each frequency is encoded as a 24 bits unsigned integer (three octets). All these  
 1691 channels are usable for DR0 to DR5 125 kHz LoRa modulation.

1692 The list of frequencies is followed by a single CFListType octet for a total of 16 octets. The  
 1693 CFListType SHALL be equal to zero (0) to indicate that the CFList contains a list of  
 1694 frequencies.

1695

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

1696

1697 The actual channel frequency in Hz is 100 x frequency whereby values representing  
 1698 frequencies below 100 MHz are reserved for future use. This allows setting the frequency of  
 1699 a channel anywhere between 100 MHz to 1.678 GHz in 100 Hz steps. Unused channels have  
 1700 a frequency value of 0. The **CFList** is OPTIONAL and its presence can be detected by the  
 1701 length of the join-accept message. If present, the **CFList** replaces all the previous channels  
 1702 stored in the end-device apart from the three default channels. The newly defined channels  
 1703 are immediately enabled and usable by the end-device for communication.

#### 1704 2.12.5 IN865-867 LinkAdrReq command

1705 The INDIA 865-867 LoRaWAN<sup>®</sup> only supports a maximum of 16 channels. When  
 1706 **ChMaskCntl** field is 0 the ChMask field individually enables/disables each of the 16 channels.  
 1707

| 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  |

1708

Table 95: IN865-867 ChMaskCntl value table

1709 If the ChMaskCntl field value is one of values meaning RFU, the end-device SHALL<sup>49</sup> reject  
 1710 the command and unset the “**Channel mask ACK**” bit in its response.

<sup>49</sup> Made SHALL from SHOULD starting in LoRaWAN<sup>®</sup> Regional Parameters Specification 1.0.3rA

1711 **2.12.6 IN865-867 Maximum payload size**

 1712 The maximum **MACPayload** size length ( $M$ ) is given by the following table. It is derived from  
 1713 limitation of the PHY layer depending on the effective modulation rate used taking into account  
 1714 a possible repeater encapsulation layer. The maximum application payload length in the  
 1715 absence of the OPTIONAL **FOpts** control field ( $N$ ) is also given for information only. The value  
 1716 of  $N$  might be smaller if the **FOpts** field is not empty:  
 1717

| 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 |     |

 1718 **Table 96: IN865-867 maximum payload size (repeater compatible)**

 1719 If the end-device will never operate with a repeater then the maximum application payload  
 1720 length in the absence of the OPTIONAL **FOpts** control field SHOULD be:  
 1721

| 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 |     |

 1722 **Table 97 : IN865-867 maximum payload size (not repeater compatible)**

 1723 **2.12.7 IN865-867 Receive windows**

 1724 By default, the RX1 receive window uses the same channel as the preceding uplink. The data  
 1725 rate is a function of the uplink data rate and the RX1DROffset as given by the following table.  
 1726 The allowed values for RX1DROffset are in the [0:7] range.

 1727 Values in the [6:7] range allow setting the Downstream RX1 data rate higher than upstream  
 1728 data rate<sup>50</sup>.

1729 The allowed values for RX1DROffset are in the [0:7] range, encoded as per the below table:

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

<sup>50</sup> 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.

1730 **Table 98: IN865-867 downlink RX1 data rate mapping**

1731 The RX2 receive window uses a fixed frequency and data rate. The default parameters are  
 1732 866.550 MHz / DR2 (SF10, 125 kHz).

1733 **2.12.8 IN865-867 Class B beacon and default downlink channel**

1734 The beacons are transmitted using the following settings

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

1735  
 1736 The beacon frame content is defined in [TS001].<sup>51</sup>

1737 The beacon default broadcast frequency is 866.550 MHz.

1738 The class B default downlink pingSlot frequency is 866.550 MHz

1739 **2.12.9 IN865-867 Default Settings**

1740 There are no specific default settings for the IN 865-867 MHz Band.

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

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

1741 **2.13 RU864-870 MHz Band**

 1742 **2.13.1 RU864-870 Preamble Format**

1743 Please refer to Section 3.0 Physical Layer.

 1744 **2.13.2 RU864-870 Band Channel Frequencies**

 1745 The network channels can be freely attributed by the network operator in compliance with the  
 1746 allowed sub-bands defined by the Russian regulation. However, the two following default  
 1747 channels SHALL be implemented in every RU864-870 MHz end-device. Those channels are  
 1748 the minimum set that all network gateways SHALL be listening on.

1749

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

1750

Table 99: RU864-870 default channels

 1751 RU864-870 MHz end-devices SHALL be capable of operating in the 864 to 870 MHz  
 1752 frequency band and SHALL feature a channel data structure to store the parameters of at  
 1753 least 16 channels. A channel data structure corresponds to a frequency and a set of data rates  
 1754 usable on this frequency.

 1755 The first two channels correspond to 868.9 and 869.1 MHz / DR0 to DR5 and SHALL be  
 1756 implemented in every end-device. For devices compliant with TS001-1.0.x, those default  
 1757 channels SHALL NOT be modified through the **NewChannelReq** command. For devices  
 1758 compliant with TS001-1.1.x and beyond, these channels MAY be modified through the  
 1759 **NewChannelReq** but SHALL be reset during the backoff procedure defined in TS001-1.1.1  
 1760 to guarantee a minimal common channel set between end-devices and network gateways.

 1761 The following table gives the list of frequencies that SHALL be used by end-devices to  
 1762 broadcast the Join-Request message. The Join-Request message transmit duty-cycle SHALL  
 1763 follow the rules described in chapter "Retransmissions back-off" of the LoRaWAN®  
 1764 specification document.

1765

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

1766

Table 100: RU864-870 Join-Request Channel List

 1767 **2.13.3 RU864-870 Data Rate and End-device Output Power encoding**

 1768 There is no dwell time limitation for the RU864-870 PHY layer. The **TxParamSetupReq** MAC  
 1769 command is not implemented in RU864-870 devices.

 1770 The following encoding is used for Data Rate (DR) and End-device EIRP (TXPower) in the  
 1771 RU864-870 band:

1772

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

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

**Table 101: RU864-870 TX Data rate table**

1773  
1774  
1775  
1776  
1777  
1778  
1779  
1780  
1781  
1782  
1783

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

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

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

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

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

**Table 102: RU864-870 Data Rate Backoff table**

1784  
1785

EIRP<sup>53</sup> refers to the Equivalent Isotropically Radiated Power, which is the radiated output power referenced to an isotropic antenna radiating power equally in all directions and whose gain is expressed in dBi.

| TXPower | Configuration (EIRP)             |
|---------|----------------------------------|
| 0       | Max EIRP                         |
| 1       | Max EIRP – 2dB                   |
| 2       | Max EIRP – 4dB                   |
| 3       | Max EIRP – 6dB                   |
| 4       | Max EIRP – 8dB                   |
| 5       | Max EIRP – 10dB                  |
| 6       | Max EIRP – 12dB                  |
| 7       | Max EIRP – 14dB                  |
| 8..14   | RFU                              |
| 15      | Defined in [TS001] <sup>52</sup> |

**Table 103: RU864-870 TX power table**

1789  
1790

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

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

1791 By default, the Max EIRP is considered to be +16 dBm. If the end-device cannot achieve  
 1792 +16 dBm EIRP, the Max EIRP SHOULD be communicated to the network server using an  
 1793 out-of-band channel during the end-device commissioning process.

#### 1794 2.13.4 RU864-870 Join-Accept CFList

1795 The RU864-870 band LoRaWAN<sup>®</sup> implements an OPTIONAL **channel frequency list**  
 1796 (CFList) of 16 octets in the Join-Accept message.

1797 In this case the CFList is a list of five channel frequencies for the channels two to six whereby  
 1798 each frequency is encoded as a 24 bits unsigned integer (three octets). All these channels are  
 1799 usable for DR0 to DR5 125 kHz LoRa modulation. The list of frequencies is followed by a  
 1800 single CFListType octet for a total of 16 octets. The CFListType SHALL be equal to zero (0)  
 1801 to indicate that the CFList contains a list of frequencies.

1802

| Size<br>(bytes)<br>CFList | 3        | 3        | 3        | 3        | 3        | 1          |
|---------------------------|----------|----------|----------|----------|----------|------------|
|                           | Freq Ch2 | Freq Ch3 | Freq Ch4 | Freq Ch5 | Freq Ch6 | CFListType |

1803

1804 The actual channel frequency in Hz is 100 x frequency whereby values representing  
 1805 frequencies below 100 MHz are reserved for future use. This allows setting the frequency of  
 1806 a channel anywhere between 100 MHz to 1.678 GHz in 100 Hz steps. Unused channels have  
 1807 a frequency value of 0. The **CFList** is OPTIONAL and its presence can be detected by the  
 1808 length of the join-accept message. If present, the **CFList** replaces all the previous channels  
 1809 stored in the end-device apart from the two default channels. The newly defined channels are  
 1810 immediately enabled and usable by the end-device for communication.

#### 1811 2.13.5 RU864-870 LinkAdrReq command

1812 The RU864-870 LoRaWAN<sup>®</sup> only supports a maximum of 16 channels. When **ChMaskCntl**  
 1813 field is 0 the ChMask field individually enables/disables each of the 16 channels.  
 1814

| 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  |

1815

**Table 104: RU864-870 ChMaskCntl value table**

1816 If the ChMaskCntl field value is one of values meaning RFU, the end-device SHALL<sup>54</sup> reject  
 1817 the command and unset the “**Channel mask ACK**” bit in its response.

#### 1818 2.13.6 RU864-870 Maximum payload size

1819 The maximum **MACPayload** size length (*M*) is given by the following table. It is derived from  
 1820 limitation of the PHY layer depending on the effective modulation rate used taking into account

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

1821 a possible repeater encapsulation layer. The maximum application payload length in the  
 1822 absence of the OPTIONAL **FOpts** control field (*N*) is also given for information only. The value  
 1823 of *N* might be smaller if the **FOpts** field is not empty:  
 1824

| 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 |     |

1825 **Table 105: RU864-870 maximum payload size (repeater compatible)**

1826 If the end-device will never operate with a repeater then the maximum application payload  
 1827 length in the absence of the OPTIONAL **FOpts** control field SHOULD be:  
 1828

| 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 |     |

1829 **Table 106 : RU864-870 maximum payload size (not repeater compatible)**

### 1830 2.13.7 RU864-870 Receive windows

1831 By default, the RX1 receive window uses the same channel as the preceding uplink. The data  
 1832 rate is a function of the uplink data rate and the RX1DROffset as given by the following table.  
 1833 The allowed values for RX1DROffset are in the [0:5] range. Values in the [6:7] range are  
 1834 reserved for future use.  
 1835

| Upstream data rate<br>RX1DROffset | Downstream data rate |     |     |     |     |     |
|-----------------------------------|----------------------|-----|-----|-----|-----|-----|
|                                   | 0                    | 1   | 2   | 3   | 4   | 5   |
| DR0                               | DR0                  | DR0 | DR0 | DR0 | DR0 | DR0 |
| DR1                               | DR1                  | DR0 | DR0 | DR0 | DR0 | DR0 |
| DR2                               | DR2                  | DR1 | DR0 | DR0 | DR0 | DR0 |
| DR3                               | DR3                  | DR2 | DR1 | DR0 | DR0 | DR0 |
| DR4                               | DR4                  | DR3 | DR2 | DR1 | DR0 | DR0 |
| DR5                               | DR5                  | DR4 | DR3 | DR2 | DR1 | DR0 |
| DR6                               | DR6                  | DR5 | DR4 | DR3 | DR2 | DR1 |
| DR7                               | DR7                  | DR6 | DR5 | DR4 | DR3 | DR2 |

1836 **Table 107: RU864-870 downlink RX1 data rate mapping**

1837

1838 The RX2 receive window uses a fixed frequency and data rate. The default parameters are  
 1839 869.1 MHz / DR0 (SF12, 125 kHz)



1840 **2.13.8 RU864-870 Class B beacon and default downlink channel**

1841 The beacons SHALL be transmitted using the following settings

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

 1842 [Table 108: RU864-870 beacon settings](#)

1843

 1844 The beacon frame content is defined in [TS001].<sup>55</sup>The beacon default broadcast frequency is  
 1845 869.1 MHz.

1846 The class B default downlink pingSlot frequency is 868.9 MHz.

 1847 **2.13.9 RU864-870 Default Settings**

1848 There are no specific default settings for the RU864-870 MHz Band.

---

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

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

**1849 3 Repeaters**

1850 Repeaters have not yet been specified by the LoRa Alliance; however, the Regional  
1851 Parameters specification does include references to repeaters and constraints which end-  
1852 devices should follow to be compliant with them.

**1853 3.1 Repeater Compatible Maximum Payload Size**

1854 Repeaters, as referenced in this specification, were intended to fully encapsulate a  
1855 MACPayload in the ApplicationPayload of another LoRaWAN<sup>®</sup> data message. In addition to  
1856 the original MACPayload, up to 20 bytes of meta-data describing the original message were  
1857 envisioned to be included with the encapsulated data message. In order to minimize impact  
1858 on the end-device and its application, repeaters would communicate with the network  
1859 (gateways) using only data rates that supported the maximum allowed MAC Payload Size of  
1860 250 bytes. Thus, these data rates show a maximum payload size which is 20 bytes fewer  
1861 when describing “Repeater Compatible” operation.  
1862

1863

## 1864 4 Physical layer

1865 The LoRaWAN® uses a physical layer to communicate with other devices. Three physical  
1866 layers are currently supported through the LoRa™, LR-FHSS and FSK modulations.

### 1867 4.1 LoRa™ description

#### 1868 4.1.1 LoRa™ packet physical structure

1869 LoRa™ messages use the radio packet explicit header mode in which the LoRa™ physical  
1870 header (**PHDR**) plus a header CRC (**PHDR\_CRC**) are included.<sup>56</sup> In explicit header mode the  
1871 **PHDR** specifies: the payload length in bytes, the forward error correction rate, and the  
1872 presence of an OPTIONAL **CRC** for the payload. The integrity of the payload is protected by  
1873 a **CRC** for uplink messages. LoRaWAN® beacons are transmitted using LoRa™ modulation  
1874 in implicit header mode with a fixed length. In implicit header mode neither the **PHDR** nor  
1875 **PHDR\_CRC** are present.

1876 The **PHDR**, **PHDR\_CRC** and payload **CRC** fields are inserted by the radio transceiver.

1877 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) |

1878

Figure 3: LoRa PHY structure

#### 1879 4.1.2 LoRa™ settings

1880 In order to be fully compliant with LoRaWAN®, an end device SHALL configure the LoRa™  
1881 physical layer as follows:

1882

| 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       |

1883

Table 109 : LoRa physical layer settings

## 1884 4.2 FSK description

### 1885 4.2.1 FSK packet physical structure

1886 FSK messages can be built either by the software stack or by the hardware transceiver,  
1887 depending on the end-device architecture.

1888 The **PHYPayload length** field contains the length in bytes of the **PHYPayload** field.

1889 The **CRC** field is computed on **PHYPayload length** and **PHYPayload** fields, using the CRC-  
1890 CCITT algorithm.

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

1891 PHY:

1892

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

1893

Figure 4: FSK PHY structure

#### 1894 4.2.2 FSK settings

1895 In order to be fully compliant with LoRaWAN®, an end device SHALL configure the FSK  
1896 physical layer as follows:

1897

| Parameter              | Uplink value                | Downlink value |
|------------------------|-----------------------------|----------------|
| Preamble size          | 5 bytes                     |                |
| SyncWord               | 0xC194C1                    |                |
| Bitrate                | 50000 bit/sec               |                |
| Tx frequency deviation | 25 kHz (SSB <sup>57</sup> ) |                |
| 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          |                |

1898

Table 110 : FSK physical layer settings

1899

1900 To avoid a non-uniform power distribution signal with the FSK modulation, a Data Whitening  
1901 DC-Free data mechanism is used as shown in the above table.

### 1902 4.3 LR-FHSS description

1903 The Long Range Frequency Hopping Spread Spectrum (LR-FHSS) modulation is only used  
1904 on the uplink.

#### 1905 4.3.1 LR-FHSS physical layer description

1906

1907 LR-FHSS is a fast frequency hopping spread spectrum (FHSS) modulation with bit rates  
1908 ranging from 162bits/s to 325bits/s.

1909

1910 When a device transmits a packet using LR-FHSS on a given channel, the packet content is  
1911 modulated across several pseudo-random frequencies than span the interval:

1912

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

1913

1914 For FCC 47 CFR Part 15 compliance, the end-device frequency hops across 60 physical  
1915 channels on a 25.4 kHz frequency grid.

1916 For ETSI based countries, the end-device frequency hops across 35 or 86 physical channels  
1917 on a 3.9 kHz frequency grid.

1918 All physical channels are statistically used equally.

1919

1920 The transmission starts on a random frequency inside the interval, and the following  
1921 frequency hopping pattern is also randomly selected and announced in the LR-FHSS packet  
1922 physical header. The transmission carrier frequency changes every 102.4 mSec for each  
1923 payload fragment, and 233.472 mSec for each PHY header.

<sup>57</sup> SSB : Single Side Bandwidth

- 1924
- 1925 The instantaneous LR-FHSS modulation bandwidth is 488 Hz. Therefore, a single LR-FHSS
- 1926 channel actually corresponds to lots of physical frequency channels.
- 1927
- 1928 The LR-FHSS frequency hopping bandwidth is region specific.
- 1929
- 1930 The LR-FHSS physical layer is described in the following table:
- 1931

| 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         |

1932 **Table 111 : LR-FHSS physical layer description**

1933

### 1934 4.3.2 LR-FHSS packet physical structure

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

- 1939 A LR-FHSS packet has the following structure:
- 1940
- 1941

| Repeated         | <i>N</i> (1 to 4) times on different frequencies  |         |          | once                |         |
|------------------|---|---------|----------|---------------------|---------|
| Size             | 114 bits with convolutional coding rate 1/2 on (PHDR + PHDR_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     |

1942 **Figure 5: LR-FHSS Packet Structure**

1943

- 1944 A LR-FHSS packet time-on-air can be computed using the following table:
- 1945

|              |                            |   |
|--------------|----------------------------|---|
|              | PHY header                 | Payload + CRC   |
| FEC          | Conv 1/2                   | Conv 1/3 or 2/3   |
| Bits per hop | 114                        | 16 info bits (CR=1/3)<br>32 (CR=2/3)  |
| Time on air  | $N * 233.472 \text{ mSec}$ | $\text{Ceil}((L+3)/2) * 102.4 \text{ msec (CR=1/3)}$<br>$\text{ceil}((L+3)/4) * 102.4 \text{ msec (2/3)}$ |

1946 **Figure 6 : LR-FHSS time-on-air**

1947

### 1947 4.3.3 LR-FHSS PHY layer settings

1948

1949 In order to be fully compliant with LoRaWAN®, an end device SHALL configure the LR-  
 1950 FHSS physical header as follows:  
 1951

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

**Table 112 : LR-FHSS physical layer settings**

1952  
 1953

1954

 1955 **5 Revisions**

 1956 **5.1 Revision RP002-1.0.3**

- 1957 • Add AS923-4 to cover 917-920 MHz (Israel)
- 1958 • Add a clarifying note regarding DR6/DR7 for AS923/IN865
- 1959 • LR-FHSS clarifications

 1960 **5.2 Revision RP002-1.0.2**

- 1961 • Added a summary table of the regional parameter for all regions except for CN470.
- 1962 • “Repeater Compatible” rationale is described (Section 3) and US902-928, AU915-
- 1963 928 and CN470-520 maximum payload sizes for “repeater compatible” operation
- 1964 were amended (relaxed) for data rates which do not support encapsulation (this
- 1965 brings them into harmony with all other regions).
- 1966 • LR-FHSS data rates added to EU868, US915, AU915. Data rate backoff progression
- 1967 explicitly documented for all regions. Data rate support requirements clarified for all
- 1968 regions.
- 1969 • Align the language and descriptions of AS923 Maximum payload size section with
- 1970 that of all the other regions.
- 1971 • Added language to all regions to align with new applications of NewChannelReq
- 1972 commands as of TS001-1.1.1.
- 1973 • RU864-870 amended to indicate that 16 channels SHALL be supported. This was
- 1974 believed to have been an editorial oversight.
- 1975 • Senegal (EU868), Montserrat (AU915), Mali (EU433), Guinea (EU433), Senegal
- 1976 (EU868), Syria (EU433, EU868, AS923-3) and Vanuatu (IN865 & AS923-3) added to
- 1977 cross-reference table
- 1978 • Israel and Morocco cross-reference table entries modified
- 1979 • Added a Channel Index ID to the Channel Plan Common Name Table
- 1980 • Added AS923-1,-2,-3 to the Channel Plan Common Name Table
- 1981 • Defined CLASS\_B\_RESP\_TIMEOUT and CLASS\_C\_RESP\_TIMEOUT (used in
- 1982 TS001-1.0.4 and later)

 1983 **5.3 Revision RP002-1.0.1**

- 1984 • AS923 modified to support multiple groups of default/join channels. Each
- 1985 country/band supports a specific configuration based on an offset from the original
- 1986 AS923 default/join channels. Country summary table updated to indicate support.
- 1987 • Cuba, Indonesia, Philippines, and Viet Nam channel plan use defined.
- 1988 • Israel support for EU433 and AS923-3 were backed out as Israel MoC has
- 1989 deprecated their use for LoRaWAN® as of November 2019. A new 900 MHz band is
- 1990 under discussion with the MoC.
- 1991 • Maximum Payload Size for AS923, Data Rate 2 was increased from 59 to 123 for
- 1992 UplinkDwellTime = 0 and DownlinkDwellTime = 0.
- 1993 • CN470-510 modified to reflect most recent regulatory requirements. Specifically,
- 1994 SF12 is no longer available and maximum payload sizes for several other data rates
- 1995 were modified to comply with the 1 second dwell time. Further, a 500 kHz LoRa data
- 1996 rate and an FSK data rate were added.
- 1997 • For dynamic channel plan regions, clarified that it is only by default that the RX1
- 1998 frequency is the same as the uplink frequency.



**1999 5.4 Revision RP002-1.0.0**

- 2000 • Initial RP002-1.0.0 revision, the regional parameters were extracted from the
- 2001 released LoRaWAN® v1.1 Regional Parameters
- 2002 • Added statement in Section 1 regarding non-authoritative source for regional
- 2003 regulatory information
- 2004 • Added Section 2.2 RegParamsRevision common names table
- 2005 • Added Regulatory Type Approval to quick reference table in Section 1
- 2006 • Added Section 3 (changing this section to section 4) to incorporate changes from CR
- 2007 00010.001.CR\_add\_physical\_layer\_description\_Kerlink.docx of the TC21 meeting.
- 2008 • Clarified Physical Header Explicit Mode (section 3.1)
- 2009 • Require end-devices in AS923 to accept MaxPayload size downlinks as defined for
- 2010 DownlinkDwellTime=0, regardless of its actual configuration.
- 2011 • Fixed several maxpayload tables when operating in “repeater compatible” mode, no
- 2012 MACPayload (M) may be larger than 230 bytes, regardless of dwell-time limitations
- 2013 • Updated and clarified section 3, Physical Layer
- 2014 • Normative language cleanup
- 2015 • Removed Beacon format definition and referred back to LoRaWAN® specification
- 2016 • Fixed the footnote for the US plan in section 2.5.3
- 2017 • Added notes concerning the use of ARIB STD-T108 for AS923 end-devices in
- 2018 section 2.10.2
- 2019 • Migrated the CN470-510 channel plan from the RP 1.2rA draft
- 2020 • Clarified the wording of the footnotes regarding ChMaskCntl
- 2021 • Made AS923 use consistent in section 2.10
- 2022 • Changed SHOULD to SHALL in section 2.6.2
- 2023 • Changed footnote references to 1.0.2rC to 1.0.3rA
- 2024 • Changed table reference from 1.0.2rC to 1.0.2rB
- 2025 • Changed CN779 duty cycle from 0.1% to 1% as per Regional Regulation Summary
- 2026 • Reduced number of default channels for CN779 plan to 3 to make consistent with
- 2027 other plans
- 2028 • Changed RX1DROffset tables in sections 2.10.7 and 2.12.7 to be direct lookup
- 2029 tables.
- 2030 • Clarified/fixed errors in sections 2.10.7 and 2.12.7
- 2031 • Added default parameter definitions for Class B (referenced in LW)
- 2032 • Modified as per CR ACK\_TIMEOUT / RETRANSMIT\_TIMEOUT
- 2033 • Modified suggest New Zealand channel plan from EU868 to IN865
- 2034 • Modified Bangladesh and Pakistan channel plans from EU868 to IN865
- 2035 • Modified Singapore channel plan from EU868 to “Other”
- 2036 • Updated Burma (Myanmar) channel plans from EU868 to “Other” and “Other” to
- 2037 AS923
- 2038 • Corrected typo error in channel plan for India Added and updated channel plans for
- 2039 Sri Lanka, Bhutan and Papua New Guinea,
- 2040 • Updated Middle East country suggested channel plan
- 2041 • Added channel plans for Samoa, Tonga and Vanuatu
- 2042 • Updated Bahrain and Kuwait channel plans
- 2043 • Corrected Qatar frequency range for EU868
- 2044 • Updated channel plans for UAE: 870-875.8 MHz band can be used withEU868
- 2045 channel plan
- 2046 • Corrected frequency range for Lebanon from 862-870 MHz to 863-87 MHz
- 2047 • Updated Africa priority one country suggested channel plan

- 2048 • Added channel plans for the following African countries: Botswana, Burundi, Cabo
- 2049 Verde, Cameroon, Ghana, Ivory Coast, Kenya, Lesotho, Niger, Rwanda, Tanzania,
- 2050 Togo, Zambia, Zimbabwe
- 2051 • Corrected frequency range for Morocco from 867.6-869MHz to 868-869.65MHz
- 2052 • Updated frequency range for Tunisia (863-868MHz added)
- 2053 • Added EU433 for Nigeria and corrected frequency range from 863-870 to 868-
- 2054 870MHz
- 2055 • Added IN865 channel plan for Uganda
- 2056 • Updated Belarus and Ukraine channel plans (EU863-870 can be used)
- 2057 • Added EU433 channel plan for Costa Rica
- 2058 • Added channel plans for Suriname
- 2059 • Added or corrected bands for Albania, Denmark, Estonia, Hungary, Ireland,
- 2060 Liechtenstein, Luxembourg, Macedonia, Norway, Poland, Slovakia, Slovenia,
- 2061 Switzerland, UK: 918-921MHz changed to 915-918MHz!
- 2062 • Added channel plans for Trinidad and Tobago, Bahamas
- 2063 • Added channel plans for Aland Islands, Holy See, Monaco and San Marino
- 2064 • Fixed the AU entry in the Quick Reference Table
- 2065 • Italicized countries in the country table to highlight those whose regulations may be
- 2066 changing soon.
- 2067 • Finalized initial Regulatory Type Approval column with information based on LA
- 2068 survey of certified end device manufacturers.
- 2069 • Italicized Indonesia due to possible changes to regulatory environment there
- 2070 • Addressed inconsistencies in CN470
- 2071

2072

2073 **6 Bibliography**2074 **6.1 References**

2075

2076 [TS001] LoRaWAN<sup>®</sup> MAC Layer Specification, v1.0 through V1.1, the LoRa Alliance.

2077 [EN300.220-2] Short Range Devices (SRD) operating in the frequency range 25 MHz to

2078 1 000 MHz; Part 2: Harmonised Standard for access to radio spectrum for non specific radio

2079 equipment, V.3.2.1, ETSI

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