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2 **RP002-1.0.0 LoRaWAN Regional Parameters**

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RP002-1.0.0 LoRaWAN® Regional Parameters

This document is a companion document to the LoRaWAN protocol specification

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Version: 2-1.0.0

Date: November 1, 2019

Status: FINAL RELEASE

81	Contents	
82	1 Introduction.....	7
83	1.1 Conventions.....	7
84	1.2 Quick cross reference table.....	8
85	2 LoRaWAN Regional Parameters.....	21
86	2.1 Regional Parameter Channel Plan Common Names.....	21
87	2.2 Regional Parameter Revision Names.....	21
88	2.3 Default Settings.....	21
89	2.4 EU863-870MHz ISM Band.....	23
90	2.4.1 EU863-870 Preamble Format.....	23
91	2.4.2 EU863-870 ISM Band channel frequencies.....	23
92	2.4.3 EU863-870 Data Rate and End-device Output Power encoding.....	24
93	2.4.4 EU863-870 JoinAccept CFList.....	24
94	2.4.5 EU863-870 LinkAdrReq command.....	25
95	2.4.6 EU863-870 Maximum payload size.....	25
96	2.4.7 EU863-870 Receive windows.....	26
97	2.4.8 EU863-870 Class B beacon and default downlink channel.....	26
98	2.4.9 EU863-870 Default Settings.....	27
99	2.5 US902-928MHz ISM Band.....	28
100	2.5.1 US902-928 Preamble Format.....	28
101	2.5.2 US902-928 Channel Frequencies.....	28
102	2.5.3 US902-928 Data Rate and End-device Output Power encoding.....	29
103	2.5.4 US902-928 JoinAccept CFList.....	30
104	2.5.5 US902-928 LinkAdrReq command.....	30
105	2.5.6 US902-928 Maximum payload size.....	31
106	2.5.7 US902-928 Receive windows.....	32
107	2.5.8 US902-928 Class B beacon.....	33
108	2.5.9 US902-928 Default Settings.....	33
109	2.6 CN779-787 MHz ISM Band.....	34
110	2.6.1 CN779-787 Preamble Format.....	34
111	2.6.2 CN779-787 ISM Band channel frequencies.....	34
112	2.6.3 CN779-787 Data Rate and End-device Output Power encoding.....	34
113	2.6.4 CN779-787 JoinAccept CFList.....	35
114	2.6.5 CN779-787 LinkAdrReq command.....	36
115	2.6.6 CN779-787 Maximum payload size.....	36
116	2.6.7 CN779-787 Receive windows.....	37
117	2.6.8 CN779-787 Class B beacon and default downlink channel.....	37
118	2.6.9 CN779-787 Default Settings.....	38
119	2.7 EU433MHz ISM Band.....	39
120	2.7.1 EU433 Preamble Format.....	39
121	2.7.2 EU433 ISM Band channel frequencies.....	39
122	2.7.3 EU433 Data Rate and End-device Output Power encoding.....	39
123	2.7.4 EU433 JoinAccept CFList.....	40
124	2.7.5 EU433 LinkAdrReq command.....	41
125	2.7.6 EU433 Maximum payload size.....	41
126	2.7.7 EU433 Receive windows.....	42
127	2.7.8 EU433 Class B beacon and default downlink channel.....	42
128	2.7.9 EU433 Default Settings.....	42
129	2.8 AU915-928MHz ISM Band.....	43
130	2.8.1 AU915-928 Preamble Format.....	43
131	2.8.2 AU915-928 Channel Frequencies.....	43
132	2.8.3 AU915-928 Data Rate and End-point Output Power encoding.....	44

133	2.8.4	AU915-928 JoinAccept CFList.....	45
134	2.8.5	AU915-928 LinkAdrReq command	46
135	2.8.6	AU915-928 Maximum payload size	46
136	2.8.7	AU915-928 Receive windows.....	47
137	2.8.8	AU915-928 Class B beacon	48
138	2.9	CN470-510MHz Band	50
139	2.9.1	CN470-510 Preamble Format.....	50
140	2.9.2	CN470-510 Channel Frequencies	50
141	2.9.3	CN470-510 Data Rate and End-point Output Power encoding	53
142	2.9.4	CN470-510 Join-Accept CFList	54
143	2.9.5	CN470-510 LinkAdrReq command.....	54
144	2.9.6	CN470-510 Maximum payload size	55
145	2.9.7	CN470-510 Receive windows.....	56
146	2.9.8	CN470-510 Class B beacon	57
147	2.9.9	CN470-510 Default Settings.....	60
148	2.10	AS923MHz ISM Band	61
149	2.10.1	AS923 Preamble Format	61
150	2.10.2	AS923 ISM Band channel frequencies	61
151	2.10.3	AS923 Data Rate and End-point Output Power encoding.....	62
152	2.10.4	AS923 JoinAccept CFList.....	63
153	2.10.5	AS923 LinkAdrReq command	63
154	2.10.6	AS923 Maximum payload size	64
155	2.10.7	AS923 Receive windows	64
156	2.10.8	AS923 Class B beacon and default downlink channel	65
157	2.10.9	AS923 Default Settings	66
158	2.11	KR920-923MHz ISM Band	67
159	2.11.1	KR920-923 Preamble Format.....	67
160	2.11.2	KR920-923 ISM Band channel frequencies	67
161	2.11.3	KR920-923 Data Rate and End-device Output Power encoding.....	68
162	2.11.4	KR920-923 JoinAccept CFList.....	69
163	2.11.5	KR920-923 LinkAdrReq command	69
164	2.11.6	KR920-923 Maximum payload size	70
165	2.11.7	KR920-923 Receive windows.....	71
166	2.11.8	KR920-923 Class B beacon and default downlink channel.....	71
167	2.11.9	KR920-923 Default Settings	71
168	2.12	IN865-867 MHz ISM Band	72
169	2.12.1	IN865-867 Preamble Format	72
170	2.12.2	IN865-867 ISM Band channel frequencies	72
171	2.12.3	IN865-867 Data Rate and End-device Output Power Encoding.....	73
172	2.12.4	IN865-867 JoinAccept CFList.....	74
173	2.12.5	IN865-867 LinkAdrReq command	74
174	2.12.6	IN865-867 Maximum payload size.....	75
175	2.12.7	IN865-867 Receive windows	75
176	2.12.8	IN865-867 Class B beacon and default downlink channel	77
177	2.12.9	IN865-867 Default Settings	77
178	2.13	RU864-870 MHz ISM Band.....	78
179	2.13.1	RU864-870 Preamble Format.....	78
180	2.13.2	RU864-870 ISM Band channel frequencies.....	78
181	2.13.3	RU864-870 Data Rate and End-device Output Power encoding.....	78
182	2.13.4	RU864-870 JoinAccept CFList	79
183	2.13.5	RU864-870 LinkAdrReq command.....	80
184	2.13.6	RU864-870 Maximum payload size	80
185	2.13.7	RU864-870 Receive windows.....	81

186	2.13.8 RU864-870 Class B beacon and default downlink channel.....	82
187	2.13.9 RU864-870 Default Settings.....	82
188	3 Physical layer.....	83
189	3.1 LoRa™ description.....	83
190	3.1.1 LoRa™ packet physical structure	83
191	3.1.2 LoRa™ settings.....	83
192	3.2 FSK description.....	83
193	3.2.1 FSK packet physical structure	83
194	3.2.2 FSK settings.....	84
195	4 Revisions	85
196	4.1 Revision RP002-1.0.0	85
197	5 Bibliography	87
198	5.1 References.....	87
199	6 NOTICE OF USE AND DISCLOSURE.....	88
200		

201 Tables

202	Table 1: Channel Plan per ISO 3166-1 Country	20
203	Table 2 Regional Parameter Common Names	21
204	Table 3 Regional Parameter Revision Names.....	21
205	Table 4: EU863-870 default channels	23
206	Table 5: EU863-870 Join-Request Channel List.....	23
207	Table 6: EU863-870 TX Data rate table	24
208	Table 7: EU863-870 TX power table	24
209	Table 8: EU863-870 ChMaskCntl value table.....	25
210	Table 9: EU863-870 maximum payload size (repeater compatible).....	26
211	Table 10 : EU863-870 maximum payload size (not repeater compatible).....	26
212	Table 11: EU863-870 downlink RX1 data rate mapping	26
213	Table 12: EU863-870 beacon settings	26
214	Table 13: US902-928 TX Data rate table	29
215	Table 14: US902-928 TX power table	30
216	Table 15: US902-928 ChMaskCntl value table.....	30
217	Table 16: US902-928 maximum payload size (repeater compatible).....	31
218	Table 17 : US902-928 maximum payload size (not repeater compatible).....	32
219	Table 18: US902-928 downlink RX1 data rate mapping	32
220	Table 19: US902-928 beacon settings	33
221	Table 20: CN779-787 Join-Request Channel List	34
222	Table 21: CN779-787 Data rate and TX power table.....	35
223	Table 22: CN779-787 ChMaskCntl value table.....	36
224	Table 23: CN779-787 maximum payload size (repeater compatible)	36
225	Table 24 : CN779-787 maximum payload size (not repeater compatible).....	37
226	Table 25: CN779-787 downlink RX1 data rate mapping.....	37
227	Table 26: CN779-787 beacon settings	37
228	Table 27: EU433 Join-Request Channel List.....	39
229	Table 28: EU433 Data rate and TX power table	40
230	Table 29: EU433 ChMaskCntl value table.....	41
231	Table 30: EU433 maximum payload size (repeater compatible).....	41
232	Table 31 : EU433 maximum payload size (not repeater compatible).....	42
233	Table 32 : EU433 downlink RX1 data rate mapping	42
234	Table 33 : EU433 beacon settings	42
235	Table 34: AU915-928 Data rate table.....	45

236	Table 35 : AU915-928 TX power table	45
237	Table 36: AU915-928 ChMaskCntl value table.....	46
238	Table 37: AU915-928 maximum payload size (repeater compatible).....	47
239	Table 38: AU915-928 Maximum repeater payload size	47
240	Table 39 : AU915-928 downlink RX1 data rate mapping	48
241	Table 40 : AU915-928 beacon settings	48
242	Table 41: Common join channels for CN470-510 channel frequencies	50
243	Table 42: channel plan type A for 20MHz antenna channel frequencies	51
244	Table 43: channel plan type B for 20MHz antenna channel frequencies	52
245	Table 44: channel plan type A for 26MHz antenna channel frequencies	52
246	Table 45: channel plan type B for 26MHz antenna channel frequencies	53
247	Table 46: CN470-510 Data rate and TX power table.....	53
248	Table 47:CH470 ChMaskCntl value table for 20M Antenna.....	54
249	Table 48: CH470 ChMaskCntl value table for 26M Antenna.....	55
250	Table 49: CN470-510 maximum payload size (repeater compatible)	55
251	Table 50: CN470-510 maximum payload size (not repeater compatible).....	56
252	Table 51: CN470-510 downlink RX1 data rate mapping.....	56
253	Table 52: RX2 Default Frequency for channel plan type A for 20MHz antenna	56
254	Table 53: RX2 Default Frequency for channel plan type B for 20MHz antenna	56
255	Table 54 : CN470-510 beacon settings	57
256	Table 55: Beacon Channel Number for channel plan type A for 20MHz antenna	57
257	Table 56: Ping-slot Channel Number for channel plan type A for 20MHz antenna	59
258	Table 57: Beacon Channel Number for channel plan type B for 20MHz antenna	59
259	Table 58: Ping-slot Channel Number for channel plan type B for 20MHz antenna	59
260	Table 59: AS923 default channels.....	61
261	Table 60: AS923 Join-Request Channel List.....	61
262	Table 61: AS923 Data rate table	62
263	Table 62: AS923 TXPower table	62
264	Table 63: AS923 ChMaskCntl value table	63
265	Table 64: AS923 maximum payload size (repeater compatible).....	64
266	Table 65: AS923 maximum payload size (not repeater compatible)	64
267	Table 66: AS923 downlink RX1 data rate mapping for DownLinkDwellTime = 0	65
268	Table 67 : AS923 beacon settings.....	65
269	Table 68: KR920-923 Center frequency, bandwidth, maximum EIRP output power table ...	67
270	Table 69: KR920-923 default channels	67
271	Table 70: KR920-923 Join-Request Channel List.....	68
272	Table 71: KR920-923 TX Data rate table	68
273	Table 72: KR920-923 TX power table	69
274	Table 73: KR920-923 ChMaskCntl value table.....	70
275	Table 74: KR920-923 maximum payload size (repeater compatible).....	70
276	Table 75 : KR920-923 maximum payload size (not repeater compatible).....	70
277	Table 76 : KR920-923 downlink RX1 data rate mapping	71
278	Table 77 : KR920-923 beacon settings	71
279	Table 78: IN865-867 default channels.....	72
280	Table 79: IN865-867 Join-Request Channel List	72
281	Table 80: IN865-867 TX Data rate table.....	73
282	Table 81: IN865-867 TXPower table	73
283	Table 82: IN865-867 ChMaskCntl value table	74
284	Table 83: IN865-867 maximum payload size (repeater compatible).....	75
285	Table 84 : IN865-867 maximum payload size (not repeater compatible)	75
286	Table 85: IN865-867 downlink RX1 data rate mapping	76
287	Table 86: RU864-870 default channels	78
288	Table 87: RU864-870 Join-Request Channel List	78

289	Table 88: RU864-870 TX Data rate table	79
290	Table 89: RU864-870 TX power table	79
291	Table 90: RU864-870 ChMaskCntl value table.....	80
292	Table 91: RU864-870 maximum payload size (repeater compatible)	81
293	Table 92 : RU864-870 maximum payload size (not repeater compatible).....	81
294	Table 93: RU864-870 downlink RX1 data rate mapping.....	81
295	Table 93: RU864-870 beacon settings	82
296	Table 95 : LoRa physical layer settings.....	83
297	Table 96 : FSK physical layer settings	84
298		

299 **Figures**

300	Figure 1: US902-928 channel frequencies	28
301	Figure 2: AU915-928 channel frequencies	43
302	Figure 3: LoRa PHY structure	83
303	Figure 4: FSK PHY structure.....	84
304		

305 **1 Introduction**

306

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

312

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

316

This document references TS001-1.0.4, which is in final draft form at the
 time of the publication of RP002-1.0.0 (this document). These
 references are clearly highlighted in the text of this document.

317

318

319

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

324

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

330 **1.1 Conventions**

331

332 The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD",
 333 "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL"

334 in this document are to be interpreted as described in BCP14 [RFC2119] [RFC8174] when,
335 and only when, they appear in all capitals, as shown here.

336

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

339 **1.2 Quick cross reference table**

340 In order to support the identification of LoRaWAN channel plans for a given country, the table
341 below provides a quick reference of suggested channel plans available to implementors for
342 each country.

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

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

347

348

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

¹ Regulations imply 902-928 MHz, but only 915-928 MHz is available

	922 - 925.0 MHz	AS923	
Barbados (BB)	902 - 928 MHz	US902-928 AU915-928	
Belarus (BY)	433.05 - 434.79 MHz	EU433	
	864.4 - 868.6 MHz	EU863-870	
	869-869.2MHz	EU863-870	
	869.4 – 869.65 MHz	EU863-870	
	869.7 – 870 MHz	EU863-870	
Belgium (BE)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	X
Belize (BZ)	902 - 928 MHz	US902-928 AU915-928	
Benin (BJ)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	
Bermuda (BM)	902 - 928 MHz	US902-928 AU915-928	
Bhutan (BT)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	
Bolivia (BO)	915 - 930 MHz	AU915-928 AS923	
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		
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	
	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	
Cameroon (CM)	433.05 – 434.79 MHz	EU433	
Canada (CA)	902 - 928 MHz	US902-928 AU915-928	X, _
Central African Republic (CF)			
Chad (TD)			
Chile (CL)	433 – 434.79 MHz	EU433	
	915 - 928MHz ¹	AU915-928 AS923	
China (CN)	920.5 - 924.5 MHz	AS923	
	779 - 787 MHz ¹	CN779-787	
	470 - 510 MHz	CN470-510	
	433.05 - 434.79 MHz	EU433	
	314-316 MHz		
	430 - 432 MHz		
Christmas Island (CX)	915 - 928 MHz	AS923	
		AU915-928	
Cocos Islands (CC)	915 - 928 MHz	AS923 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		
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 AU915-928	
Costa Rica (CR)	433.05 - 434.79 MHz	EU433	
	920.5 - 928 MHz	AS923	
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		

¹ 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.

Curaçao (CW)	433.05 - 434.79 MHz	EU433	
	920 - 925 MHz	AS923	
Cyprus (CY)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	X
Czechia (CZ)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	X
Denmark (DK)	433.05 - 434.79 MHz	EU433	
	863 - 873 MHz	EU863-870	X
	915 - 918 MHz		
Djibouti (DJ)			
Dominica (DM)	902 - 928 MHz	US902-928 AU915-928	
Dominican Republic (DO)	915 - 928 MHz	AU915-928	
Ecuador (EC)	902 - 928 MHz	US902-928 AU915-928 AS923	
<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 AS923	
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		
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	
Greece (GR)	433.05 - 434.79 MHz	EU433	
	868 - 870 MHz	EU863-870	X
Greenland (GL)			
Grenada (GD)	902 - 928 MHz	US902-928 AU915-928	
Guadeloupe (GP)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	X
Guam (GU)	902 - 928 MHz	US902-928 AU915-928	X, _
Guatemala (GT)	915 – 928 MHz ¹	AU915-928 AS923	
Guernsey (GG)	433.05 - 434.79 MHz	EU433	
	863 - 873 MHz	EU863-870	
	915 – 918 MHz		
Guinea (GN)			
Guinea-Bissau (GW)			
Guyana (GY)			
Haiti (HT)			
Heard Island and McDonald Islands (HM)	915 – 928 MHz	AU915-928 AS923	
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	
Hungary (HU)	433.05 - 434.79 MHz	EU433	
	863 - 873 MHz	EU863-870	X
	915 - 918 MHz		
Iceland (IS)	433.05 - 434.79 MHz	EU433	
	863 - 873 MHz	EU863-870	X
India (IN)	865 - 867 MHz	IN865-867	X
<i>Indonesia (ID)</i>	920 - 923 MHz		
Iran (IR)	433.05 - 434.79 MHz	EU433	

	863 - 873 MHz	EU863-870	
	915 - 918 MHz		
Iraq (IQ)			
Ireland (IE)	433.05 – 434.79 MHz	EU433	
	863 – 873 MHz	EU863-870	X
	915 – 918 MHz		
Isle of Man (IM)	433.05 - 434.79 MHz	EU433	
	863 - 873 MHz	EU863-870	
	915 – 918 MHz		
Israel (IL)	433.05 - 434.79 MHz	EU433	
	915 - 917 MHz		
Italy (IT)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	X
Jamaica (JM)	915 - 928 MHz ¹	AU915-928	
Japan (JP)	920.6 - 928.0 MHz (steps of 200kHz & 600kHz)	AS923	X
Jersey (JE)	433.05 - 434.79 MHz	EU433	
	863 - 873 MHz	EU863-870	
	915 – 918 MHz		
<i>Jordan (JO)</i>	433.05 – 434.79 MHz	EU433	
	865 - 868 MHz	IN865-867	
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		
Kyrgyzstan (KG)			
Lao People's Democratic Republic (LA)	433 - 435 MHz	EU433	
	862 - 875 MHz	EU863-870	
	923 - 925 MHz	AS923	
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		
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		
Macao (MO)	433.05 - 434.79 MHz	EU433	
	920 - 925 MHz	AS923	
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	
	919 - 924 MHz	AS923	
Maldives (MV)			
Mali (ML)			
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 AU915-928	
Micronesia (FM)			
Moldova (MD)	433.05 - 434.79 MHz	EU433	
	862 - 873 MHz	EU863-870	
	915 - 918 MHz		
Monaco (MC)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	
Mongolia (MN)			
Montenegro (ME)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	
Montserrat (MS)			
Morocco (MA)	433.05 - 434.79 MHz	EU433	
	868 - 869 MHz	EU863-870	

	869.4 – 869.65 MHz	EU863-870	
Mozambique (MZ)			
Myanmar (MM)	433 - 435 MHz	EU433	
	866 - 869MHz		
	919 - 924 MHz	AS923	
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 AU915-928	
	819 - 824 MHz		
	864 - 868MHz	IN865-867	
	433.05 - 434.79 MHz	EU433	
Nicaragua (NI)	915 - 928 MHz ¹	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 AU915-928	
Norfolk Island (NF)	915 - 928 MHz	AS923 AU915-928	
Northern Mariana Islands (MP)	902 – 928 MHz	US902-928 AU915-928	X, _
Norway (NO)	433.05 - 434.79 MHz	EU433	
	863 - 873 MHz	EU863-870	
	915 - 918 MHz		
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	
Palau (PW)			
Palestine (PS)			

Panama (PA)	902 - 928 MHz	US902-928 AU915-928 AS923	
Papua New Guinea (PG)	433.05 - 434.79 MHz	EU433	
	915 - 928 MHz	AU915-928 AS923	
Paraguay (PY)	433.05 - 434.79 MHz	EU433	
	915 - 928 MHz	AU915-928 AS923	
Peru (PE)	915 - 928 MHz	AU915-928 AS923	
Philippines (PH)	915 - 918 MHz		
	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		
Portugal (PT)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	X
Puerto Rico (PR)	902 - 928 MHz	US902-928 AU915-928	X, _
Qatar (QA)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	
	915 - 921 MHz		
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)		
Rwanda (RW)	433.05 - 434.79 MHz	EU433	
	863 - 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	US902-928 AU915-928	

Saint Lucia (LC)	902 – 928 MHz	US902-928 AU915-928	
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	US902-928 AU915-928	
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		
<i>Senegal (SN)</i>			
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	
	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		
Slovenia (SI)	433.05 - 434.79 MHz	EU433	
	863 - 873 MHz	EU863-870	X
	915 - 918 MHz		
Solomon Islands (SB)	918 - 926 MHz	AS923	
Somalia (SO)	433.05 - 434.79 MHz	EU433	
	863 - 870 MHz	EU863-870	
	915 - 918 MHz		
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	
	915 - 921 MHz		
South Georgia and the South Sandwich Islands (GS)			
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	
Sudan (SD)			
Suriname (SR)	915 – 928 MHz ¹	AU915-928 AS923	
Svalbard and Jan Mayen (SJ)	868 - 870 MHz	EU863-870	
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		
Syrian Arab Republic (SY)			
Taiwan, Province of China (TW)	920 - 925 MHz	AS923	X
Tajikistan (TJ)			
Tanzania (TZ)	433.05 - 434.79 MHz	EU433	
	866 - 869 MHz		
	920 - 925 MHz	AS923	
Thailand (TH)	433.05 – 434.79 MHz	EU433	
	920 – 925 MHz	AS923	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 AU915-928	
Tonga (TO)	433.05 – 434.79 MHz	EU433	
	915 – 928 MHz	AU915-928 AS923	
Trinidad and Tobago (TT)	902 – 928 MHz	US902-928 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 Error! Bookmark not defined.	AU915-928 AS923	
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	
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		
United Kingdom of Great Britain and Northern Ireland (GB)	433.05 - 434.79 MHz	EU433	
	863 - 873 MHz	EU863-870	X
	915 - 918 MHz		
United States Minor Outlying Islands (UM)	902 - 928 MHz	US902-928 AU915-928	X, _
United States of America (US)	902 - 928 MHz	US902-928 AU915-928	X, _
Uruguay (UY)	915 - 928 MHz ¹	AU915-928 AS923	
Uzbekistan (UZ)	433.05 – 434.79 MHz	EU433	
Vanuatu (VU)	433.05 - 434.79 MHz	EU433	
	819 - 824 MHz		
	864 - 868 MHz	IN865-867	
Venezuela (VE)	922 - 928 MHz	AS923	
Viet Nam (VN)	433.05 - 434.79 MHz	EU433	
	918 - 923 MHz		
Virgin Islands, UK (VG)	915 - 928 MHz ¹	AU915-928 AS923	
Virgin Islands, US (VI)	902 - 928 MHz	US902-928 AU915-928	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

2 LoRaWAN Regional Parameters

2.1 Regional Parameter Channel Plan Common Names

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

Channel Plan	Common Name
EU863-870	EU868
US902-928	US915
CN779-787	CN779
EU433	EU433
AU915-928	AU915
CN470-510	CN470
AS923	AS923
KR920-923	KR920
IN865-867	IN865
RU864-870	RU864

Table 2 Regional Parameter Common Names

2.2 Regional Parameter Revision Names

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

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

Table 3 Regional Parameter Revision Names

2.3 Default Settings

The following parameters are RECOMMENDED values for all regions.

RECEIVE_DELAY1	1 s
RECEIVE_DELAY2	2 s (SHALL be RECEIVE_DELAY1 + 1s)
RX1DROffset	0 (table index)
JOIN_ACCEPT_DELAY1	5 s
JOIN_ACCEPT_DELAY2	6 s
MAX_FCNT_GAP ¹	16384
ADR_ACK_LIMIT	64
ADR_ACK_DELAY	32
RETRANSMIT_TIMEOUT	2 +/- 1 s (random delay between 1 and 3 seconds)

¹ MAX_FCNT_GAP was deprecated and removed from LoRaWAN 1.0.4 and subsequent versions

DownlinkDwellTime	0 (No downlink dwell time enforced, impacts Datarate Offset calculations)
UplinkDwellTime	Uplink dwell time is country specific and is the responsibly of the end-device to comply with
PING_SLOT_PERIODICITY	7 ($2^7 = 128$)
PING_SLOT_DATARATE	The value of the BEACON DR defined for each regional band
PING_SLOT_CHANNEL	Defined in each regional band

368
 369 If the actual parameter values implemented in the end-device are different from those default
 370 values (for example the end-device uses a longer JOIN_ACCEPT_DELAY1 and
 371 JOIN_ACCEPT_DELAY2 latency), those parameters SHALL be communicated to the
 372 network server using an out-of-band channel during the end-device commissioning process.
 373 The network server may not accept parameters different from those default values.
 374

375 RETRANSMIT_TIMEOUT was known as ACK_TIMEOUT in versions prior to 1.0.4 of
 376 LoRaWAN specification. It is renamed in version 1.0.4 and subsequent versions of the
 377 LoRaWAN specification to better reflect its intended use.
 378

379 MAX_FCNT_GAP is removed from use in version 1.0.4 of the LoRaWAN specification.
 380

381 MAC commands exist in the LoRaWAN specification to change the value of
 382 RECEIVE_DELAY1 (using *RXTimingSetupReq*, *RXTimingSetupAns*) as well as
 383 ADR_ACK_LIMIT and ADR_ACK_DELAY (using *ADRParamSetupReq*,
 384 *ADRParamSetupAns*). Also, *RXTimingSettings* are transmitted to the end device along with
 385 the JOIN_ACCEPT message in OTAA mode.
 386

387 The default values for PING_SLOT_PERIODICITY, PING_SLOT_DATARATE, and
 388 PING_SLOT_CHANNEL can be adjusted using Class B MAC commands.
 389

390 2.4 EU863-870MHz ISM Band

391 2.4.1 EU863-870 Preamble Format

392 Please refer to Section 3.0 Physical Layer.

393 2.4.2 EU863-870 ISM Band channel frequencies

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

396 The network channels can be freely attributed by the network operator. However, the three
397 following default channels SHALL be implemented in every EU868MHz end-device. Those
398 channels are the minimum set that all network gateways SHALL be listening on.

399

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

400

Table 4: EU863-870 default channels

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

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

411 The first three channels correspond to 868.1, 868.3, and 868.5 MHz / DR0 to DR5 and SHALL
412 be implemented in every end-device. Those default channels cannot be modified through the
413 **NewChannelReq** command and guarantee a minimal common channel set between end-
414 devices and network gateways.

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

419

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

420

Table 5: EU863-870 Join-Request Channel List

421 2.4.3 EU863-870 Data Rate and End-device Output Power encoding

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

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

426

DataRate	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 LoRaWAN ¹	

Table 6: EU863-870 TX Data rate table

427

428

429 EIRP² refers to the Equivalent Isotropically Radiated Power, which is the radiated output
 430 power referenced to an isotropic antenna radiating power equally in all directions and whose
 431 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 LoRaWAN

Table 7: EU863-870 TX power table

432

433

434 By default, the Max EIRP is considered to be +16dBm. If the end-device cannot achieve
 435 16dBm EIRP, the Max EIRP SHOULD be communicated to the network server using an out-
 436 of-band channel during the end-device commissioning process.

437

438 2.4.4 EU863-870 JoinAccept CFList

439

440 The EU 863-870 ISM band LoRaWAN implements an OPTIONAL **channel frequency list**
 441 (CFList) of 16 octets in the JoinAccept message.

¹ DR15 and TXPower15 are defined in the *LinkADRRReq* MAC command of the LoRaWAN1.0.4 and subsequent specifications and were previously RFU

² ERP = EIRP – 2.15dB; it is referenced to a half-wave dipole antenna whose gain is expressed in dBd

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

447

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

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

455 2.4.5 EU863-870 LinkAdrReq command

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

458

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

459

Table 8: EU863-870 ChMaskCntl value table

460 If the ChMaskCntl field value is one of values meaning RFU, the end-device SHALL¹ reject
 461 the command and unset the “**Channel mask ACK**” bit in its response.

462 2.4.6 EU863-870 Maximum payload size

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

468

DataRate	M	N
0	59	51
1	59	51
2	59	51
3	123	115

¹ Made SHALL from SHOULD starting in LoRaWAN Regional Parameters Specification 1.0.3rA

4	230	222
5	230	222
6	230	222
7	230	222
8:15	Not defined	

Table 9: EU863-870 maximum payload size (repeater compatible)

469

470 If the end-device will never operate with a repeater then the maximum application payload
 471 length in the absence of the OPTIONAL **FOpt** control field SHALL be:
 472

DataRate	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 10 : EU863-870 maximum payload size (not repeater compatible)

473

474 2.4.7 EU863-870 Receive windows

475 The RX1 receive window uses the same channel as the preceding uplink. The data rate is a
 476 function of the uplink data rate and the RX1DROffset as given by the following table. The
 477 allowed values for RX1DROffset are in the [0:5] range. Values in the [6:7] range are reserved
 478 for future use.
 479

RX1DROffset	0	1	2	3	4	5
Upstream data rate	Downstream data rate in RX1 slot					
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 11: EU863-870 downlink RX1 data rate mapping

480

481

482 The RX2 receive window uses a fixed frequency and data rate. The default parameters are
 483 869.525 MHz / DR0 (SF12, 125 kHz)

484 2.4.8 EU863-870 Class B beacon and default downlink channel

485 The beacons SHALL be transmitted using the following settings

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

Table 12: EU863-870 beacon settings

486

487

 488 The beacon frame content is defined in [TS001].¹

489 The beacon default broadcast frequency is 869.525 MHz.

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

 491 **2.4.9 EU863-870 Default Settings**

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

493

¹ Prior to LoRaWAN 1.0.4, the EU863-870 beacon format was defined here as:

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

494 **2.5 US902-928MHz ISM Band**

495 This section defines the regional parameters for the USA, Canada and all other countries
 496 adopting the entire FCC-Part15 regulations in 902-928 ISM band.

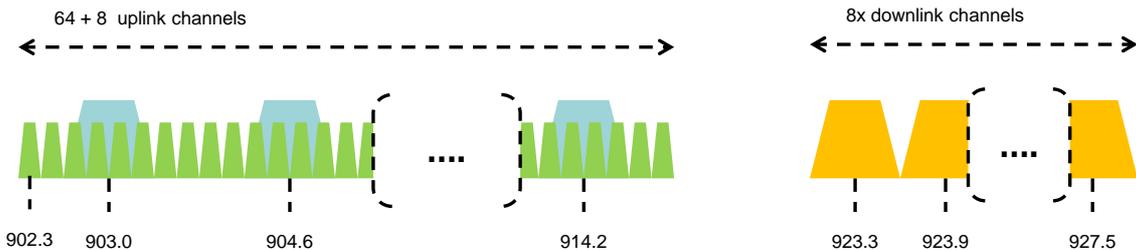
497 **2.5.1 US902-928 Preamble Format**

498 Please refer to Section 3.0 Physical Layer.

499 **2.5.2 US902-928 Channel Frequencies**

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

- 501 • Upstream – 64 channels numbered 0 to 63 utilizing LoRa 125 kHz BW varying from
- 502 DR0 to DR3, using coding rate 4/5, starting at 902.3 MHz and incrementing linearly
- 503 by 200 kHz to 914.9 MHz
- 504 • Upstream – 8 channels numbered 64 to 71 utilizing LoRa 500 kHz BW at DR4
- 505 starting at 903.0 MHz and incrementing linearly by 1.6 MHz to 914.2 MHz
- 506 • Downstream – 8 channels numbered 0 to 7 utilizing LoRa 500 kHz BW at DR8 to
- 507 DR13, starting at 923.3 MHz and incrementing linearly by 600 kHz to 927.5 MHz
- 508



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

511 915 MHz ISM band end-devices are required to operate in compliance with the relevant
 512 regulatory specifications, the following note summarizes some of the current (March 2017)
 513 relevant regulations.

514 Frequency-Hopping, Spread-Spectrum (FHSS) mode, which requires
 515 the device transmit at a measured conducted power level no greater
 516 than +30 dBm, for a period of no more than 400 msec and over at least
 517 50 channels, each of which occupy no greater than 250 kHz of
 518 bandwidth.

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

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

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

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

537
 538 If using the over-the-air activation procedure, the end-device SHALL transmit the Join-
 539 Request message on random 125 kHz channels amongst the 64 125kHz channels defined
 540 using **DR0** and on 500 kHz channels amongst the 8 500kHz channels defined using **DR4**.
 541 The end-device SHALL change channels for every transmission.

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

548 Example: First pass: Random channel from [0-7], followed by [8-15]... [56-63], then 64
 549 Second pass: Random channel from [0-7], followed by [8-15]... [56-63], then
 550 65
 551 Last pass: Random channel from [0-7], followed by [8-15]... [56-63], then 71

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

554 2.5.3 US902-928 Data Rate and End-device Output Power encoding

555 FCC regulation imposes a maximum dwell time of 400ms on uplinks. The *TxParamSetupReq*
 556 MAC command is not implemented by US902-928 devices.

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

559

DataRate	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
5:7	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 LoRaWAN ¹	

Table 13: US902-928 TX Data rate table

560

¹ DR15 and TXPower15 are defined in the LinkADRReq MAC command of the LoRaWAN1.0.4 and subsequent specifications and were previously RFU

561
562
563

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

TXPower	Configuration (conducted power)
0	30 dBm – 2*TXPower
1	28 dBm
2	26 dBm
3 : 13
14	2 dBm
15	Defined in LoRaWAN ¹

564

Table 14: US902-928 TX power table

565 2.5.4 US902-928 JoinAccept CFList

566

567 For LoRaWAN1.0.1, the US902-928 does not support the use of the OPTIONAL **CFlist**
568 appended to the JoinAccept message. If the **CFlist** is not empty it is ignored by the end-
569 device.

570

571 The US902-928 LoRaWAN supports the use of the OPTIONAL **CFlist** appended to the Join-
572 Accept message. If the **CFlist** is not empty, then the **CFlistType** field SHALL contain the
573 value one (0x01) to indicate the **CFlist** contains a series of ChMask fields. The ChMask
574 fields are interpreted as being controlled by a virtual ChMaskCntl that initializes to a value of
575 zero (0) and increments for each ChMask field to a value of four (4). (The first 16 bits
576 controls the channels 0 to 15...)

577

Size (bytes)	[2]	[2]	[2]	[2]	[2]	[2]	[3]	[1]
CFlist	ChMask0	ChMask1	ChMask2	ChMask3	ChMask4	RFU	RFU	CFlistType

578 2.5.5 US902-928 LinkAdrReq command

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

581

ChMaskCntl	ChMask applies to
0	Channels 0 to 15
1	Channels 16 to 31
..	..
4	Channels 64 to 71
5	8LSBs controls Channel Blocks 0 to 7 8MSBs are RFU
6	All 125 kHz ON ChMask applies to channels 64 to 71
7	All 125 kHz OFF ChMask applies to channels 64 to 71

582

Table 15: US902-928 ChMaskCntl value table

¹ DR15 and TXPower15 are defined in the LinkADRReq MAC command of the LoRaWAN1.0.4 and subsequent specifications and were previously RFU

583 If **ChMaskCntl** = 5¹ then the corresponding bits in the ChMask enable and disable a bank of
 584 8 125kHz channels and the corresponding 500kHz channel defined by the following
 585 calculation: $[\text{ChannelMaskBit} * 8, \text{ChannelMaskBit} * 8 + 7], 64 + \text{ChannelMaskBit}$.

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

590

591 **Note:** FCC regulation requires hopping over at least 50 channels when
 592 using maximum output power. It is possible to have end-devices with
 593 less channels when limiting the end-device conducted transmit power to
 594 21 dBm.

595 **Note:** A common network server action may be to reconfigure a device
 596 through multiple LinkAdrReq commands in a contiguous block of MAC
 597 Commands. For example, to reconfigure a device from 64 channel
 598 operation to the first 8 channels could contain two LinkAdrReq, the first
 599 (**ChMaskCntl** = 7) to disable all 125 kHz channels and the second
 600 (**ChMaskCntl** = 0) to enable a bank of 8 125 kHz channels. Alternatively,
 601 using **ChMaskCntl** = 5 a device can be re-configured from 64 channel
 602 operation to support the first 8 channels in a single LinkAdrReq.
 603

604 2.5.6 US902-928 Maximum payload size

605 The maximum **MACPayload** size length (*M*) is given by the following table. It is derived from
 606 the maximum allowed transmission time at the PHY layer taking into account a possible
 607 repeater encapsulation. The maximum application payload length in the absence of the
 608 OPTIONAL **FOpt** MAC control field (*N*) is also given for information only. The value of *N* MAY
 609 be smaller if the **FOpt** field is not empty:
 610

DataRate	<i>M</i>	<i>N</i>
0	19	11
1	61	53
2	133	125
3	230	222
4	230	222
5:7	Not defined	
8	41	33
9	117	109
10	230	222
11	230	222
12	230	222
13	230	222
14:15	Not defined	

Table 16: US902-928 maximum payload size (repeater compatible)

611

612

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

¹ Added in LoRaWAN Regional Parameters Specification version 1.0.3rA

615

DataRate	<i>M</i>	<i>N</i>
0	19	11
1	61	53
2	133	125
3	250	242
4	250	242
5:7	Not defined	
8	61	53
9	137	129
10	250	242
11	250	242
12	250	242
13	250	242
14:15	Not defined	

616

Table 17 : US902-928 maximum payload size (not repeater compatible)

617 2.5.7 US902-928 Receive windows

618

619

620

621

622

623

624

- The RX1 receive channel is a function of the upstream channel used to initiate the data exchange. The RX1 receive channel can be determined as follows.
 - RX1 Channel Number = Transmit Channel Number modulo 8
- The RX1 window data rate depends on the transmit data rate (see Table 18 below).
- The RX2 (second receive window) settings uses a fixed data rate and frequency. Default parameters are 923.3MHz / DR8

Upstream data rate	Downstream data rate			
	0	1	2	3
RX1DROffset				
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

625

 Table 18: US902-928 downlink RX1 data rate mapping¹

626

627

628

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

¹ Re-defined in the LoRaWAN1.0.1 specification to eliminate RX1DROffset values beyond DR4

629 **2.5.8 US902-928 Class B beacon¹**

630 The beacons SHALL BE transmitted using the following settings:

631

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

632

Table 19: US902-928 beacon settings

633 The downstream channel used for a given beacon is:

634

$$635 \text{ Channel} = \left[\text{floor} \left(\frac{\text{beacon_time}}{\text{beacon_period}} \right) \right] \text{ modulo } 8$$

636

- 637 • whereby beacon_time is the integer value of the 4 bytes “Time” field of the beacon
- 638 frame
- 639 • whereby beacon_period is the periodicity of beacons, 128 seconds
- 640 • whereby floor(x) designates rounding to the integer immediately inferior or equal to x

641

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

644

645

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

646

647

 648 The beacon frame content is defined in [TS001].²

649

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

 651 **2.5.9 US902-928 Default Settings**

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

653

¹ Class B beacon operation was first defined in the LoRaWAN1.0.3 specification

² Prior to LoRaWAN 1.0.4, the beacon was defined here as:

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

654 2.6 CN779-787 MHz ISM Band¹

655 2.6.1 CN779-787 Preamble Format

656 Please refer to Section 3.0 Physical Layer.

657 2.6.2 CN779-787 ISM Band channel frequencies

658 CN779-787 devices may not be produced, imported or installed after 2021-
659 01-01; deployed devices may continue to operate through their normal end-
660 of-life.

661 The LoRaWAN can be used in the Chinese 779-787MHz band as long as the radio device
662 EIRP is less than 12.15dBm.

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

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

- 665 • Minimum frequency: 779.5MHz
- 666 • Maximum frequency: 786.5 MHz

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

671 The first three channels correspond to 779.5, 779.7 and 779.9 MHz with DR0 to DR5 and
672 SHALL be implemented in every end-device. Those default channels cannot be modified
673 through the **NewChannelReq** command and guarantee a minimal common channel set
674 between end-devices and gateways of all networks. Other channels can be freely distributed
675 across the allowed frequency range on a network per network basis.

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

681

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

682

Table 20: CN779-787 Join-Request Channel List

683 2.6.3 CN779-787 Data Rate and End-device Output Power encoding

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

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

¹ Defined in the LoRaWAN1.0.1 specification

688

DataRate	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 LoRaWAN ¹		15	Defined in LoRaWAN ¹⁵

Table 21: CN779-787 Data rate and TX power table

689

690

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

694 By default, Max EIRP is considered to be +12.15dBm. If the end-device cannot achieve
 695 12.15dBm EIRP, the Max EIRP SHOULD be communicated to the network server using an
 696 out-of-band channel during the end-device commissioning process.

697 2.6.4 CN779-787 JoinAccept CFList

698 The CN780 ISM band LoRaWAN implements an OPTIONAL **channel frequency list** (CFList)
 699 of 16 octets in the JoinAccept message.

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

705

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

706

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

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

¹ DR15 and TXPower15 are defined in the LinkADRReq MAC command of the LoRaWAN1.0.4 and subsequent specifications and were previously RFU

715 **2.6.5 CN779-787 LinkAdrReq command**

 716 The CN780 LoRaWAN only supports a maximum of 16 channels. When **ChMaskCntl** field is
 717 0 the ChMask field individually enables/disables each of the 16 channels.
 718

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

 719 **Table 22: CN779-787 ChMaskCntl value table**

719

720

 721 If the ChMask field value is one of values meaning RFU, then end-device SHALL¹ reject the
 722 command and unset the “**Channel mask ACK**” bit in its response.

 723 **2.6.6 CN779-787 Maximum payload size**

 724 The maximum **MACPayload** size length (M) is given by the following table. It is derived from
 725 limitation of the PHY layer depending on the effective modulation rate used taking into account
 726 a possible repeater encapsulation layer. The maximum application payload length in the
 727 absence of the OPTIONAL **FOpt** control field (N) is also given for information only. The value
 728 of N MAY be smaller if the **FOpt** field is not empty:
 729

DataRate	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	

 730 **Table 23: CN779-787 maximum payload size (repeater compatible)**

730

731

 732 If the end-device will never operate with a repeater then the maximum application payload
 733 length in the absence of the OPTIONAL **FOpt** control field SHALL be:
 734

¹ Made SHALL from SHOULD starting in LoRaWAN Regional Parameters Specification 1.0.3rA

DataRate	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	

 735 **Table 24 : CN779-787 maximum payload size (not repeater compatible)**

 736 **2.6.7 CN779-787 Receive windows**

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

741

RX1DROffset	0	1	2	3	4	5
Upstream data rate	Downstream data rate in RX1 slot					
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

 742 **Table 25: CN779-787 downlink RX1 data rate mapping**

 743 The RX2 receive window uses a fixed frequency and data rate. The default parameters are
 744 786 MHz / DR0.

 745 **2.6.8 CN779-787 Class B beacon and default downlink channel**

746 The beacons SHALL be transmitted using the following settings

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

 747 **Table 26: CN779-787 beacon settings**

 748 The beacon frame content is defined in [TS001].¹ The beacon default broadcast frequency is
 749 785MHz.

¹ Prior to LoRaWAN 1.0.4, the beacon was defined here as:

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

750 The class B default downlink pingSlot frequency is 785MHz

751 **2.6.9 CN779-787 Default Settings**

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

753

754

755 **2.7 EU433MHz ISM Band**

756 **2.7.1 EU433 Preamble Format**

757 Please refer to Section 3.0 Physical Layer.

758 **2.7.2 EU433 ISM Band channel frequencies**

759 The LoRaWAN can be used in the ETSI 433-434 MHz band as long as the radio device EIRP
760 is less than 12.15dBm.

761 The end-device transmit duty-cycle SHALL be lower than 10%¹

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

- 763 • Minimum frequency: 433.175 MHz
- 764 • Maximum frequency: 434.665 MHz

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

769 The first three channels correspond to 433.175, 433.375 and 433.575 MHz with DR0 to DR5
770 and SHALL be implemented in every end-device. Those default channels cannot be modified
771 through the **NewChannelReq** command and guarantee a minimal common channel set
772 between end-devices and gateways of all networks. Other channels can be freely distributed
773 across the allowed frequency range on a network per network basis.

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

778

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

Table 27: EU433 Join-Request Channel List

779
780

781 **2.7.3 EU433 Data Rate and End-device Output Power encoding**

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

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

786
787
788

¹ Defined in the LoRaWAN Regional Parameters 1.0.2 specification

DataRate	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 LoRaWAN ¹		15	Defined in LoRaWAN ¹⁹

Table 28: EU433 Data rate and TX power table

789

790

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

794 By default, the Max EIRP is considered to be +12.15dBm. If the end-device cannot achieve
 795 12.15dBm EIRP, the Max EIRP SHALL be communicated to the network server using an
 796 out-of-band channel during the end-device commissioning process.

797 2.7.4 EU433 JoinAccept CFList

798

799 The EU433 ISM band LoRaWAN implements an OPTIONAL **channel frequency list**
 800 (CFList) of 16 octets in the JoinAccept message.

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

806

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

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

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

¹ DR15 and TXPower15 are defined in the LinkADRReq MAC command of the LoRaWAN1.0.4 and subsequent specifications and were previously RFU

815 2.7.5 EU433 LinkAdrReq command

816 The EU433 LoRaWAN only supports a maximum of 16 channels. When **ChMaskCntl** field is
 817 0 the ChMask field individually enables/disables each of the 16 channels.
 818

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

819 **Table 29: EU433 ChMaskCntl value table**

820 If the ChMask field value is one of the values meaning RFU, then end-device SHALL¹ reject
 821 the command and unset the “**Channel mask ACK**” bit in its response.

822 2.7.6 EU433 Maximum payload size

823 The maximum **MACPayload** size length (*M*) is given by the following table. It is derived from
 824 limitation of the PHY layer depending on the effective modulation rate used taking into account
 825 a possible repeater encapsulation layer. The maximum application payload length in the
 826 absence of the OPTIONAL **FOpt** control field (*N*) is also given for information only. The value
 827 of *N* might be smaller if the **FOpt** field is not empty:
 828

DataRate	<i>M</i>	<i>N</i>
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	

829 **Table 30: EU433 maximum payload size (repeater compatible)**

830
 831 If the end-device will never operate with a repeater then the maximum application payload
 832 length in the absence of the OPTIONAL **FOpt** control field SHALL be:
 833

DataRate	<i>M</i>	<i>N</i>
0	59	51
1	59	51
2	59	51
3	123	115
4	250	242
5	250	242
6	250	242
7	250	242

¹ Made SHALL from SHOULD starting in LoRaWAN Regional Parameters Specification 1.0.3rA

8:15	Not defined
------	-------------

Table 31 : EU433 maximum payload size (not repeater compatible)

 834
835

836 2.7.7 EU433 Receive windows

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

841

RX1DROffset	0	1	2	3	4	5
Upstream data rate	Downstream data rate in RX1 slot					
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

842

Table 32 : EU433 downlink RX1 data rate mapping

843 The RX2 receive window uses a fixed frequency and data rate. The default parameters are
844 434.665MHz / DR0 (SF12, 125 kHz).

845 2.7.8 EU433 Class B beacon and default downlink channel

846 The beacons SHALL be transmitted using the following settings

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

847

Table 33 : EU433 beacon settings

848 The beacon frame content is defined in [TS001].¹

849 The beacon default broadcast frequency is 434.665MHz.

850 The class B default downlink pingSlot frequency is 434.665MHz

851 2.7.9 EU433 Default Settings

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

853

¹ Prior to LoRaWAN 1.0.4, the beacon was defined here as:

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

854 **2.8 AU915-928MHz ISM Band¹**

855

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

858 **2.8.1 AU915-928 Preamble Format**

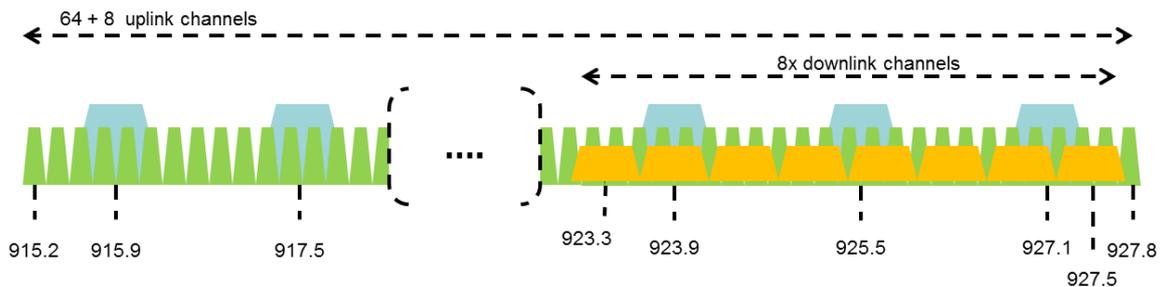
859 Please refer to Section 3.0 Physical Layer.

860 **2.8.2 AU915-928 Channel Frequencies**

861 The AU ISM Band SHALL be divided into the following channel plans.

- 862 • Upstream – 64 channels numbered 0 to 63 utilizing LoRa 125 kHz BW varying from
863 DR0 to DR5, using coding rate 4/5, starting at 915.2 MHz and incrementing linearly
864 by 200 kHz to 927.8 MHz
- 865 • Upstream – 8 channels numbered 64 to 71 utilizing LoRa 500 kHz BW at DR6
866 starting at 915.9 MHz and incrementing linearly by 1.6 MHz to 927.1 MHz
- 867 • Downstream – 8 channels numbered 0 to 7 utilizing LoRa 500 kHz BW at DR8 to
868 DR13) starting at 923.3 MHz and incrementing linearly by 600 kHz to 927.5 MHz

869



870

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

872 AU ISM band end-devices MAY use a maximum EIRP of +30 dBm.

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

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

881

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

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

¹ Defined in the LoRaWAN1.0.1 specification

888 Example: First pass: Random channel from [0-7], followed by [8-15]... [56-63], then 64
 889 Second pass: Random channel from [0-7], followed by [8-15]... [56-63], then
 890 65
 891 Last pass: Random channel from [0-7], followed by [8-15]... [56-63], then 71

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

894
 895 The default Join-Request Data Rate SHALL be DR2 (SF10/125 kHz), this setting ensures
 896 that end-devices are compatible with the 400ms dwell time limitation until the actual dwell
 897 time limit is notified to the end-device by the network server via the MAC command
 898 ***TxParamSetupReq***.

899
 900 AU915-928 end-devices SHALL consider UplinkDwellTime = 1 during boot stage until
 901 reception of the ***TxParamSetupReq*** command.

902
 903 AU915-928 end-devices SHALL always consider DownlinkDwellTime = 0, since downlink
 904 channels use 500 kHz bandwidth without any dwell time limit.

905 **2.8.3 AU915-928 Data Rate and End-point Output Power encoding**

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

908
 909 If the field UplinkDwellTime is set to 1 by the network server in the ***TxParamSetupReq***
 910 command, AU915-928 end-devices SHALL adjust the time between two consecutive uplink
 911 transmissions to meet the local regulation. Twenty seconds (20s) are recommended
 912 between 2 uplink transmissions when UplinkDwellTime = 1 but this value MAY be adjusted
 913 depending on local regulation.

914
 915 There is no such constraint on time between two consecutive transmissions when
 916 UplinkDwellTime = 0.

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

919

DataRate	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	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 LoRaWAN ¹	

Table 34: AU915-928 Data rate table

920

921

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

922

923

924

TXPower	Configuration (EIRP)
0	Max EIRP
1:14	Max EIRP – 2*TXPower
15	Defined in LoRaWAN ²³

Table 35 : AU915-928 TX power table

925

926

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

930

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

935 2.8.4 AU915-928 JoinAccept CFList

936

937 The AU915-928 LoRaWAN supports the use of the OPTIONAL **CFList** appended to the Join-
 938 Accept message. If the **CFList** is not empty, then the CFListType field SHALL contain the
 939 value one (0x01) to indicate the CFList contains a series of ChMask fields. The ChMask
 940 fields are interpreted as being controlled by a virtual ChMaskCntl that initializes to a value of

¹ DR15 and TXPower15 are defined in the LinkADRReq MAC command of the LoRaWAN1.0.4 and subsequent specifications and were previously RFU

941 zero (0) and increments for each ChMask field to a value of four (4). (The first 16 bits
 942 controls the channels 1 to 16...)
 943

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

944 2.8.5 AU915-928 LinkAdrReq command

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

947

948

ChMaskCntl	ChMask applies to
0	Channels 0 to 15
1	Channels 16 to 31
..	..
4	Channels 64 to 71
5	8LSBs controls Channel Blocks 0 to 7 8MSBs are RFU
6	All 125 kHz ON ChMask applies to channels 64 to 71
7	All 125 kHz OFF ChMask applies to channels 64 to 71

949

Table 36: AU915-928 ChMaskCntl value table

950 If **ChMaskCntl** = 5¹ then the corresponding bits in the ChMask enable and disable a bank of
 951 8 125kHz channels and the corresponding 500kHz channel defined by the following
 952 calculation: [ChannelMaskBit * 8, ChannelMaskBit * 8 +7],64+ChannelMaskBit.

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

957 2.8.6 AU915-928 Maximum payload size

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

¹ Added in LoRaWAN Regional Parameters Specification version 1.0.3rA

964

DataRate	UplinkDwellTime=0		UplinkDwellTime=1	
	<i>M</i>	<i>N</i>	<i>M</i>	<i>N</i>
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	Not defined		Not defined	
8	41	33	41	33
9	117	109	117	109
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	

965

Table 37: AU915-928 maximum payload size (repeater compatible)

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

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

970

DataRate	UplinkDwellTime=0		UplinkDwellTime=1	
	<i>M</i>	<i>N</i>	<i>M</i>	<i>N</i>
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	Not defined		Not defined	
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	

971

Table 38: AU915-928 Maximum repeater payload size

972

973 2.8.7 AU915-928 Receive windows

- 974 • The RX1 receive channel is a function of the upstream channel used to initiate the
 975 data exchange. The RX1 receive channel can be determined as follows.
 976 ○ RX1 Channel Number = Transmit Channel Number modulo 8
- 977 • The RX1 window data rate depends on the transmit data rate (see Table 18 below).
- 978 • The RX2 (second receive window) settings uses a fixed data rate and frequency.
 979 Default parameters are 923.3MHz / DR8

980

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

 981
982

Table 39 : AU915-928 downlink RX1 data rate mapping

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

985 2.8.8 AU915-928 Class B beacon

986 The beacons are transmitted using the following settings:

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

987

Table 40 : AU915-928 beacon settings

988 The downstream channel used for a given beacon is:

989

$$990 \text{ Channel} = \left[\text{floor} \left(\frac{\text{beacon_time}}{\text{beacon_period}} \right) \right] \text{ modulo } 8$$

991

- 992 • whereby beacon_time is the integer value of the 4 bytes “Time” field of the beacon frame
- 993
- 994 • whereby beacon_period is the periodicity of beacons, 128 seconds
- 995 • whereby floor(x) designates rounding to the integer immediately inferior or equal to x

996

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

998

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

999

- 1000 The beacon frame content is defined in [TS001].¹
- 1001 The default Class B PING_SLOT_CHANNEL is defined in the LoRaWAN specification. AU915-
1002 928 Default Settings
- 1003 There are no specific default settings for AU 915-928 MHz ISM Band.

¹ Prior to LoRaWAN 1.0.4, the beacon was defined here as:

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

1004 **2.9 CN470-510MHz Band¹**

 1005

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

 1006

prior revisions and should be considered experimental pending

 1007

published documents confirming plan compliant devices have been

 1008

granted local regulatory approval.

 1009 **2.9.1 CN470-510 Preamble Format**

1010 Please refer to Section 3.0 Physical Layer.

 1011 **2.9.2 CN470-510 Channel Frequencies**

1012 In China, this band is defined by SRRC to be used for civil metering applications.

1013 In the areas where channels are used by China Electric Power, they SHOULD be disabled.

1014 For CN470-510MHz band, the bandwidth is the biggest and the frequency is the lowest
 1015 compared to all the countries and areas in this document. The bandwidth and the frequency
 1016 affect the design of antennas. There are several different antenna solutions for CN470-
 1017 510MHz band.

1018 The 470MHz SRD Band shall be divided into the channel plans as follows:

- 1019
- 1020 • The channel plan for 20MHz antenna (type A and B);
 - 1021 • The channel plan for 26MHz antenna (type A and B);

1022 20 common join channels are defined for all the channel plans mentioned above.

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

 1028 **Table 41: Common join channels for CN470-510 channel frequencies**

1029 All the above channel plans SHALL be implemented in the CN470 end-devices.
 1030

¹ Heavily modified, and not backwardly compatible with, CN470-510 as previously defined in v1.0

1031 End devices SHALL scan all the common join channels. If the end-device receives the join-
 1032 accept message from one of the above DL common join channel, the end-device SHALL
 1033 use the corresponding channel plan¹ in the above table.

1034 **2.9.2.1 Channel Plan for 20MHz Antenna**

1035 For 20MHz Antennas, the 470M Band shall be divided into two channel plans: plan Type A
 1036 and plan Type B.

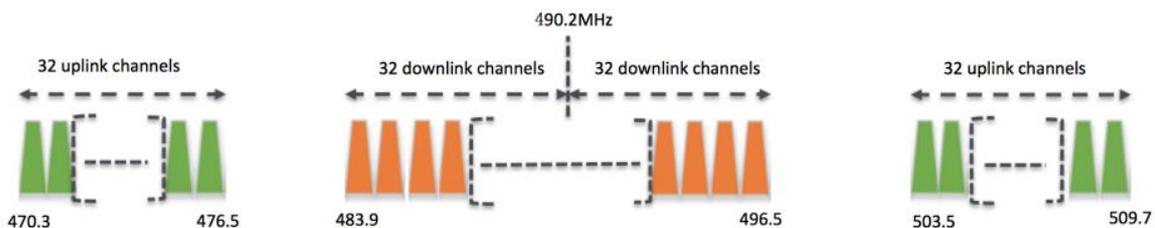
1037 For channel plan Type A:

1038 • Upstream (Group 1) – 32 channels numbered 0 to 31 utilizing LoRa 125 kHz BW varying
 1039 from DR0 to DR5, using coding rate 4/5, starting at 470.3 MHz and incrementing linearly
 1040 by 200 kHz to 476.5 MHz.

1041 • Downstream (Group 1) – 32 channels numbered 0 to 31 utilizing LoRa 125 kHz BW
 1042 varying from DR0 to DR5, using coding rate 4/5, starting at 483.9 MHz and incrementing
 1043 linearly by 200 kHz to 490.1 MHz.

1044 • Downstream (Group 2) – 32 channels numbered 32 to 63 utilizing LoRa 125 kHz BW
 1045 varying from DR0 to DR5, using coding rate 4/5, starting at 490.3 MHz and incrementing
 1046 linearly by 200 kHz to 496.5 MHz.

1047 • Upstream (Group 2) – 32 channels numbered 32 to 63 utilizing LoRa 125 kHz BW
 1048 varying from DR0 to DR5, using coding rate 4/5, starting at 503.5 MHz and incrementing
 1049 linearly by 200 kHz to 509.7 MHz.



1050

1051

Table 42: channel plan type A for 20MHz antenna channel frequencies

1052

1053

¹ 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.

1054 For channel plan Type B:

1055 • Upstream (Group 1) – 32 channels numbered 0 to 31 utilizing LoRa 125 kHz BW varying
 1056 from DR0 to DR5, using coding rate 4/5, starting at 476.9 MHz and incrementing linearly
 1057 by 200 kHz to 483.1 MHz.

1058 • Downstream (Group 1) – 32 channels numbered 0 to 31 utilizing LoRa 125 kHz BW
 1059 varying from DR0 to DR5, using coding rate 4/5, starting at 476.9 MHz and incrementing
 1060 linearly by 200 kHz to 483.1 MHz.

1061 • Upstream (Group 2) – 32 channels numbered 32 to 63 utilizing LoRa 125 kHz BW
 1062 varying from DR0 to DR5, using coding rate 4/5, starting at 496.9 MHz and incrementing
 1063 linearly by 200 kHz to 503.1 MHz.

1064 • Downstream (Group 2) – 32 channels numbered 32 to 63 utilizing LoRa 125 kHz BW
 1065 varying from DR0 to DR5, using coding rate 4/5, starting at 496.9 MHz and incrementing
 1066 linearly by 200 kHz to 503.1 MHz.



Table 43: channel plan type B for 20MHz antenna channel frequencies

1069 **2.9.2.2 Channel Plan for 26MHz antenna**

1070 For 26MHz Antennas, the 470M Band shall be divided into two channel plans: plan Type A
 1071 and plan Type B.

1072 For channel plan Type A:

1073 • Upstream – 48 channels numbered 0 to 47 utilizing LoRa 125 kHz BW varying from
 1074 DR0 to DR5, using coding rate 4/5, starting at 470.3 MHz and incrementing linearly by
 1075 200 kHz to 479.7 MHz

1076 • Downstream – 24 channels numbered 0 to 23 utilizing LoRa 125 kHz BW at DR0 to
 1077 DR5, starting at 490.1 MHz and incrementing linearly by 200 kHz to 494.7 MHz.
 1078 Additional frequencies from 494.9 to 495.9 MHz are available for configurable downlink
 1079 parameters (beacon frequency, ping-slot frequency and RX2 frequency).

1080 • RX2 DefaultChannel -- the 12th downstream channel 492.5 MHz

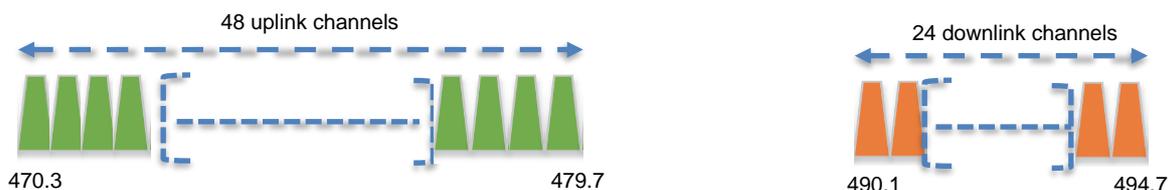
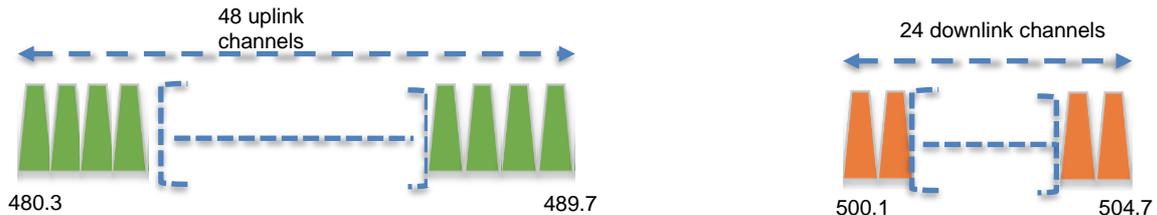


Table 44: channel plan type A for 26MHz antenna channel frequencies

1081
1082

1083 For channel plan Type B:

- 1084 • Upstream – 48 channels numbered 0 to 47 utilizing LoRa 125 kHz BW varying from
1085 DR0 to DR5, using coding rate 4/5, starting at 480.3 MHz and incrementing linearly by
1086 200 kHz to 489.7 MHz
- 1087 • Downstream – 24 channels numbered 0 to 23 utilizing LoRa 125 kHz BW at DR0 to
1088 DR5, starting at 500.1 MHz and incrementing linearly by 200 kHz to 504.7 MHz.
1089 Additional frequencies from 504.9 to 505.9 MHz are available for configurable downlink
1090 parameters (beacon frequency, ping-slot frequency and RX2 frequency).
- 1091 • RX2 DefaultChannel -- the 12th downstream channel 502.5 MHz



1092 **Table 45: channel plan type B for 26MHz antenna channel frequencies**

1095 If using the over-the-air activation procedure, the end-device SHALL broadcast the Join-
1096 Request message on a random 125 kHz channel amongst the 20 uplink channels defined
1097 previously in this section using **DR5 to DR0**.

1098 Personalized devices SHALL have all channels enabled corresponding to activation plan
1099 following a reset.

1100 **2.9.3 CN470-510 Data Rate and End-point Output Power encoding**

1101 There is no dwell time limitation for the CN470-510 PHY layer. The *TxParamSetupReq* MAC
1102 command is not implemented by CN470-510 devices.

1103 The following encoding is used for Data Rate (**DR**) and end-point EIRP (**TXPower**) in the
1104 CN470-510 band:

DataRate	Configuration	Indicative physical bit rate [bit/sec]	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
6:14	RFU		6	Max EIRP – 12dB
			7	Max EIRP – 14dB
			8...14	RFU
15	Defined in LoRaWAN ¹		15	Defined in LoRaWAN ²⁸

1105 **Table 46: CN470-510 Data rate and TX power table**

1106
1107

¹ DR15 and TXPower15 are defined in the LinkADRRReq MAC command of the LoRaWAN1.0.4 and subsequent specifications and were previously RFU

1108 EIRP refers to the Equivalent Isotropically Radiated Power, which is the radiated output
 1109 power referenced to an isotropic antenna radiating power equally in all directions and whose
 1110 gain is expressed in dBi.

1111
 1112 By default, the Max EIRP is considered to be +19.15dBm. If the end-device cannot achieve
 1113 19.15dBm EIRP, the Max EIRP SHOULD be communicated to the network server using an
 1114 out-of-band channel during the end-device commissioning process.

1115 2.9.4 CN470-510 Join-Accept CFList

1116
 1117 The CN470 LoRaWAN supports the use of the OPTIONAL CFList appended to the Join-
 1118 Accept message. If the CFList is not empty, then the CFListType field SHALL contain the
 1119 value one (0x01) to indicate the CFList contains a series of ChMask fields. The ChMask
 1120 fields are interpreted as being controlled by a virtual ChMaskCntl that initializes to a value of
 1121 zero (0) and increments for each ChMask field to a value of four (3) for 20 MHz plans A or B
 1122 and three (2) for 26 MHz plans A or B. (The first 16 bits controls the channels 0 to 15...)
 1123

1124 For 20MHz Antenna Systems:

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

1125
 1126 For 26MHz Antenna Systems:

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

1128

1129 2.9.5 CN470-510 LinkAdrReq command

1130 2.9.5.1 Channel Plan for 20MHz antenna

1131
 1132 For 20MHz antenna the ChMaskCntl field of the *LinkADRReq* command has the following
 1133 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 ¹

1134

Table 47:CH470 ChMaskCntl value table for 20M Antenna

¹ This command must be followed by another LinkADRReq command enabling at least one channel.

1135

1136 If the ChMask field value is one of the values indicating RFU, then end-device SHALL reject
1137 the command and unset the “**Channel mask ACK**” bit in its response.

1138 2.9.5.2 Channel Plan for 26MHz antenna

1139

1140 The **ChMaskCntl** field of the *LinkADRReq* command has the following meaning:

1141

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 ¹
5	RFU
6	RFU
7	RFU

Table 48: CH470 ChMaskCntl value table for 26M Antenna

1142

1143

1144 If the ChMask field value is set to a higher value than 3, the end-device SHALL reject the
1145 command and unset the “**Channel mask ACK**” bit in its response.

1146 2.9.6 CN470-510 Maximum payload size

1147 The maximum **MACPayload** size length (*M*) is given by the following table. It is derived from
1148 the maximum allowed transmission time at the PHY layer taking into account a possible
1149 repeater encapsulation. The maximum application payload length in the absence of the
1150 OPTIONAL **FOpt** MAC control field (*N*) is also given for information only. The value of *N* might
1151 be smaller if the **FOpt** field is not empty:

1152

DataRate	<i>M</i>	<i>N</i>
0	59	51
1	59	51
2	59	51
3	123	115
4	230	222
5	230	222
6:15	Not defined	

Table 49: CN470-510 maximum payload size (repeater compatible)

1153

1154 If the end-device will never operate with a repeater then the maximum application payload
1155 length in the absence of the OPTIONAL **FOpt** control field SHALL be:

1156

DataRate	<i>M</i>	<i>N</i>
0	59	51
1	59	51
2	59	51
3	123	115
4	250	242
5	250	242

¹ This command must be followed by another *LinkADRReq* command enabling at least one channel

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

1157
1158

Table 50: CN470-510 maximum payload size (not repeater compatible)

1159 2.9.7 CN470-510 Receive windows

1160 The RX1 data rate depends on the transmit data rate (see Table 51 below).
1161 The RX2 default data rate is DR0.

1162

RX1DROffset	0	1	2	3	4	5
Upstream data rate	Downstream data rate in RX1 slot					
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

1163
1164

Table 51: CN470-510 downlink RX1 data rate mapping

1165 The allowed values for RX1DROffset are in the [0:5] range. Values in the range [6:7] are
1166 reserved for future use.

1167 2.9.7.1 Channel Plan for 20MHz Antenna Systems

1168 For channel plan Type A:

- 1169 ○ The RX1 downlink channel is the same as the uplink channel number
- 1170 ○ The RX2 channel number for OTAA devices is defined in Table 52
- 1171 ○ The RX2 channel number for ABP devices is 486.9 MHz

1172

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

1173

Table 52: RX2 Default Frequency for channel plan type A for 20MHz antenna

1174 For channel plan Type B:

- 1175 ○ The RX1 downlink channel is the same as the uplink channel number
- 1176 ○ The RX2 channel number for OTAA devices is defined in Table 53
- 1177 ○ The RX2 channel number for ABP devices is 498.3 MHz

1178

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

1179

Table 53: RX2 Default Frequency for channel plan type B for 20MHz antenna

1180 **2.9.7.2 Channel Plan for 26MHz Antenna Systems**

- 1181 ○ For both plans, the RX1 receive channel is a function of the upstream channel used
-
- 1182 to initiate the data exchange. The RX1 receive channel can be determined as
-
- 1183 follows.
-
- 1184 ○ RX1 Channel Number = Transmit Channel Number modulo 24
-
- 1185 ○ The RX2 default frequency is:
-
- 1186 ○ For Channel plan A: 492.5MHz
-
- 1187 ○ For Channel plan B: 502.5MHz

 1188 **2.9.8 CN470-510 Class B beacon**

 1189
 1190 The beacon frame content is defined in [TS001].¹

1191 The beacons are transmitted using the following settings:

1192

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

1193

Table 54 : CN470-510 beacon settings

 1194 **2.9.8.1 Default Beacon and Ping-Slot Channel Numbers and Ping-Slots for 20MHz**
 1195 **Antenna Systems**

1196 By default, for channel plan Type A:

 1197 The downstream channel used for beacon is as the following table according to the common
 1198 join channel the end-device used:

1199

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	$56 + \left\lfloor \frac{\text{beacon_time}}{\text{beacon_period}} \right\rfloor \text{ modulo } 8$

1200

Table 55: Beacon Channel Number for channel plan type A for 20MHz antenna

¹ Prior to LoRaWAN 1.0.4, the beacon was defined here as:

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

1201

1202

1203

1204

1205

1206

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

1207 The downstream channel used for a Ping-slot channel is as the following table according to
 1208 the common join channel the end-device used:
 1209

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	$56 + \left[\text{DevAddr} + \text{floor} \left(\frac{\text{beacon_time}}{\text{beacon_period}} \right) \right] \text{ modulo } 8$

1210 **Table 56: Ping-slot Channel Number for channel plan type A for 20MHz antenna**

1211

1212 By default, for channel plan Type B:

1213 The downstream channel used for beacon is as the following table according to the common
 1214 join channel the end-device used:

1215

Common Join Channel Index	Beacon Channel Number
8	23
9	55

1216 **Table 57: Beacon Channel Number for channel plan type B for 20MHz antenna**

1217

- 1218 • whereby beacon_time is the integer value of the 4 bytes “Time” field of the beacon
- 1219 frame
- 1220 • whereby beacon_period is the periodicity of beacons, 128 seconds
- 1221 • whereby $\text{floor}(x)$ designates rounding to the integer immediately inferior or equal to
- 1222 x
- 1223

1224 The downstream channel used for a Ping-slot channel is as the following table according to
 1225 the common join channel the end-device used:

1226

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	$32 + \left[\text{DevAddr} + \text{floor} \left(\frac{\text{beacon_time}}{\text{beacon_period}} \right) \right] \text{ modulo } 32$

1227 **Table 58: Ping-slot Channel Number for channel plan type B for 20MHz antenna**

1228

1229 **2.9.8.2 Default Beacon and Ping-Slot Frequencies for 26MHz antenna Systems**

1230 By default, beacons and downlink ping-slot messages are transmitted using the following
1231 frequencies:

1232 For Channel Plan A: 494.9MHz

1233 For Channel Plan B: 504.9MHz

1234 **2.9.9 CN470-510 Default Settings**

1235 There are no specific default settings for the CN470-510 MHz ISM Band.

1236 **2.10 AS923MHz ISM Band**

 1237 **2.10.1 AS923 Preamble Format**

1238 Please refer to Section 3.0 Physical Layer.

 1239 **2.10.2 AS923 ISM Band channel frequencies**

 1240 This section applies to regions where the frequencies [923...923.5MHz] are present in an ISM
 1241 band.

1242

 1243 AS923 end-devices operated in Japan SHALL perform Listen Before Talk (LBT) based on
 1244 ARIB STD-T108 regulations. The ARIB STD-T108 regulation is available for free and should
 1245 be consulted as needed by the user.

1246

 1247 AS923 end-devices LBT time, max TX time, duty cycle or other parameters depend on
 1248 channels.

 1249 The network channels can be freely attributed by the network operator. However, the two
 1250 following default channels SHALL be implemented in every AS923 end-device. Those
 1251 channels are the minimum set that all network gateways SHALL always be listening on.

1252

Modulation	Bandwidth [kHz]	Channel Frequency [MHz]	FSK Bitrate or LoRa DR / Bitrate	Nb Channels	Duty cycle
LoRa	125	923.20 923.40	DR0 to DR5 / 0.3-5 kbps	2	< 1%

1253

Table 59: AS923 default channels

 1254 Those default channels SHALL be implemented in every end-device and cannot be modified
 1255 through the **NewChannelReq** command and guarantee a minimal common channel set
 1256 between end-devices and network gateways.

1257 AS923 end-devices SHOULD use the following default parameters

1258

- Default EIRP: 16 dBm

 1259 AS923 end-devices SHALL feature a channel data structure to store the parameters of at least
 1260 16 channels. A channel data structure corresponds to a frequency and a set of data rates
 1261 usable on this frequency.

 1262 The following table gives the list of frequencies that SHALL be used by end-devices to
 1263 broadcast the Join-Request message.

Modulation	Bandwidth [kHz]	Channel Frequency [MHz]	FSK Bitrate or LoRa DR / Bitrate	Nb Channels	Duty cycle
LoRa	125	923.20 923.40	DR2 to DR5	2	< 1%

1264

Table 60: AS923 Join-Request Channel List

1265

 1266 The default Join-Request Data Rate utilizes the range DR2-DR5 (SF10/125 kHz – SF7/125
 1267 kHz), this setting ensures that end-devices are compatible with the 400ms dwell time limitation

1268 until the actual dwell time limit is notified to the end-device by the network server via the MAC
 1269 command “TxParamSetupReq”.

1270

1271 The Join-Request message transmit duty-cycle SHALL follow the rules described in chapter
 1272 “Retransmissions back-off” of the LoRaWAN specification document.

1273 2.10.3 AS923 Data Rate and End-point Output Power encoding

1274 The “TxParamSetupReq/Ans” MAC command SHALL be implemented by the AS923 devices.

1275 The following encoding is used for Data Rate (DR) in the AS923 band:

1276

DataRate	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 LoRaWAN ¹	

Table 61: AS923 Data rate table

1277

1278

1279 The TXPower table indicates power levels relative to the Max EIRP level of the end-device,
 1280 as per the following table:

1281

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 LoRaWAN ³²

Table 62: AS923 TXPower table

1282

1283

1284 EIRP refers to the Equivalent Isotropically Radiated Power, which is the radiated output
 1285 power referenced to an isotropic antenna radiating power equally in all directions and whose
 1286 gain is expressed in dBi.

¹ DR15 and TXPower15 are defined in the LinkADRReq MAC command of the LoRaWAN1.0.4 and subsequent specifications and were previously RFU

1287 By default, the Max EIRP SHALL be 16dBm. The Max EIRP can be modified by the network
 1288 server through the **TxParamSetupReq** MAC command and SHOULD be used by both the
 1289 end-device and the network server once **TxParamSetupReq** is acknowledged by the device
 1290 via **TxParamSetupAns**,

1291 **2.10.4 AS923 JoinAccept CFList**

1292 The AS923 LoRaWAN implements an OPTIONAL channel frequency list (CFList) of 16 octets
 1293 in the JoinAccept message.

1294 In this case the CFList is a list of five channel frequencies for the channels two to six whereby
 1295 each frequency is encoded as a 24 bits unsigned integer (three octets). All these channels are
 1296 usable for DR0 to DR5 125 KHz LoRa modulation. The list of frequencies is followed by a
 1297 single CFListType octet for a total of 16 octets. The CFListType SHALL be equal to zero (0)
 1298 to indicate that the CFList contains a list of frequencies.

1299

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

1300

1301 The actual channel frequency in Hz is 100 x frequency whereby values representing
 1302 frequencies below 100 MHz are reserved for future use. This allows setting the frequency of
 1303 a channel anywhere between 915 and 928MHz in 100 Hz steps. Unused channels have a
 1304 frequency value of 0. The CFList is OPTIONAL and its presence can be detected by the length
 1305 of the join-accept message. If present, the CFList replaces all the previous channels stored in
 1306 the end-device apart from the two default channels. The newly defined channels are
 1307 immediately enabled and usable by the end-device for communication.

1308 **2.10.5 AS923 LinkAdrReq command**

1309 The AS923 LoRaWAN only supports a maximum of 16 channels. When **ChMaskCntl** field is
 1310 0 the ChMask field individually enables/disables each of the 16 channels.

1311

ChMaskCntl	ChMask applies to
0	Channels 0 to 15
1	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

1312

Table 63: AS923 ChMaskCntl value table

1313 If the ChMask field value is one of values meaning RFU, the end-device SHALL reject the
 1314 command and unset the “**Channel mask ACK**” bit in its response.

1315

1316 **2.10.6 AS923 Maximum payload size**

 1317 The maximum **MACPayload** size length (M) is given by the following table for both dwell time
 1318 configurations: No Limit and 400ms. It is derived from the PHY layer limitation depending on
 1319 the effective modulation rate used taking into account a possible repeater encapsulation layer.

1320

DataRate	Uplink MAC Payload Size (M)		Downlink MAC Payload Size (M)	
	UplinkDwellTime = 0	UplinkDwellTime = 1	DownlinkDwellTime = 0	DownlinkDwellTime = 1
0	59	N/A	59	N/A
1	59	N/A	59	N/A
2	59	19	59	19
3	123	61	123	61
4	230	133	230	133
5	230	230	230	230
6	230	230	230	230
7	230	230	230	230
8:15	RFU		RFU	

1321

Table 64: AS923 maximum payload size (repeater compatible)

 1322 If the end-device will never operate with a repeater then the maximum MAC payload length
 1323 SHALL be:

1324

DataRate	Uplink MAC Payload Size (M)		Downlink MAC Payload Size (M)	
	UplinkDwellTime = 0	UplinkDwellTime = 1	DownlinkDwellTime = 0	DownlinkDwellTime = 1
0	59	N/A	59	N/A
1	59	N/A	59	N/A
2	59	19	59	19
3	123	61	123	61
4	250	133	250	133
5	250	250	250	250
6	250	250	250	250
7	250	250	250	250
8:15	RFU		RFU	

1325

Table 65: AS923 maximum payload size (not repeater compatible)

 1326 The maximum application payload length in the absence of the OPTIONAL **FOpt** control field
 1327 (M) is eight bytes lower than the MACPayload value in the above table. The value of N might
 1328 be smaller if the **FOpt** field is not empty.

 1329 The end-device SHALL only enforce the maximum Downlink MAC Payload Size defined for
 1330 DownlinkDwellTime = 0 (no dwell time enforced) regardless of the actual setting. This
 1331 prevents the end-device from discarding valid downlink messages which comply with the
 1332 regulatory requirements which may be unknown to the device (for example, when the device
 1333 is joining the network).

 1334 **2.10.7 AS923 Receive windows**

 1335 The RX1 receive window uses the same channel as the preceding uplink. The data rate is a
 1336 function of the uplink data rate and the RX1DROffset as given by the following table. The
 1337 allowed values for RX1DROffset are in the [0:7] range.

 1338 Values in the [6:7] range allow setting the Downstream RX1 data rate higher than upstream
 1339 data rate.

1340 When **DownlinkDwellTime** is zero, the allowed values for RX1DROffset are in the [0:7] range,
 1341 encoded as per the below table.

1342

RX1DROffset Upstream 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

Table 66: AS923 downlink RX1 data rate mapping for DownLinkDwellTime = 0

1343

1344

1345 When **DownlinkDwellTime** is one, the allowed values for RX1DROffset are in the [0:7] range,
 1346 encoded as per the below table.

1347

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

Table 67: AS923 downlink RX1 data rate mapping for DownLinkDwellTime =1

1348

1349 The RX2 receive window uses a fixed frequency and data rate. The default parameters are
 1350 923.2 MHz / DR2 (SF10/125KHz).

1351 2.10.8 AS923 Class B beacon and default downlink channel

1352 The beacons SHALL be transmitted using the following settings

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

1353

Table 67 : AS923 beacon settings

1354 The beacon frame content is defined in [TS001].¹

1355 The beacon default broadcast frequency is 923.4MHz.

¹ Prior to LoRaWAN 1.0.4, the beacon was defined here as:

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

1356 The class B default downlink pingSlot frequency is 923.4MHz

1357 **2.10.9 AS923 Default Settings**

1358 There are no specific default settings for the AS923 ISM Band.

1359 **2.11 KR920-923MHz ISM Band**

 1360 **2.11.1 KR920-923 Preamble Format**

1361 Please refer to Section 3.0 Physical Layer.

 1362 **2.11.2 KR920-923 ISM Band channel frequencies**

 1363 The center frequency, bandwidth and maximum EIRP output power for the South Korea
 1364 RFID/USN frequency band are defined by Korean Government, which has allocated LPWA
 1365 based IoT networks the frequency band from 920.9 to 923.3MHz.

1366

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

1367

Table 68: KR920-923 Center frequency, bandwidth, maximum EIRP output power table

 1368 The first three channels correspond to 922.1, 922.3 and 922.5MHz / DR0 to DR5 and SHALL
 1369 be implemented in every KR920-923 end-device. Those default channels cannot be modified
 1370 through the **NewChannelReq** command and guarantee a minimal common channel set
 1371 between end-devices and network gateways.

 1372 The following table gives the list of frequencies that SHALL be used by end-devices to
 1373 broadcast the Join-Request message. The Join-Request message transmit duty-cycle SHALL
 1374 follow the rules described in chapter “Retransmissions back-off” of the LoRaWAN specification
 1375 document.

1376

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

1377

Table 69: KR920-923 default channels

 1378 In order to access the physical medium, the South Korea regulations impose several
 1379 restrictions. The South Korea regulations allow the choice of using either a duty-cycle
 1380 limitation or Listen Before Talk Adaptive Frequency Agility (LBT AFA) transmission
 1381 management. The current LoRaWAN specification for the KR920-923 ISM band exclusively
 1382 uses LBT channel access rule to maximize MACPayload size length and comply with the
 1383 South Korea regulations.

1384 KR920-923MHz ISM band end-devices SHALL use the following default parameters

- 1385 • Default EIRP output power for end-device(920.9~921.9MHz): 10 dBm
- 1386 • Default EIRP output power for end-device(922.1~923.3MHz): 14 dBm
- 1387 • Default EIRP output power for gateway: 23 dBm

1388 KR920-923MHz end-devices SHALL be capable of operating in the 920 to 923MHz frequency
 1389 band and SHALL feature a channel data structure to store the parameters of at least 16
 1390 channels. A channel data structure corresponds to a frequency and a set of data rates usable
 1391 on this frequency.

1392 The following table gives the list of frequencies that SHALL be used by end-devices to
 1393 broadcast the Join-Request message.

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

1394 **Table 70: KR920-923 Join-Request Channel List**

1395 2.11.3 KR920-923 Data Rate and End-device Output Power encoding

1396 There is no dwell time limitation for the KR920-923 PHY layer. The *TxParamSetupReq* MAC
 1397 command is not implemented by KR920-923 devices.

1398 The following encoding is used for Data Rate (DR), and EIRP Output Power (TXPower) in the
 1399 KR920-923 band:

1400

DataRate	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 LoRAWAN ¹	

1401 **Table 71: KR920-923 TX Data rate table**

1402

1403

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 LoRAWAN ³⁴

¹ DR15 and TXPower15 are defined in the LinkADRReq MAC command of the LoRaWAN1.0.4 and subsequent specifications and were previously RFU

1404
 1405

Table 72: KR920-923 TX power table

1406 EIRP refers to the Equivalent Isotropically Radiated Power, which is the radiated output
 1407 power referenced to an isotropic antenna radiating power equally in all directions and whose
 1408 gain is expressed in dBi.

1409 By default, the Max EIRP is considered to be +14dBm. If the end-device cannot achieve
 1410 14dBm EIRP, the Max EIRP SHOULD be communicated to the network server using an out-
 1411 of-band channel during the end-device commissioning process.

1412
 1413 When the device transmits in a channel whose frequency is <922MHz, the transmit power
 1414 SHALL be limited to +10dBm EIRP even if the current transmit power level set by the
 1415 network server is higher.

1416 2.11.4 KR920-923 JoinAccept CFList

1417 The KR920-923 ISM band LoRaWAN implements an OPTIONAL **channel frequency list**
 1418 (CFList) of 16 octets in the JoinAccept message.

1419 In this case the CFList is a list of five channel frequencies for the channels three to seven
 1420 whereby each frequency is encoded as a 24 bits unsigned integer (three octets). All these
 1421 channels are usable for DR0 to DR5 125 kHz LoRa modulation. The list of frequencies is
 1422 followed by a single CFListType octet for a total of 16 octets. The CFListType SHALL be equal
 1423 to zero (0) to indicate that the CFList contains a list of frequencies.

1424

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

1425 The actual channel frequency in Hz is 100 x frequency whereby values representing
 1426 frequencies below 100 MHz are reserved for future use. This allows setting the frequency of
 1427 a channel anywhere between 100 MHz to 1.67 GHz in 100 Hz steps. Unused channels have
 1428 a frequency value of 0. The **CFList** is OPTIONAL and its presence can be detected by the
 1429 length of the join-accept message. If present, the **CFList** replaces all the previous channels
 1430 stored in the end-device apart from the three default channels. The newly defined channels
 1431 are immediately enabled and usable by the end-device for communication.

1432 2.11.5 KR920-923 LinkAdrReq command

1433 The KR920-923 LoRaWAN only supports a maximum of 16 channels. When **ChMaskCntl**
 1434 field is 0 the ChMask field individually enables/disables each of the 16 channels.
 1435

1436

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

1437

1438

Table 73: KR920-923 ChMaskCntl value table

1439 If the ChMaskCntl field value is one of values meaning RFU, the end-device SHALL¹ reject
1440 the command and unset the “**Channel mask ACK**” bit in its response.

1441 2.11.6 KR920-923 Maximum payload size

1442 The maximum **MACPayload** size length (M) is given by the following table for the regulation
1443 of dwell time; less than 4 sec with LBT. It is derived from limitation of the PHY layer depending
1444 on the effective modulation rate used taking into account a possible repeater encapsulation
1445 layer. The maximum application payload length in the absence of the OPTIONAL **FOpt** control
1446 field (N) is also given for information only. The value of N might be smaller if the **FOpt** field is
1447 not empty:

1448

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

1449

Table 74: KR920-923 maximum payload size (repeater compatible)

1450 If the end-device will never operate with a repeater then the maximum application payload
1451 length in the absence of the OPTIONAL **FOpt** control field SHOULD be:

1452

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

1453

1454

Table 75 : KR920-923 maximum payload size (not repeater compatible)

¹ Made SHALL from SHOULD starting in LoRaWAN Regional Parameters Specification 1.0.3rA

1455 **2.11.7 KR920-923 Receive windows**

 1456 The RX1 receive window uses the same channel as the preceding uplink. The data rate is a
 1457 function of the uplink data rate and the RX1DROffset as given by the following table. The
 1458 allowed values for RX1DROffset are in the [0:5] range. Values in the [6:7] range are reserved
 1459 for future use.

1460

RX1DROffset	0	1	2	3	4	5
Upstream data rate	Downstream data rate in RX1 slot					
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

1461

Table 76 : KR920-923 downlink RX1 data rate mapping

 1462 The RX2 receive window uses a fixed frequency and data rate. The default parameters are
 1463 921.90MHz / DR0 (SF12, 125 kHz).

 1464 **2.11.8 KR920-923 Class B beacon and default downlink channel**

1465 The beacons SHALL be transmitted using the following settings

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

1466

Table 77 : KR920-923 beacon settings

1467

 1468 The beacon frame content is defined in [TS001].¹

1469 The beacon default broadcast frequency is 923.1MHz.

1470 The class B default downlink pingSlot frequency is 923.1MHz

 1471 **2.11.9 KR920-923 Default Settings**

1472 There are no specific default settings for the KR920-923 MHz ISM Band.

¹ Prior to LoRaWAN 1.0.4, the beacon was defined here as:

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

1473 **2.12 IN865-867 MHz ISM Band**

 1474 **2.12.1 IN865-867 Preamble Format**

1475 Please refer to Section 3.0 Physical Layer.

 1476 **2.12.2 IN865-867 ISM Band channel frequencies**

1477 This section applies to the Indian sub-continent.

 1478 The network channels can be freely attributed by the network operator. However, the three
 1479 following default channels SHALL be implemented in every India 865-867MHz end-device.
 1480 Those channels are the minimum set that all network gateways SHALL be listening on.

1481

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

1482

Table 78: IN865-867 default channels

 1483 End-devices SHALL be capable of operating in the 865 to 867 MHz frequency band and
 1484 should feature a channel data structure to store the parameters of at least 16 channels. A
 1485 channel data structure corresponds to a frequency and a set of data rates usable on this
 1486 frequency.

 1487 The first three channels correspond to 865.0625, 865.4025, and 865.985 MHz / DR0 to DR5
 1488 and SHALL be implemented in every end-device. Those default channels cannot be modified
 1489 through the **NewChannelReq** command and guarantee a minimal common channel set
 1490 between end-devices and network gateways.

 1491 The following table gives the list of frequencies that SHALL be used by end-devices to
 1492 broadcast the Join-Request message. The Join-Request message transmit duty-cycle SHALL
 1493 follow the rules described in chapter "Retransmissions back-off" of the LoRaWAN specification
 1494 document.

1495

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

1496

Table 79: IN865-867 Join-Request Channel List

1497

1498 **2.12.3 IN865-867 Data Rate and End-device Output Power Encoding**

 1499 There is no dwell time or duty-cycle limitation for the INDIA 865-867 PHY layer. The
 1500 ***TxParamSetupReq*** MAC command is not implemented by INDIA 865-867 devices.

 1501 The following encoding is used for Data Rate (DR) and End-device Output Power (TXPower)
 1502 in the INDIA 865-867 band:

1503

DataRate	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 LoRaWAN ¹	

Table 80: IN865-867 TX Data rate table

1504

1505

 1506 The TXPower table indicates power levels relative to the Max EIRP level of the end-device,
 1507 as per the following table:

1508

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 LoRAWAN ³⁷

Table 81: IN865-867 TXPower table

1509

1510

 1511 EIRP refers to the Equivalent Isotropically Radiated Power, which is the radiated output power
 1512 referenced to an isotropic antenna radiating power equally in all directions and whose gain is
 1513 expressed in dBi.

¹ DR15 and TXPower15 are defined in the LinkADRReq MAC command of the LoRaWAN1.0.4 and subsequent specifications and were previously RFU

1514 By default, Max EIRP is considered to be 30dBm. If the end-device cannot achieve 30dBm
 1515 EIRP, the Max EIRP SHOULD be communicated to the network server using an out-of-band
 1516 channel during the end-device commissioning process.
 1517

1518 2.12.4 IN865-867 JoinAccept CFList

1519 The India 865-867 ISM band LoRaWAN implements an OPTIONAL **channel frequency list**
 1520 (CFList) of 16 octets in the JoinAccept message.

1521 In this case the CFList is a list of five channel frequencies for the channels three to seven
 1522 whereby each frequency is encoded as a 24 bits unsigned integer (three octets). All these
 1523 channels are usable for DR0 to DR5 125 kHz LoRa modulation.

1524 The list of frequencies is followed by a single CFListType octet for a total of 16 octets. The
 1525 CFListType SHALL be equal to zero (0) to indicate that the CFList contains a list of
 1526 frequencies.

1527

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

1528

1529 The actual channel frequency in Hz is 100 x frequency whereby values representing
 1530 frequencies below 100 MHz are reserved for future use. This allows setting the frequency of
 1531 a channel anywhere between 100 MHz to 1.67 GHz in 100 Hz steps. Unused channels have
 1532 a frequency value of 0. The **CFList** is OPTIONAL and its presence can be detected by the
 1533 length of the join-accept message. If present, the **CFList** replaces all the previous channels
 1534 stored in the end-device apart from the three default channels. The newly defined channels
 1535 are immediately enabled and usable by the end-device for communication.

1536 2.12.5 IN865-867 LinkAdrReq command

1537 The INDIA 865-867 LoRaWAN only supports a maximum of 16 channels. When **ChMaskCntl**
 1538 field is 0 the ChMask field individually enables/disables each of the 16 channels.
 1539

ChMaskCntl	ChMask applies to
0	Channels 0 to 15
1	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

1540

Table 82: IN865-867 ChMaskCntl value table

1541 If the ChMaskCntl field value is one of values meaning RFU, the end-device SHALL¹ reject
 1542 the command and unset the “**Channel mask ACK**” bit in its response.

¹ Made SHALL from SHOULD starting in LoRaWAN Regional Parameters Specification 1.0.3rA

1543 **2.12.6 IN865-867 Maximum payload size**

 1544 The maximum **MACPayload** size length (M) is given by the following table. It is derived from
 1545 limitation of the PHY layer depending on the effective modulation rate used taking into account
 1546 a possible repeater encapsulation layer. The maximum application payload length in the
 1547 absence of the OPTIONAL **FOpt** control field (N) is also given for information only. The value
 1548 of N might be smaller if the **FOpt** field is not empty:
 1549

DataRate	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	

 1550 **Table 83: IN865-867 maximum payload size (repeater compatible)**

 1551 If the end-device will never operate with a repeater then the maximum application payload
 1552 length in the absence of the OPTIONAL **FOpt** control field SHOULD be:
 1553

DataRate	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	

 1554 **Table 84 : IN865-867 maximum payload size (not repeater compatible)**

 1555 **2.12.7 IN865-867 Receive windows**

 1556 The RX1 receive window uses the same channel as the preceding uplink. The data rate is a
 1557 function of the uplink data rate and the RX1DROffset as given by the following table. The
 1558 allowed values for RX1DROffset are in the [0:7] range.

 1559 Values in the [6:7] range allow setting the Downstream RX1 data rate higher than upstream
 1560 data rate.

1561 The allowed values for RX1DROffset are in the [0:7] range, encoded as per the below table:

RX1DROffset	0	1	2	3	4	5	6	7
Upstream data rate	Downstream data rate in RX1 slot							
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
DR6	RFU	RFU	RFU	RFU	RFU	RFU	RFU	RFU
DR7	DR7	DR5	DR5	DR4	DR3	DR2	DR7	DR7

1562

Table 85: IN865-867 downlink RX1 data rate mapping

1563

The RX2 receive window uses a fixed frequency and data rate. The default parameters are

1564

866.550 MHz / DR2 (SF10, 125 kHz).

1565 **2.12.8 IN865-867 Class B beacon and default downlink channel**

1566 The beacons are transmitted using the following settings

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

1567

 1568 The beacon frame content is defined in [TS001].¹

1569 The beacon default broadcast frequency is 866.550MHz.

1570 The class B default downlink pingSlot frequency is 866.550MHz

 1571 **2.12.9 IN865-867 Default Settings**

1572 There are no specific default settings for the IN 865-867 MHz ISM Band.

¹ Prior to LoRaWAN 1.0.4, the beacon was defined here as:

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

1573 **2.13 RU864-870 MHz ISM Band**

 1574 **2.13.1 RU864-870 Preamble Format**

1575 Please refer to Section 3.0 Physical Layer.

 1576 **2.13.2 RU864-870 ISM Band channel frequencies**

 1577 The network channels can be freely attributed by the network operator in compliance with the
 1578 allowed sub-bands defined by the Russian regulation. However, the two following default
 1579 channels SHALL be implemented in every RU864-870 MHz end-device. Those channels are
 1580 the minimum set that all network gateways SHALL be listening on.

1581

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

1582

Table 86: RU864-870 default channels

 1583 RU864-870 MHz end-devices SHALL be capable of operating in the 864 to 870 MHz
 1584 frequency band and SHALL feature a channel data structure to store the parameters of at
 1585 least 8 channels. A channel data structure corresponds to a frequency and a set of data rates
 1586 usable on this frequency.

 1587 The first two channels correspond to 868.9 and 869.1 MHz / DR0 to DR5 and SHALL be
 1588 implemented in every end-device. Those default channels cannot be modified through the
 1589 **NewChannelReq** command and guarantee a minimal common channel set between end-
 1590 devices and network gateways.

 1591 The following table gives the list of frequencies that SHALL be used by end-devices to
 1592 broadcast the Join-Request message. The Join-Request message transmit duty-cycle SHALL
 1593 follow the rules described in chapter "Retransmissions back-off" of the LoRaWAN specification
 1594 document.

1595

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

1596

Table 87: RU864-870 Join-Request Channel List

 1597 **2.13.3 RU864-870 Data Rate and End-device Output Power encoding**

 1598 There is no dwell time limitation for the RU864-870 PHY layer. The **TxParamSetupReq** MAC
 1599 command is not implemented in RU864-870 devices.

 1600 The following encoding is used for Data Rate (DR) and End-device EIRP (TXPower) in the
 1601 RU864-870 band:

1602

DataRate	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 LoRaWAN ¹	

Table 88: RU864-870 TX Data rate table

1603

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1605

1606

1607

EIRP² 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 LoRAWAN ⁴⁰

Table 89: RU864-870 TX power table

1608

1609

1610

1611

1612

1613

1614

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

1615 2.13.4 RU864-870 JoinAccept CFList

1616

1617

The RU 864-870 ISM band LoRaWAN implements an OPTIONAL **channel frequency list** (CFList) of 16 octets in the JoinAccept message.

1618

1619

1620

1621

1622

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

1623

¹ DR15 and TXPower15 are defined in the LinkADDRReq MAC command of the LoRaWAN1.0.4 and subsequent specifications and were previously RFU

² ERP = EIRP – 2.15dB; it is referenced to a half-wave dipole antenna whose gain is expressed in dBd

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

1624

1625 The actual channel frequency in Hz is 100 x frequency whereby values representing
 1626 frequencies below 100 MHz are reserved for future use. This allows setting the frequency of
 1627 a channel anywhere between 100 MHz to 1.67 GHz in 100 Hz steps. Unused channels have
 1628 a frequency value of 0. The **CFList** is OPTIONAL and its presence can be detected by the
 1629 length of the join-accept message. If present, the **CFList** replaces all the previous channels
 1630 stored in the end-device apart from the two default channels. The newly defined channels are
 1631 immediately enabled and usable by the end-device for communication.

1632 2.13.5 RU864-870 LinkAdrReq command

1633 The RU864-870 LoRaWAN only supports a maximum of 16 channels. When **ChMaskCntl**
 1634 field is 0 the ChMask field individually enables/disables each of the 16 channels.
 1635

ChMaskCntl	ChMask applies to
0	Channels 0 to 15
1	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 90: RU864-870 ChMaskCntl value table

1636

1637 If the ChMaskCntl field value is one of values meaning RFU, the end-device SHALL¹ reject
 1638 the command and unset the “**Channel mask ACK**” bit in its response.

1639 2.13.6 RU864-870 Maximum payload size

1640 The maximum **MACPayload** size length (*M*) is given by the following table. It is derived from
 1641 limitation of the PHY layer depending on the effective modulation rate used taking into account
 1642 a possible repeater encapsulation layer. The maximum application payload length in the
 1643 absence of the OPTIONAL **FOpt** control field (*N*) is also given for information only. The value
 1644 of *N* might be smaller if the **FOpt** field is not empty:

¹ Made SHALL from SHOULD starting in LoRaWAN Regional Parameters Specification 1.0.3rA

1645

DataRate	<i>M</i>	<i>N</i>
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	

1646

Table 91: RU864-870 maximum payload size (repeater compatible)

1647 If the end-device will never operate with a repeater then the maximum application payload
 1648 length in the absence of the OPTIONAL **Fopt** control field SHOULD be:

1649

DataRate	<i>M</i>	<i>N</i>
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	

1650

Table 92 : RU864-870 maximum payload size (not repeater compatible)

1651 2.13.7 RU864-870 Receive windows

1652 The RX1 receive window uses the same channel as the preceding uplink. The data rate is a
 1653 function of the uplink data rate and the RX1DROffset as given by the following table. The
 1654 allowed values for RX1DROffset are in the [0:5] range. Values in the [6:7] range are reserved
 1655 for future use.

1656

RX1DROffset	0	1	2	3	4	5
Upstream data rate	Downstream data rate in RX1 slot					
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

1657

Table 93: RU864-870 downlink RX1 data rate mapping

1658

1659 The RX2 receive window uses a fixed frequency and data rate. The default parameters are
 1660 869.1MHz / DR0 (SF12, 125 kHz)

1661

1662 **2.13.8 RU864-870 Class B beacon and default downlink channel**

1663 The beacons SHALL be transmitted using the following settings

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

 1664 [Table 94: RU864-870 beacon settings](#)

1665

 1666 The beacon frame content is defined in [TS001].¹The beacon default broadcast frequency is
 1667 869.1 MHz.

1668 The class B default downlink pingSlot frequency is 868.9 MHz.

 1669 **2.13.9 RU864-870 Default Settings**

1670 There are no specific default settings for the RU 864-870 MHz ISM Band.

¹ Prior to LoRaWAN 1.0.4, the beacon was defined here as:

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

1671 3 Physical layer

1672 The LoRaWAN uses a physical layer to communicate with other devices. Two physical
1673 layers are currently supported through the LoRa™ and FSK modulations.

1674 3.1 LoRa™ description

1675 3.1.1 LoRa™ packet physical structure

1676 LoRa™ messages use the radio packet explicit header mode in which the LoRa physical
1677 header (**PHDR**) plus a header CRC (**PHDR_CRC**) are included.¹ In explicit header mode the
1678 **PHDR** specifies: the payload length in bytes, the forward error correction rate, and the
1679 presence of an OPTIONAL **CRC** for the payload. The integrity of the payload is protected by
1680 a **CRC** for uplink messages. LoRaWAN beacons are transmitted using LoRa™ modulation in
1681 implicit header mode with a fixed length. In implicit header mode neither the **PHDR** nor
1682 **PHDR_CRC** are present.

1683 The **PHDR**, **PHDR_CRC** and payload **CRC** fields are inserted by the radio transceiver.

1684 PHY:

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

1685 **Figure 3: LoRa PHY structure**

1686 3.1.2 LoRa™ settings

1687 In order to be fully compliant with LoRaWAN, an end device SHALL configure the LoRa™
1688 physical layer as follows:

1689

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 Datarate, specified in each region	
Bandwidth		
IQ polarization	Not-inverted	Inverted

1690 **Table 95 : LoRa physical layer settings**

1691 3.2 FSK description

1692 3.2.1 FSK packet physical structure

1693 FSK messages can be built either by the software stack or by the hardware transceiver,
1694 depending on the end-device architecture.

1695 The **PHYPayload length** field contains the length in bytes of the **PHYPayload** field.

1696 The **CRC** field is computed on **PHYPayload length** and **PHYPayload** fields, using the CRC-
1697 CCITT algorithm.

1698 PHY:

¹ See the LoRa radio transceiver datasheet for a description of LoRa radio packet implicit/explicit modes.

1699

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

1700

Figure 4: FSK PHY structure

1701

1702 3.2.2 FSK settings

1703 In order to be fully compliant with LoRaWAN, an end device SHALL configure the FSK
1704 physical layer as follows:

1705

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

1706

Table 96 : FSK physical layer settings

1707

1708 To avoid a non-uniform power distribution signal with the FSK modulation, a Data Whitening
1709 DC-Free data mechanism is used as shown in the above table.

1710

1711

¹ SSB : Single Side Bandwidth

1712 4 Revisions

1713 4.1 Revision RP002-1.0.0

- 1714 • Initial RP002-1.0.0 revision, the regional parameters were extracted from the
- 1715 released LoRaWAN v1.1 Regional Parameters
- 1716 • Modified suggest New Zealand channel plan from EU868 to IN865
- 1717 • Modified Bangladesh and Pakistan channel plans from EU868 to IN865
- 1718 • Modified Singapore channel plan from EU868 to “Other”
- 1719 • Updated Burma (Myanmar) channel plans from EU868 to “Other” and “Other” to
- 1720 AS923
- 1721 • Corrected typo error in channel plan for India Added and updated channel plans for
- 1722 Sri Lanka, Bhutan and Papua New Guinea,
- 1723 • Updated Middle East country suggested channel plan
- 1724 • Added channel plans for Samoa, Tonga and Vanuatu
- 1725 • Updated Bahrain and Kuwait channel plans
- 1726 • Corrected Qatar frequency range for EU868
- 1727 • Updated channel plans for UAE: 870-875.8MHz band can be used with EU868
- 1728 channel plan
- 1729 • Corrected frequency range for Lebanon from 862-870MHz to 863-87MHz
- 1730 • Updated Africa priority one country suggested channel plan
- 1731 • Added channel plans for the following African countries: Botswana, Burundi, Cabo
- 1732 Verde, Cameroon, Ghana, Ivory Coast, Kenya, Lesotho, Niger, Rwanda, Tanzania,
- 1733 Togo, Zambia, Zimbabwe
- 1734 • Corrected frequency range for Morocco from 867.6-869MHz to 868-869.65MHz
- 1735 • Updated frequency range for Tunisia (863-868MHz added)
- 1736 • Added EU433 for Nigeria and corrected frequency range from 863-870 to 868-
- 1737 870MHz
- 1738 • Added IN865 channel plan for Uganda
- 1739 • Updated Belarus and Ukraine channel plans (EU863-870 can be used)
- 1740 • Added EU433 channel plan for Costa Rica
- 1741 • Added channel plans for Suriname
- 1742 • Added or corrected bands for Albania, Denmark, Estonia, Hungary, Ireland,
- 1743 Liechtenstein, Luxembourg, Macedonia, Norway, Poland, Slovakia, Slovenia,
- 1744 Switzerland, UK: 918-921MHz changed to 915-918MHz!
- 1745 • Added statement in Section 1 regarding non-authoritative source for regional
- 1746 regulatory information.
- 1747 • Added Authors list
- 1748 • Added Section 2.2 RegParamsRevision common names table
- 1749 • Added Regulatory Type Approval to quick reference table in Section 1
- 1750 • Added Section 3 (changing this section to section 4) to incorporate changes from CR
- 1751 00010.001.CR_add_physical_layer_description_Kerlink.docx of the TC21 meeting.
- 1752 • Added table caption for tables in section 2
- 1753 • Updated TOC and TOT
- 1754 • Modified as per CR ACK_TIMEOUT
- 1755 • Italicized countries in the country table to highlight those whose regulations may be
- 1756 changing soon.
- 1757 • Added notes concerning the use of ARIB STD-T108 for AS923 end-devices in
- 1758 section 2.10.2
- 1759 • Updated list of the countries in the table 1 according to ISO 3166-1
- 1760 • Added channel plans for Trinidad and Tobago, Bahamas

- 1761 • Added channel plans for Aland Islands, Holy See, Monaco and San Marino
- 1762 • General cleanup, fixed TOC and LOF
- 1763 • Changes based online by line review
- 1764 • Fixed the AU entry in the Quick Reference Table
- 1765 • Fixed the footnote for the US plan in section 2.5.3
- 1766 • Migrated the CN470-510 channel plan from the RP 1.2rA draft
- 1767 • Clarified the wording of the footnotes regarding ChMaskCntl
- 1768 • Made AS923 use consistent in section 2.10
- 1769 • Changed SHOULD to SHALL in section 2.6.2
- 1770 • Changed footnote references to 1.0.2rC to 1.0.3rA
- 1771 • Changed table reference from 1.0.2rC to 1.0.2rB
- 1772 • Changed CN779 duty cycle from 0.1% to 1% as per Regional Regulation Summary
- 1773 • Reduced number of default channels for CN779 plan to 3 to make consistent with
- 1774 other plans
- 1775 • Changed RX1DROffset tables in sections 2.10.7 and 2.12.7 to be direct lookup
- 1776 tables.
- 1777 • Clarified/fixed errors in sections 2.10.7 and 2.12.7
- 1778 • Cleaned up quick reference table and have header row repeated for each page to aid
- 1779 review
- 1780 • Finalized initial Regulatory Type Approval column with information based on LA
- 1781 survey of certified end device manufacturers.
- 1782 • Italicized Indonesia due to possible changes to regulatory environment there
- 1783 • Added default parameter definitions for Class B (referenced in LW)
- 1784 • Clarified Physical Header Explicit Mode (section 3.1)
- 1785 • Require end-devices in AS923 to accept MaxPayload size downlinks as defined for
- 1786 DownlinkDwellTime=0, regardless of its actual configuration.
- 1787 • Normative language cleanup
- 1788 • Removed Beacon format definition and referred back to LoRaWAN specification
- 1789 • Fixed several maxpayload tables when operating in “repeater compatible” mode, no
- 1790 MACPayload (M) may be larger than 230 bytes, regardless of dwell-time limitations
- 1791 • Updated and clarified section 3, Physical Layer
- 1792 • Addressed inconsistencies in CN470
- 1793
- 1794

1795 **5 Bibliography**1796 **5.1 References**

1797

1798 [TS001] LoRaWAN MAC Layer Specification, v1.0 through V1.1, the LoRa Alliance.

1799

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