1 LoRaWAN Regional Parameters

1.1 RU 864-869MHz ISM Band

1.1.1 RU864-879 Preamble Format

The following synchronization words should be used:

Modulation	Sync word	Preamble length
LORA	0x34	8 symbols
GFSK	0xC194C1	5 bytes

Table 1: RU864-879 synch words

1.1.2 RU864-879 ISM Band channel frequencies

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

The network channels can be freely attributed by the network operator. However the three following default channels must be implemented in every RU868MHz end-device. Those channels are the minimum set that all network gateways should always be listening on.

Modulation	Bandwidth [kHz]	Channel Frequency [MHz]	FSK Bitrate or LoRa DR / Bitrate	Nb Channels	Duty cycle
LoRa	125	864.10 864.30 864.50	DR0 to DR5 / 0.3-5 kbps	3	<0.1%

Table 2: RU864-879 default channels

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

RU868MHz ISM band end-devices should use the following default parameters

- Default ERP: 14 dBm

RU868MHz end-devices should be capable of operating in the 863 to 870 MHz frequency band and should feature a channel data structure to store the parameters of at least 16 channels. A channel data structure corresponds to a frequency and a set of data rates usable on this frequency.

The first three channels correspond to 864.1, 864.3, and 864.5 MHz / DR0 to DR5 and must be implemented in every end-device. Those default channels cannot be modified through the ***NewChannelReq*** command and guarantee a minimal common channel set between end-devices and network gateways.

The following table gives the list of frequencies that should be used by end-devices to broadcast the JoinReq message. The JoinReq message transmit duty-cycle shall follow the

rules described in chapter “Retransmissions back-off” of the LoRaWAN specification document.

Modulation	Bandwidth [kHz]	Channel Frequency [MHz]	FSK Bitrate or LoRa DR / Bitrate	Nb Channels
LoRa	125	864.10 864.30 864.50	DR0 – DR5 / 0.3-5 kbps	3

Table 3: RU864-879 JoinReq Channel List

1.1.3 RU864-879 Data Rate and End-device Output Power encoding

There is no dwell time limitation for the RU864-879 PHY layer. The ***TxParamSetupReq*** MAC command does not have to be implemented by RU864-879 devices.

The following encoding is used for Data Rate (DR) and End-device Output Power (TXPower) in the RU864-879 band:

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..15	RFU	

Table 4: TX Data rate table

TXPower	Configuration (ERP)
0	20 dBm
1	14 dBm
2	11 dBm
3	8 dBm
4	5 dBm
5	2 dBm
6..15	RFU

Table 5: TX power table

1.1.4 RU864-879 JoinAccept CFList

The RU 864-869 ISM band LoRaWAN implements an optional **channel frequency list** (CFlist) of 16 octets in the JoinAccept message.

In this case the CFList is a list of five channel frequencies for the channels four to eight whereby each frequency is encoded as a 24 bits unsigned integer (three octets). All these channels are usable for DR0 to DR5 125kHz LoRa modulation. The list of frequencies is followed by a single RFU octet for a total of 16 octets.

Size (bytes)	3	3	3	3	3	1
CFList	Freq Ch4	Freq Ch5	Freq Ch6	Freq Ch7	Freq Ch8	RFU

The actual channel frequency in Hz is 100 x frequency whereby values representing frequencies below 100 MHz are reserved for future use. This allows setting the frequency of a channel anywhere between 100 MHz to 1.67 GHz in 100 Hz steps. Unused channels have a frequency value of 0. The **CFList** is optional and its presence can be detected by the length of the join-accept message. If present, the **CFList** replaces all the previous channels stored in the end-device apart from the three default channels as defined in Chapter **Error! Reference source not found.**. The newly defined channels are immediately enabled and usable by the end-device for communication.

1.1.5 RU864-879 LinkAdrReq command

The RU864-879 LoRaWAN only supports a maximum of 16 channels. When **ChMaskCntl** field is 0 the ChMask field individually enables/disables each of the 16 channels.

ChMaskCntl	**ChMask applies to**
0	Channels 1 to 16
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 6: ChMaskCntl value table

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

1.1.6 RU864-879 Maximum payload size

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

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	

Table 7: RU864-879 maximum payload size

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

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 8 : RU864-879 maximum payload size (not repeater compatible)

1.1.7 RU864-879 Receive windows

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

RX1DROffset **Upstream data rate**	**0**	**1**	**2**	**3**	**4**	**5**
	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

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

1.1.8 RU864-879 Default Settings

The following parameters are recommended values for the RU864-879MHz band.

RECEIVE_DELAY1	1 s
RECEIVE_DELAY2	2 s (must be RECEIVE_DELAY1 + 1s)
JOIN_ACCEPT_DELAY1	5 s
JOIN_ACCEPT_DELAY2	6 s
MAX_FCNT_GAP	16384

1	ADR_ACK_LIMIT	64
2	ADR_ACK_DELAY	32
3	ACK_TIMEOUT	2 +/- 1 s (random delay between 1 and 3 seconds)

4 If the actual parameter values implemented in the end-device are different from those default
5 values (for example the end-device uses a longer RECEIVE_DELAY1 and
6 RECEIVE_DELAY2 latency), those parameters must be communicated to the network
7 server using an out-of-band channel during the end-device commissioning process. The
8 network server may not accept parameters different from those default values.
9