2.11 RU864-870 MHz ISM Band

2.11.1 RU864-870 Preamble Format

The following synchronization words SHOULD be used:

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

Table 75: RU864-870 synch words

2.11.2 RU864-870 ISM Band channel frequencies

The network channels can be freely attributed by the network operator in compliance with the allowed sub-bands defined by the Russian regulation. However the two following default channels MUST be implemented in every RU864-870 MHz 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	868.9 869.1	DR0 to DR5 / 0.3-5 kbps	2	<1%

Table 76: RU864-870 default channels

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

The first two channels correspond to 868.9 and 869.1 MHz / DR0 to DR5 and 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 SHALL 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	868.9 869.1	DR0 – DR5 / 0.3-5 kbps	2

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1547 **Table 77: RU864-870 JoinReq Channel List**

1548 **2.11.3 RU864-870 Data Rate and End-device Output Power encoding**

1549 There is no dwell time limitation for the RU864-870 PHY layer. The *TxParamSetupReq*
1550 MAC command is not implemented in RU864-870 devices.

1551 The following encoding is used for Data Rate (DR) and End-device EIRP (TXPower) in the
1552 RU864-870 band:

1553

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]	

1554 **Table 78: RU864-870 TX Data rate table**
1555

1556 EIRP[2] refers to the Equivalent Isotropically Radiated Power, which is the radiated output
1557 power referenced to an isotropic antenna radiating power equally in all directions and whose
1558 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

1559 **Table 79: RU864-870 TX power table**
1560
1561
1562

1563 By default MaxEIRP is considered to be +16dBm. If the end-device cannot achieve +16dBm
1564 EIRP, the Max EIRP SHOULD be communicated to the network server using an out-of-band
1565 channel during the end-device commissioning process.
1566

---

[1] *DR15 and TXPower15 are defined in the LinkADRReq MAC command of the LoRaWAN1.1 specification*
[2] *ERP = EIRP – 2.15dB; it is referenced to a half-wave dipole antenna whose gain is expressed in dBd*

1567 **2.11.4 RU864-870 JoinAccept CFList**

1568

1569 The RU 864-870 ISM band LoRaWAN implements an optional **channel frequency list**
1570 (CFlist) of 16 octets in the JoinAccept message.

1571 In this case the CFList is a list of five channel frequencies for the channels two to six
1572 whereby each frequency is encoded as a 24 bits unsigned integer (three octets). All these
1573 channels are usable for DR0 to DR5 125kHz LoRa modulation. The list of frequencies is
1574 followed by a single CFListType octet for a total of 16 octets. The CFListType SHALL be
1575 equal to zero (0) to indicate that the CFList contains a list of frequencies.

1576

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

1577 The actual channel frequency in Hz is 100 x frequency whereby values representing
1578 frequencies below 100 MHz are reserved for future use. This allows setting the frequency of
1579 a channel anywhere between 100 MHz to 1.67 GHz in 100 Hz steps. Unused channels have
1580 a frequency value of 0. The **CFList** is optional and its presence can be detected by the
1581 length of the join-accept message. If present, the **CFList** replaces all the previous channels
1582 stored in the end-device apart from the two default channels. The newly defined channels
1583 are immediately enabled and usable by the end-device for communication.

1584 **2.11.5 RU864-870 LinkAdrReq command**

1585 The RU864-870 LoRaWAN only supports a maximum of 16 channels. When **ChMaskCntl**
1586 field is 0 the ChMask field individually enables/disables each of the 16 channels.

1587

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

1588 **Table 80: RU864-870 ChMaskCntl value table**

1589 If the ChMaskCntl field value is one of values meaning RFU, the end-device SHOULD reject
1590 the command and unset the "**Channel mask ACK**" bit in its response.

1591 **2.11.6 RU864-870 Maximum payload size**

1592 The maximum **MACPayload** size length (*M)* is given by the following table. It is derived from
1593 limitation of the PHY layer depending on the effective modulation rate used taking into
1594 account a possible repeater encapsulation layer. The maximum application payload length in
1595 the absence of the optional **FOpt** control field (*N*) is also given for information only. The
1596 value of N might be smaller if the **FOpt** field is not empty:

1597

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	

1598
Table 81: RU864-870 maximum payload size

1599 If the end-device will never operate with a repeater then the maximum application payload
1600 length in the absence of the optional **FOpt** control field SHOULD be:
1601

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	

1602
Table 82 : RU864-870 maximum payload size (not repeater compatible)

1603 ## 2.11.7 RU864-870 Receive windows

1604 The RX1 receive window uses the same channel as the preceding uplink. The data rate is a
1605 function of the uplink data rate and the RX1DROffset as given by the following table. The
1606 allowed values for RX1DROffset are in the [0:5] range. Values in the [6:7] range are
1607 reserved for future use.
1608

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

1609
Table 83: RU864-870 downlink RX1 data rate mapping

1610

1611 The RX2 receive window uses a fixed frequency and data rate. The default parameters are
1612 869.1MHz / DR0 (SF12, 125 kHz)

1613

1614 ## 2.11.8 RU864-870 Class B beacon and default downlink channel

1615 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

1616   **Table 84: RU864-870 beacon settings**

1617

1618   The beacon frame content is:

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

1619   The beacon default broadcast frequency is 869.1 MHz.

1620   The class B default downlink pingSlot frequency is 868.9 MHz.

1621

2.11.9 RU864-870 Default Settings

1622

1623   The following parameters are recommended values for the RU864-870 MHz band.

1624   RECEIVE_DELAY1   1 s
1625   RECEIVE_DELAY2   2 s (MUST be RECEIVE_DELAY1 + 1s)
1626   JOIN_ACCEPT_DELAY1   5 s
1627   JOIN_ACCEPT_DELAY2   6 s
1628   MAX_FCNT_GAP   16384
1629   ADR_ACK_LIMIT   64
1630   ADR_ACK_DELAY   32
1631   ACK_TIMEOUT   2 +/- 1 s (random delay between 1 and 3 seconds)

1632   If the actual parameter values implemented in the end-device are different from those default
1633   values (for example the end-device uses a longer RECEIVE_DELAY1 and
1634   RECEIVE_DELAY2 latency), those parameters MUST be communicated to the network
1635   server using an out-of-band channel during the end-device commissioning process. The
1636   network server may not accept parameters different from those default values.

1637