

有关 LORA Symbol Rate 问题

Page 25 有 bandwidth,spread factor, error coding rate,nominal RB,sensitivity 的表格如下：

Bandwidth (kHz)	Spreading Factor	Coding rate	Nominal Rb (bps)	Sensitivity indication (dBm)	Frequency Reference
10.4	6	4/5	782	-131	TCXO
	12	4/5	24	-147	
20.8	6	4/5	1562	-128	
	12	4/5	49	-144	
62.5	6	4/5	4688	-121	XTAL
	12	4/5	146	-139	
125	6	4/5	9380	-118	
	12	4/5	293	-136	

Page 27 有关于 spreading factor, forward error correct coding rate 的介绍

4.1.1.2. Spreading Factor

The spread spectrum LoRa™ modulation is performed by representing each bit of payload information by multiple chips of information. The rate at which the spread information is sent is referred to as the symbol rate (Rs), the ratio between the nominal symbol rate and chip rate is the spreading factor and represents the number of symbols sent per bit of information. The range of values accessible with the LoRa™ modem are shown in the following table.

Table 13 Range of Spreading Factors

SpreadingFactor (RegModulationCfg)	Spreading Factor (Chips / symbol)	LoRa Demodulator SNR
6	64	-5 dB
7	128	-7.5 dB
8	256	-10 dB
9	512	-12.5 dB
10	1024	-15 dB
11	2048	-17.5 dB
12	4096	-20 dB

4.1.1.3. Coding Rate

To further improve the robustness of the link the LoRa™ modem employs cyclic error coding to perform forward error detection and correction. Such error coding incurs a transmission overhead - the resultant additional data overhead per transmission is shown in the table below.

Table 14 Cyclic Coding Overhead

CodingRate (RegTxCfg1)	Cyclic Coding Rate	Overhead Ratio
1	4/5	1.25
2	4/6	1.5
3	4/7	1.75
4	4/8	2

Page 28 页，有个表格指明了 LORA 调制的监管条件

4.1.1.4. Signal Bandwidth

An increase in signal bandwidth permits the use of a higher effective data rate, thus reducing transmission time at the expense of reduced sensitivity improvement. There are of course regulatory constraints in most countries on the permissible occupied bandwidth. Contrary to the FSK modem which is described in terms of the single sideband bandwidth, the LoRa™ modem bandwidth refers to the double sideband bandwidth (or total channel bandwidth). The range of bandwidths relevant to most regulatory situations is given in the LoRa™ modem specifications table (see Section 2.5.5).

Table 15 LoRa Bandwidth Options

Bandwidth (kHz)	Spreading Factor	Coding rate	Nominal Rb (bps)
7.8	12	4/5	18
10.4	12	4/5	24
15.6	12	4/5	37
20.8	12	4/5	49
31.2	12	4/5	73
41.7	12	4/5	98
62.5	12	4/5	146
125	12	4/5	293
250	12	4/5	586
500	12	4/5	1172

Page 28 页，也说明了 Rs,BW,SF 三者之间的关系，如下图：

4.1.1.5. LoRa™ Transmission Parameter Relationship

With a knowledge of the key parameters that can be controlled by the user we define the LoRa™ symbol rate as:

$$R_s = \frac{BW}{2^{SF}}$$

where BW is the programmed bandwidth and SF is the spreading factor. The transmitted signal is a constant envelope signal. Equivalently, one chip is sent per second per Hz of bandwidth.

上面这个公式，只是说明了 Rs,BW,SF 之间的关系，用这个公式来计算速率时，发现结果和上面的表格中的关系不一样。经过反复计算推理，基本得出了三者之间精确的计算公式，经验证和上面的表格的数据是一致的。

$$R_s = BW / (2^{SF} / (overhead\ ratio) * SF)$$

比如：带宽是 125K，SF=12，Error Coding=4/5,则速率 Rs 计算公式为：

$$125000 / (4096 * 1.25) * 12 = 294.91 \quad \text{和公式中的 293 基本一致。}$$

比如：带宽是 125K，SF=6，Error Coding=4/5,则速率 Rs 计算公式为：

$$125000 / (64 * 1.25) * 6 = 9375 \quad \text{和公式中的 9380 基本一致。}$$