SIGFOX Device

South Korea

White Paper

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Table of Contents

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CHANGES DESCRIPTION

Version	Description	Author	Date
1.0	Creation	T. Schmidt, S. Hamard, S. Barreiro	11/09/2017
2.0	Updates in ITU emission class	T. Schmidt, S. Barreiro	13/11/2017
2.1	Bandwidth update	S. Barreiro	22/09/2018

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1. Introduction

The IoT presents a different set of communications challenges than those related to conventional internet or cellular networks. Unlike cellphones and computers, IoT devices do not need to transfer large amounts of data. However, requirements for battery life and hardware costs are much more stringent and difficult to meet. For example, a soil moisture sensor might send a single moisture reading – one number – every hour, but for the farmer the batteries in the sensor need to last for at least one growing season, and ideally several years.

The Sigfox network provides a simplified way to connect low energy isolated devices to customer's applications across diverse territories, through a high efficiency radio technology with extreme budget links despite low radiations, and at very low costs.
Customers can then build their applications without having to consider heavy radio network issues and management, and, almost, without having to consider the radio-communication aspects.

Sigfox is building an IoT network that operates in the 920,8-923.4 MHz band in South Korea. Connected devices will behave as low power radio stations for telemeter, telecontrol and data transmissions, following Korea - RF_equipmentRule30-2016.

Sigfox imposes rules on "customer devices" that are in fact much more stringent on resource usage than the rules given in the regulation and the related Korea - RF_equipmentRule30-2016.

This whitepaper aims to explain Sigfox device technology and operation in the 920 MHz band and to demonstrate how it complies with Korea - RF_equipmentRule30-2016 and specific requirements such as frequency tolerance, carrier sense …

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2. SIGFOX technology

The Sigfox network system is designed to provide low throughput connectivity and long battery life application. Connected devices can send and receive messages with a payload of 1 to 12 bytes. Devices are limited by a network policy to a maximum of 140 of these messages per day.
Sigfox's system is composed of terminals (end-devices) and base-stations (collecting nodes). Both uplink (from terminals to base-stations) and downlink (from base-station to devices) communications are possible.
For both uplink and downlink, a fixed center frequency is defined for communication.

2.1 Spectrum Access method

Sigfox uses Ultra Narrow Band (UNB) signals coupled with a carrier sense mechanism. This choice is valid for operation in South Korea, as per Korea - RF_equipmentRule30-2016.

The main reasons for the choice of UNB signals were not dictated by budget link gains (ie: range) -similar performance being achievable with the other mentioned techniques- but by a better resilience to unexpected or largely unpredictable interferences under "shared spectrums" (typically license exempt bands), and by higher capacity of short messages per MHz, with a low if not inexistent synchronization protocol and the reception of more than 300 simultaneous messages.

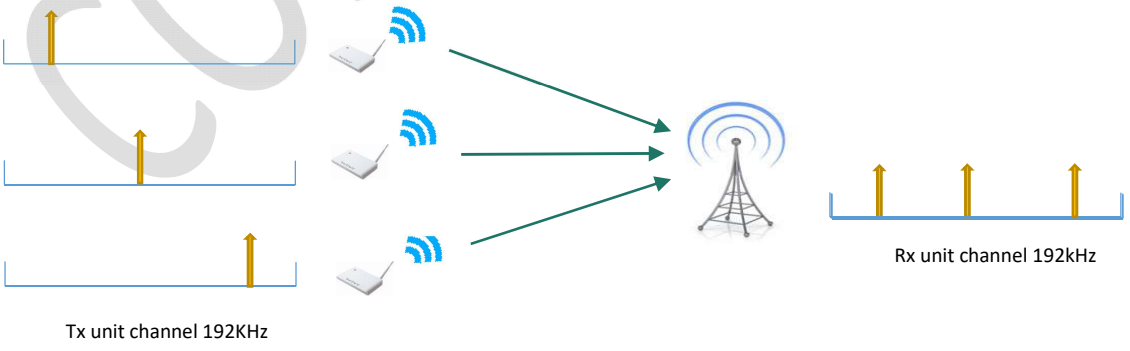

Figure 1- Multi-points to point reception

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2.2 Signal characteristic and channelization

The modulation used by devices is a composite modulation mixing an SSB-SC modulation with a 100 bps D-BPSK modulation of the sub-carriers. The figure below shows a typical "customer's device" spectral occupation.

Each equipment uses one preset unit channel of 200kHz as per Korea - RF_equipmentRule30-2016. The instantaneous occupied bandwidth of each transmission is 100Hz. The use of the whole channel of 200kHz over the time is nevertheless mandatory to ensure the appropriate rate and quality of data transmissions at the reception point.

SIGFOX specifies the exact channel of operation during network deployment. Equipment can be set within the 922 to 923,4MHz band, channel numbers 26 to 32.

2.3 Emission class and multiplex description

As indicated above, the device uses a single side band modulation (SSB) with fully suppressed carrier, where a subcarrier is modulated by a 100 bps D-BPSK data modulation.

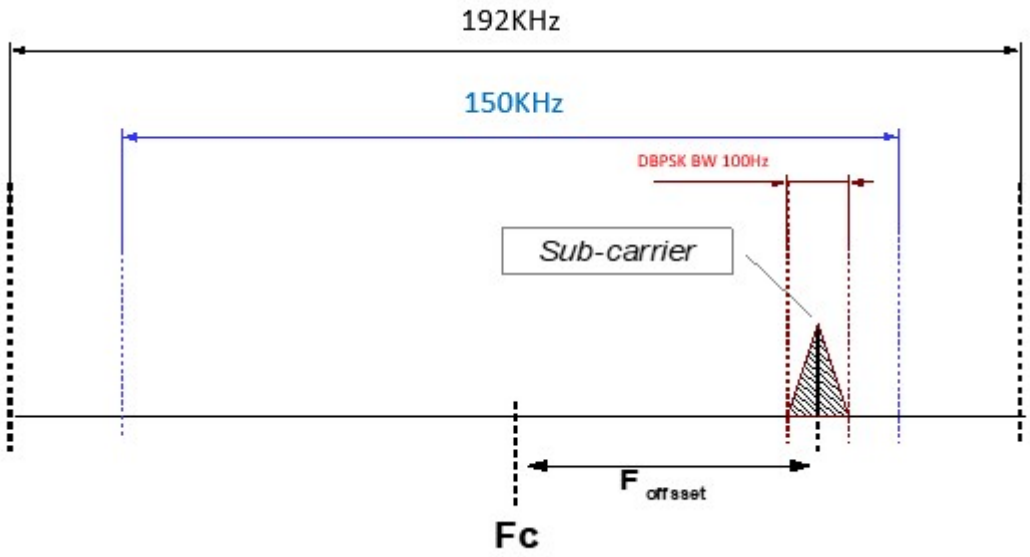

Figure 2- Single side-band modulation illustration

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SSB modulation is centered on a fixed central frequency Fc and sub-carrier frequency Fsc are pseudo-randomly selected within a range of +/- 75 kHz (150kHz), where Fsc= Fc+ Foffest. Frequency offsets are fixed and predetermined values.

This random distribution is necessary to ensure the required quality of service at the reception point, where up to 300 different sub-carriers are aggregated.

SSB modulation takes into account natural terminal frequency error in order to ensure an absolute maximum frequency offset of +/- 96 kHz. This spectral occupation is a validating item within SIGFOX Ready certification program applicable to all SIGFOX terminals.

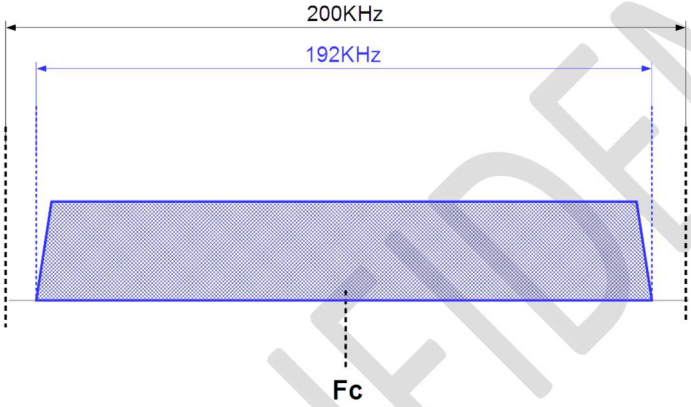

Figure 3- Maximum absolute modulation range (including terminal frequency error)

The related ITU emission class for SIGFOX modulation is: 142KD2D

- Emission in which the main carrier is amplitude and angle-modulated either simultaneously or in a pre-established sequence (D), with modulating subcarrier (2) modulated by a data content (D) over a 142kHz necessary bandwidth (142K)

The related ITU emission class for sub-carrier modulation is: G1D

- Phase modulation (G), without modulating subcarrier (1) modulated by a data content (D)

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2.4 Necessary bandwidth

For a given class of emission, the width of the frequency band which is just sufficient to ensure the transmission of information at the rate and with the quality required under specified conditions.

The necessary bandwidth (Bn) of SIGFOX signal is calculated as two times the maximum frequency offset (separation) between the furthest sub-carrier frequency and the suppressed carrier at center frequency (Cmax), plus the D-BPSK modulation bandwidth (M).

Bn = 2Cmax + M = 2 x 74.950 + 100 = 150.000Hz

2.5 Medium access control and transmission sequence

When transmitting continuously, devices will randomly distribute sub-carriers within the channel with frame time of 2s. They will select the transmit frequency from a **pseudorandom sequence (PN11 generator)** to ensure the equally usage of the necessary bandwidth over the time.

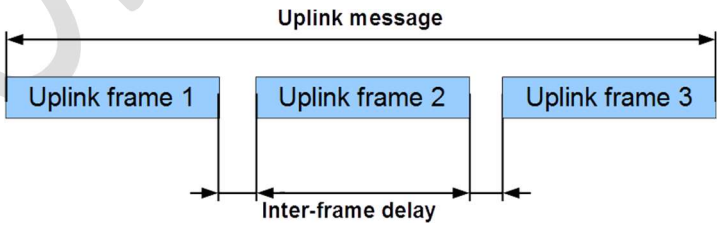

Figure 4- Up-link sequence

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Korea - RF_equipmentRule30-2016 standard defines a carrier sense mechanism ('Listen-Before-Talk' - LBT) to rule the RF medium access. Below the definition of the parameters for the 'listen-before-talk' function.

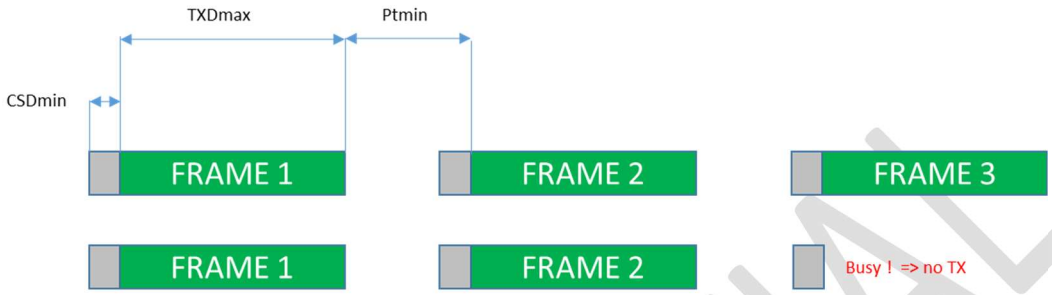

Figure 5- LBT timing specification

SIGFOX radio equipment will implement a 'listen-before-talk' mechanism as follow:

Equipment shall sense channel power for CSDmin or more before transmitting.

- If channel is busy, equipment shall not transmit.
- If channel is idle, equipment is authorized to transmit.

Channel shall be considered as busy if the integrated RF power in the 200kHz of the unit radio channel to transmit is superior or equal to CDTH (in dBm). Channel is considered as idle in the other case.

Equipment transmission duration shall be less than TXDmax maximum (TX max. time)
Equipment shall wait at least PTmin time before transmitting again (Pause time)

	Korea - RF_equipmentRule30-2016	
LBT parameter	Min	Max
CDTH (in 200Khz BW)	-	-65dBm
CSD_{min}	5ms	-
TXD_{max}	-	4s
PT_{min}	50ms	-

Table 1- LBT parameters limits

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2.6 Maximum power

As per Coreen regulation, SIGFOX also imposes a maximum device's radiated power of 14 dBm e.i.r.p (25mWatts).

2.7 Channels used

Sigfox devices use now following channels:

⇒ TX: channel 32

⇒ RX: channel 27

3. Typical resource usage

The nature of IoT communications, and the need to preserve battery life, means that it is very unusual for Sigfox devices to transmit data continuously. The radio is generally only powered up when there is some data to send. When there is no data to send the radio is completely turned off to save power. As a result, the radio is normally active for a few seconds per day or less. This is how Sigfox connected devices are able to achieve a battery life of several years.

A frame is composed, of a signaling/protocol data embedding a "commercial payload" of 1 to 12 Bytes. Consequently, at 100 Bps, a frame lasts between 1 and 2s, and shall not exceed 4s.

In summary, due to Sigfox's "internal specifications", a Sigfox device appears less than 1 % of the time (cumulated, hour or day basis) over the 920 MHz spectrum.

Devices cannot be "remote controlled" upon a network initiative. They can only be possibly reached by the network right after an uplink (20 to 30 seconds later, so that base stations can be organized to "multiplex" to more than one device).

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4. ANNEXE 2: Reference documents

1. Korea – RF equipment Rule 30 - 2016
2. SIGFOX – PRS-UNBT document – Ultra Narrow Band Transceiver Product Requirements Specifications
3. SIGFOX – OTP Field Test Procedure – Contractual Coverage Test Procedure for a SIGFOX network
4. SIGFOX – SIGFOX technology introduction
5. SIGFOX – Downlink Modes in SIGFOX networks
6. ETSI – EN 300-220
7. Appendix 1 (Rev. WRC-12) of the Radio Regulations (ITU) - "Necessary bandwidths and classification of emissions"

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