Sigfox Device

ETSI Mode

White Paper

SIGFOX
425 rue Jean Rostand
31670 LABEGE – FRANCE

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425 rue Jean Rostand
31670 LABEGE – FRANCE

CHANGES DESCRIPTION

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4.0	Updates in ITU emission class	T. Schmidt, S. Barreiro	13/11/2017
5.0	Updates of Annexes (add of ETSI checklist et Tests applicable to Sigfox)	M BEAL	19/11/2018

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425 rue Jean Rostand
31670 LABEGE – FRANCE

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 868-868.6MHz band. Connected devices will behave as low power radio stations for telemeter, telecontrol and data transmissions, following ETSI EN 300 220-1 and ETSI EN 300 220-2.

SIGFOX imposes rules on "customer's devices" that are in fact much more stringent on resource usage than the rules given in ETSI EN 300 220-1 and ETSI EN 300 220-2.

This whitepaper aims to explain Sigfox device technology and operation in the 868-868,6MHz band and to demonstrate how it complies with ETSI EN 300 220-2 and ETSI EN 300 220-1.

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.

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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 use Ultra Narrow Band (UNB) signals coupled with Duty Cycle. This choice is valid for operation in Europe, as per ETSI EN 300 220-2 and ETSI EN 300 220-1.

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.

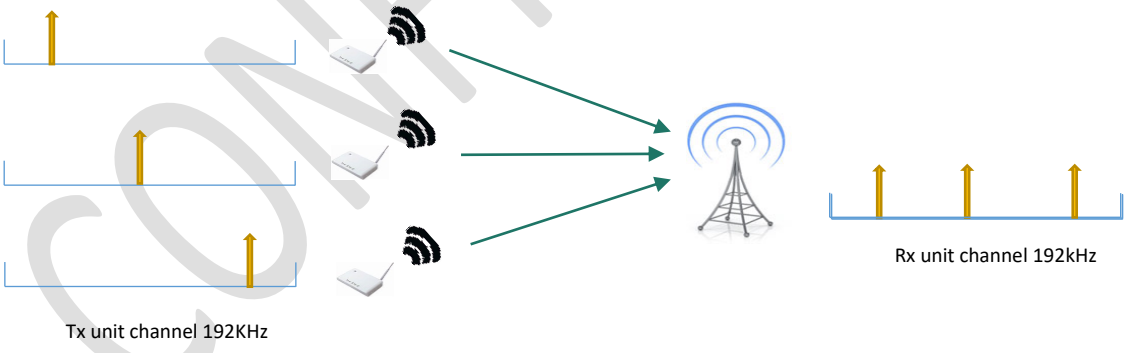

Figure 1- Multi-points to point reception

2.2 Signal characteristics

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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 show a typical "customer's device" spectral occupation.

The nominal center frequencies are distributed randomly in a frequency band of 192KHz. The instantaneous occupied bandwidth of each transmission is between 300Hz and 600Hz. The use of the whole channel of 192kHz over the time is nevertheless mandatory to ensure the appropriate rate and quality of data transmissions at the reception point.

Each equipment uses an operating channel (OC) of 192KHz as per EN 300 220-1. The instantaneous occupied bandwidth of each transmission is between 300 to 600Hz. The use of the whole channel of 192KHz over the time is nevertheless mandatory to ensure the appropriate rate and quality of data transmissions at the reception point.

2.3 Modulation description

As indicated above, the device uses a 100 bps D-BPSK data modulation.

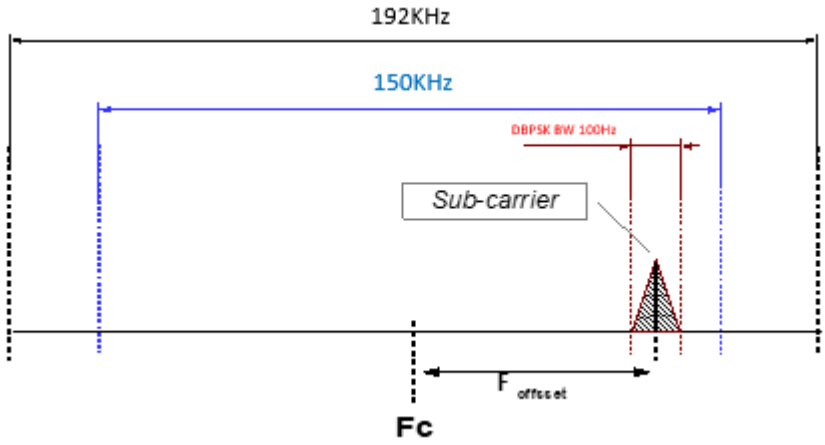

Figure 2- Single side-band modulation illustration

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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 (150 kHz), 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.

The related ITU emission class for SIGFOX modulation is: 150KD2D

- 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 150kHz necessary bandwidth (150K)

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

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

This spectral occupation is a validating item within SIGFOX Ready certification program applicable to all SIGFOX terminals.

2.4 Maximum power

SIGFOX also imposes a maximum device's radiated power of 14 dBm e.r.p (25mWatts).

TX reference:

Operational Frequency Band		Maximum effective radiated power, e.r.p.	Channel access and occupation rules (e.g. Duty cycle or LBT + AFA)	Maximum occupied bandwidth	Other usage restrictions	Band number from EC Decision 2013/752/EU [I.3]	Class 1 sub-class number according Commission Decision 2000/299/EU [I.7]
M	868,000 MHz to 868,600 MHz	25 mW e.r.p.	≤ 1 % duty cycle or polite spectrum access	The whole band except for audio & video applications limited to 300 kHz		48	28

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31670 LABEGE – FRANCE

RX reference:

Operational Frequency Band	Maximum effective radiated power, e.r.p.	Channel access and occupation rules (e.g. Duty cycle or LBT + AFA)	Maximum occupied bandwidth	Other usage restrictions	Band number from EC Decision 2013/752/EU [L3]	Class 1 sub-class number according Commission Decision 2000/299/EU [L7]
P	869,400 MHz to 869,650 MHz	500 mW e.r.p.	≤ 10 % duty cycle or polite spectrum access	The whole band		54b	30

2.5 Duty cycle

A SIGFOX device has less than 1 % of the time (cumulated, hour or day basis) over the 868MHz spectrum.

2.6 Bandwidth

Operational frequency band: entry in the frequency allocation table for short range devices within which the device is intended to operate and to perform the intended function of the equipment; defined by two frequency edges values: Flow_OFB and Fhigh_OFB

- ⇨ TX: 868,0 MHz to 868,6 MHz (band M)
- ⇨ RX: 869.40 to 869,65 MHz (band P)

Operating frequency: nominal center frequency of Transmission

- ⇨ TX: Center frequency of transmission is 868,13MHz
- ⇨ RX: Center frequency in reception is 869,525MHz

Operating Channel Width (OCW): bandwidth between the two frequencies declared as operating channel

- ⇨ 192KHz

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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 868 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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425 rue Jean Rostand
31670 LABEGE – FRANCE

4. ANNEXE 1: ETSI Checklist

Information to declare according to ETSI (SIGFOX application (based on checklist of document ETSI EN 300 220-2 V3.2.1 (2018-06)))

	Remarks *(when it is already filled → SIGFOX characteristics)*
The name of the manufacturer or his trademark	
The type equipment designation	
The application(s) of the equipment	
The operating channel OC or channels *Flow and Fhigh of each OC* *Nominal centre frequency*	 TX: 868,034MHz to 868.226 MHz RX: 869.429MHz to 869.621MHz TX: 868.13 MHz RX: 869.525MHz
Operational frequency Band	TX: Band M (48) RX: Band P (54)
Operating channel(s) width(s)	192kHz
Maximum radio-frequency power transmitted in the frequency band(s) in which the radio equipment operates. Where multiple powers are possible, also state rated power for each level or range of levels	25mW e.r.p.
Upper and lower temperature of the operational profile	
Upper and lower extreme test voltages	
Antenna maximum gain if EUT has a permanent RF connector	
Spectrum access mechanism of the equipment	Duty cycle
Is the equipment battery powered?	

Note: For Sigfox device RC1: FHSS, Polite Spectrum, LBT and frequency agile are not applicable.

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425 rue Jean Rostand
31670 LABEGE – FRANCE

5. ANNEXE 2: Tests applicable to Sigfox technology

Tests applicable to a device using Sigfox technology, according to ETSI EN 300 220-2 (Annexe D.2).

Harmonised Standard ETSI EN 300 220-2					
Requirement				Requirement Conditionality	
ETSI Test Number	Description	Essential Requirements of Directive	Clause(s) of the present document	U/C	Condition
1	Operating frequency	3.2	4.2.1	U	
2	Unwanted missions in the spurious domain	3.2	4.2.2	U	
3	TX effective radiated power	3.2	4.3.1	U	
5	TX Duty cycle	3.2	4.3.3	C	Applicable to SIGFOX devices *Not applicable to EUT with polite spectrum access where permitted in annex B, table B.1.*
6	TX Occupied bandwidth	3.2	4.3.4	U	
7	TX out of band emissions	3.2	4.3.5	C	Applicable to SIGFOX devices *Applies to EUT with OCW > 25 kHz.*
8	TX Transient	3.2	4.3.6	U	
10	TX behaviour under low voltage conditions	3.2	4.3.8	C	Applicable to SIGFOX devices *Applies to battery powered EUT.*
15	RX Blocking	3.2	4.4.2	U	

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6. ANNEXE 3: Reference documents

1. ETSI – EN 300 200-2 Short Range Devices (SRD) operating in the frequency range 25 MHz to 1 000 MHz; Part 2: Harmonised Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU for non-specific radio equipment

2. ETSI – EN 300 200-1 Short Range Devices (SRD) operating in the frequency range 25 MHz to 1 000 MHz; Part 1: Technical characteristics and methods of measurement

3. SIGFOX – PRS-UNBT document – Ultra Narrow Band Transceiver Product Requirements Specifications

4. SIGFOX – OTP Field Test Procedure – Contractual Coverage Test Procedure for a SIGFOX network

5. SIGFOX – SIGFOX technology introduction

6. SIGFOX – Downlink Modes in SIGFOX networks

7. Appendix 1 (Rev. WRC-12) of the Radio Regulations (ITU) - “Necessary bandwidths and classification of emissions”

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