sigfox
Make Things Come Alive

AppNote
-
Managing noisy RF environment in RC3c

Content

1 Document Purpose

Recent field testing in RC3c/Japan revealed that Sigfox devices can be installed in very noisy RF environment that can potentially block message transmission due to the LBT mechanism and consequently drastically decrease message transmission success rate.

The impact on the Quality of Service can be very serious and this application note aims at educating device makers on such complex RF environment as well as providing guidance on different technical topics (Hardware, Software, Testing…) to maximize the Message Success Rate.

2 Definitions

LBT	Stands for **L**isten **B**efore **T**alk and is the Radio Spectrum access mechanism mandated in Japan.
Device Makers	Providers of the end-product that will communicate on Sigfox network and integrating a Sigfox wireless module or chipsets from Semiconductors.
MIC	Japanese **M**inistry of **I**nternal Affairs and **C**ommunication: grants market access to Radio products and complying with the **Japanese Radio Law**.
RSSI	Radio Signal Strength Indicator.
Semiconductors	Vendors providing chipsets integrating Sigfox technology (including Sigfox modulation) to be integrated into wireless modules or Sigfox devices.
Wireless Modules	Sigfox modems integrating semiconductor chipset and subject to Sigfox Verified certification.

3 Reminder on LBT

LBT (**L**isten **B**efore **T**alk) is a feature specified by local regulatory authority, the Ministry of Internal Affairs and Communication (known as **MIC**), that mandates devices to verify that the Sigfox operated 200 kHz channel is free of any signal stronger than −80dBm before transmitting:

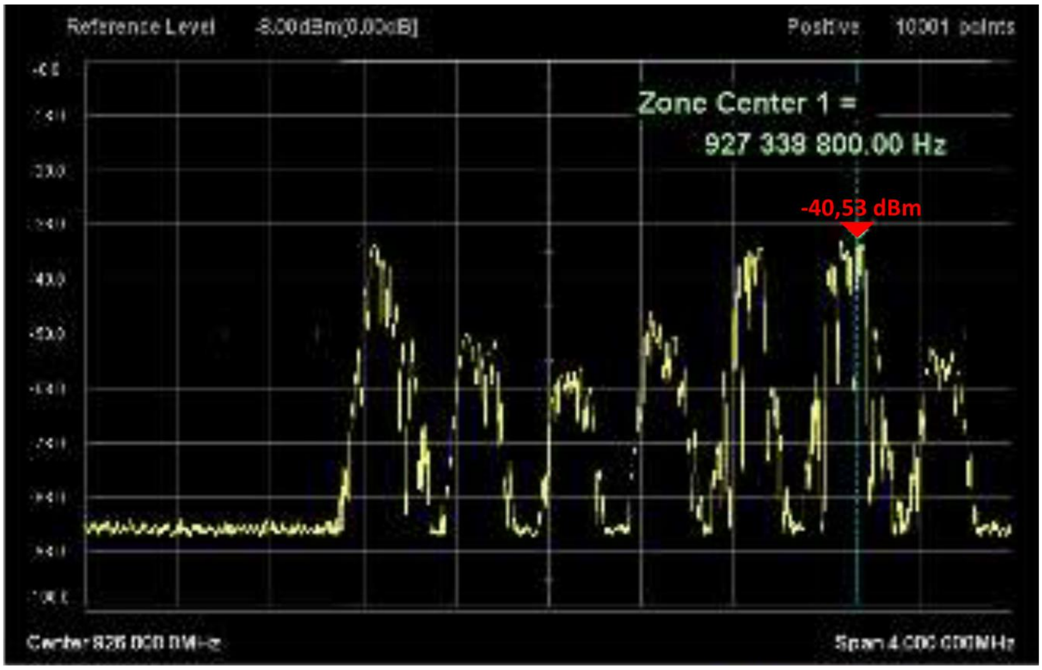
- When the channel is free for a duration of 5ms, a device can transmit for 4 seconds maximum on the considered channel,
- A device intending to keep using the same channel for transmission must insert an interframe of at least 50 ms,
- These requirements apply to Sigfox devices as well to all other devices using different protocols and different adjacent channels in the unlicensed band.

With such requirements well implemented (and if spurious requirements are also properly fulfilled), one device cannot block the transmission of another one.

4 Observed Issue and Current Understanding

During the field testing mentioned in **"1 Document Purpose"**, there were some geographic locations where the adjacent channels above the Sigfox channel (from 924MHz up to 930MHz) were very noisy and prevented a specific Sigfox device to transmit.

The chart below captured with a spectrum analyser depicts such RF conditions with interferers up to -40 dBm 4MHz away from Sigfox channel:



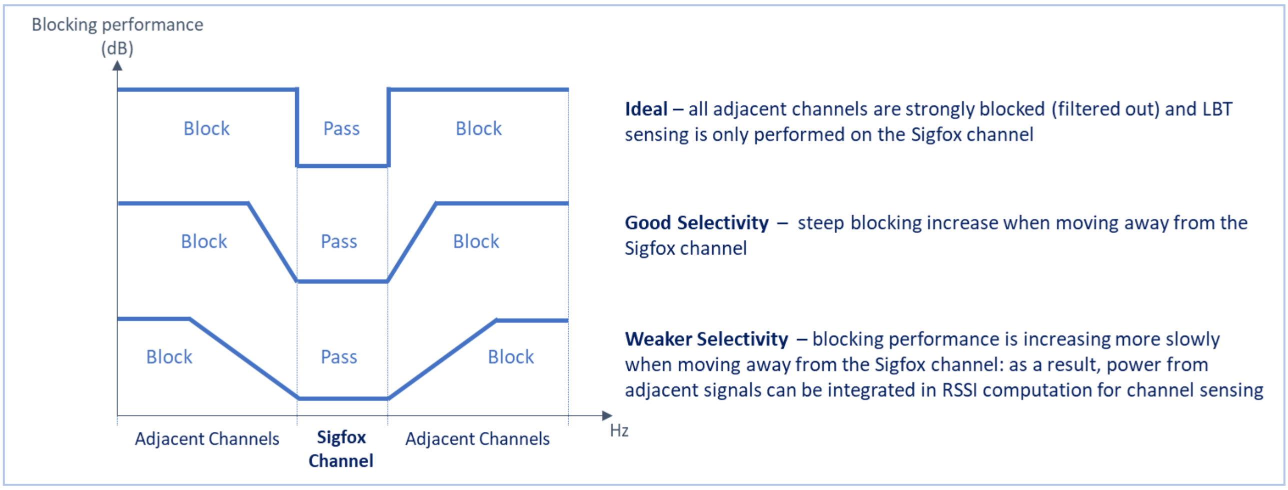
It is suspected that such RF noise could be generated by multiple Wi-Sun smart meters in very close proximity with the Sigfox device.

Despite these strong interferers are present in adjacent channel, they can generate **RSSI spurious** above the -80 dBm threshold inside the Sigfox channel that the LBT mechanism will wrongly report as busy.

5 Understanding the RSSI Selectivity Parameter

Implementing LBT mechanism requires to sense the Sigfox channel to detect a 5 ms free time window.

Ideally, the sensing algorithm shall only report the RSSI from the Sigfox channel, but reality shows that strong interferers from close adjacent channels are not fully filtered out (or blocked) and will generate RSSI spurious.

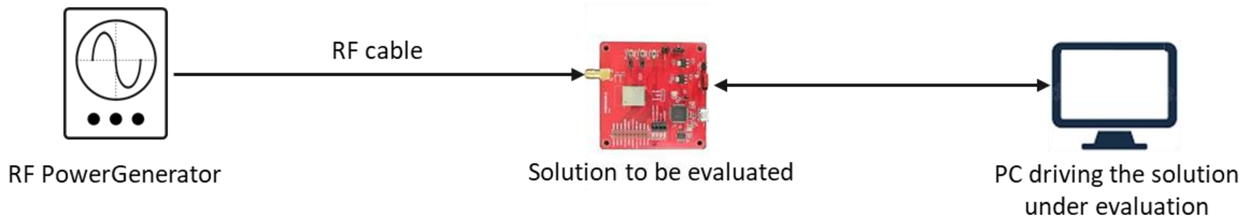


This **RSSI Selectivity or Blocking parameter** is fully dependent on the selected radio transceiver and device makers shall understand that the performance can widely vary from one provider to another.

Note that such Selectivity Performance are not part of neither the Sigfox specification nor the Japanese Radio Law.

6 Assessing the RSSI Selectivity Performance

Whenever the RSSI Selectivity criteria is not provided by the semiconductor partner, a device maker can easily set-up a lab configuration to assess its solution robustness to adjacent interferers:



Use a RF power generator in continuous wave mode to generate strong interferers in adjacent channels and find the weakest power that blocks the device transmission starting from -40 dBm up to 0 or more.	Send requests so that the Sigfox device will continuously send messages and after each message request monitor the return code to detect when LBT block the transmission

Doing such test will enable to build a table like the one below with for each adjacent frequency the value of the CW signal that will block the LBT:

Frequency (MHz)	916	917	918	919	920	921	922	Sigfox Channel	924	925	926	927	928	929	930
CW Signal Strength (dBm)	>5	-11	-15	-15	-19	-20	-24	N/A	-24	-20	-19	-15	-15	-11	>5

Above values are example *Above values are example*

Evolution on adjacent channels

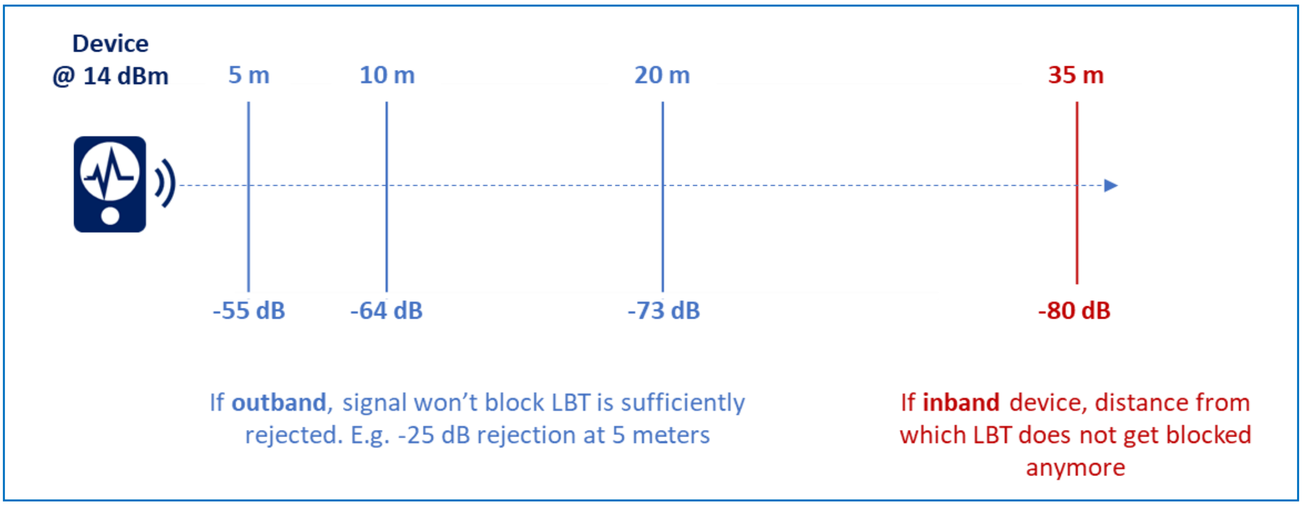
When moving away from the Sigfox channel, the level of rejection improves

Typical Values > 0 dBm		Robust in harsh ennvironment (e.g. desn urban area)
< -30 dBm		Suited for environment free of any heavy interferers (e.g. agricultural area)

7 Relation with distance on the Field

This section aims at explaining how technical parameters such as dBm can have an influence on the field and at understanding how they relate to distance with other objects.

The chart below describes how the RF TX power of an object evolves with distance: note that numbers are assuming complete free propagation field and therefore are theoretical.



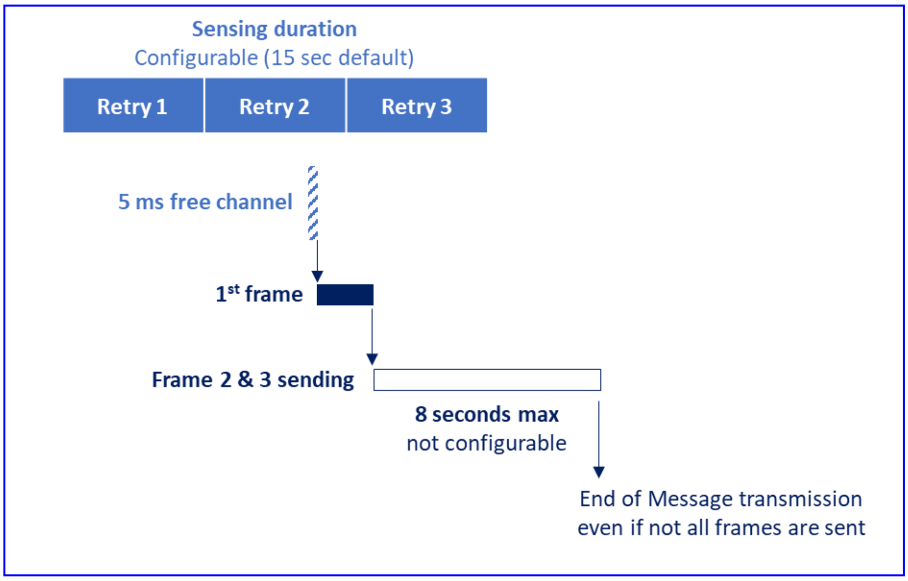
This chart is very theoretical: it assumes that other devices (transmitting in Sigfox or adjacent channels) can be localized. When deploying in dense urban area, a spectrum analyser could be used to assess the power of interferers in Sigfox channel as well as in adjacent channels.

8 LBT parameters and Software Fall-back

The Sigfox Library has a built-in retry mechanism on the Sigfox channel sensing that is configurable.

Default parameters are 3 retries and 5 second duration for each retries giving a complete sensing duration of 15 seconds.

Note however, that this retry mechanism only applies for the first frame sending:

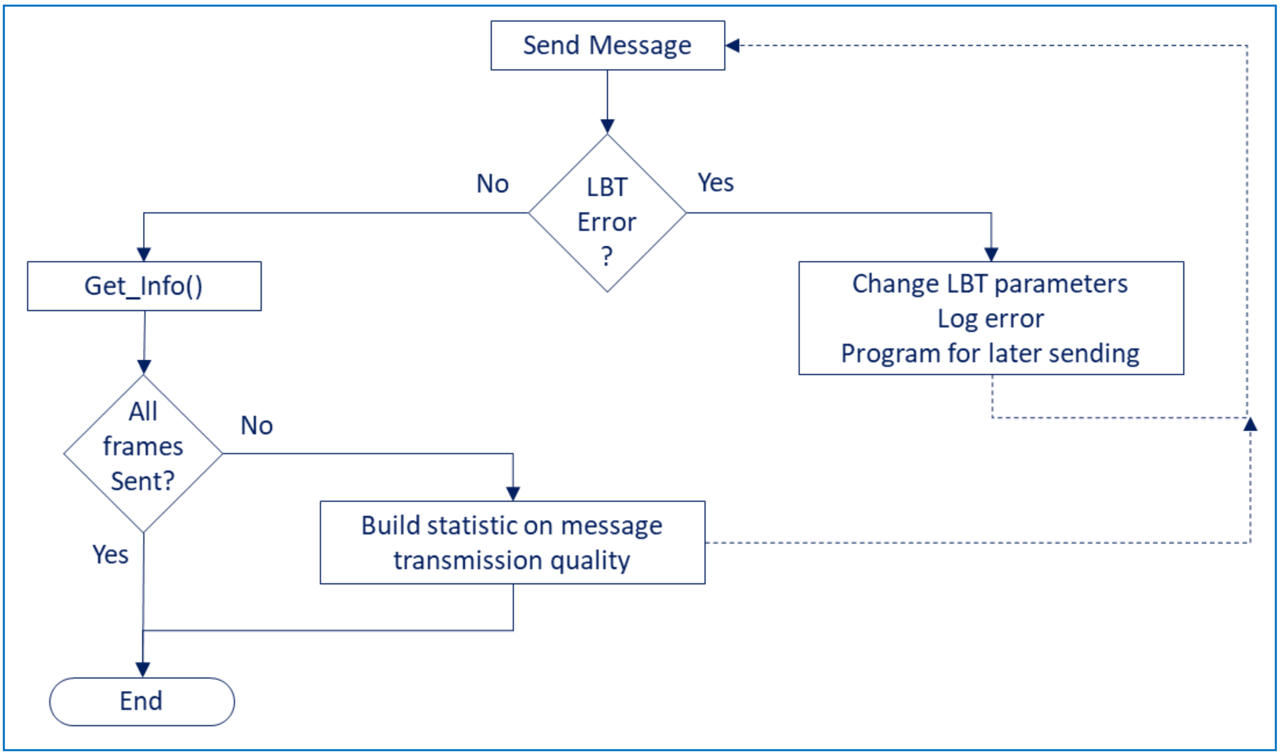


It is important to recall that LBT can block transmission possibly because of **outband** transmission (i.e devices transmitting in adjacent channels). But it can also be blocked by **inband** transmission (i.e. devices transmitting in the Sigfox channel).

As Sigfox devices need to wait for the unique channel to be freed up, the only way to cope with occupied channel is to use **Time Diversity**. 2 options are possible:

1) Increase the sensing duration by using the ***SIGFOX_API_set_std_config()*** API:
   - Either or both number and duration of retries can be reconfigured to increase the sensing period.
   - Note that this API can be mapped onto an AT command when using a module.
2) Implement a fall-back mechanism at application level when the LBT mechanism blocks fully or partly the frame transmission:
   - An error will be returned on the message transmission command when no frame is sent,
   - If at least, one frame is sent, no error is returned but the device application can retrieve the number of sent frames using the ***SIGFOX_API_get_info()*** API.
   - In either case, the device application can decide to re-send the message later (can be much later to increase time diversity);

Both 1) and 2) can be combined or 1) can be used only when transmission fails.



In the early phase of the deployment, during field tests/pilot, it is important to monitor the LBT mechanism both on device and backend side to build a learning database and tune the LBT mechanism to best suit the RF environment. This may require deploying a significant number of devices for a significant period as environmental parameters can widely change depending on location and overtime.