



sigfox

Make Things Come Alive

AppNote

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**How to check if your device is
candidate for sigfox ?**

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RSA pre-testing

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1 Document Purpose

This document is intended to be used by any device maker who would like to check the capability of existing device to be candidate for sigfox modulation and protocol integration.

2 Prerequisites on HW/SW analysis

2.1 DBPSK modulation

NATIVE DBPSK

In case of using a native DBPSK modulation @100bps or @600bps inside the RF_IC, this chapter is not applicable.

Please refer to programming guide to use the RF IC for modulation.

For the other requirements on oscillator/aoscillator stability etc ..., please refer to ref design or schematics provided by RF_IC maker.

SOFTWARE DBPSK :

If this is not the case, « software modulation » driven by MCU has to be implemented to build sigfox signals.

DBPSK modulation is based on non constant envelop in AM with phase shifting of Pi radians. Spectrum shaping is specific to each 100/600 modulation rate.

In many cases, DBPSK is implemented through a real time control on RF_IC to build a modulating signal to be mixed with carrier. This is possible through real time bus control between MCU and RF_IC.

Prerequisites on RF_IC :

- For TX : a way to control the frequency/phase + PA levels without switching off the carrier
- For TX : a way to control PA level with steps accurate enough to filter AM modulating signal (at least 1/2dB step from PA max to PA min value)
- For RX : a native GFSK @600bps with RX filter sharp enough to receive signal at least -126dBm for a TX @14dBm.

Prerequisite on BUS control (SPI command speed)

- one MCU command every (5us to 10us) for each SPI (validated by RF_IC CS)
- predictable spi command cycle to avoid any spurious on spectrum TX shaping.
- As requested in the device requirement document, datarate must be at 1% accuracy. Depending on the kind of solution chosen (HW + SW) , MCU clocking will be the main contributor of the modulation datarate accuracy as modulation must be a “software” modulation driven by MCU.
- Any MCU clocked with internal RC won't be candidate due to unstability of such kind of clock with temperature and environment. Anyway , during modulation , SW can use external clock coming from RF IC to be more accurate for modulation. For that, a signal coming from RF_IC must be plugged to the MCU to synchronize MCU timer on RF IC clock.

Prerequisites on oscillator circuit

Transitional/established frequency dynamic drift :

- This parameter is very important for sigfox due to very narrow bandwidth signals : using a chrystal could be enough , only carrier stability during frame transmission is important for sigfox. Oscillator connection with RF_IC must be clean to avoid any dynamic drift when oscillator is starting.
- Oscillator datasheet must be aligned with sigfox requirement concerning static frequency accuracy (aging, accuracy, temperature variation < 20ppm)
- RSA tools is the best tool to check the dynamic drift (not static as SDR dongle is not calibrated itself in frequency).
- TCXO usage is not mandatory !
- Chrystal must be stabilized before sending any symbol on the radio : this helps a lot to satisfy this requirement.

- Crystal placement on the board could impact the drift (warmup of RF IC PA, proximity with any warming source, oscillator too closed to RF_IC).
- Power supply stability helps a lot for dynamic drift.

Prerequisite on MCU/memory

- MCU flash size to integrate sigfox library between 5 and 10KB flash and 200bytes RAM
- timers
 - one for radio control : very accurate (<1 %)
 - one for sigfox protocol timings
- Non volatile memory access (eeprom or eeprom emulator on flash, alive RAM device) : a way to store and restore a buffer or less than 10bytes with a unlimited number of read/write accesses (at least device life) . Every frame sending will need to store data in this memory. Anyway any optimization can be done to save R/W number of cycles on non volatile memory.
- Between 1KB and 5KB for modulation software depending on the software implementation for DBPSK modulation .
- ROM memory to store sigfox credentials (id,key PAC) : possibility to lock or secure this part of memory : responsibility of the device maker to secure this part of memory to avoid any hacking on the device.
- AES 128b module : this can be hardware or software module. For a software module, reserve additional at least 2KB footprint in Flash.

2.2 GFSK demodulation

GFSK is the modulation used for the device RX path. Downlink for sigfox network is always initiated by the device with a specific uplink frame.

A Sgfox device can operate on the network in uplink only. Downlink is optional.

To be candidate for RX, device must use a native 2GFSK demodulation at 600bps.

Native GFSK is the simpler way for RX demodulation. RX filtering is very important to reach the sensitivity level requested by sigfox for a balanced budget link.

3 How to verify candidate with RSA + SDR dongle ?

After a first static analysis done in chapter 1 and 2, a real test must be done to check definitely if HW / SW design is candidate or not.

This can be done without any sigfox library integration but at least sigfox modulation (+ demod if needed) must be implemented.

This chapter will help you to test it through RSA + SDR dongle tool.

3.1 RSA + SDR dongle setup

- Buy SDR dongle : follow this link :
 - <https://build.sigfox.com/sdr-dongle>



- Download the RSA last version tool on build.sigfox.com and follow instructions

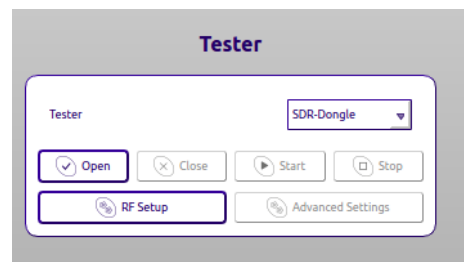
<https://build.sigfox.com/sdr-dongle/#rsa-getting-started>

- Connect SDR dongle to USB port and connect your device with attenuator provided in SDR dongle package
- start RSA

Computer with Radio_Signal_Analyser



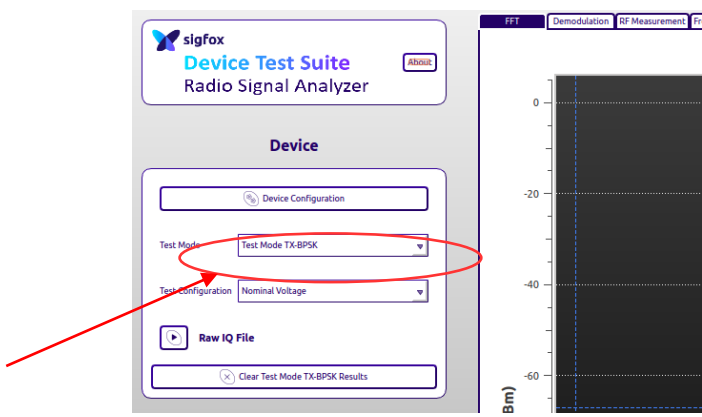
- Configure your device RC , id and key as following :
default values are :
 - RC1
 - ID=FEDCBA98
 - KEY=0123456789ABCDEF0123456789ABCDEF



Device STATIC Configuration	Device DYNAMIC Configuration
<p>Any change of static configuration will result in a RESET of Information / Prerequisites / Verdicts tables</p> <p>Modem Type: <input type="text" value="Uplink and Downlink"/></p> <p>Radio Configuration: <input type="text" value="RC1"/></p> <p>Sigfox Library Version: <input type="text" value="V2.2 OR LATER"/></p> <p>Payload encryption capable: <input type="checkbox"/></p>	<p>Device ID: ID[0] = 0x08 ... ID[3] = 0xFF <input checked="" type="checkbox"/> FEDCBA98</p> <p>Device ID Filter: <input type="checkbox"/></p> <p>Rollover counter: <input checked="" type="checkbox"/> 0</p> <p>Key Selection: <input type="text" value="Private Key"/></p> <p>Device Private Key: Key[0] = 0x01 ... Key[15] = 0xEF <input checked="" type="checkbox"/> 0123456789ABCDEF0123456789ABCDEF</p> <p>Downlink Delay (s): <input type="text" value="30,000"/></p> <p>Downlink Payload (B Bytes): <input checked="" type="checkbox"/> 3031323334353637</p> <p>Radio Signal Analyser Mode: <input type="text" value="Certification"/></p> <p><input type="button" value="Downlink Send Test"/></p>

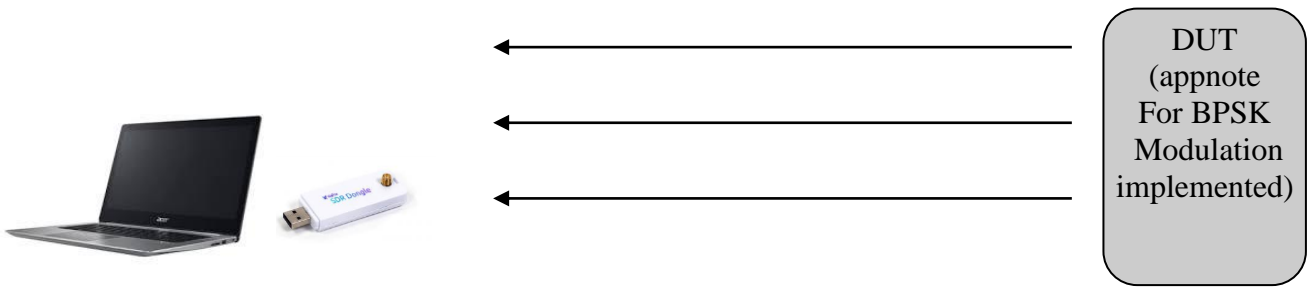
3.2 TX modulation tests

- Select the TX_BPSK mode
- Open SDR dongle to connect RSA



- You are now ready to send the 3 frames with your device at same frequency (central operated frequency : eg 868130000 Hz for RC1)
 - See chapter 4 for device software.
- Pattern used on device side to make DBPSK tests is the following

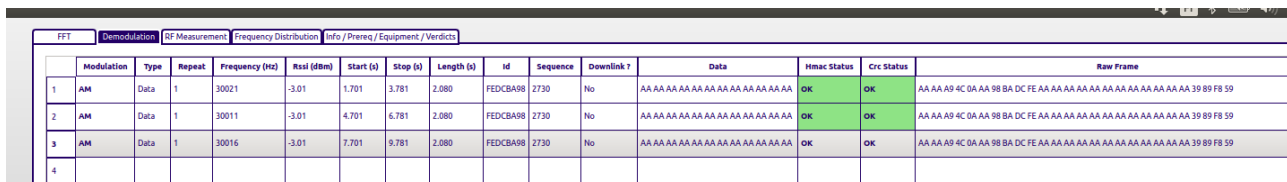
PATTERN_TX_BPSK =
 AAAAA94C0AAA98BADCFEAAAAAAAAAAAAAAAAAAAAAAAAAAAA3989F859



- With TX_BPSK test mode, all RF following RF parameters will be tested.

Requirement	Test Mode	Config	Test Setup
Static Frequency Tolerance	TX-BPSK	3	TX Test Setup - DBPSK Modulation Quality
DBPSK Modulation envelop	TX-BPSK	3	TX Test Setup - DBPSK Modulation Quality
Phase Measurement	TX-BPSK	3	TX Test Setup - DBPSK Modulation Quality
Extra symbols before the first Sigfox bit of the frame	TX-BPSK	3	TX Test Setup - DBPSK Modulation Quality
Extra symbols after the last Sigfox bit of the frame	TX-BPSK	3	TX Test Setup - DBPSK Modulation Quality
TX Max Symbol duration	TX-BPSK	3	TX Test Setup - DBPSK Modulation Quality
Max TX Baudrate Cumulated Error	TX-BPSK	3	TX Test Setup - DBPSK Modulation Quality
Power Spectral Density	TX-BPSK	3	TX Test Setup - DBPSK Modulation Quality
Narrow Band Power Distribution	TX-BPSK	3	TX Test Setup - DBPSK Modulation Quality
Transitional Frequency Dynamic Drift	TX-BPSK	3	TX Test Setup - DBPSK Modulation Quality
Established Frequency Dynamic Drift	TX-BPSK	3	TX Test Setup - DBPSK Modulation Quality
Modulated Conducted Output Power	TX-BPSK	3	TX Test Setup - DBPSK Modulation Quality
I/Q Wave record	TX-BPSK	3	TX Test Setup - DBPSK Modulation Quality

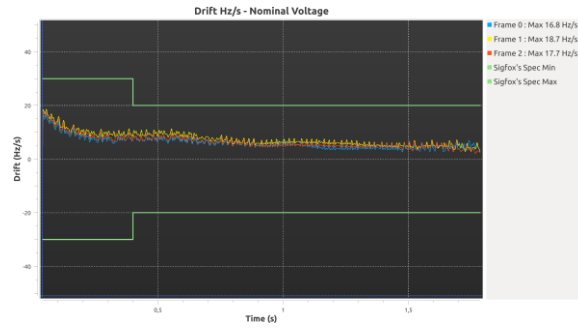
- Results you should obtain on demodulation windows on RSA should appear like this :



Modulation	Type	Repeat	Frequency (Hz)	Rssi (dBm)	Start (s)	Stop (s)	Length (s)	Id	Sequence	Downlink ?	Data	Hmac Status	Crc Status	Raw Frame
AM	Data	1	30021	-3.01	1.701	3.781	2.080	FEDCBA98	2730	No	AA AA AA AA AA AA AA AA AA AA AA AA	OK	OK	AA AA A9 4C 0A AA 9B BA DC FE AA AA AA AA AA AA AA AA AA AA AA AA 39 89 F8 59
AM	Data	1	30011	-3.01	4.701	6.781	2.080	FEDCBA98	2730	No	AA AA AA AA AA AA AA AA AA AA AA AA	OK	OK	AA AA A9 4C 0A AA 9B BA DC FE AA AA AA AA AA AA AA AA AA AA AA AA 39 89 F8 59
AM	Data	1	30016	-3.01	7.701	9.781	2.080	FEDCBA98	2730	No	AA AA AA AA AA AA AA AA AA AA AA AA	OK	OK	AA AA A9 4C 0A AA 9B BA DC FE AA AA AA AA AA AA AA AA AA AA AA AA 39 89 F8 59

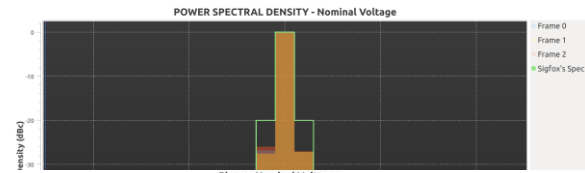
- You should obtain the following curves if modulation is good enough. RSA is able to show the automatic test results in verdict table here

FFT	Demodulation	RF Measurement	Frequency Distribution	Info / Prereq / Equipment / Verdicts							
Export Results : Save RF Measurements and Verdicts Table											
Information	Prerequisites	Equipment	Verdicts								
<input type="checkbox"/>	PRS-UNBT	Description	Modem	Test Type	Voltage Condition	Criteria 1	Criteria 2	Result 1	Result 2	Verdict	Comment

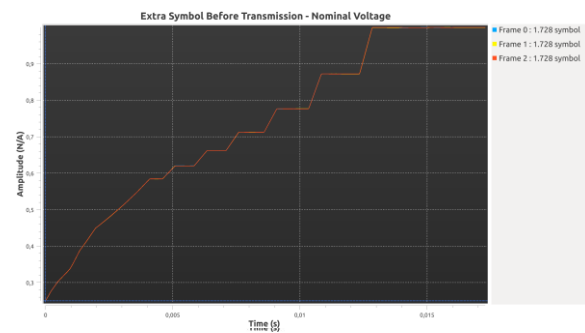
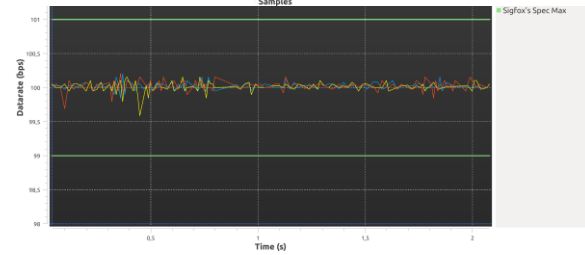


Drift requirement

Spectrum shaping



Phase shifting and datarate

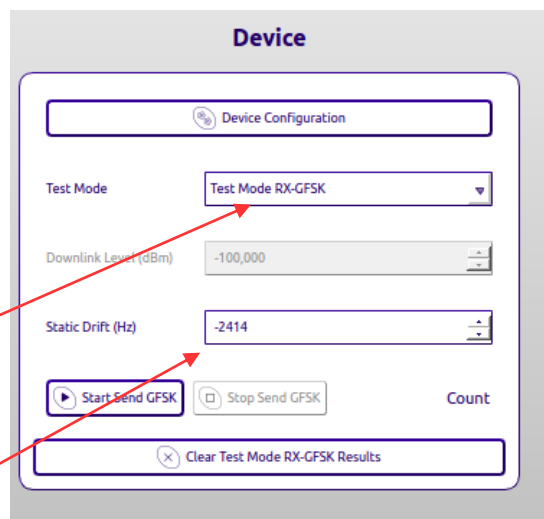


Ramp up and ramp down for TX

3.3 RX Tests

RSA is able to execute some RX tests but only to verify the capability and RF IC configuration. For performances tests, a signal vector generator must be used for sensitivity.

- Choose RSA TX_BPSK mode
- Send a TX_BPSK frame with device (this allows the RSA to compute the static drift compared to SDR dongle frequency (which is not calibrated itself) : this procedure will align device and SDR dongle on same relative frequency.
- Choose RSA RX_GFSK mode (you should retrieve the static drift between device and RSA SDR dongle)
- Configure the device in RX_GFSK mode : receiving at RX center frequency a dedicated pattern described in the next chapter appnote.



This value is computed by RSA during the TX_BPSK mode previously executed

- RSA will send RX_GFSK patterns at RX center frequency (specific for each RC) every seconds to the device.

- Device should print any GFSK pattern with RSSI level as described in application note

4 Usecase SX127x based device

In this chapter, the device is based on SX1272 RF IC .

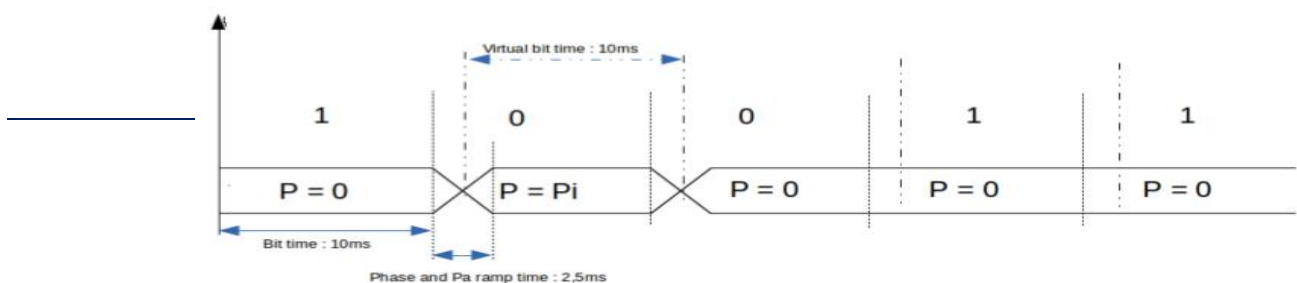
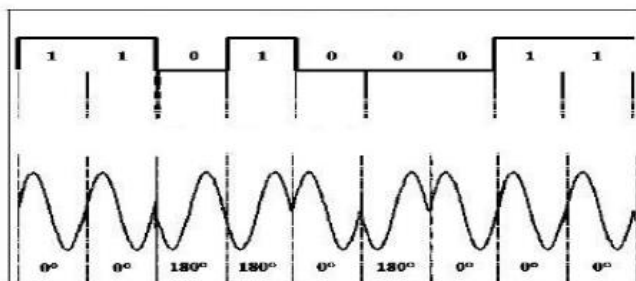
A specific package is available to evaluate your device to check if it is candidate for sigfox RF modulation and protocol future integration.

You will find enclosed tar.gz file containing and sample of source code to control the SX1272 to make a « software » modulation through an MCU.

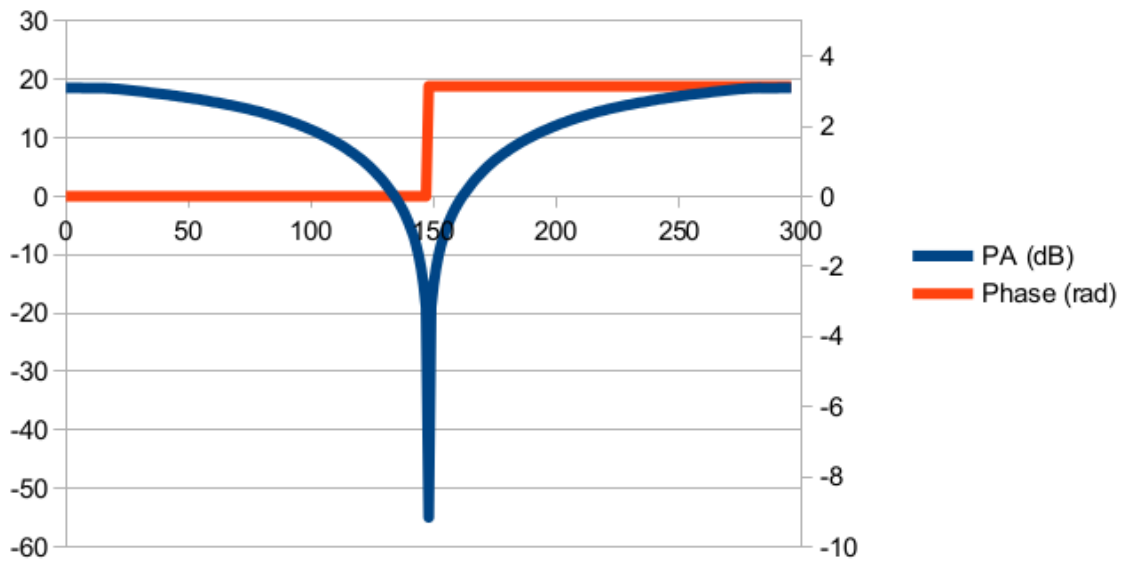
This code is generic for any MCU but contains all functions to make minimum of SW integration to run preliminary tests with RSA.

4.1 Principle

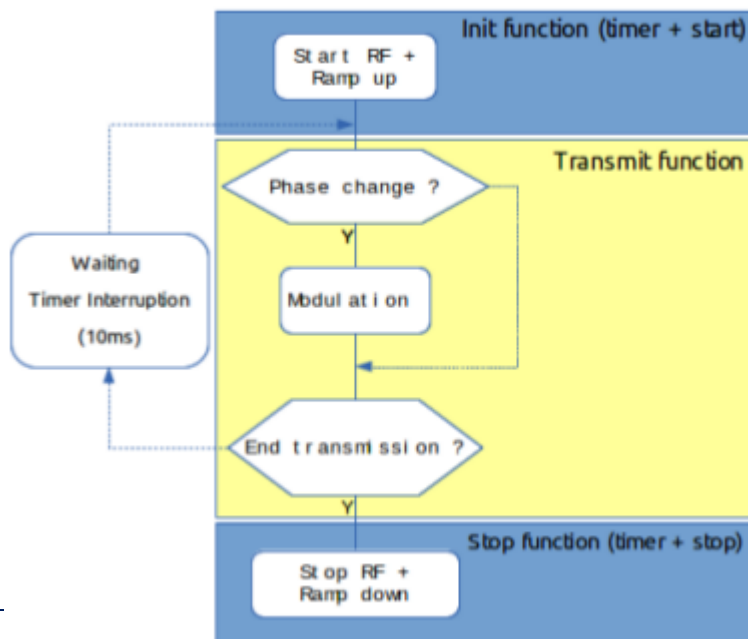
DBPSK principle is to change shift phase of π radians each time '0' symbol has to be sent on the radio. To ensure spectrum shaping filtering, AM modulation is needed to reduce the spectrum footprint.



Principle of modulation consists in control simultaneously PA and phase to modify in real time the RF IC carrier.



4.2 Algorithm for the « software modulation »

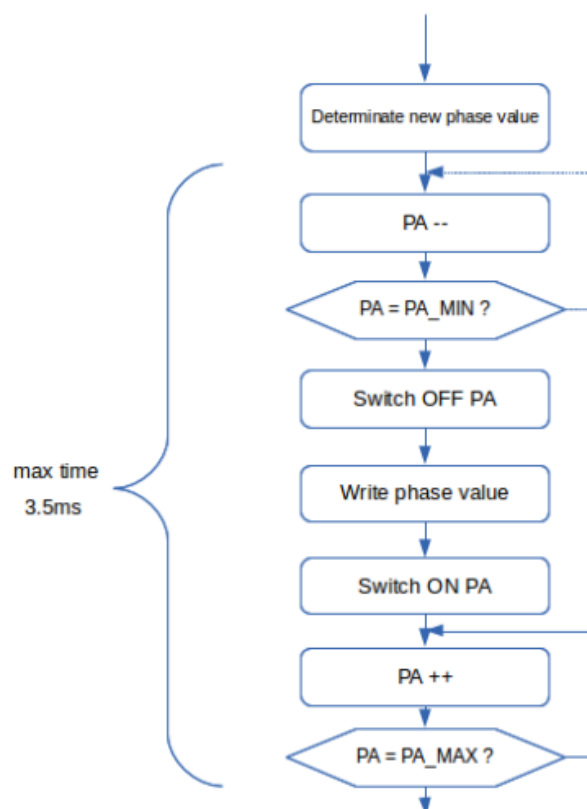


A timer is in place to clock the modulation datarate (this must be at <1 % accuracy).

Every occurrence of the timer, algorithm is processing the phase change and PA ramping process . This process duration must be completed before next timer occurrence (eg 10ms for 100bps and 1/6 ms for 600bps)

PA ramping is a simple increments of PA values in SX registers (linear control), which impacts a logarithmic control on the PA.

If this way to control the PA is not eficient enough , a LUT (Lookup Table containing PA values for each SPI command) can be used for filtering modulating signal (helps a lot to implement a real RRC (root rate cosine) filtering according data to be modulated (this is promoted by Semtech team implementation but takes more flash space to store the LUT in memory). In this case, a specific LUT is available in the attached « Alternate_semtech_app_note » directory.



4.3 Appnotes attached source code

This section explains how is organized the attached compressed file. This source code is dedicated to check if your device is candidate for Sigfox requirements concerning the modulation and demodulation.

The content of the SigfoxCandidate_Sx127x.tar.gz is described hereafter.

SigfoxCandidate_SX127x

