Telit SigFox library software user guide

1VV0301117 Rev.2 – 2014-11-13

Making machines talk.

APPLICABILITY TABLE (sample)

PRODUCT
LE51-868 S

SW Version
TLT.01.00-Rx0-1.2

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1. Introduction

1.1. Scope

Scope of this document is to describe the application programming interface (API) exported by the Telit SigFox Library. The Telit SigFox Library will allow customers to use the SigFox® protocol through the LE51 module.

1.2. Audience

This document is intended for programmers developing an application to be run inside LE51 module.

1.3. Contact Information, Support

For general contact, technical support, to report documentation errors and to order manuals, contact Telit Technical Support Center (TTSC) at:

TS-EMEA@telit.com
TS-NORTHAMERICA@telit.com
TS-LATINAMERICA@telit.com
TS-APAC@telit.com

Alternatively, use:

http://www.telit.com/en/products/technical-support-center/contact.php

For detailed information about where you can buy the Telit modules or for recommendations on accessories and components visit:

http://www.telit.com

To register for product news and announcements or for product questions contact Telit Technical Support Center (TTSC).

Our aim is to make this guide as helpful as possible. Keep us informed of your comments and suggestions for improvements.

Telit appreciates feedback from the users of our information.

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1.4. Document Organization

This document contains the following chapters (sample):

"Chapter 1: "Introduction" provides a scope for this document, target audience, contact and support information.

"Chapter 2: "Overview" gives an overview of the features of the library.

"Chapter 3: "Platform Library API" describes in details the APIs available in the Telit SigFox® library.

"Chapter 4: "ACRONYMS AND ABBREVIATIONS" provides the meaning of all acronyms and abbreviations used into the document.

"Chapter 5: "Document History" describes the revision history of the document.

1.5. Text Conventions

Danger – This information MUST be followed or catastrophic equipment failure or bodily injury may occur.

Caution or Warning – Alerts the user to important points about integrating the module, if these points are not followed, the module and end user equipment may fail or malfunction.

Tip or Information – Provides advice and suggestions that may be useful when integrating the module.

All dates are in ISO 8601 format, i.e. YYYY-MM-DD.

1.6. Related Documents

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2. Overview

The Telit SigFox® library for LE51 provides a software interface for user applications written in C language and running in LE51 module. Using this library, an application will be able to send data using SigFox® protocol.
The library is distributed as an object file (with extension r90) containing compiled library code and a header file (telit_sfx.h) containing declarations of data types and functions. The name of the object file is SigFoxLib_128A4U.r90. Applications using this library must be built using IAR System's tools for Atmel AVR microcontrollers, configured for ATxmega128A4U processor, shall use Normal DLIB library and shall configure the main clock frequency at 16 MHz.

NOTE:

This library can be used with AVR Studio code (low-level driver implemented by Atmel and provided with ASF) but the compiler must be always the IAR compiler.

2.1. Hardware used by the library

The Telit SigFox library makes a reserved use of some of the peripherals available on the ATxmega128A4U. For this reason, developers using the library can access all the peripherals available on the ATxmega128A4U except the ones listed below:

- **PORTC**: is completely used by the SPI (SPIC) for micro/transceiver communications
- **GPIO PD4**: used to manage TCXO
- **Timer Counter TC0 and TD0**: used for time management
- ADC - **ADCA**: used for temperature sensor and battery voltage measurement
- **AES**: used for encryption
- **EEPROM**: the addresses from 0x0090 to 0x00BF are used by the library
- **User signature raw (USR)**: the use of the USR is reserved by Telit

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2.2. Input/Output pins

The LE51 module exports several pins; the developer can use them following the features provided by the Atmel® product specification. The pins are:

LE51 pin	Atmel name
J3	PA0
J4	PA3
J5	PA5
J6	PA7
J7	PB2
J8	PB3
J18	PD3
J9	PD5
J2	PD6
J1	PD7
J24	PE0
J22	PE1
J21	PE2
J19	PE3

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3. Platform Library API

3.1. Data Types

3.1.1. enum SIGFOX_ERROR_t

It is an enumeration holding all the possible values. Possible values:

- SIGFOX_ERR_NONE : no error
- SIGFOX_ERR_INIT: error during initialization
- SIGFOX_ERR_ID_KEY: ID or AES key error
- SIGFOX_ERR_STATEMACHINE: State machine error
- SIGFOX_ERR_SIZE : Sending message size is more than biggest frame available
- SIGFOX_ERR_SEND: manufacturer send error
- SIGFOX_ERR_GETVOLT: error reading voltage
- SIGFOX_ERR_CLOSE: error during closing function
- SIGFOX_ERR_API: error code from external function
- SIGFOX_ERR_PN9: error code PN9 Get or set
- SIGFOX_ERR_FREQCY: frequency not available error
- SIGFOX_ERR_FRAME: error in frame build
- SIGFOX_ERR_DELAY: error from delay function
- SIGFOX_ERR_CBACK: error from callBack function
- SIGFOX_ERR_TIME
- SIGFOX_ERR_FREQ
- SIGFOX_ERR_RECEIVE
- SIGFOX_ERR_NO_INIT: the user is trying to call function before calling SystemInit function
- SIGFOX_ERR_BAD_PARAM: function called with wrong parameter

3.1.2. enum SIGFOX_STATE_t

It is an enumeration holding all the possible values of the library FSM. Possible values:

- SIGFOX_STATE_IDLE: uninitialized
- SIGFOX_STATE_READY: ready to transmit

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- SIGFOX_STATE_TX: transmission on going
- SIGFOX_STATE_RX: reception on going

3.1.3. InitStruct_t

It is the structure used as parameter of SystemInit function.

```
typedef struct initStruct
{
  SerialTxFunc          TxSerial;
  En_Radio_Irq_Func     EnRadioIrq;
  Dis_Radio_Irq_Func    DisRadioIrq;
  Sleep_delay           Sleep;
  struct
  {
    void *par1;
    void *par2;
  }AesInfos;
} InitStruct_t;
```

3.1.3.1. SerialTxFunc

It is the callback used to print result during reception test mode.

```
typedef void (*SerialTxFunc)(unsigned char *buffer, unsigned int size);
```

3.1.3.2. En_Radio_Irq_Func

It is the callback used to register a specific interrupt routine by the library radio driver for SyncWord detection interrupt and Rx FIFO overflow interrupt. It allows the system to manage interrupt generated by radio GPIO (PORTC: gpio 1 used for SyncWord detection, gpio 2 used for Rx FIFO overflow). It is mandatory to set this callback if the user wants to use the downlink feature.

```
typedef void (*En_Radio_Irq_Func)(unsigned char pin, void (*func)(void *),
void *arg);
```

3.1.3.3. Dis_Radio_Irq_Func

It is the callback used to unregister a specific interrupt routine by the library radio driver for SyncWord detection and Rx FIFO overflow interrupt. It allows the system to remove interrupt associated to radio GPIOs. It is mandatory to set this callback if the user wants to use the downlink feature.

```
typedef void (*Dis_Radio_Irq_Func)(unsigned char pin);
```

3.1.3.4. Sleep_delay

It is the callback used to put the module in sleep mode for a specific period (seconds) during the waiting time before receiving the ack. If the callback is not set, during the waiting time, the module remain awake.

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```
typedef void (*Sleep_delay)(unsigned int seconds);
```

3.2. Global defines

3.2.1. SIGFOX_MAX_CUSTOMER_DATA_LENGTH

It's the maximum payload length for a SigFox® packet.

3.2.2. SIGFOX_LIBRARY_VERSION_LENGTH

It's the string length returned by the function SigFoxGetLibVersion

3.2.3. SIGFOX_DOWNLINK_DATA_LENGTH

It's the length of the buffer used as ack when the user enables the ack

3.2.4. INIT_SIGFOX

It is a macro used to declare and initialize the InitStruct_t

```
#define INIT_SIGFOX(x)  \
  static InitStruct_t x = \
  {\
    .TxSerial =       NULL,\
    .EnRadioIrq =     NULL,\
    .DisRadioIrq =    NULL,\
    .Sleep =          NULL,\
    .AesInfos.par1 =  NULL,\
    .AesInfos.par2 =  NULL,\
  };
```

3.3. Function Description

3.3.1. SystemInit

Initialize the platform library. This function sets time counter; it initializes memory, EEPROM and AES. It must be called just once and before any other library function is executed.

3.3.1.1. Prototype

```
SIGFOX_ERROR_t SystemInit(InitStruct_t arg);
```

3.3.1.2. Parameters

- Arg must be initialized using INIT_SIGFOX macro, and then the user can assign to every structure element the new value

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3.3.1.3. Return Values

SIGFOX_ERR_NONE on success, other error code if an error happens.

3.3.2. SigFoxInit

This function must be called at first to:

- Change the state to SIGFOX_STATE_READY
- Configure the modulation table

Each time user change the RF configuration, it must call this function first. After the execution of SigFoxInit and before calling SigFoxClose, the user can call several times any of the APIs dedicated to send messages. In order to improve power saving we suggest to call SigFoxClose, otherwise the transceiver will remain switched on.

3.3.2.1. Prototype

```
SIGFOX_ERROR_t SigFoxInit(unsigned char deltaPower);
```

3.3.2.2. Parameters

- deltaPower: the value must be always 0.

3.3.2.3. Return Values

- SIGFOX_ERR_NO_INIT: the function has been called before SystemInit function
- SIGFOX_ERR_STATEMACHINE : Library is not in correct state when function was called.
- SIGFOX_ERR_INIT : Internal error status.
- SIGFOX_ERR_ID_KEY : Id or Key pointer Null status.
- SIGFOX_ERR_NONE : No error status

3.3.3. SigFoxClose

This function should be called in order to release memory buffers and radio resources. This operation is usually needed after all the messages have been sent and or in case of error during SigFoxInit or any of the send API.

3.3.3.1. Prototype

```
SIGFOX_ERROR_t SigFoxClose(void);
```

3.3.3.2. Parameters

None.

3.3.3.3. Return Values

- SIGFOX_ERR_NO_INIT: the function has been called before SystemInit function
- SIGFOX_ERR_CLOSE if error
- SIGFOX_ERR_NONE if no error

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3.3.4. SigFoxSendFrame

This function is used to send a customer_data buffer of customer_data_length bytes. Customer_data_length can be from 0 to 12bytes. Set the status to SIGFOX_STATE_TX. If an error occur, state stays at SIGFOX_STATE_TX and, SigFoxClose() and SigFoxInit() needs to be done to be able to try sending new frame. If sending finishes successfully, the function turns the status in SIGFOX_STATE_READY.

3.3.4.1. Prototype

```
SIGFOX_ERROR_t SigFoxSendFrame(unsigned char *customer_data, unsigned char
customer_data_length, unsigned char *buff, bool ack);
```

3.3.4.2. Parameters

- customer_data : pointer to data to send
- customer_data_length : size of the customer data
- buff: buffer where the ack will be stored; it must be NULL if ack is false
- ack: enable the radio acknowledge

3.3.4.3. Return Values

- SIGFOX_ERR_NONE : no error when sending frame
- SIGFOX_ERR_NO_INIT: the function has been called before SystemInit function
- SIGFOX_ERR_STATEMACHINE : not in correct state for sending data
- SIGFOX_ERR_SIZE : Data size not correct
- SIGFOX_ERR_FRAME : error in building data frame
- SIGFOX_ERR_FREQCY : error in frequency hoping
- SIGFOX_ERR_SEND : error in sending data
- SIGFOX_ERR_DELAY : error in delay execution
- SIGFOX_ERR_CBACK : error in callback function

3.3.5. SigFoxSendBit

This function is used to send a bit value with a status (0 or 1).Set the status to SIGFOX_STATE_TX. If an error occur, state stay at SIGFOX _STATE_TX and, SigFoxClose() and SigFoxInit() needs to be done to be able trying to send new frame.
If sending finishes successfully, the function turns the status in SIGFOX_STATE_READY.

3.3.5.1. Prototype

```
SIGFOX_ERROR_t SigFoxSendBit(bool BitState, unsigned char *buff, bool ack);
```

3.3.5.2. Parameters

- BitState : state of the bit (0, 1)
- buff: buffer where the ack will be stored; it must be NULL if ack is false

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- ack: indicate if an ack is expected.

3.3.5.3. Return Values

- SIGFOX_ERR_NONE : no error when sending frame
- SIGFOX_ERR_NO_INIT: the function has been called before SystemInit function
- SIGFOX_ERR_STATEMACHINE : not in correct state for sending data
- SIGFOX_ERR_SIZE : Data size not correct
- SIGFOX_ERR_FRAME : error in building data frame
- SIGFOX_ERR_FREQCY : error in frequency hoping
- SIGFOX_ERR_SEND : error in sending data
- SIGFOX_ERR_DELAY : error in delay execution
- SIGFOX_ERR_CBACK : error in callback function

3.3.6. SigFoxSendOutOfBand

This function is used to send an out of band keep-alive message. This is not a customer message but it is used for network to alert some device global status concerning temperature and power supply level. This function can be called periodically (every 24h for example) or can be disabled for power saving.
Values received by backend are interpreted and alert can be set for customer. Set the status to SIGFOX_STATE_TX. If an error occur, state stays at SIGFOX_STATE_TX and SigFoxClose() and SigFoxInit() needs to be done to be able to try sending new frame. If send finish successfully, the function turns the status in SIGFOX_STATE_READY

3.3.6.1. Prototype

```
SIGFOX_ERROR_t SigFoxSendOutOfBand(void);
```

3.3.6.2. Parameters

None.

3.3.6.3. Return Values

- SIGFOX_ERR_NONE : no error when sending frame
- SIGFOX_ERR_NO_INIT: the function has been called before SystemInit function
- SIGFOX_ERR_STATEMACHINE : not in correct state for sending data
- SIGFOX_ERR_SIZE : Data size not correct
- SIGFOX_ERR_FRAME : error in building data frame
- SIGFOX_ERR_FREQCY : error in frequency hoping
- SIGFOX_ERR_SEND : error in sending data
- SIGFOX_ERR_DELAY : error in delay execution
- SIGFOX_ERR_CBACK : error in callback function

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3.3.7. SigFoxGetTxState

This function is used to get the exact status of the library, if it is in use or not. In case of non-blocking send_data_stream function.

3.3.7.1. Prototype

```
SIGFOX_STATE_t SigFoxGetTxState(void);
```

3.3.7.2. Parameters

None.

3.3.7.3. Return Values

Current library status:

- SIGFOX_STATE_IDLE: uninitialized
- SIGFOX_STATE_READY: ready to transmit
- SIGFOX_STATE_TX: transmission on going

3.3.8. SigFoxGetLibVersion

This function is used to get the exact library version.

3.3.8.1. Prototype

```
unsigned char * SigFoxGetLibVersion(void);
```

3.3.8.2. Parameters

None.

3.3.8.3. Return Values

The function returns a pointer to the library version string (the size is 22 bytes plus a string terminator).

3.3.9. SigFoxTxTestMode

Used to put the module in transmission test mode

3.3.9.1. Prototype

```
SIGFOX_ERROR_t SigFoxTxTestMode(signed int frame_count, signed int channel,
unsigned int period);
```

3.3.9.2. Parameters

- frame_count: number of frame to send
- channel: number of channel to use (0 – 480; -1 means random channel)
- period: interval time between to sending frame

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3.3.9.3. Return Values

- SIGFOX_ERR_NO_INIT if the library is not initialized
- SIGFOX_ERR_BAD_PARAM bad parameter value
- SIGFOX_ERR_NONE no error

3.3.10. SigFoxRxTestMode

Used to put the module in reception test mode

3.3.10.1. Prototype

```
SIGFOX_ERROR_t SigFoxRxTestMode(unsigned char* ReplyForm, int channel,
unsigned int Sequence_nb, unsigned int Temps);
```

3.3.10.2. Parameters

- ReplyForm: buffer where data received will be stored
- channel: number of channel to use (0 – 480)
- Sequence_nb: sequence number expected
- Temps: test time duration (-1 means infinite time)

3.3.10.3. Return Values

- SIGFOX_ERR_NO_INIT if the library is not initialized
- SIGFOX_ERR_NONE no error

3.3.11. SigFoxSetTxCenterFrequency

It sets the center frequency for uplink (default is 868130000 Hz)

3.3.11.1. Prototype

```
void SigFoxSetTxCenterFrequency(unsigned long freq);
```

3.3.11.2. Parameters

- freq: center frequency expressed in Hz

3.3.12. SigFoxSetRxCenterFrequency

It sets the center frequency for downlink (default is 869525000 Hz)

3.3.12.1. Prototype

```
void SigFoxSetRxCenterFrequency(unsigned long freq);
```

3.3.12.2. Parameters

- freq: center frequency expressed in Hz

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3.3.13. SigFoxSetTxRepetition

It sets the number of sending repetitions in case of acknowledge enabled

3.3.13.1. Prototype

```
void SigFoxSetTxRepetition(unsigned char value);
```

3.3.13.2. Parameters

- value: number of repetitions (0 – 2, default is 2)

3.3.14. SigFoxGetTxCenterFrequency

It gets the center frequency for uplink

3.3.14.1. Prototype

```
unsigned long SigFoxGetTxCenterFrequency(void);
```

3.3.14.2. Parameters

None

3.3.14.3. Return Values

Center frequency expressed in Hz

3.3.15. SigFoxGetRxCenterFrequency

It gets the center frequency for downlink

3.3.15.1. Prototype

```
unsigned long SigFoxGetRxCenterFrequency(void);
```

3.3.15.2. Parameters

None

3.3.15.3. Return Values

Center frequency expressed in Hz

3.3.16. SigFoxGetTxRepetition

It gets the number of sending repetitions in case of acknowledge enabled

3.3.16.1. Prototype

```
unsigned char SigFoxGetTxRepetition(void);
```

3.3.16.2. Parameters

None

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3.3.16.3. Return Values

Number of sending repetitions

3.3.17. SigFoxSetDefaultDelay

It sets the delay duration between two sending frame when acknowledge is not enabled, from 0 to 2 seconds

3.3.17.1. Prototype

```
SIGFOX_ERROR_t SigFoxSetDefaultDelay(unsigned char value);
```

3.3.17.2. Parameters

- value: number of hundredth of seconds (0 – 200)

3.3.17.3. Return Values

- SIGFOX_ERR_BAD_PARAM bad parameter value
- SIGFOX_ERR_NONE no error

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4. ACRONYMS AND ABBREVIATIONS

AES	Advanced Encryption Standard
API	Application Programming Interface
EEPROM	Electrically Erasable Programmable Read-Only Memory
USR	User Signature Raw
ADC	Analog to Digital Converter
SPI	Serial Peripheral Interface
ASF	Atmel Software Framework®
FSM	Finite State Machine

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5. Document History

Revision	Date	Changes
0	2013-12-11	First issue
1	2014-07-07	Introduction of SigFox downlink feature
2	2014-11-13	Changed Tx center frequency

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