LE51-868 S RF Module User Guide

1VV0301131 Rev.0 – 2014-01-16

APPLICABILITY TABLE

PRODUCT
LE51-868 S

SPECIFICATIONS SUBJECT TO CHANGE WITHOut Notice

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Contents

1.   Introduction

1.1.   Scope

Scope of this document is to present the features and the application of the Telit LE51-868 S radio modules.

1.2.   Audience

This document is intended for developers using Telit LE51-868 S radio modules.

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-SRD@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

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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.

1.4.   Document Organization

This document contains the following chapters

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

"Chapter 2: "Requirements" gives an overview of the limitations imposed by Reference standards.

"Chapter 3: "General Characteristics" describes in detail the characteristics of the product.

"Chapter 4: "Technical Description" describes in detail the signals and pin-out of the product.

"Chapter 5: "Process information" describes in detail the delivery, storage, soldering and placement of the product.

"Chapter 6: "Board Mounting Recommendations" describes in detail the interface and coupling of the product.

"Chapter 8: "Glossary" shows acronyms used in the document.

"Chapter 9: "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

- [1] EN 300 220-2 v2.4.1, ETSI Standards for SRD , May 2012

- [2] ERC Rec 70-03, ERC Recommendation for SRD, October 2012

- [3] 2002/95/EC, Directive of the European Parliament and of the Council, 27 January 2003

- [4] SR Tool User Guide, 1vv0300899

- [5] 2006/771/EC, Harmonization of the radio spectrum for use by short-range devices

- [6] 2009/381/EC, Amending Decision 2006/771/EC on harmonization of the radio spectrum for use by short-range devices

- [7] Sigfox Stand-Alone Module User Guide, 1vv0301109

2.   Requirements

2.1.   General Requirements

The LE51-868 S module is a multi-channel radio board, delivering up to 35 mW in the 868 MHz ISM band (unlicensed frequency band).

It is delivered with preloaded protocol stack:

- LE51-868 S SIGFOX™ Network Software.

LE51-868 S is pin-to-pin compatible with LE, NE and ME modules working at different frequencies.

LE51-868 S is also pin-to-pin compatible with Telit ZE Family (ZigBee 2007 and ZigBee PRO stack).

2.2.   868 MHz band Requirements

The "ERC recommendation 70-03" describes the different usable sub-bands in the 868 MHz license free band, in terms of bandwidth, maximum power, duty cycle and channel spacing. LE51-868 S can operate on Annex 1, g1 band where "ERC recommendation 70-03" gives the following limitations:

ERC recommendation 70-03				
Band	*Frequency band (MHz)*	*Maximum radiated power (mW)*	*Channel spacing (kHz)*	*Duty cycle (%)*
Annex 1 g1	868.0 – 868.6	25	No channel spacing specified	1
Band g3	869.400 – 869.650	500	25 kHz or the whole band	10

This band is free to use but the module and the user must respect some limitations. Most of these restrictions are integrated in the conception of the module, except the duty cycle. For example, the g1 sub-band from 868.000 to 868.600 MHz band is limited to a 1% duty cycle. This means that each module is limited to a total transmit time of 36 seconds per hour. It is the responsibility of the user to respect the duty cycle. Sigfox has also a limitation on this band to ensure unsaturated network.

In order to fulfil the ETSI 70-03 specification requirement regarding duty cycle on ISM band and to be aligned with Sigfox network management, each hour the application can send up to 72 Bytes (e.g., 6 messages of 12 bytes each).

Furthermore, the module complies with the ETSI 300-220-2 v2.3.1 standards (specific for SRD) whose main requirements are described in Appendix 1.

Finally, the module complies with the European Directive 2002/95/EC concerning the Restrictive Usage of Hazardous Substances (RoHS).

National Restrictions for non specific SR devices Annex 1 band g1-g4:

Country	Restriction	Reason/Remark
Band G		
Austria	Not Implemented	Planned
Finland	Limited Implementation	Audio, video and voice not allowed - Planned 2011
Georgia	Not Implemented	
Spain	Limited implementation	to the band 863-868 MHz
Sweden	Not Implemented	
The Netherlands	Not Implemented	Under study
Ukraine	Limited implementation	863-865 / 868-868.6 / 868.6-868.7 / 869.2-869.25 MHz
Band G1		
Georgia	Not Implemented	
Russian Federation	Not Implemented	
Ukraine	Not Implemented	e.i.r.p. ≤25 mW

2.3.   Other Requirements

The module complies with the European Directive 2002/95/EC concerning the Restrictive Usage of Hazardous Substances (RoHS).

2.4.   Functional Requirements

The LE51-868 S module is a complete solution from serial interface to RF interface. The LE51-868 module has a digital part and a RF part. The radio link on Sigfox network is a mono-directional link, since RX features are not required to be compliant with the network protocol.

The digital part has the following functionalities:
· Communication interface
· I/O management
· Micro controller with embedded Telit Software Stack supporting Sigfox protocol

The RF part has the following functionalities:
· Frequency synthesis
· Front-end
· Power amplification

- Packet handling

2.5.   Software

The LE51-868 S module is provided pre-flashed with one of the available Telit in-house Protocol Stack.

Please refer to Protocol Stack User Guide [7] for detailed information.

2.6.   Temperature Requirements

	Minimum	*Typical*	*Maximum*	*Unit*
Operating				
Temperature	- 40	25	+ 85	°C
Relative humidity @ 25°C	20		75	%
Storage				
Temperature	- 40	25	+ 85	°C

3.   General Characteristics

3.1.   Mechanical Characteristics

Size :	Rectangular 25.8 x 15 mm
Height :	3 mm
Weight :	1.7 g
PCB thickness:	0.8 mm
Cover* :	• Dimensions : 25 x 14.2 x 2.2mm • Thickness : 200µm
Components :	All SMD components, on one side of the PCB.
Connectors :	The terminals allowing conveying I/O signals are LGA
Mounting :	• SMD • LGA on the 4 external sides
Number of pins :	30

*: The metallic shield used on LE51-868 S covers all the SMD components

3.2.   Mechanical dimensions
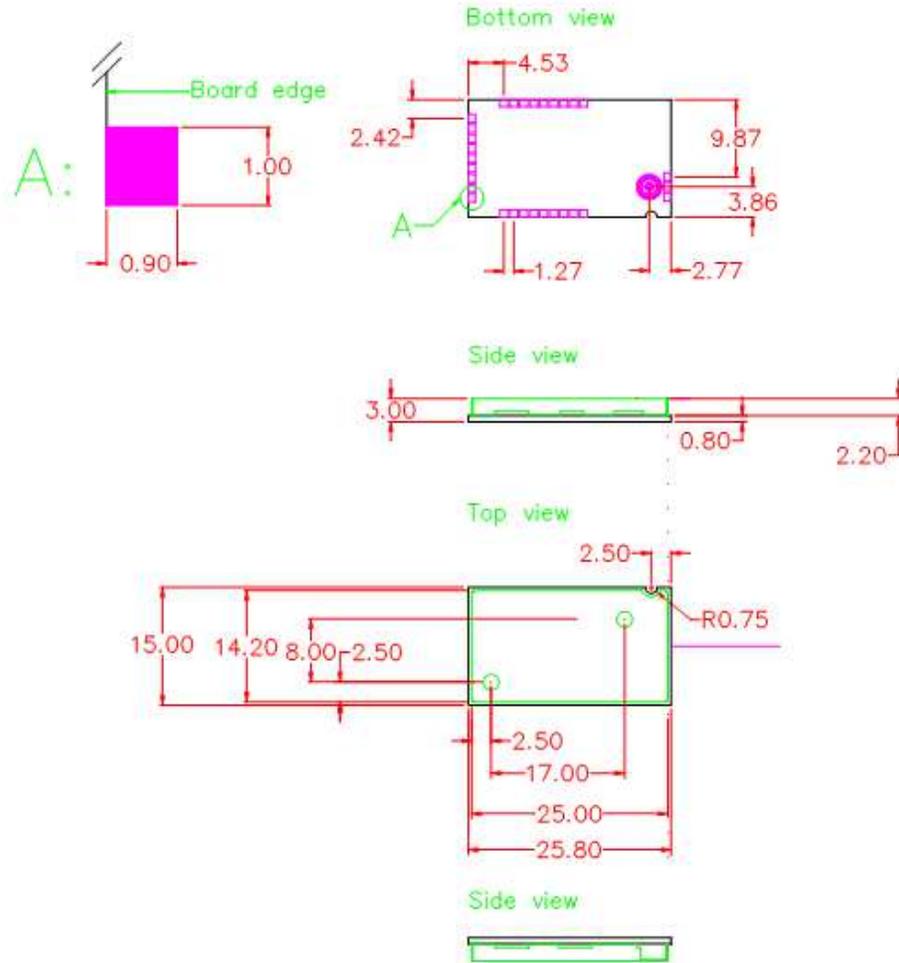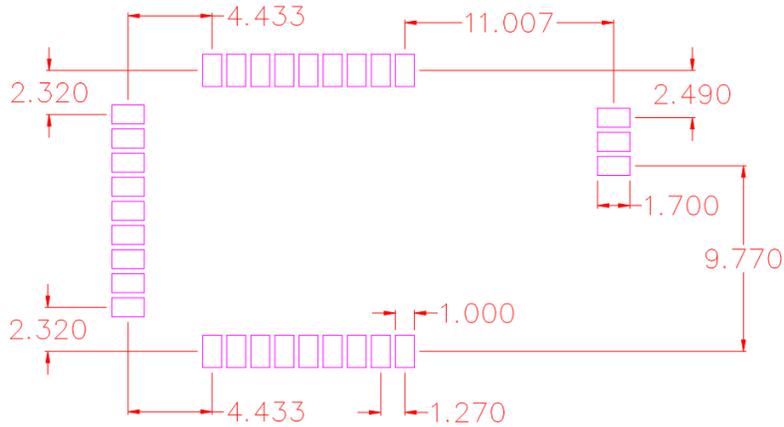
3.3.   Recommended Land pattern

3.4.   DC Characteristics

Measured on DIP interface with T = 25°C, Vdd = 3V, 50Ω impedance and default power register setting if nothing else noted.

Max limits apply over the entire operating range, T=-40°C to +85°C, Vdd=2V to 3.6V and all channels.

Characteristics LE51-868 S	Min.	Typ.	Max.
Power Supply (VDD):	+2.0V	+3.0V	+3.6V
Consumption			
Transmission:		55mA@25mW	66mA@35mW
Command/Data mode		11mA	13mA
Reception :		TBD	
Stand-by (32.768 kHz On) :		< 2uA	
I/O low level :	GND	-	0.2x V_{DD}
I/O high level :	0.8x V_{DD}	-	V_{DD}

3.5.   LE51-868 S Functional Characteristics

Measured on DIP interface with T = 25°C, Vdd = 3V, 50Ω impedance and default power register setting if nothing else noted.

Frequency Band	868.178 MHz – 868.222 MHz
RF Data Rate	100 bps
Number of channels	1
Total slot number	480
Slot Width	100 Hz
Blacklisted slots	0 to 19; 221 to 259; 460 to 480
Center Frequency	868.2 MHz
Total Bandwidth	48 kHz
Transmission	
Modulation Format	(D)BPSK
Technology	Sigfox Protocol
RF Output Power	Up to 30mW @3.0 Volts

Limits allowed by ETSI Standard are reported in the table below:

Limits allowed by ETSI standard [1]				
Transmission				
Frequency error	+/- 12.5 kHz @ 25 kHz channelization +/- 87 kHz (+/-100 ppm) > 25 kHz channelization			
ACP for channels ≤ 25 kHz	- 37 dBm in 16 kHz "receiver" filter BW under normal test conditions - 32 dBm in 16 kHz "receiver" filter BW under extreme test conditions			
Modulation bandwidth	Reference Bandwidth (RBW)	Limit	Lower envelope point Minimum frequency	Upper envelope point maximum frequency
	1 kHz	- 30 dBm (1 µW)	$f_{c, lower}$	$f_{c, upper}$
	1 kHz	- 36 dBm (250 nW)	$(f_{c, lower} - 200\,kHz)$	$(f_{c, upper} + 200\,kHz)$
	10 kHz	- 36 dBm (250 nW)	$(f_{c, lower} - 400\,kHz)$	$(f_{c, upper} + 400\,kHz)$
	100 kHz	- 36 dBm (250 nW)	$(f_{c, lower} - 1\,MHz)$	$(f_{c, upper} + 1\,MHz)$
Unwanted emissions in the spurious domain	Frequency	47 MHz to 74 MHz 7,5 MHz to 118 MHz 174 MHz to 230 MHz 470 MHz to 862 MHz	Other frequencies below 1 000 MHz	Frequencies above 1 000 MHz
	State			
	Operating	- 54 dBm (4 nW)	- 36 dBm (250 nW)	- 30 dBm (1 µW)
	Standby	- 57 dBm (2 nW)	- 57 dBm (2 nW)	- 47 dBm (20 nW)
Reception				
Blocking for class 2 equipments	Frequency offset of the unwanted signal	Receiver bandwidth	Minimum offset between wanted and unwanted signals	
	+/-2 MHz	15 kHz	≥ 35 dB	
		25 kHz	≥ 33 dB	
		81 kHz	≥ 28 dB	
		122 kHz	≥ 26 dB	
	+/-10 MHz	15 kHz	≥ 60 dB	
		25 kHz	≥ 58 dB	
		81 kHz	≥ 53 dB	
		122 kHz	≥ 51 dB	
Spurious radiation	Below 1000 MHz		Above 1000 MHz	
	- 57 dBm (2 nW)		- 47 dBm (20 nW)	

3.6.   Digital Characteristic

Function	Characteristics
µC	• 128 kB + 8 kB in system programmable flash • 8 kB RAM • 2 kB E^{2}PROM
Serial link	• RS232 TTL Full Duplex • 1200 to 115200 bps • 7 or 8 bits • Parity management • Flow control o Hardware (RTS/CTS)
Embedded software functionality	• Flexibility: o Pre flashed o Customization capability o Download over the air

3.7.   Absolute Maximum Ratings

Voltage applied to Vcc, V$_{DD}$:	-0.3V to +3.6V
Voltage applied to "TTL" Input :	-0.3V to V$_{DD}$+0.3V

3.8.   Ordering Information

The following equipments can be ordered:

- The SMD version (LE51-868 S)

- The DIP interface version (LE51-868 S)

- The Demo Case (LE51-868 S) composed by n.1 evaluation boards, n.1 DIP interface boards, RF antennas, serial cable, battery.

The versions below are considered standard and should be readily available. For other versions, please contact Telit. Please make sure to give the complete part number when ordering.

Equipment
SMD Version
LE51-868 S/SMD
DIP Version
B LE51-868 S
Demo Case
D LE51-868 S
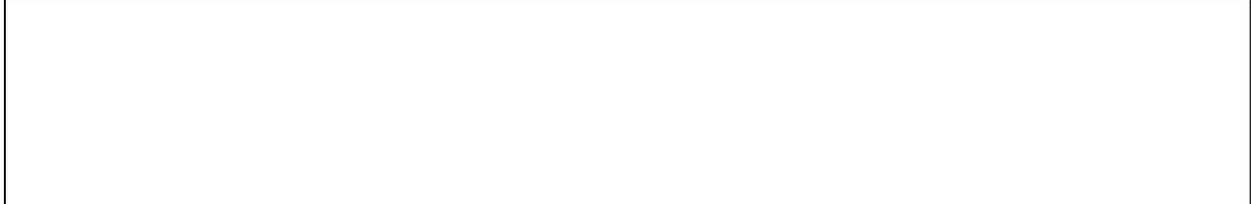
4.   Technical Description

4.1.   Module Top View (cover side)
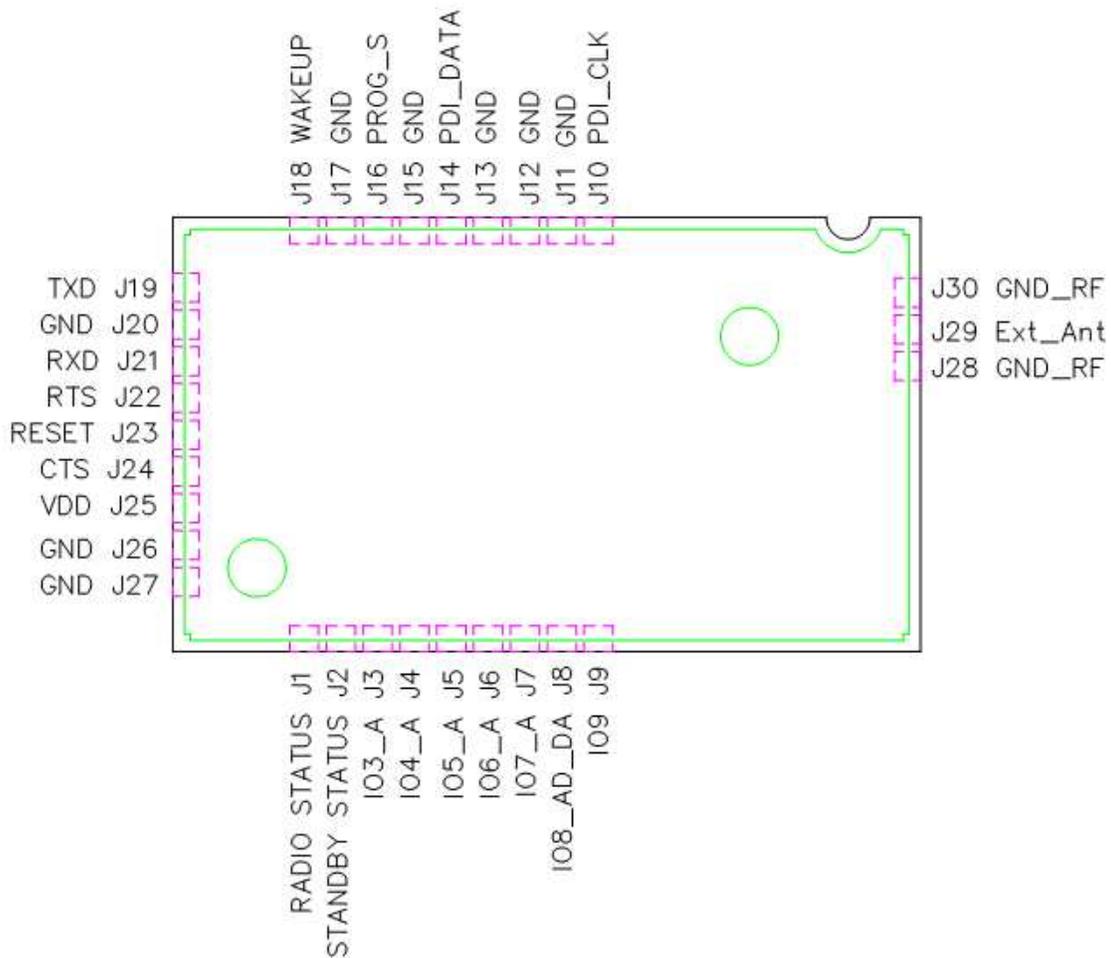
⚠️	*CAUTION: reserved pins must not be connected*

⚠️	*CAUTION: In case you want to use in the same application Telit ZE51 or ZE61 modules J9 and J8 should not be connected, since reserved on these modules (see foot notes on Pin-Out tables.*

4.2.   Pin-out of the module LE51-868 S

Pin	Pin name	Pin type	Signal level	Function
J30	GND	Gnd		RF Ground connection for external antenna
J29	Ext_Antenna	RF		RF I/O connection to external antenna
J28	GND	Gnd		RF Ground connection for external antenna
J27	GND	Gnd		Ground
J26	GND	Gnd		Ground
J25	VDD	Power		Digital and Radio part power supply pin
J24	CTS	I	TTL	Clear To Send
J23	RESET	I	TTL	µC reset (Active low with internal pull-up)
J22	RTS	O	TTL	Request To Send
J21	RXD	I	TTL	RxD UART – Serial Data Reception
J20	GND	Gnd		Ground
J19	TXD	O	TTL	TxD UART – Serial Data Transmission
J18	WAKEUP	I	TTL	Wake-up (Active high with internal pull-down: when set to 1 the module is awakened)
J17	GND	Gnd		Ground
J16	PROG	I	TTL	Signal for serial µC flashing (Active high with internal pull-down)
J15	GND	Gnd		Ground
J14	PDI_DATA	I/O	TTL	Program and Debug Interface DATA
J13	GND	Gnd		Ground
J12	GND	Gnd		Ground
J11	GND	Gnd		Ground
J10	PDI_CLK	I	TTL	Program and Debug Interface CLOCK
J9	IO9[1]	I/O	TTL	Digital I/O N°9 with interrupt
J8	IO8_A	I/O	analog	Analog Input I/O N°8 with interrupt (Logic I/O capability)
J7	IO7_A	I/O	analog	Analog Input N°7 (Logic I/O capability)
J6	IO6_A	I/O	analog	Analog Input N°6 (Logic I/O capability)
J5	IO5_A	I/O	analog	Analog Input N°5 (Logic I/O capability)
J4	IO4_A	I/O	analog	Analog Input N°4 (Logic I/O capability)
J3	IO3_A	I/O	analog	Analog Input N°3 (Logic I/O capability)
J2	STANDBY STATUS	O	TTL	Signal indicating stand-by status
J1	RADIO STATUS	O	TTL	Signal indicating reception or transmission of radio frame

[1,2] In case you want to use in the same application Telit ZE51 or ZE61 modules J9 and J8 should not be connected, since reserved on these modules.

4.3.   Pin-out of the DIP Interface

4.4.   Pin-out correspondence table

Pin-Out correspondence between LE51-868 S/DIP and LE51-868 S/SMD.

| LE51-868 S/DIP			LE51-868 S/SMD		Comments
Connector	Pin	Name	Pin	Pin Name	
J1	1				
	2			GND	
	3	P1	J5	IO5_A	
	4	P2	J9	IO9_I	Reserved Pin
	5	P3	J2	STANDBY STATUS	
	6	P4	J1	RADIO STATUS	
	7	P5	J4	IO4_A	
	8	P6	J3	IO3_A	
	9			GND	
	10		J25	VDD	
J2	11		J16	PROG	
	12		J22	RTS	
	13		J24	CTS	
	14		J23	RESET	
	15		J21	RxD	
	16		J19	TxD	
	17		J18	WAKEUP	
	18		J22	RTS	
	19	P7	J6	IO6_A	
	20			GND	
J4	1		J14	PDI_DATA	J4 Connector for debugging and flashing
	2		J10	PDI_CLK	
	3		J23	RESET	
	4		J25	VDD	
	5			GND	
			J7	IO7_A	
			J8	IO8_AD_DA	Reserved Pin
RF connection					
J3	SMA connector		J29	Ext_Antenna (Unbalanced RF)	A 50 Ohm coplanar wave guide and a matching network connect J29 to J3

4.5.   Description of the signals

Signals	Description
RESET	External hardware reset of the radio module. Active on low state.
TXD, RXD	Serial link signals, format NRZ/TTL: TXD is for outgoing data. RXD is for incoming data. The '1' is represented by a high state.
CTS	Incoming signal. Indicates whether the module can send serial data to user (Active, on low state) or not (inactive, on high state).
RTS	Outgoing signal. Indicates whether the user can transmit serial data (active, on low state) or not (inactive, on high state).
IO	I/O, configurable as input or as output.
WAKEUP	Input signal which indicates to the module to wake up from low-power mode.
RADIO STATUS	Output signal which indicates the status of the radio. Set to VCC during radio transmission or as soon as a radio frame is detected with correct synchronization word. The signals returns to GND at the end of transmission or as soon as the frame reception is finished.
STANDBY STATUS	The 'STAND BY STATUS' output signal is set to logical '1' while the module is operating and return to '0' during stand by periods.

5.   Process Information

5.1.   Delivery

LE51-868 S modules are delivered in plastic tray packaging, each tray including 50 units. The dimensions of the tray are the following: 329 mm x 176 mm x 5.6 mm. Each unit is placed in a 26.6 mm x 16 mm location. An empty tray weights 45 g and a loaded tray weights around 130 g.
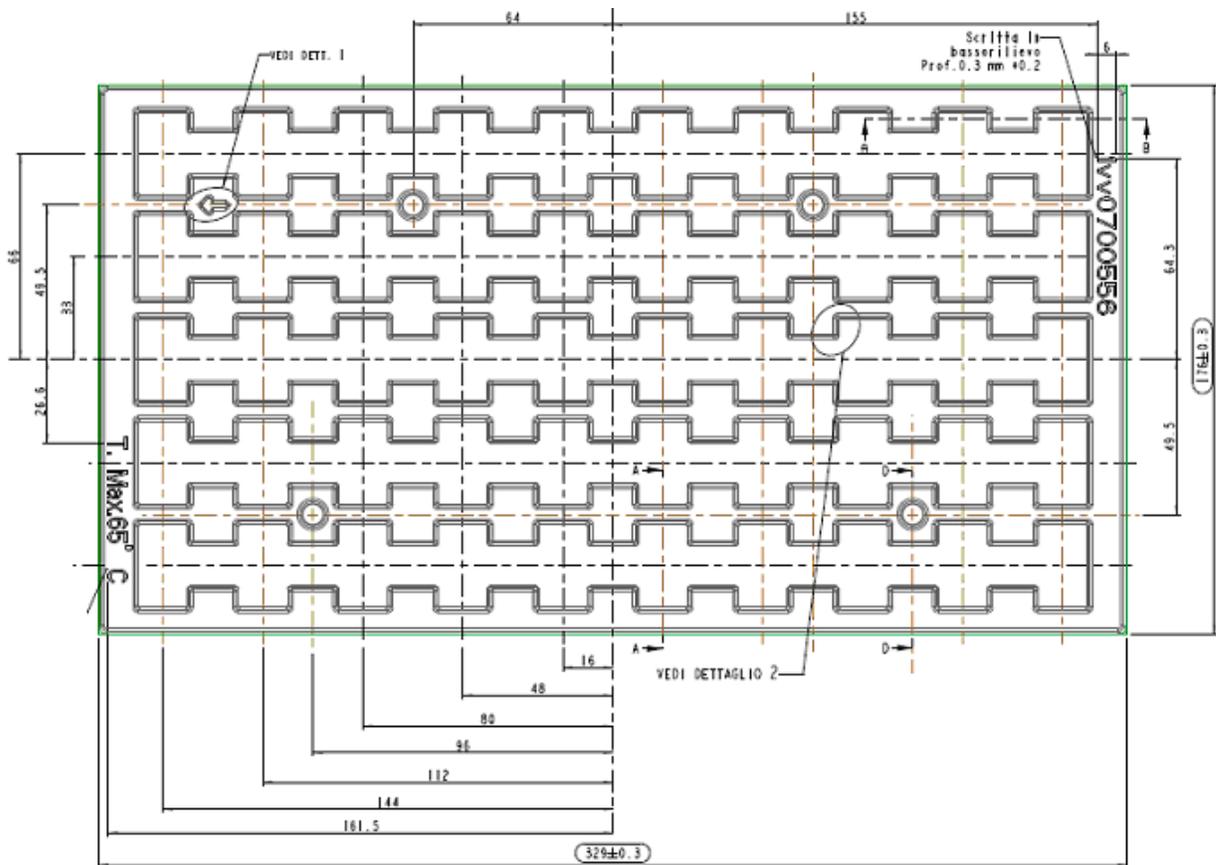
5.2.   Storage

The optimal storage environment for LE51-868 S modules should be dust free, dry and the temperature should be included between -40°C and +85°C.

In case of a reflow soldering process, LE51-868 S radio modules must be submitted to a drying bake at +60°C during 24 hours. The drying bake must be used prior to the reflow soldering process in order to prevent a popcorn effect. After being submitted to the drying bake, LE modules must be soldered on host boards within 168 hours.

Also, it must be noted that due to some components, LE51-868 S modules are ESD sensitive device. Therefore, ESD handling precautions should be carefully observed.

5.3.   Soldering pad pattern

The surface finished on the printed circuit board pads should be made of Nickel/Gold surface. The recommended soldering pad layout on the host board for the LE51-868 S is shown in the diagram below:
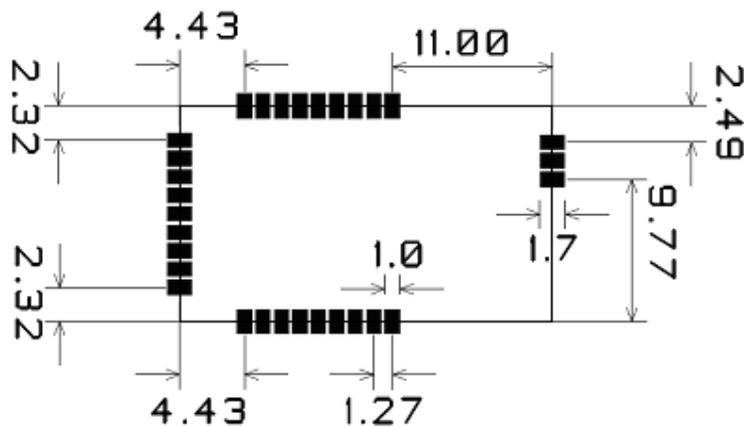
All dimensions in mm

Neither via-holes nor wires are allowed on the PCB upper layer in area occupied by the module.

5.4.   Solder past

LE51-868 S module is designed for surface mounting using half-moon solder joints (see diagram below). For proper module assembly, solder paste must be printed on the target surface of the host board. The solder paste should be eutectic and made of 95.5% of SN, 4% of Ag and 0.5% of Cu. The recommended solder paste height is 180 μm.

The following diagram shows mounting characteristics for ME integration on host PCB:
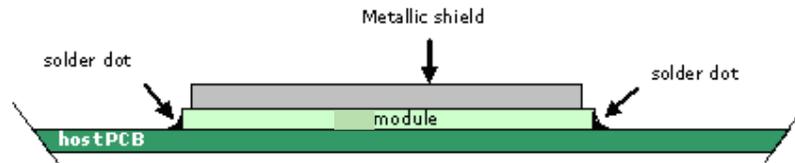
5.5.   Placement

The LE51-868 S module can be automatically placed on host boards by pick-and-place machines like any integrated circuit.

## 5.6.   Soldering Profile (RoHS Process)

It must be noted that LE51-868 S module should not be allowed to be hanging upside down during the reflow operation. This means that the module has to be assembled on the side of the printed circuit board that is soldered last.

The recommendation for lead-free solder reflow in IPC/JEDEC J-STD-020D Standard should be followed.

Profile Feature	Sn-Pb Eutectic Assembly	Pb-Free Assembly
Average Ramp-UP Rate (Ts max to Tp)	3°C/second max.	3°C/second max.
Preheat		
- Temperature Min (Ts min)	100°C	150°C
- Temperature Max (Ts max)	150°C	200°C
- Time (ts min to ts max)	60 - 120 seconds	60 - 120 seconds
Time maintained above:		
- Temperature (TL)	183°C	221°C
- Time (tL)	35 - 90 seconds	45 - 90 seconds
Peak/Classification Temperature (Tp)	max. Peak Temp. 225°C	max. Peak Temp. 260°C
Time within 5°C of actual Peak Temperature (tp)	10 - 30 seconds	10 seconds
Ramp-Down Rate	4°C/second max.	4°C/second max.
Time 25°C to Peak Temperature	6 minutes max.	8 minutes max.
Minimum Solderjoint Peak-Temperature		235°C/ 10sec.

Note 1: All temperatures refer to topside of the package, measured on the package body surface.
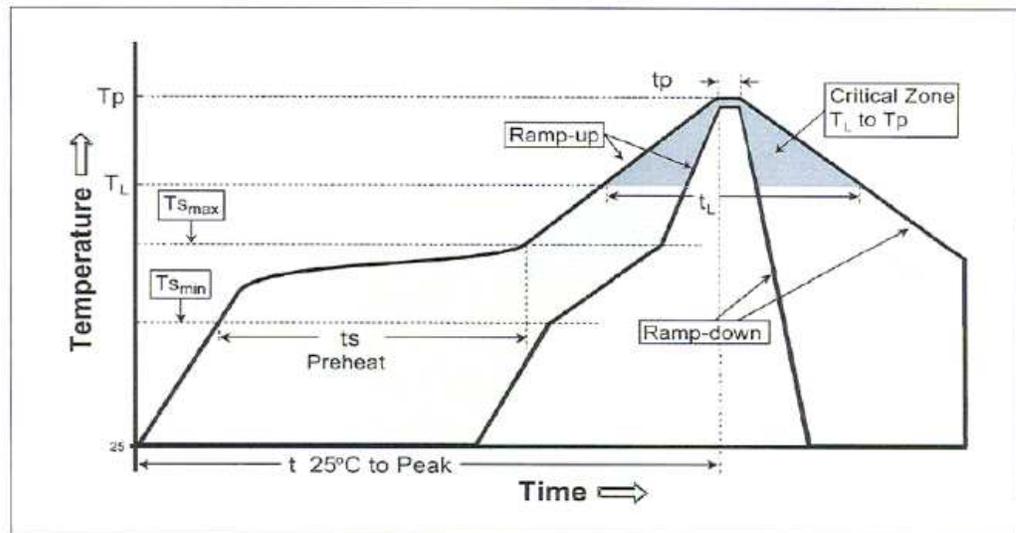
The barcode label located on the module shield is able to withstand the reflow temperature.

⚠️ *CAUTION - It must also be noted that if the host board is submitted to a wave soldering after the reflow operation, a solder mask must be used in order to protect the LE51-868 S radio module's metal shield from being in contact with the solder wave.*

6.   Board Mounting Recommendation

6.1.   Electrical environment

The best performances of the LE51-868 S module are obtained in a "clean noise" environment. Some basic recommendations must be followed:

- Noisy electronic components (serial RS232, DC-DC Converter, Display, Ram, buses, ...) must be placed as far as possible from the LE51-868 S module.

- Switching components circuits (especially RS-232/TTL interface circuit power supply) must be decoupled with a 100 µF tantalum capacitor. And the decoupling capacitor must be as close as possible to the noisy chip.

6.2.   Power supply decoupling on LE51-868 S module

The power supply of LE51-868 S module must be nearby decoupled. A LC filter must be placed as close as possible to the radio module power supply pin, VDD.

Power Supply ──○──[**L1**]──●────●──○── **V$_{dd}$**
                          C1 ═╪═ ═╪═ **C2**
                               ⏚   ⏚
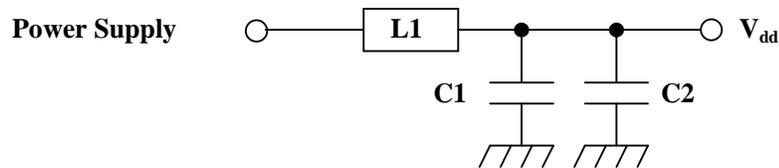
Symbols	Reference	Value	Manufacturer
L1	LQH31MN1R0K03	1µH	Murata
C1	GRM31CF51A226ZE01	22µF	Murata
C2	Ceramic CMS 25V	100nF	Multiple

6.3.   RF layout considerations

Basic recommendations must be followed to achieve a good RF layout:

- It is recommended to fill all unused PCB area around the module with ground plane

- The radio module ground pin must be connected to solid ground plane.

- If the ground plane is on the bottom side, a via (plated hole) must be used in front of each ground pad. Especially J28 and J30 (RF Gnd) pins should be grounded by means of several holes to be located right next to the pins, thus minimizing inductance and preventing mismatch and losses.

6.4.   Antenna connections on printed circuit boards

Special care must be taken when connecting an antenna or a connector to the module. The RF output impedance is 50Ω, so the strip between the pad and the antenna or connector must be 50Ω following the tables below. Ground lines should be connected to the ground plane with as many vias as possible, but not too close to the signal line.

PCB material	PCB thickness H (mm)	Coplanar line W (mm)	Coplanar line G (mm)
FR4	0.8	1	0.3
	1.6	1	0.2

Table 1 : Values for double face PCB with ground plane around and under coplanar wave guide (recommended)

PCB material	PCB thickness H (mm)	Coplanar line W (mm)	Coplanar line G (mm)
FR4	0.8	1	0.22
	1.6	1	0.23

Table 2 : Values for simple face PCB with ground plane around coplanar wave guide (not recommended)

6.5.   LE51-868 S Interfacing

Comments :
 - Schema for sensor connexion.
 - Reset : Internal Pull-Up resistor.
 - WAKEUP   : Internal Pull-Down resistor.
 - IO7_A: Logic Input/Ouput (0 to Vdd) with interrupt.
 - IO3_A & IO7_A : Analog Input. 12 bits precision.
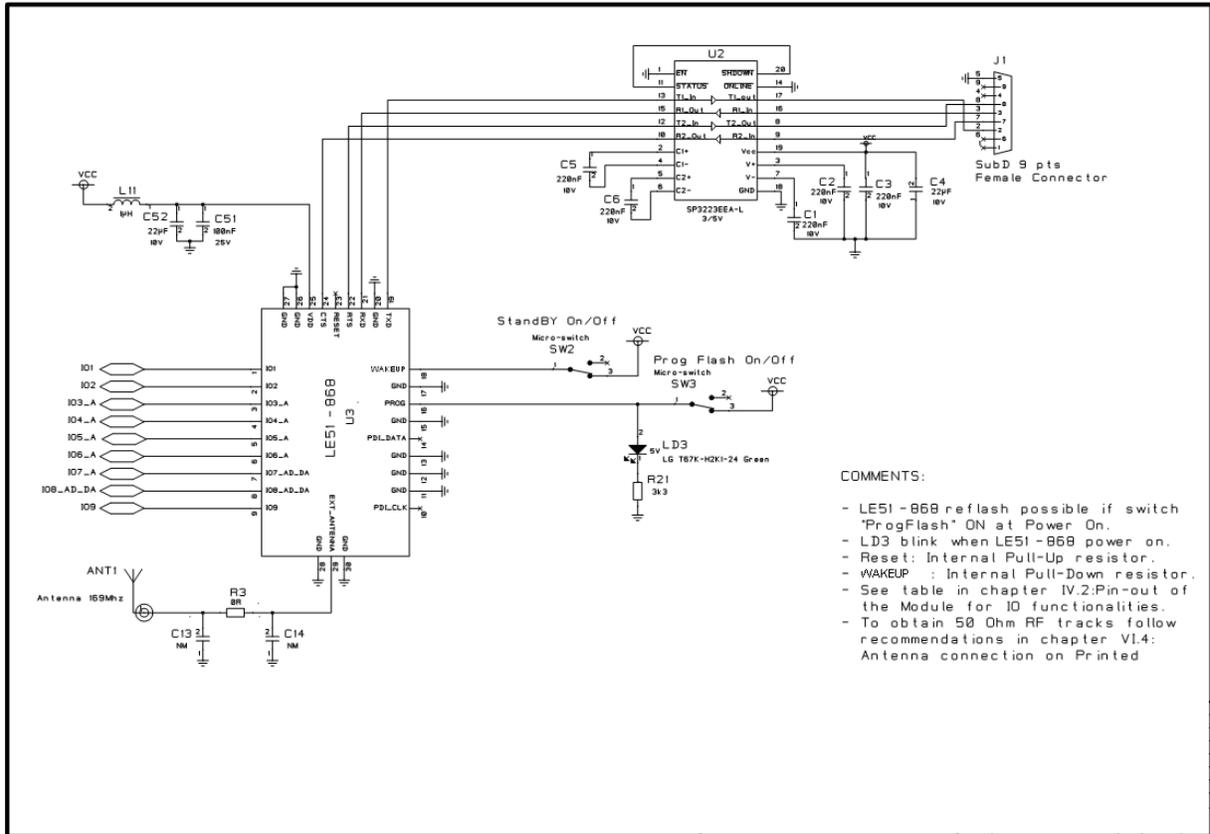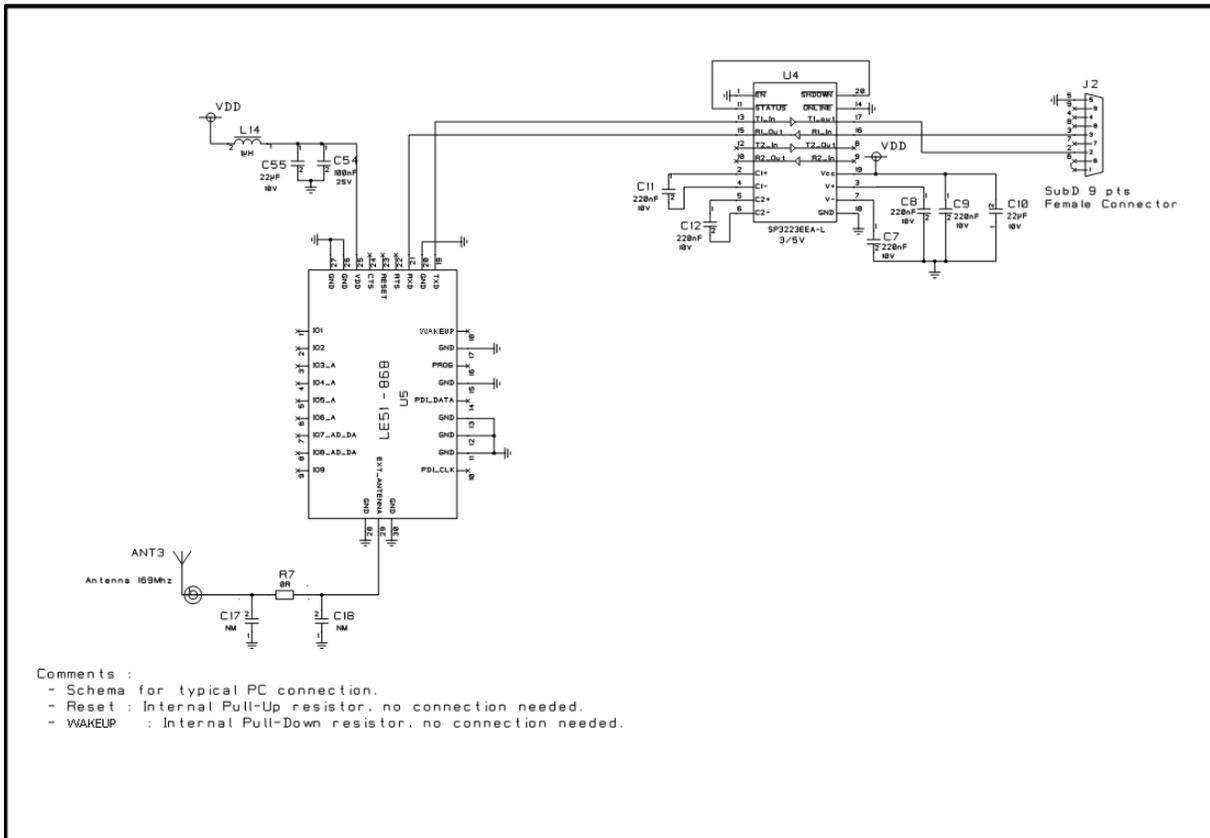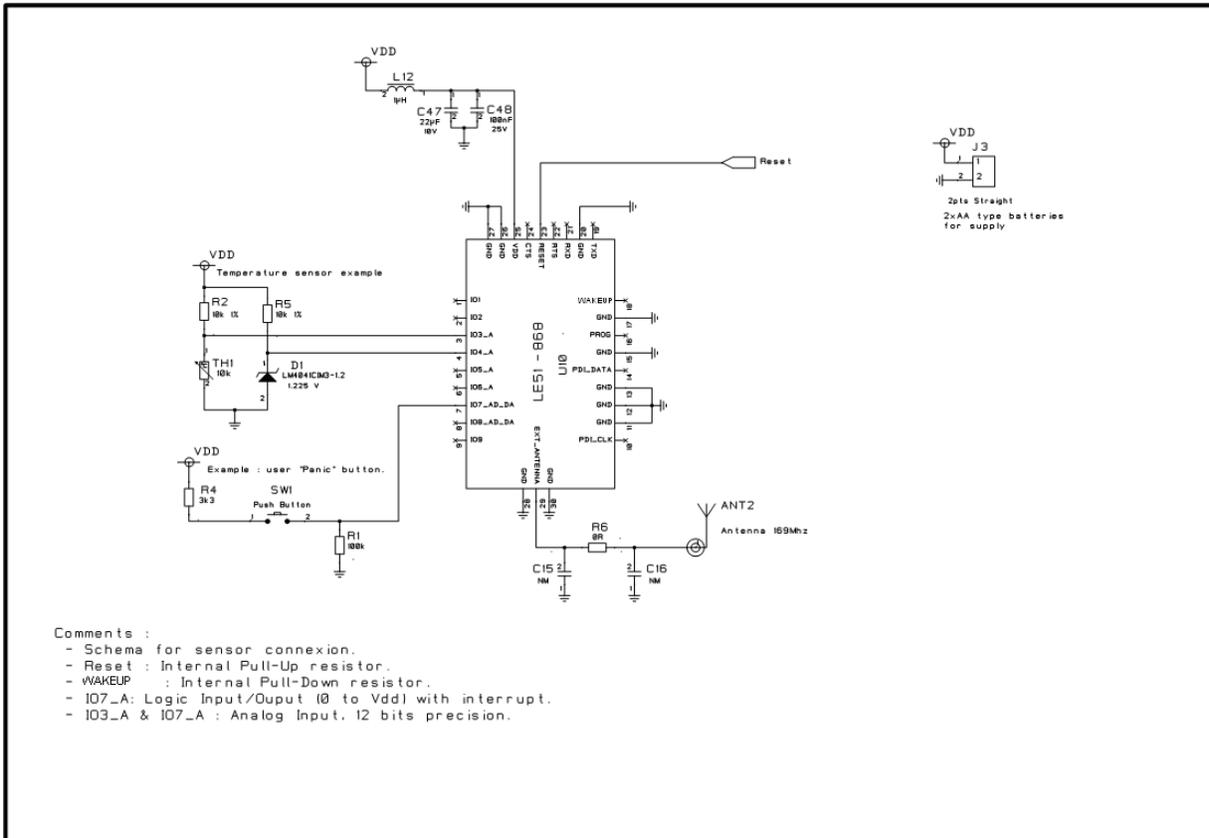
7.   Safety Recommendations

READ CAREFULLY

Be sure the use of this product is allowed in the country and in the environment required. The use of this product may be dangerous and has to be avoided in the following areas:
- Where it can interfere with other electronic devices in environments such as hospitals, airports, aircrafts, etc.
- Where there is risk of explosion such as gasoline stations, oil refineries, etc. It is responsibility of the user to enforce the country regulation and the specific environment regulation.

Do not disassemble the product; any mark of tampering will compromise the warranty validity. We recommend following the instructions of the hardware user guides for a correct wiring of the product. The product has to be supplied with a stabilized voltage source and the wiring has to be conforming to the security and fire prevention regulations. The product has to be handled with care, avoiding any contact with the pins because electrostatic discharges may damage the product itself. Same cautions have to be taken for the SIM, checking carefully the instruction for its use. Do not insert or remove the SIM when the product is in power saving mode.

The system integrator is responsible of the functioning of the final product; therefore, care has to be taken to the external components of the module, as well as of any project or installation issue, because the risk of disturbing the GSM network or external devices or having impact on the security. Should there be any doubt, please refer to the technical documentation and the regulations in force. Every module has to be equipped with a proper antenna with specific characteristics. The antenna has to be installed with care in order to avoid any interference with other electronic devices and has to guarantee a minimum distance from the body (20 cm). In case of this requirement cannot be satisfied, the system integrator has to assess the final product against the SAR regulation.

The European Community provides some Directives for the electronic equipments introduced on the market. All the relevant information's are available on the European Community website:

http://ec.europa.eu/enterprise/sectors/rtte/documents/

The text of the Directive 99/05 regarding telecommunication equipments is available, while the applicable Directives (Low Voltage and EMC) are available at:

http://ec.europa.eu/enterprise/sectors/electrical/

8.   Glossary

ACP	Adjacent Channel Power
AFA	Adaptive Frequency Agility
bps	Bits per second
BPSK	Binary Phase Shift Keying
BW	Bandwidth
dB	Decibel
dBm	Power level in decibel milliwatt (10 log (P/1mW))
E^{2}PROM	Electrically Erasable Programmable Read Only Memory
e.r.p	Effective radiated power
ETSI	European Telecommunication Standard Institute
GFSK	Gaussian Frequency Shift Keying
I	Input
ISM	Industrial, Scientific and Medical
kB	KiloByte
kbps	Kilobits per second
kcps	Kilochips per second
kHz	Kilo Hertz
LBT	Listen Before Talk
LGA	Land Grid Array
MHz	Mega Hertz
mW	milliwatt
O	Output
PER	Packet Error Rate
ppm	Parts per million
RAM	Random Access Memory
RF	Radio Frequency
RoHS	Restriction of Hazardous Substances
RxD	Receive Data
SMD	Surface Mounted Device
SRD	Short Range Device
TxD	Transmit Data
UART	Universal Asynchronous Receiver Transmitter
µC	microcontroller

9.   Document History

Revision	Date	Changes
0	2014/01/16	First release