LE51-868 S RF Module User Guide

1VV0301131 Rev.1 – 2014-04-04

Making machines talk.

APPLICABILITY TABLE

PRODUCT
LE51-868 S

SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE

Notice

While reasonable efforts have been made to assure the accuracy of this document, Telit assumes no liability resulting from any inaccuracies or omissions in this document, or from use of the information obtained herein. The information in this document has been carefully checked and is believed to be entirely reliable. However, no responsibility is assumed for inaccuracies or omissions. Telit reserves the right to make changes to any products described herein and reserves the right to revise this document and to make changes from time to time in content hereof with no obligation to notify any person of revisions or changes. Telit does not assume any liability arising out of the application or use of any product, software, or circuit described herein; neither does it convey license under its patent rights or the rights of others.

It is possible that this publication may contain references to, or information about Telit products (machines and programs), programming, or services that are not announced in your country. Such references or information must not be construed to mean that Telit intends to announce such Telit products, programming, or services in your country.

Copyrights

This instruction manual and the Telit products described in this instruction manual may be, include or describe copyrighted Telit material, such as computer programs stored in semiconductor memories or other media. Laws in the Italy and other countries preserve for Telit and its licensors certain exclusive rights for copyrighted material, including the exclusive right to copy, reproduce in any form, distribute and make derivative works of the copyrighted material. Accordingly, any copyrighted material of Telit and its licensors contained herein or in the Telit products described in this instruction manual may not be copied, reproduced, distributed, merged or modified in any manner without the express written permission of Telit. Furthermore, the purchase of Telit products shall not be deemed to grant either directly or by implication, estoppel, or otherwise, any license under the copyrights, patents or patent applications of Telit, as arises by operation of law in the sale of a product.

Computer Software Copyrights

The Telit and 3rd Party supplied Software (SW) products described in this instruction manual may include copyrighted Telit and other 3rd Party supplied computer programs stored in semiconductor memories or other media. Laws in the Italy and other countries preserve for Telit and other 3rd Party supplied SW certain exclusive rights for copyrighted computer programs, including the exclusive right to copy or reproduce in any form the copyrighted computer program. Accordingly, any copyrighted Telit or other 3rd Party supplied SW computer programs contained in the Telit products described in this instruction manual may not be copied (reverse engineered) or reproduced in any manner without the express written permission of Telit or the 3rd Party SW supplier. Furthermore, the purchase of Telit products shall not be deemed to grant either directly or by implication, estoppel, or otherwise, any license under the copyrights, patents or patent applications of Telit or other 3rd Party supplied SW, except for the normal non-exclusive, royalty free license to use that arises by operation of law in the sale of a product.

Usage and Disclosure Restrictions

License Agreements

The software described in this document is the property of Telit and its licensors. It is furnished by express license agreement only and may be used only in accordance with the terms of such an agreement.

Copyrighted Materials

Software and documentation are copyrighted materials. Making unauthorized copies is prohibited by law. No part of the software or documentation may be reproduced, transmitted, transcribed, stored in a retrieval system, or translated into any language or computer language, in any form or by any means, without prior written permission of Telit

High Risk Materials

Components, units, or third-party products used in the product described herein are NOT fault-tolerant and are NOT designed, manufactured, or intended for use as on-line control equipment in the following hazardous environments requiring fail-safe controls: the operation of Nuclear Facilities, Aircraft Navigation or Aircraft Communication Systems, Air Traffic Control, Life Support, or Weapons Systems (High Risk Activities"). Telit and its supplier(s) specifically disclaim any expressed or implied warranty of fitness for such High Risk Activities.

Trademarks

TELIT and the Stylized T Logo are registered in Trademark Office. All other product or service names are the property of their respective owners.

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.

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

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.

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: Product Description gives an overview of the module's characteristics

Chapter 3: Applicable regulations summarizes limitations imposed by applicable standards

Chapter 4: Pin description describes the module's pinout

Chapter 5: Electrical specifications details the LE51-868 S electrical characteristics

Chapter 6: Integration guidelines provide suggestions for developing customer applications based on LE51-868 S.

Chapter 7: Mechanical specifications detail the mechanical dimensions of the module.

Chapter 8: Process information describes handling and mounting requirements

Chapter 9: Ordering information lists available products and ordering codes.

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] LE51-868 S SW User Guide User Guide, 1vv0301109
- [8] Star Network Protocol Stack User Guide, 1vv0300873

2. Product description

The LE51-868 S module is a high performance certified short range to long range module, designed to cover the 863-870MHz unlicensed band working with Telit proprietary Star Network protocol, and additionally being able to act as a certified Sigfox™ gateway.

It is delivered with preloaded protocol stack:

- LE51-868 S SIGFOX™ Network Software.
- "Star Network" Protocol stack

LE51-868 S is over-the-air compatible with LE50-868 modules using Telit Star Network protocol, the only difference being the highest baudrate attainable, as detailed in 2.2.

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).

2.1. Main features

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 Half-Duplex bidirectional link.

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

2.2. Software

The LE51-868 S is compatible to LE50-868 modules, except for the highest baudrate available, which is limited to 100kbps instead of 115.2kbps. Please refer to *LE51-868 SW User Guide* [7] and to *Star Network protocol User Guide* [8] for detailed information on the preflashed firmware.

2.3. Digital Characteristics

DIGITAL	
Function	**Characteristics**
µC	• 128 kB + 8 kB in system programmable flash • 8 kB RAM • 2 kB E^2PROM
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
Real time clock	• 32.768kHz clock, 4 timers
I/O ports	• 9 GPIOs available

3. Applicable regulations

The following section summarizes the applicable regulations the LE51-868 is designed to comply to.

3.1. 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 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	863.0-870.0	25	=< 100 for 47 or more channels	0.1(1)
Annex 1 g1.1	868.0 – 868.6	25	No channel spacing specified	1
Annex 1 g1.2	868.7-869.2	25	No channels spacing specified	0.1
Annex 1 g1.3	869.400 – 869.650	500	25 for one or more channel	10
Annex 1 g1.4	869.7-870.0	5	No channel spacing specified	100

(1) Duty cycle may be increased to 1% if the band is limited to 865MHz to 868MHz

Most of these restrictions are integrated in the conception of the module, except the duty cycle. For example, the 869.400 to 869.650 MHz band is limited to a 10% duty cycle. This means that each module is limited to a total transmit time of 6 minutes per hour. Compliance to these limits is left to the user.

3.1.1. Summary of ETSI EN 220 V2.4.1 requirements

The LE51-868 module complies with the Harmonized Standard ETSI EN 220 V2.4.1, whose main requirements are summarized in the following table:

<table>
<tr><th colspan="6">ETSI EN 300 220 V2.4.1</th></tr>
<tr><th colspan="6">Transmission</th></tr>
<tr><td>Frequency error</td><td colspan="5">+/- 12.5 kHz @ 25 kHz channelization
+/- 87 kHz (100 ppm) > 25 kHz channelization</td></tr>
<tr><td>ACP</td><td colspan="5">- 37 dBm in 16 kHz BW under normal test conditions
- 32 dBm in 16 kHz BW under extreme test conditions</td></tr>
<tr><td rowspan="5">Modulation bandwidth</td><td>Reference Bandwidth (RBW)</td><td colspan="2">Limit</td><td>Lower envelope point Minimum frequency</td><td>Upper envelope point maximum frequency</td></tr>
<tr><td>1 kHz</td><td colspan="2">- 30 dBm (1 µW)</td><td>$f_{e, lower}$</td><td>$f_{e, upper}$</td></tr>
<tr><td>1 kHz</td><td colspan="2">36 dBm (250 nW)</td><td>($f_{e, lower}$ – 200 kHz)</td><td>($f_{e, upper}$ + 200 kHz)</td></tr>
<tr><td>10 kHz</td><td colspan="2">- 36 dBm (250 nW)</td><td>($f_{e, lower}$ – 400 kHz)</td><td>($f_{e, upper}$ + 400 kHz)</td></tr>
<tr><td>100 kHz</td><td colspan="2">- 36 dBm (250 nW)</td><td>($f_{e, lower}$ – 1 MHz)</td><td>($f_{e, upper}$ + 1 MHz)</td></tr>
<tr><td rowspan="3">Unwanted emissions in the spurious domain</td><td>Frequency
State</td><td colspan="2">47 MHz to 74 MHz 7,5 MHz to 118 MHz 174 MHz to 230 MHz 470 MHz to 862 MHz</td><td>Other frequencies below 1 000 MHz</td><td>Frequencies above 1 000 MHz</td></tr>
<tr><td>Operating</td><td colspan="2">- 54 dBm (4 nW)</td><td>- 36 dBm (250 nW)</td><td>- 30 dBm (1 µW)</td></tr>
<tr><td>Standby</td><td colspan="2">- 57 dBm (2 nW)</td><td>- 57 dBm (2 nW)</td><td>- 47 dBm (20 nW)</td></tr>
<tr><th colspan="6">Reception</th></tr>
<tr><td rowspan="7">Blocking for class 2 equipments</td><td colspan="2">Frequency offset of the unwanted signal</td><td colspan="2">Receiver bandwidth</td><td>Minimum offset between wanted and unwanted signals</td></tr>
<tr><td colspan="2" rowspan="3">+/-2 MHz</td><td colspan="2">10 kHz</td><td>≥ 37 dB</td></tr>
<tr><td colspan="2">100 kHz</td><td>≥ 27 dB</td></tr>
<tr><td colspan="2">250 kHz</td><td>≥ 23 dB</td></tr>
<tr><td colspan="2" rowspan="3">+/-10 MHz</td><td colspan="2">10 kHz</td><td>≥ 62 dB</td></tr>
<tr><td colspan="2">100 kHz</td><td>≥ 52 dB</td></tr>
<tr><td colspan="2">250 kHz</td><td>≥ 48 dB</td></tr>
<tr><td>spurious radiation</td><td colspan="3">Below 1000 MHz</td><td colspan="2">Above 1000 MHz</td></tr>
<tr><td colspan="3">- 57 dBm (2 nW)</td><td colspan="2">- 47 dBm (20 nW)</td></tr>
</table>

3.2. Duty-cycle limitations in Sigfox™ mode

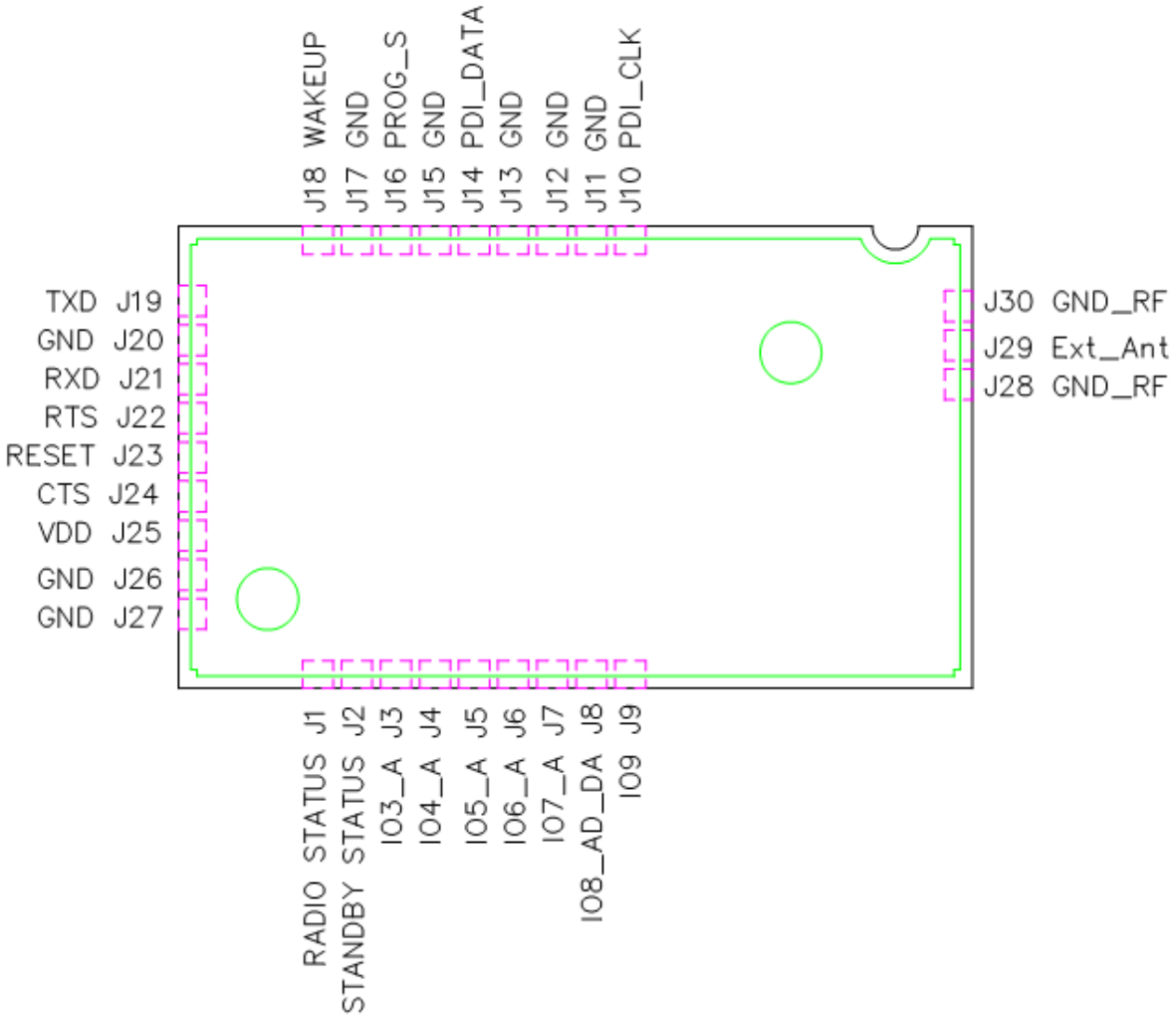
While acting as a Sigfox™ gateway, the LE51-868 module transmits on a 48 kHz band centered around 868.2MHz at a 100bps baudrate, therefore limitations as per Annex 1 band g1.1 apply. In order to fulfill the specification requirement regarding duty cycle on ISM band and to be aligned with Sigfox™ network management, the application is allowed to send up to 72 Bytes per hour (e.g., 6 messages of 12 payload bytes each).

3.3. RoHS compliance

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

4. Pin description

4.1. Module Top View (cover side)



CAUTION: reserved pins must not be connected

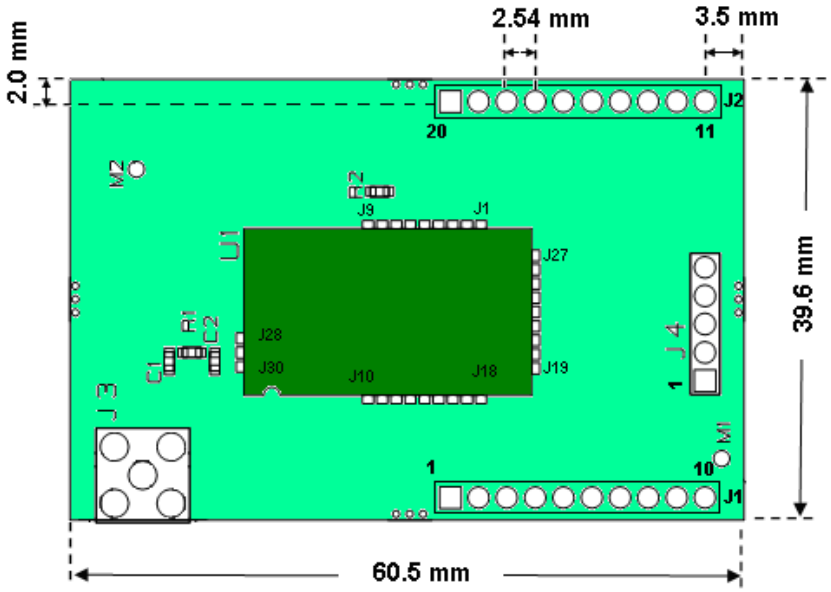
CAUTION: In case you want to use in the same application Telit ZE51 or ZE61 modules J9 and J8 should not be connected, since reserved on these modules (see foot notes on Pin-Out tables.

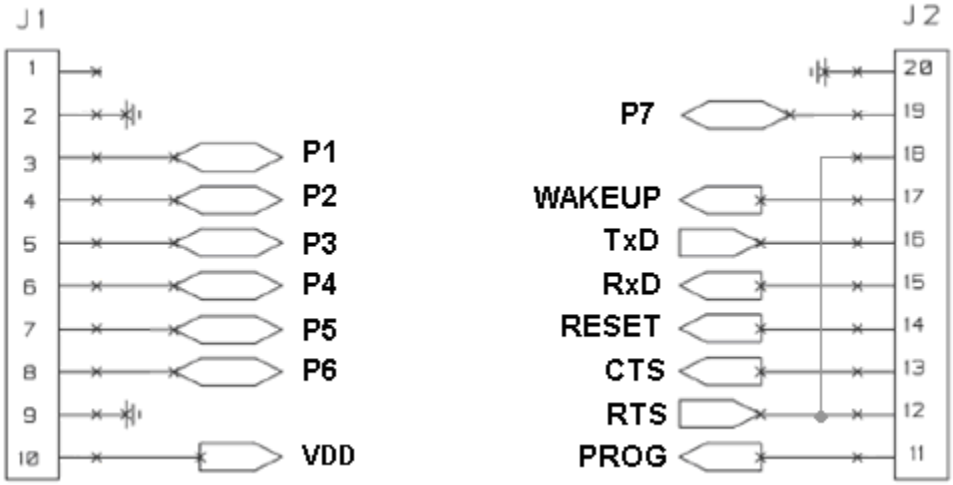
4.2. LE51-868 S pinout

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. DIP Interface pinout





4.4. Pinout correspondence table

Pinout 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 Ω coplanar wave guide and a matching network connect J29 to J3

4.5. Signal description

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. Electrical specifications

5.1. Absolute Maximum Ratings

Voltage applied to Vcc, VDD :	-0.3V to +3.6V
Voltage applied to “TTL” Input :	-0.3V to VDD+0.3V

Danger – Stresses beyond the above limits may cause permanent damage to the module...

5.2. Functional Characteristics

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

5.2.1. Temperature Rating

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

5.2.2. DC specifications

Characteristics LE51-868 S	Min.	Typ.	Max.
Power Supply (VDD):	+2.0V	+3.0V	+3.6V
Current consumption			
Transmission		59mA@30mW	61mA@30mW
Command/Data mode		11mA	13mA
Reception		32mA	35mA
Transmission (Sigfox mode)		58mA	61mA
Stand-by (32.768 kHz On)		< 2µA	< 2µA

5.2.3. Digital IO levels

Characteristics LE51-868 S	Min.	Typ.	Max.
I/O low level :	GND	-	$0.2 \times V_{DD}$
I/O high level :	$0.8 \times V_{DD}$	-	V_{DD}

5.2.4. AC specifications

5.2.4.1. Star network mode

Data rates from 4.8kbps to 9.6kbps					
ERC/REC70-03 Frequency (MHz)	**Band g 863.000 -870.000**	**Band g1.1 868.000 -868.600**	**Band g1.2 868.700 -869.200**	**Band g1.3 869.400 -869.650**	**Band g1.4 869.700 -870.000**
Global					
RF data rate	(1): 4.8 kbps (2): 9.6 kbps				
Numbers of channels	60 (1) 60 (2)	12 (1) 12 (2)	10 (1) 10 (2)	1 (1) 1 (2)	6 (1) 6 (2)
Channel width	50 kHz	50 kHz	50 kHz	250 kHz	50 kHz
Channel 0	865.025 MHz	868.025 MHz	868.725 MHz	869.525 MHz	869.725 MHz
Total Bandwidth	3 MHz	600 kHz	500 kHz	250 kHz	300 kHz
Transmission					
Duty cycle	≤ 1%	≤ 1%	≤ 0.1%	≤ 10%	No requirement
Modulation	GFSK with ±7 kHz deviation (1) GFSK with ±7 kHz deviation (2)				
e.r.p	8 levels from -8dBm to +14dBm	8 levels from -8dBm to +14dBm	8 levels from -8dBm to +14dBm	8 levels from -8dBm to +14dBm	6 levels from -8dBm to +7dBm
	max 25 mW	max 25 mW	max 25 mW	max 25 mW	max 5 mW
Reception					
Sensitivity for PER < 80%	(1): Max -116 dBm (2): Max -114 dBm	(1): Max -117 dBm (2): Max -114 dBm	(1): Max -117 dBm (2): Max -114 dBm	(1): Max -117 dBm (2): Max -114 dBm	(1): Max -116 dBm (2): Max -114 dBm

Data rates from 19.2kbps to 100.0kbps					
ERC/REC70-03 Frequency (MHz)	**Band g1 863.000 - 870.000**	**Band g1.1 868.000 -868.600**	**Band g1.2 868.700 - 869.200**	**Band g1.3 869.400 - 869.650**	**Band g1.4 869.700 - 870.000**
Global					
RF data rate	(1): 19.2 kbps (2): 38.4 kbps (3): 100.0 kbps				
Numbers of channels	20 (1) 10 (2) 0 (3)	6 (1) 3 (2) 1 (3)	5 (1) 2 (2) 1 (3)	1 (1) 1 (2) 0 (3)	3 (1) 2 (2) 0 (3)
Channel width	100 kHz (1) 200 kHz (2)	100 kHz (1) 200 kHz (2) 600 kHz (3)	100 kHz (1) 200 kHz (2) 500 kHz (3)	250 kHz	100 kHz (1) 150 kHz (2)
Channel 0	865.550 MHz (1) 865.600 MHz (2)	868.050 MHz (1) 868.100 MHz (2) 868.300 MHz (3)	868.750 MHz (1) 868.850 MHz (2) 868.950 MHz (3)	869.5250 MHz	869.750 MHz (1) 869.775 MHz (2)
Total Bandwidth	2 MHz	600 kHz	500 kHz	250 kHz	300 kHz
Transmission					
Duty cycle	≤ 1%	≤ 1%	≤ 0.1%	≤ 10%	No requirement
Modulation	GFSK with ± 10 kHz deviation (1) GFSK with ± 20 kHz deviation (2) GFSK with ± 50 kHz deviation (3)				
e.r.p	8 levels from -8dBm to +14dBm	8 levels from -8dBm to +14dBm	8 levels from -8dBm to +14dBm	8 levels from -8dBm to +14dBm	6 levels from -8dBm to +7dBm
	max 25 mW	max 25 mW	max 25 mW	max 25 mW	max 5 mW
Reception					
Sensitivity for PER < 80%		(1): Max -113 dBm (2): Max -109 dBm (3): Max -104 dBm	(1): Max -113 dBm (2): Max -109 dBm (3): Max -104 dBm	(1): Max -113 dBm (2): Max -109 dBm	(1): Max -112 dBm (2): Max -109 dBm

5.2.4.2. Sigfox™ mode

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

6. Integration guidelines

6.1. Electrical environment

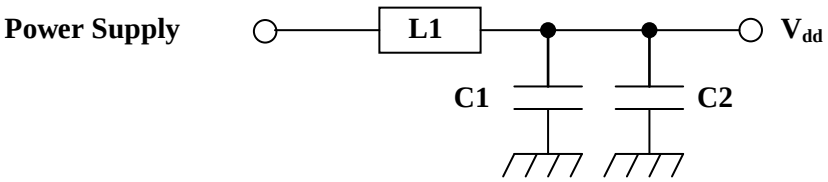
The best performances of the LE51-868 S module are obtained in a “clean noise” environment. Some basic recommendations must be followed:

- 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.

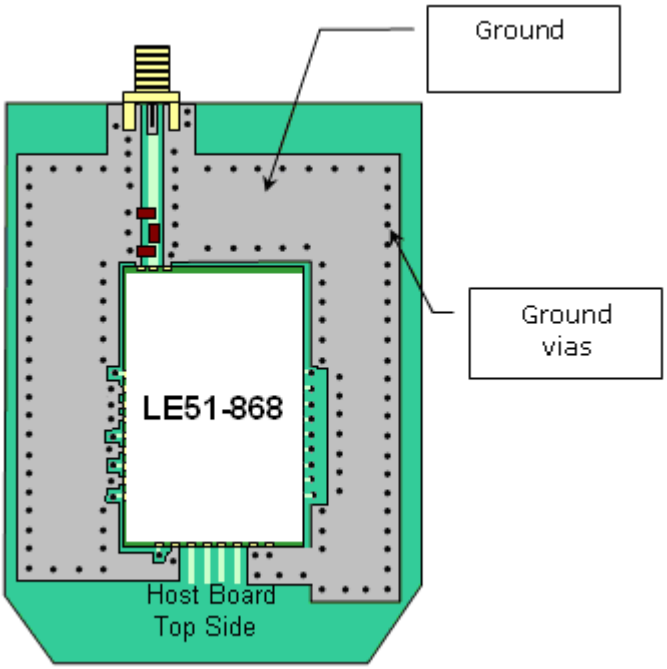


Symbols	Reference	Value	Manufacturer
L1	LQH31MN1R0K03	1µH	Murata
C1	GRM31CF51A226ZE01	22µF	Murata
C2	Ceramic CMS 25V	100nF	Multiple

6.3. RF layout considerations

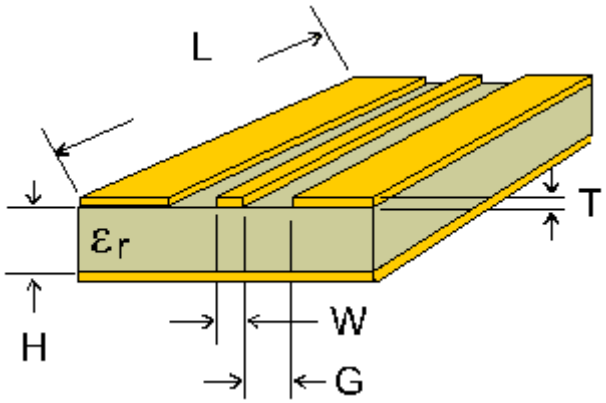
Basic recommendations must be followed to achieve a good RF layout:

- 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.



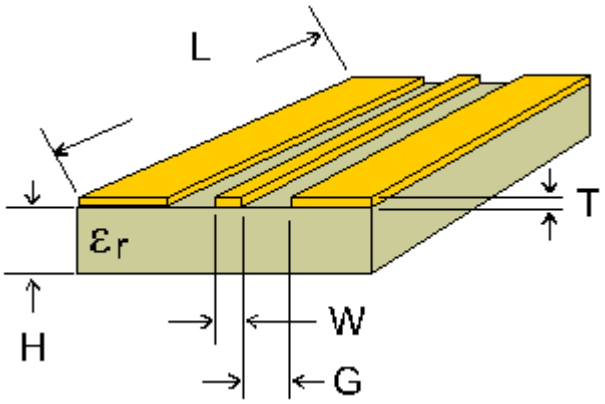
6.4. Antenna connections on printed circuit boards

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

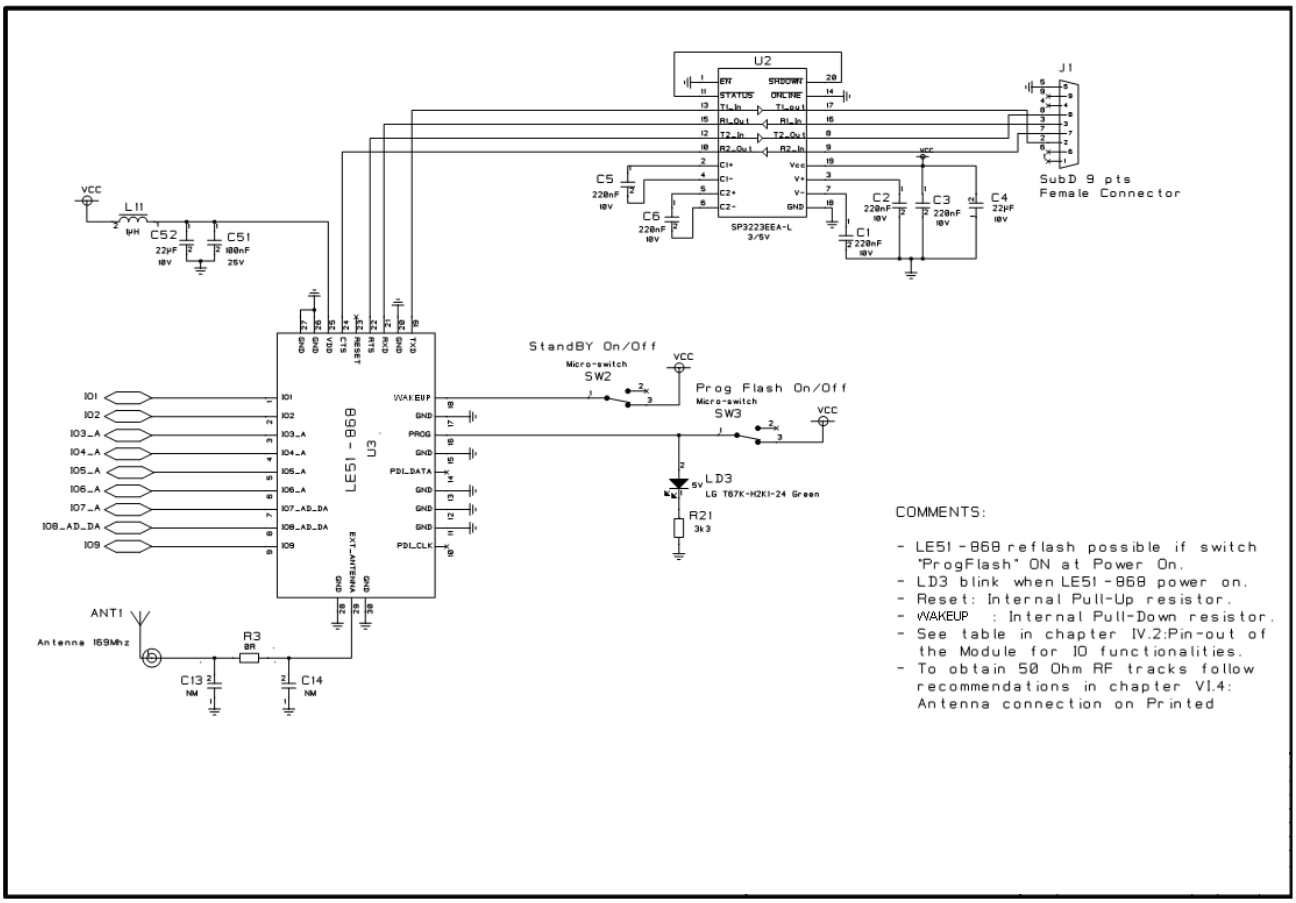
Table 1: Values for double face PCB with ground plane around and under coplanar wave guide (recommended)

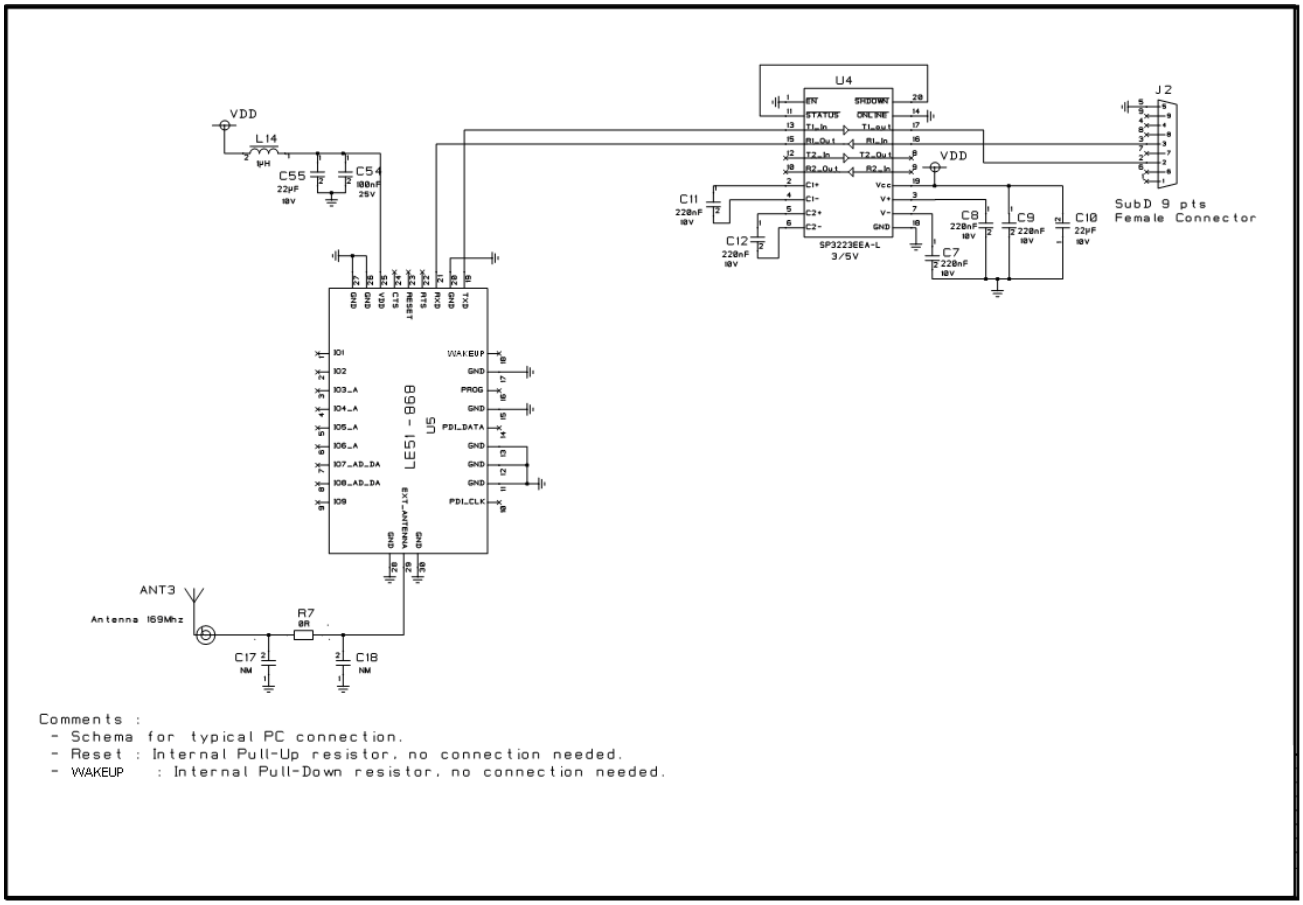


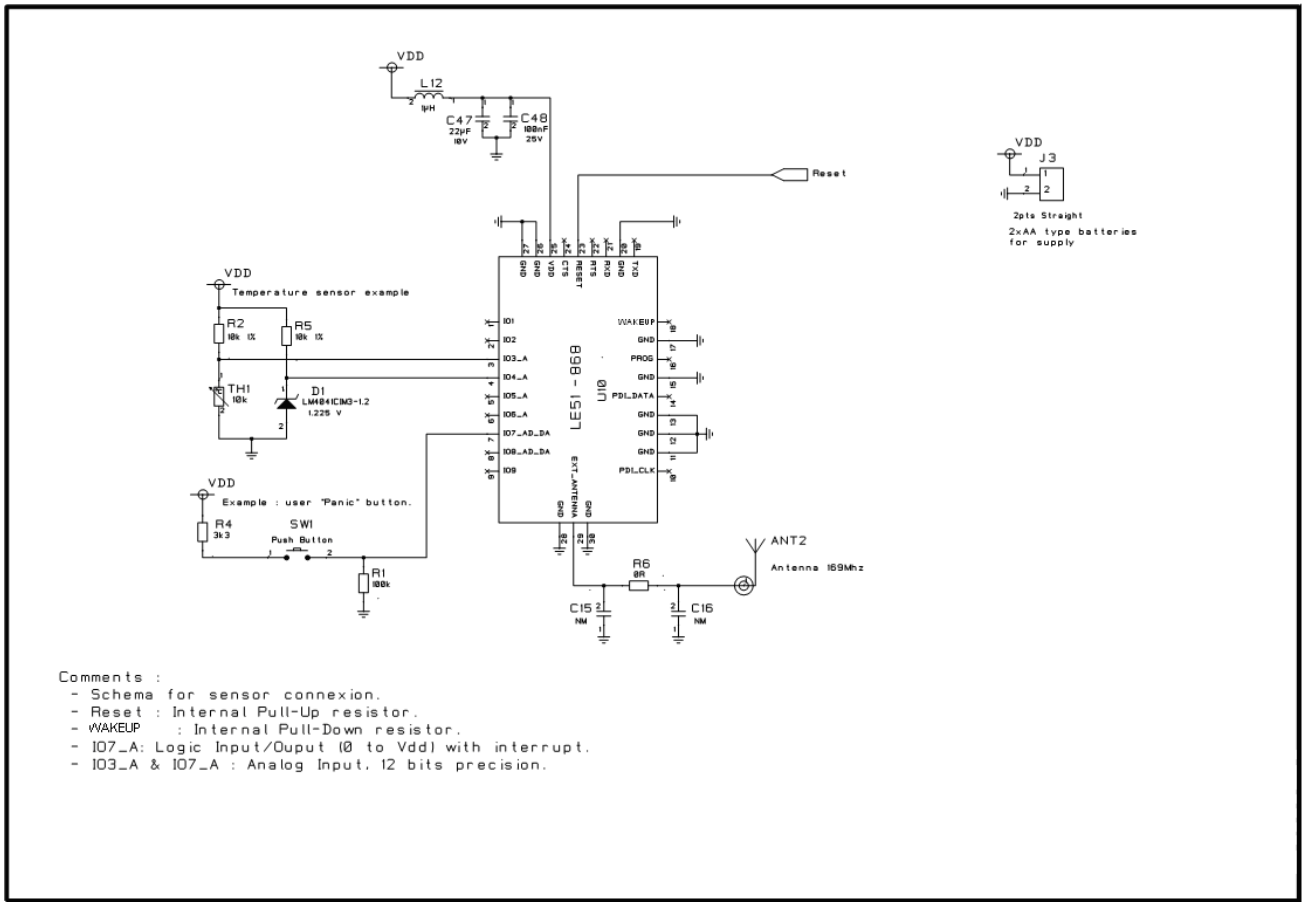
PCB material	PCB thickness H (mm)	Coplanar line W (mm)	Coplanar line G (mm)
FR4	0.8	1	0.22
	1.6	1	0.23

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

6.5. LE51-868 S Interfacing




VDD
L14
C55
C54
U4
J2
SubD 9 pts
Female Connector
C11
C12
C8
C9
C10
C7
SP3223EEA-L
3/5V
LE51-868
U5
WAKEUP
PROG
PDI_DATA
PDI_CLK
ANT3
Antenna 169Mhz
R7
0R
C17
C18
NM
Comments :
- Schema for typical PC connection.
- Reset : Internal Pull-Up resistor, no connection needed.
- WAKEUP : Internal Pull-Down resistor, no connection needed.



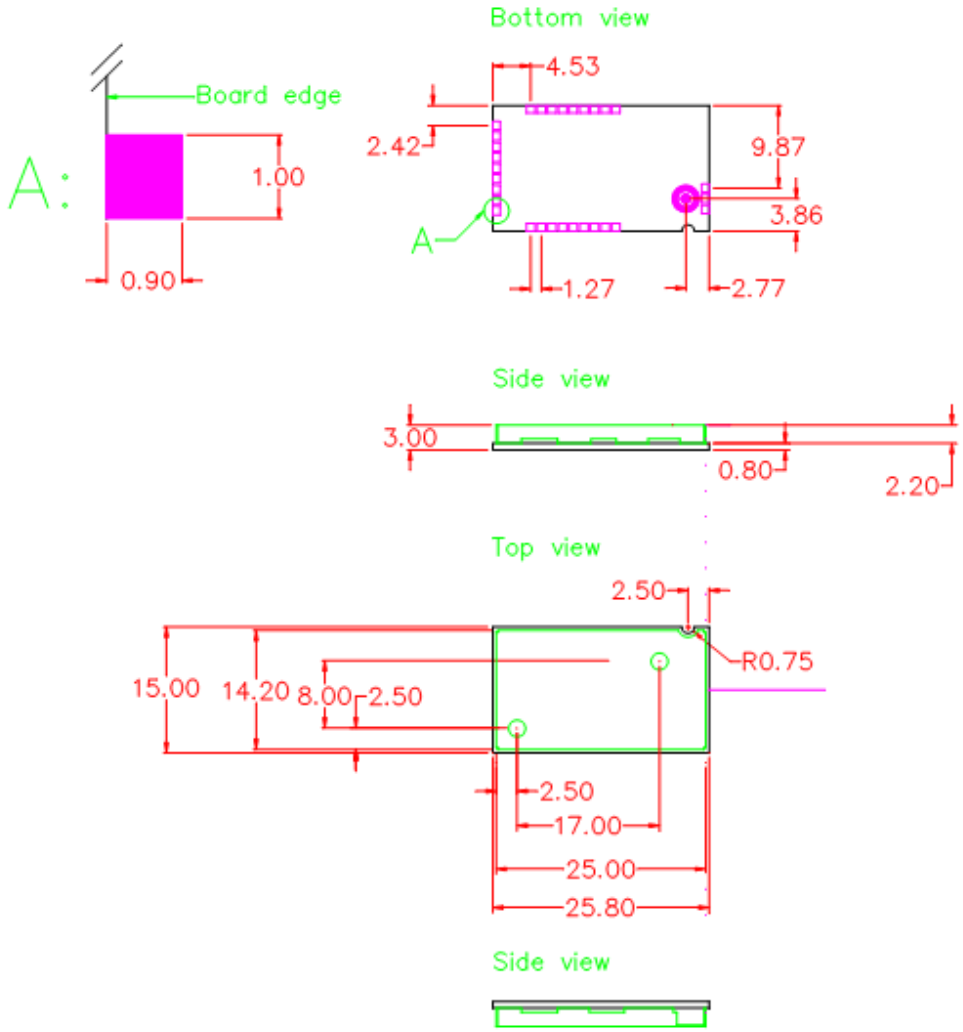
7. Mechanical specifications

7.1. Module 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

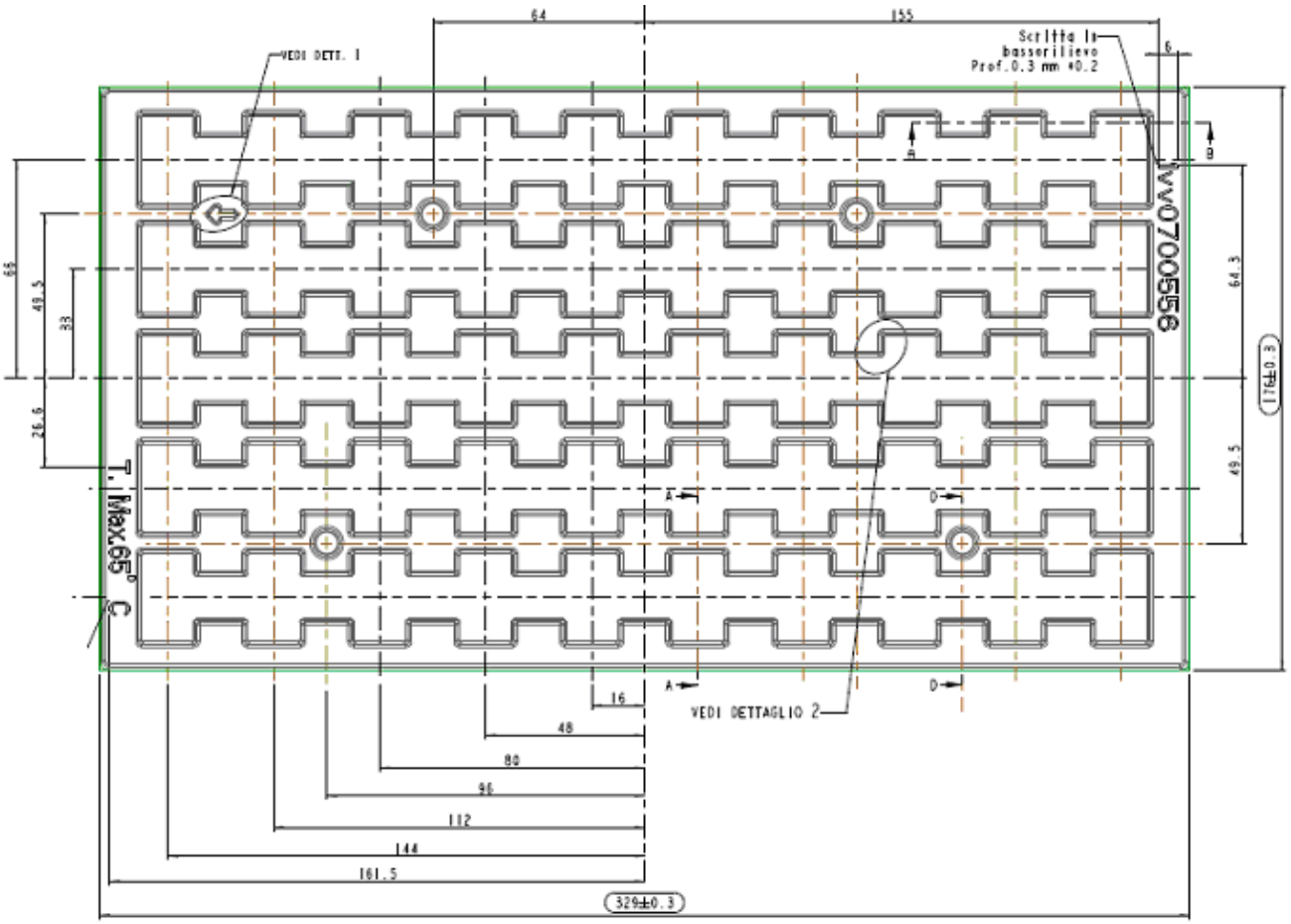
7.2. Mechanical drawings



8. Process information

8.1. 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.



8.2. 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.

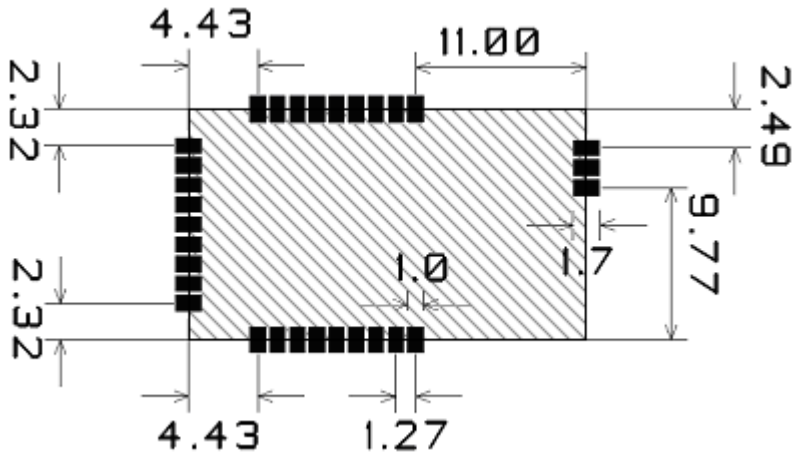
In case of a reflow soldering process, LE51-868 S radio modules must be submitted to a drying bake at +60°C during 24 hours. The drying bake must be used prior to the reflow soldering process in order to prevent a popcorn effect. After being submitted to the drying bake, LE modules must be soldered on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

8.3. 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

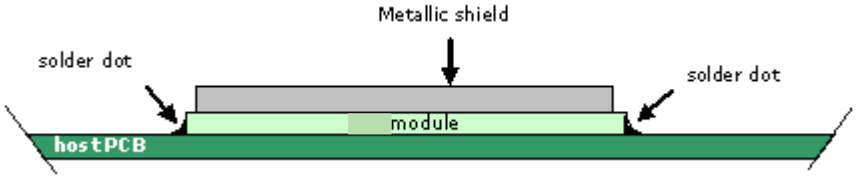
The dashed area represents a routing inhibit area 26.8mm ×16mm wide.

CAUTION: Exposed test points are present on the bottom side of the module: these pads shall not be unconnected. In order to prevent the risk of short circuits, neither via holes nor traces are allowed under the module, as indicated by the dashed area in the picture.

8.4. Solder paste

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:



8.5. Placement

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

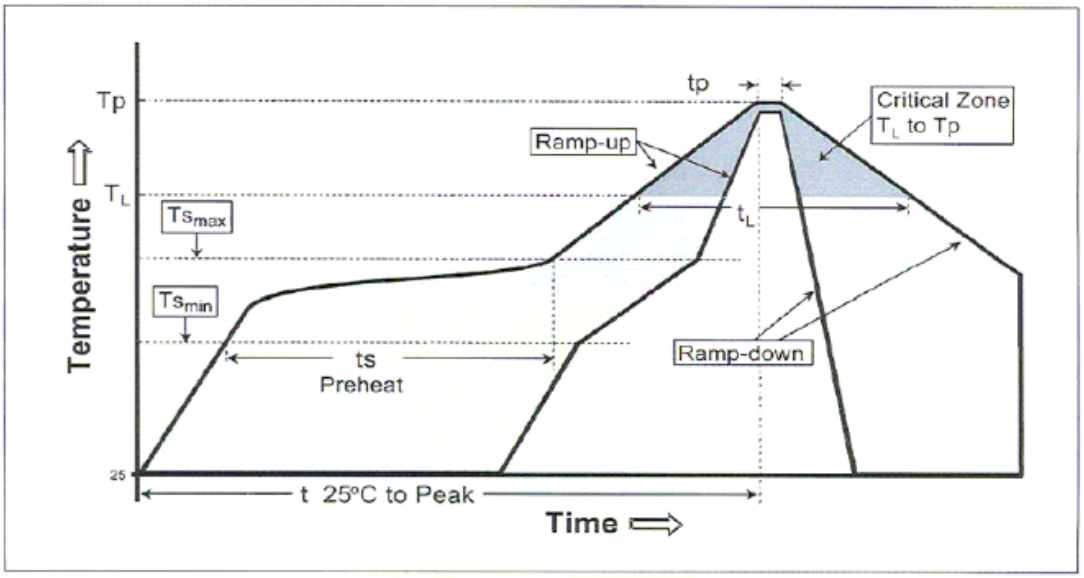
8.6. Soldering Profile (RoHS Process)

The 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) - Temperature Max (Ts max) - Time (ts min to ts max)	 100°C 150°C 60 - 120 seconds	 150°C 200°C 60 - 120 seconds
Time maintained above: - Temperature (TL) - Time (tL)	 183°C 35 - 90 seconds	 221°C 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 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.

9. Ordering information

The following equipments can be ordered:

- The SMD version (LE51-868 S)
- The DIP interface version (LE51-868 S)
- The Demo Unit (LE51-868 S) composed by 1 evaluation boards, 1 DIP interface boards, 1 RF antenna, 1 serial cable and a 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 Unit
D LE51-868 S


10. 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/

11. 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^2PROM	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

12. Document History

Revision	Date	Changes
0	2013/12/20	Preliminary release
1	2014/04/04	Document structure update, consumption and sensitivity data inserted