WiMOD iM881A-XL

Datasheet

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Aim of this Document

The aim of this document is to give a detailed product description including interfaces, features and performance of the radio module iM881A-XL.

Table of Contents

1.   Introduction

The iM881A-XL is a compact, low power, bidirectional radio module for the 868 MHz frequency band using Semtech's LoRa™ modulation technology. The module provides ultra-long range spread spectrum communication and high interference immunity whilst minimising current consumption. Using the iM881A-XL in an application minimizes the need for an expensive and time-consuming RF development. Fast time to market is possible with this pre-qualified module.

The iM881A-XL provides an optimized RF performance for the extreme temperature range. In addition, the iM881A-XL is optimized for battery driven application and is equipped with a powerful STM32L081 controller.
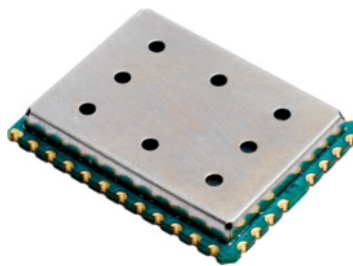
Figure 1-1: Picture of iM881A-XL

1.1   Key Features

- Compact module 20.0 x 25.0 x 3.3 mm
- LoRa™ modulation technology
- Sensitivity down to -138 dBm
- UART, SPI and I²C interface[1]
- Digital inputs and outputs
- Analog inputs
- Supply voltage range from 1.8 to 3.6 V
- RF interface matched to 50 Ω
- Output power level up to +15 dBm
- High link budget up to 153 dB
- Range up to 12000m (Line of Sight)
- STM32L081Cx
- Pre-Certified according to EN 300 220

1.2   Applications

- Automated Meter Reading
- Wireless Networks
- Home-, Building-, Industrial automation
- Remote Control
- Wireless Sensors
- Telemetry
- Wireless Alarm and Security Systems
- …

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[1] Default host controller interface is UART. SPI and I²C functionality available on request.

2.   Module Overview

The iM881A-XL is an ultra-long range, high-performance, pre-certified module for wireless communication. It operates in the license free 868 MHz SRD frequency band and includes all necessary passive components for wireless communication as depicted in the following figure.
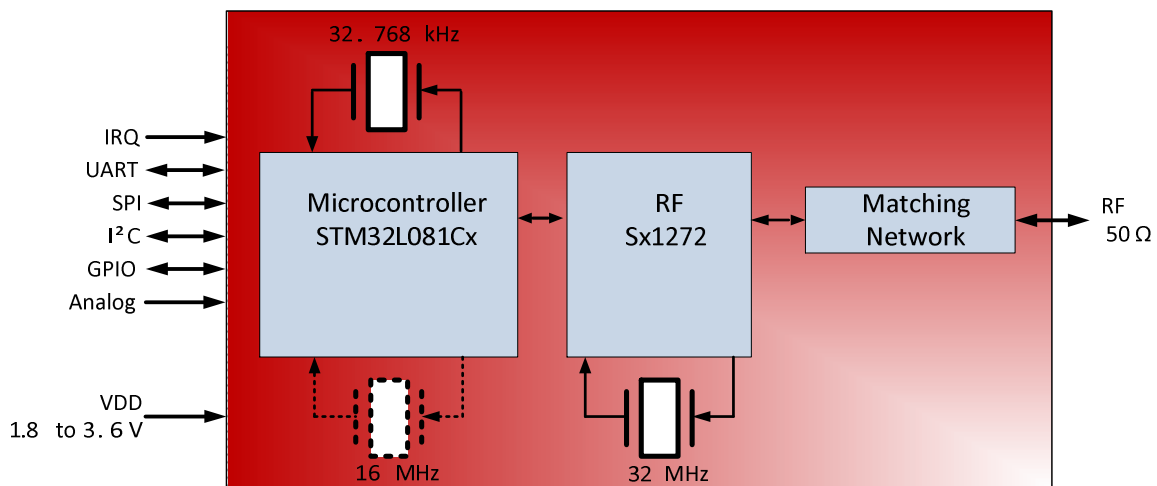

Figure 2-1: Block Diagram of Radio Module iM881A-XL

The iM881A-XL uses Semtech's patented LoRa modulation technique which combines spread spectrum modulation and forward error correction techniques to increase the range and robustness of radio communication links compared with traditional FSK or OOK based modulation. Typically examples of iM881A-XL receive performances are given in the following table.

Signal Bandwidth/[kHz]	Spreading Factor	Sensitivity/[dBm]
125	7	-123
125	12	-138
250	7	-121
250	12	-135
500	7	-116
500	12	-130

Table 2-1: Typically Radio Performance of iM881A

This high sensitivity combined with the integrated +14 dBm power amplifier yields industry leading link budget.

The module is solderable like a SMD component and can easily be mounted on a simple carrier board with a minimum of required external connections. It is RoHS compliant and pre-qualified in accordance to ETSI EN 300 220.

The wide range of capabilities provided by the iM881A-XL can be tested by using the WiMOD Demo Board (part of the WiMOD Starter Kit).

3.   LoRa Modulation Technique

The iM881A-XL uses Semtech's LoRa proprietary spread spectrum modulation technique. This modulation, in contrast to conventional modulation techniques, permits an increase in link budget and increased immunity to in-band interference. It achieves sensitivies 8 dB better than FSK modulation.

LoRa also provides significant advantages in both blocking and selectivity, solving the traditional design compromise between range, interference immunity and energy consumption.

In LoRa mode the iM881A-XL offers three bandwidth options of 125 kHz, 250 kHz, and 500 kHz with spreading factors ranging from 7 to 12.

The spread spectrum LoRa modulation is performed by representing each bit of payload information by multiple chips of information. The rate at which the spread information is sent is referred to as the symbol rate (Rs), the ratio between the nominal symbol rate and chip rate is the spreading factor and represents the number of symbols sent per bit of information. The range of parameters which can be configured are given in the following tables.

Spreading Factor	Chips/Symbol	SNR/[dB]
7	128	-7.5
8	256	-10
9	512	-12.5
10	1024	-15
11	2048	-17.5
12	4096	-20

Table 3-1: Spreading Factors of Sx1272

Note that the spreading factor must be known in advance on both transmit and receive sides of the radio link as different spreading factors are orthogonal to each other. Note also the resulting signal to noise ratio (SNR) required at the receiver input. It is the capability to receive signals with negative SNR that increases the sensitivity, so link budget and range, of the LoRa receiver.

To further improve the robustness of the radio link iM881A-XL provides cyclic error coding with different coding rates. With using this coding scheme forward error detection and correction can be applied.

Coding Rate	Cyclic Coding Rate	Overhead Ratio
1	4/5	1.25
2	4/6	1.5
3	4/7	1.75
4	4/8	2

Table 3-2: Coding Rate of iM881A-XL

4.   Electrical Characteristics

In the following different electrical characteristics of the iM881A-XL are listed. Furthermore details and other parameter ranges are available on request.

> Note: Stress exceeding of one or more of the limiting values listed under "Absolute Maximum Ratings" may cause permanent damage to the radio module.

4.1   Absolute Maximum Ratings

Parameter	Condition	Min	Typ.	Max	Unit
Supply Voltage (VDD)		-0.3	-	3.9	V
Storage Temperature		-40	-	+85	°C
Operating Temperature		-40	-	+85	°C
RF Input Power				+10	dBm
ESD (Human Body Model)			2000		V
ESD (Charge Device Model)			500		V
Notes: 1) Unless otherwise noted, all voltages are with respect to GND					

Table 4-1: Absolute Maximum Ratings

4.2   Global Electrical Characteristics

T = 25°C, VDD = 3.0 V (typ.) if nothing else stated

Parameter	Condition	Min	Typ.	Max	Unit
Supply Voltage (VDD)		1.8	3.0	3.6	V
Current Consumption Low Power Mode	RTC off		800		nA
	RTC on		1.4		μA
Current Consumption System IDLE	TRX sleep mode, μC idle mode		4		mA
Current Consumption RECEIVE LoRa	TRX receive mode, μC sleep mode		11.2		mA
Current Consumption TRANSMIT	TRX transmit mode, μC sleep mode, all μC units off, max. RF power level		38		mA
	TRX transmit mode, μC sleep mode, all μC units off, power level 13 dBm		29		mA
	TRX transmit mode, μC sleep mode, all μC units off, power level 10 dBm		25		mA
MCU operation frequency			32		MHz
			32.768		kHz
Memory (Flash)	iM881A-XL		192		kByte
Flash Memory Endurance	Program memory	10k			Erase/ Write Cycles
	Data memory	300k			
Memory (RAM)	iM881A-XL		20		kByte
Memory (EEPROM)	iM881A-XL		6		kByte
iM881A-XL uses STM32L081CZT6 MCU					

Table 4-2: General Characteristics

4.3 Module Interface Characteristics

T = 25°C, VDD = 3 V (typ.) if nothing else stated

Parameter	Condition	Min	Typ.	Max	Unit
Digital output voltage (high level)	$1.8\ V \leq VDD \leq 3.6\ V$, $|I_{IO}| \leq 4\ mA$	VDD -0.45			V
Digital output voltage (low level)	$1.8\ V \leq VDD \leq 3.6\ V$, $|I_{IO}| \leq 4\ mA$			0.45	V
Digital input voltage (high level)		0.7 VDD		VDD	V
Digital input voltage (low level)				0.3 VDD	V
Reset Input (Pin 7) (high level)		1.4		VDD	V
Reset Input (Pin 7) (low level)		GND		0.8	V
Bootloader Input (Pin 26) (high level)		1.4		VDD	V
Bootloader Input (Pin 26) (low level)				0.14 VDD	V
UART baud rate			115.2		kbps
RF input power				-20	dBm
Notes: 1) Unless otherwise noted, all voltages are with respect to GND					

Table 4-3: Module Interface Characteristics

4.4 RF Characteristics

4.4.1 Applicable Frequency Bands and Sub-Bands

Following table depicts the applicable frequency bands within the 868 MHz band for "Non-Specific Short Range Devices" specified in the ERC Recommendation 70-03, [2].

Band	Edge Frequencies		Field Power	Spectrum Access	Band Width
g (Note1,2)	863 MHz	870 MHz	+14 dBm	0.1% or LBT+AFA	7 MHz
(Note2)	863 MHz	870 MHz	-4.5 dBm / 100 kHz	0.1% or LBT+AFA	7 MHz
(Note2)	865 MHz	870 MHz	-0.8 dBm / 100 kHz	0.1% or LBT+AFA	5 MHz
	865 MHz	868 MHz	+14 dBm	1% or LBT+AFA	3 MHz
g1	868.0 MHz	868.6 MHz	+14 dBm	1% or LBT+AFA	600 kHz
g2	868.7 MHz	869.2 MHz	+14 dBm	0.1% or LBT+AFA	500 kHz
g3	869.4 MHz	869.65 MHz	+27 dBm	10% or LBT+AFA	250 kHz
g4	869.7 MHz	870 MHz	+14 dBm	1% or LBT+AFA	300 kHz
g4	869.7 MHz	870 MHz	+7 dBm	No requirement	300 kHz
Note1: Modulation bandwidth ≤ 300 kHz is allowed. Preferred channel spacing is ≤ 100 kHz. Note2: Sub-bands for alarms are excluded (see ERC/REC 70-03 Annex 7).					

Table 4-4: Applicable Frequency Bands for Non-Specific Short Range Devices

Note: National laws and regulations, as well as their interpretation can vary with the country. In case of uncertainty, it is recommended to contact either IMST's accredited Test Center or to consult the local authorities of the relevant countries.

4.4.2 Transmitter RF Characteristics

The iM881A has an excellent transmitter performance as given by Table 4-5. For further details, refer to Figure 4-1 which gives an overview of RF output power levels versus power level settings and its current consumption with microcontroller in sleep mode.

T = 25°C, VDD = 3 V (typ.), 866.5 MHz if nothing else stated

Parameter	Condition	Min	Typ.	Max	Unit
Frequency Range		863	-	870	MHz
RF Output Power	868 MHz Band		13.0		dBm
Modulation Techniques	FSK, LoRa™				
TX Frequency Variation vs. Temperature	-40 to +85°C	-	±10	-	kHz
TX Power Variation vs. Temperature		-	±0.5	-	dB

Table 4-5: Transmitter RF Characteristics

Note: The duty cycle of transmission at maximum output power is limited to 1%. The antenna has to be matched with a maximum VSWR of 3:1.
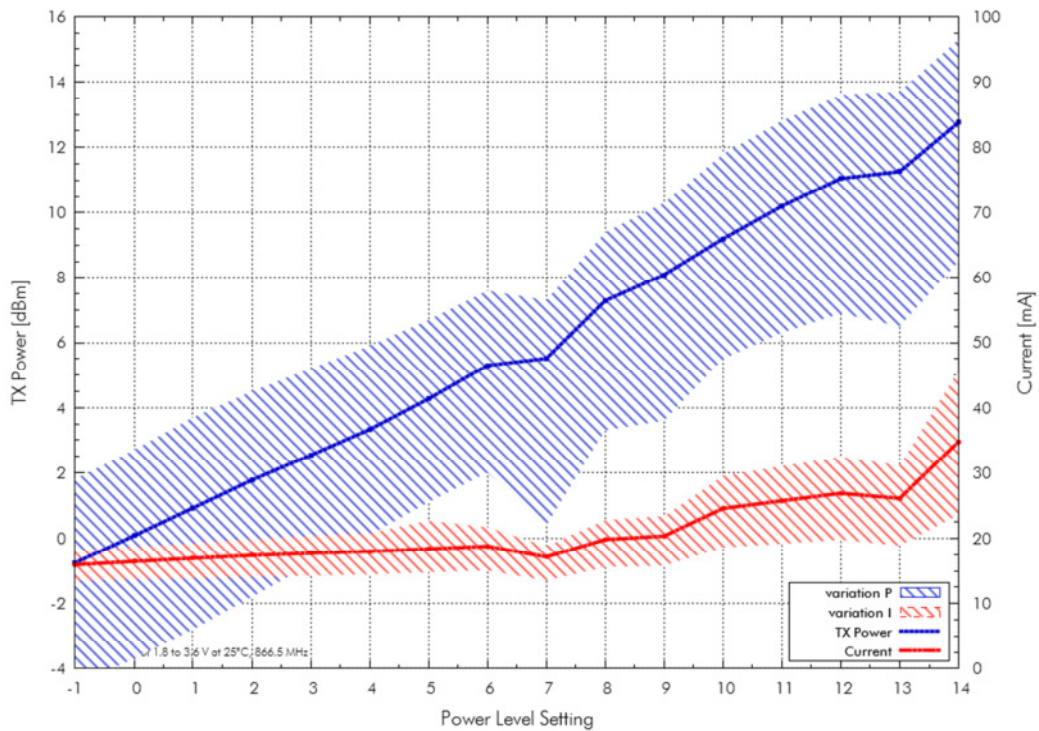

Figure 4-1: RF output power level and current consumption versus power stages from -1 to 14 @ room temperature and supply voltages from 1.8V to 3.6V

5.   Module Package

In the following the iM881A-XL module package is described. This description includes the iM881A-XL pinout as well as the modules dimensions. Furthermore a recommendation for a suitable footprint is given, which should be used for further mounting on appropriate carrier boards.

5.1   Pinout Description

Figure 5-1 depicts a description of the iM881A-XL's pads on the bottom side. The figure shows the module with its pinout in top view (right figure). A detailed description of the individual pins can be found in Table 5-1: iM881A-XL Pinout Table.
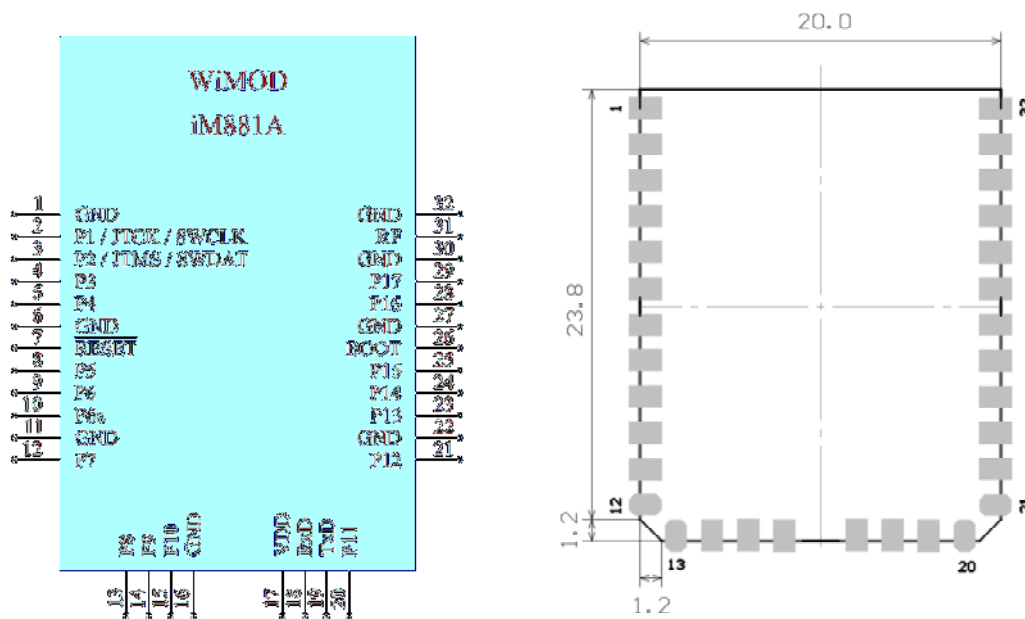

Figure 5-1: Description of iM881A-XL module pins and top view

PIN	PIN Name	PIN Type	MCU Pin (number)	5 V Tolerance	Description
1	GND	Supply		-	Ground connection
2	P1	D IN/OUT	PA14 (P37)	Yes	Digital IO / SWCLK
3	P2	D IN/OUT	PA13 (P34)	Yes	Digital IO / SWDIO
4	P3	D IN/OUT	PB11 (P22)	Yes	Digital IO
5	P4	D IN/OUT	PA8 (P29)	Yes	Digital IO
6	GND	Supply		-	Ground connection
7	nReset	D IN	NRST (P7)	Yes	
8	P5	D IN/OUT	PA11 (P32)	Yes	Digital IO / USART1_CTS
9	P6	D IN/OUT	PA12 (P33)	Yes	Digital IO / USART1_RTS
10	P6a	D IN/OUT	PB9 (P46)	Yes	Digital IO
11	GND	Supply		-	Ground connection
12	P7	D IN/OUT	PB4 (P40)	Yes	Digital IO / SPI1_MISO
13	P8	D IN/OUT	PB5 (P41)	Yes	Digital IO / SPI1_MOSI
14	P9	D IN/OUT	PB3 (P39)	Yes	Digital IO / SPI1_SCK
15	P10	D IN/OUT	PA15 (P38)	Yes	Digital IO / SPI1_NSS
16	GND	Supply		-	Ground connection
17	VDD	Supply		-	Supply voltage
18	RxD	D IN/OUT	PA10 (P31)	Yes	Digital IO / USART1_RX
19	TxD	D IN/OUT	PA9 (P30)	Yes	Digital IO / USART1_TX
20	P11	D IN/OUT	PB8 (P45)	Yes	Digital IO
21	P12	D IN/OUT	PB6 (P42)	Yes	Digital IO / I2C1_SCL
22	GND	Supply		-	Ground connection
23	P13	D IN/OUT	PB7 (P43)	Yes	Digital IO / I2C1_SDA
24	P14	D IN/OUT, A IN	PA0 (P10)	No	Digital IO / ADC_IN0
25	P15	D IN/OUT	PC13 (P2)	Yes	Digital IO / WKUP2
26	BOOT	D IN	BOOT0 (P44)	No	Bootloader Pin 0, internally pulled-down by 47 kΩ
27	GND	Supply		-	Ground connection
28	P16	D IN/OUT	PA1 (P11)	Yes	Digital IO / ADC_IN1
29	P17	D IN/OUT, A IN	PA3 (P13)	Yes	Digital IO / ADC_IN3
30	GND	Supply		-	Ground connection
31	RF	A IN/OUT		-	External 50Ω port for monostatic antenna connection
32	GND	Supply		-	Ground connection

Table 5-1: iM881A-XL Pinout Table

5.2 Module Dimensions

The outer dimensions of the iM881A-XL are given by Figure 5-2 and Figure 5-3. The height of the module is 3.3mm.
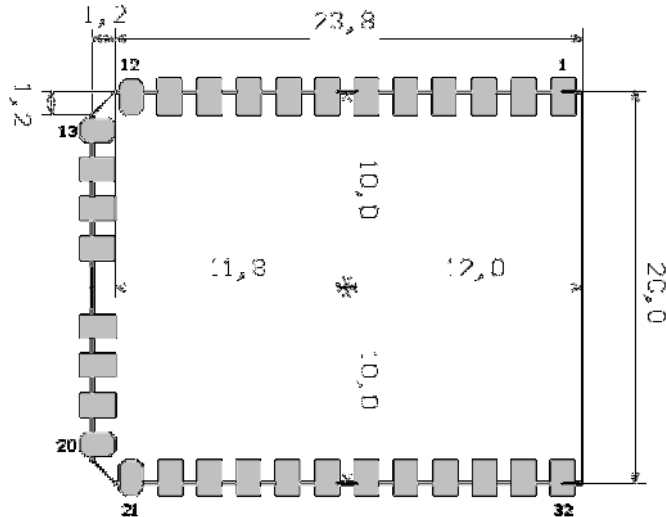

Figure 5-2: Outer Dimensions of the iM881A-XL (top view)

5.3 Recommended Footprint

According to Chapter 5.2, a recommendation for the footprint of the iM881A-XL is given by Figure 5-3.
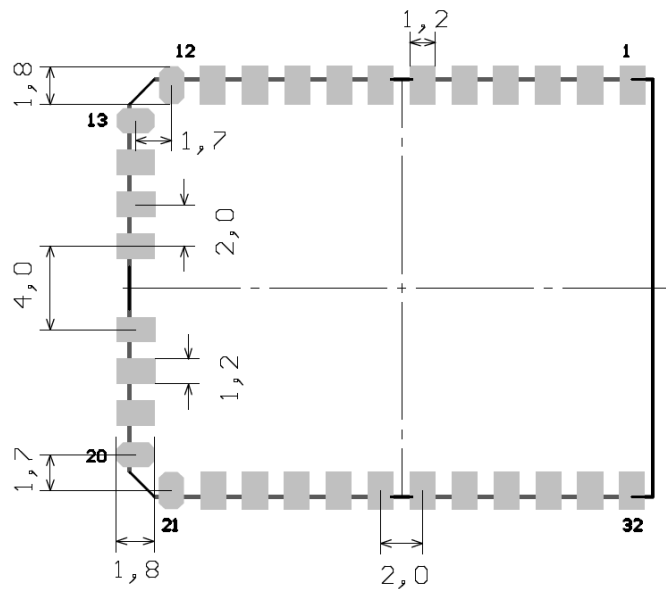

Figure 5-3: Recommended footprint of the iM881A-XL (top view)

6.   Module Interface Characteristics

6.1   Programming Interface

For programming the module with special firmware versions, there are two types of interfaces supported: A SWD-interface, which require a special programmer, as well as a bootloader-interface, for updating the modules firmware via UART-interface. For more details refer to [3].

7.   Integration Guide

The iM881A-XL provides 32 connectors as described in Chapter 5. For integrating the iM881A-XL into an environment, a typically circuit as given in Chapter 7.1 can be used. While designing the PCB Layout, the recommendations of Chapter 7.2 should be applied, as well as the recommendation for soldering in Chapter 7.3.
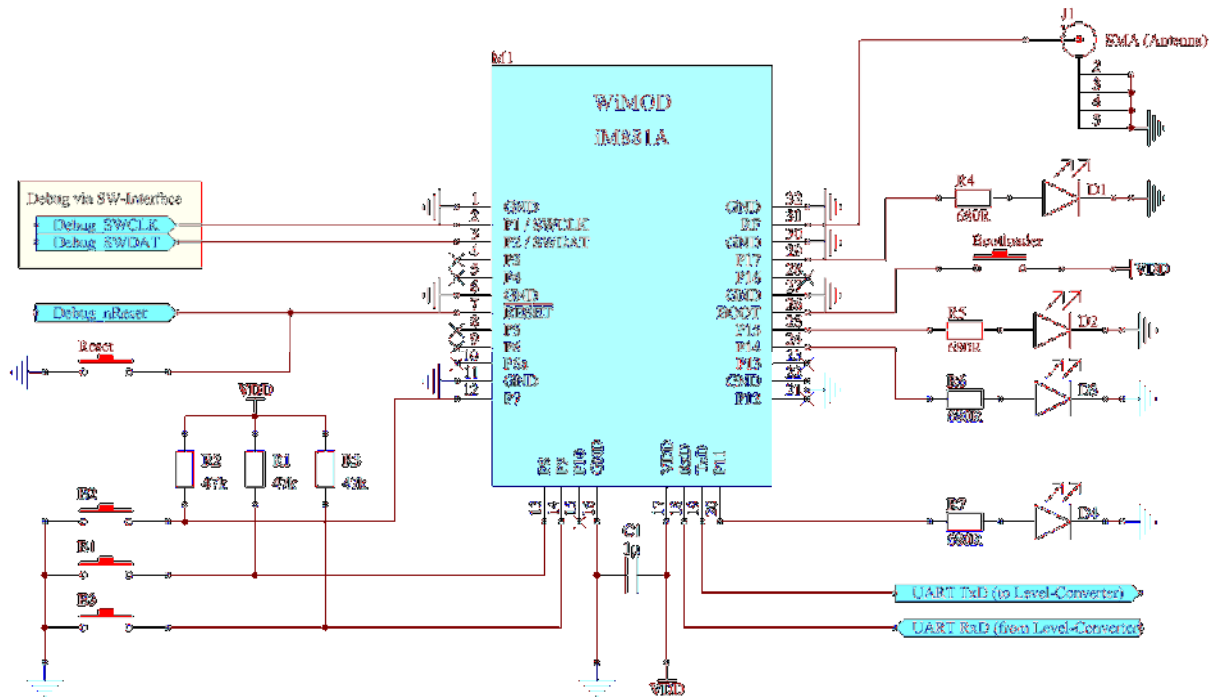
7.1   Typical Application Schematic

Figure 7-1: Typical Application Schematic for iM881A-XL

7.2   PCB Design Recommendation

The Top Layer of the carrier board should be kept free of Tracks and Vias under the iM881A because there are some test pads on the bottom side of the module which are not covered by solder resist.

All GND pads of the module should be connected via low impedance path to GND.

The iM881A's RF interface is already matched to 50 Ω. By using an adequate 50 Ω antenna, no additional matching components are required[1]. For an ideal signal transmission between the modules RF pad and the antenna, the transmission line should be as short as possible and represent an impedance of 50 Ω.

> Note: Disregarding this recommendation can affect the RF performance respective RF output power, sensitivity, and unwanted emissions.

This impedance depends on frequency and PCB structure. It is recommended to use a grounded coplanar waveguide (CPWG) structure to reduce effects of electromagnetic fields. The impedance of transmission line for grounded CPWG is basically affected by height H and material of the substrate, gap G between transmission line and ground on the top layer, as well as width W and thickness T of the transmission lines (Figure 7-2).
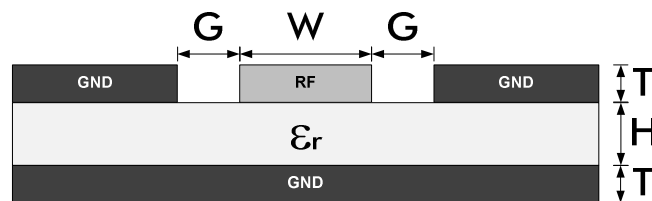

Figure 7-2: Structure of a grounded CPWG

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[1] In other case a special matching network is required

Assuming a frequency of approx. 868 MHz, FR4 ($\varepsilon_r \approx 4.8$) as substrate material, copper as conductor material, $G = 0.4$ mm and $T = 35\,\mu$m, the width of transmission line is given by Table 7-1.

H [mm]	W [mm]
1.0	1.37
1.6	1.85

Table 7-1: Recommended width of transmission line for CPWG and 868 MHz

7.3 Recommended Soldering Conditions

An example of the temperature profile for the soldering process of the iM881A is depicted in Figure 7-3 with the corresponding values as given by Table 7-2. The temperature values should not exceed the limits.
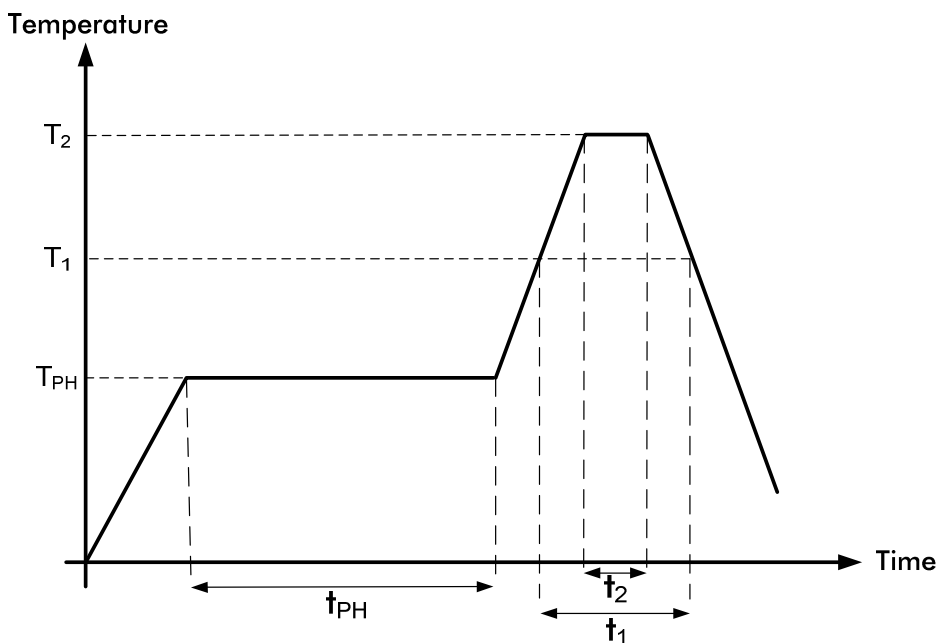

Figure 7-3: Soldering Profile

Phase	Pb-Free Conditions
Preheating	$t_{PH} = 120$s $T_{PH} = 160\sim180°C$
Primary heat	$t_1 = 60$s $T_1 = 220°C$
Peak	$t_2 = 10$s (max) $T_2 = 255°C$

Table 7-2: Recommended Soldering Parameter for Temperature and Timing

> **Note:** The quality of the soldering process depends on several parameters, e.g. soldering paste, carrier board design, fabrication equipment,...

8.   Ordering Information

Ordering Part Number	Description	Distributor
iM881A-XL	Radio Module iM881A-XL 192 KB Flash, 20 KB RAM, 6 KB EEPROM, 16 MHz MCU crystal	sales@imst.de
SK – iM881A-XL	Starter Kit for the iM881A-XL. See Notes.	sales@imst.de
AB – iM881A-XL	2x Adapter Board with iM881A-XL	sales@imst.de
Notes: The Starter Kit contains two Demo Boards, two Adapter Boards with iM881A-XL, two antennas, and a CD or USB memory stick with documentation.		

Table 8-1: Ordering Information

9. Appendix

9.1 List of Abbreviations

ADC   Analog-to-Digital Converter

BER   Bit Error Rate

BSC   Basic Spacing between Centers

CPWG   Coplanar Waveguide

CW   Continuous Wave

GND   Ground

GPIO   General Purpose Input/Output

I^2C Inter-Integrated Circuit

MCU   Microcontroller Unit

PCB   Printed Circuit Board

RAM   Random Access Memory

RF   Radio Frequency

SMBus   System Management Bus

SMT   Surface Mounted Technology

SPI   Serial Peripheral Interface

TRX   Transceiver

USB   Universal Serial Bus

9.2   List of Figures

9.3   List of Tables

9.4   References

[1]   Semtech Sx1272 Data Sheet from www.semtech.com

[2]   REC Recommendation 70-03 "Relating to the use of Short Range Devices
           (SRD)", Tromsø 1997, CEPT ECC subsequent amendments 9 th October 2012

[3]   see Application Note for firmware update (iM880B) on
           www.wireless-solutions.de

10. Restrictions and Limitations

10.1 Hardware Restrictions and Limitations

The characteristic values given by the present document are typically obtained by measurements based on evaluation kits of the entitled device. Using other carrier boards or connected equipment might lead to different characteristics. Subject to given measurement results the characteristic values might show the best performance of the entitled device, independent from any compliancy restriction of final operation purposes.

10.2 Software Restrictions and Limitations

The present document is a datasheet of the entitled device which intentional use is to provide information about basic characteristics related to the device hardware. Typically all described characteristic values require software for obtaining them accordingly. All features of the available software are subject to changes without claim to be complete at any time. Characteristically values might also be provided based on datasheets of the appropriate key components unless there are test results available based on the available software. For more information regarding current supported features of the available software refer to www.wireless-solutions.de.

10.3 Compliancy Restrictions and Limitations

The entitled device has been designed to comply with the standards namely given in the present document. The intentional operation shall be in so called ISM bands, which can be used free of charge within the European Union and typically licences free all over the world. Nevertheless, restrictions such as maximum allowed radiated RF power or duty cycle may apply which might result in a reduction of these parameters accordingly.

In addition, the use of radio frequencies might be limited by national regulations which requirements also need to be met.

In case the entitled device will be embedded into other products (referred as "final products"), the manufacturer for this final product is responsible to declare the conformity to required standards accordingly. A proof of conformity for the entitled device is available from IMST GmbH on request. Beside the entitled device the conformity also considers software as well as supporting hardware characteristics which might also have an impact accordingly.

The applicable regulation requirements are subject to change. IMST GmbH does not take any responsibility for the correctness and accuracy of the aforementioned information. National laws and regulations, as well as their interpretation can vary with the country. In case of uncertainty, it is recommended to contact either IMST's accredited Test Center or to consult the local authorities of the relevant countries.

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