WiMOD Mote II

Datasheet

Document ID: 4100/40140/0108

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Document Information

File name	Mote_II_Datasheet.docx
Created	2016-01-26
Total pages	29

Revision History

Version	Note
0.5	Created
0.6	Added important user information (chapter 1); changed operating temperature (Table 8-1)
1.0	Review by QMB

Aim of this Document

The aim of this document is to give a detailed product description including interfaces, features and performance of the device Mote II.

Table of Contents

1. Important User Information

This device is only for usage of professionals or authorized person.

	Caution Read complete instructions prior operation of the device.

In no event will IMST GmbH be responsible or liable for indirect or consequential damages resulting from use of this device.

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1.1 Safety Considerations

	Caution: Risk of Damage Only use alkaline standard batteries type AAA. Take care of polarization.

For long-term outdoor usage the housing has to be supplied with a pressure compensating membrane (Bopla DA-D11). For further information and mounting instructions please contact sales@imst.de.

2. Introduction

The Mote II is a demonstration platform intended to be used in a variety of applications. It is fitted with the low power, bidirectional radio module iM881A and sensors like accelerometer, altimeter, and temperature sensor. Additionally it provides a GPS module.

iM881A was specially designed for battery driven LoRa® applications. It supports LoRaWAN™ operation modes and offers an excellent RF performance combined with low current consumption.

Figure 2-1: Mote II

2.1 Key Features

- Compact size 151 x 80 x 50 mm
- LoRa® modulation technology
- GPS module included
- Accelerometer, Altimeter, Temperature Sensor
- Display, 3 LEDs, 3 buttons
- Supplied by 3 AAA alkaline cells (1.5V type)
- LDO voltage regulator to 3.3V
- Integrated antenna
- Output power level up to +14 dBm
- High link budget up to 152 dB
- iM881A LoRa® radio module
- IP 65 housing
- Certified according to R&TTE directive 1999/5/EC

2.2 Applications

- LoRaWAN™, IoT, Smart Cities
- Automated Meter Reading
- Wireless Networks
- Home-, Building-, Industrial automation
- Wireless Sensors
- Telemetry
- Wireless Alarm and Security Systems
- …

Please visit our web site www.wireless-solutions.de for more information.

3. Device Overview

The Mote II is an ultra-long range, high-performance, certified sensor device for LoRaWAN™. It operates in the license free 868 MHz SRD frequency band and includes all necessary passive components for wireless communication as depicted in Figure 3-2.

The housing can be easily opened. No additional tools are needed.

The Mote II has a USB interface for configuration and development purposes. In normal use the Mote II is battery powered with three AAA-cells. For best performance please do not use rechargeable batteries.

Figure 3-1: Mote II with open Cover

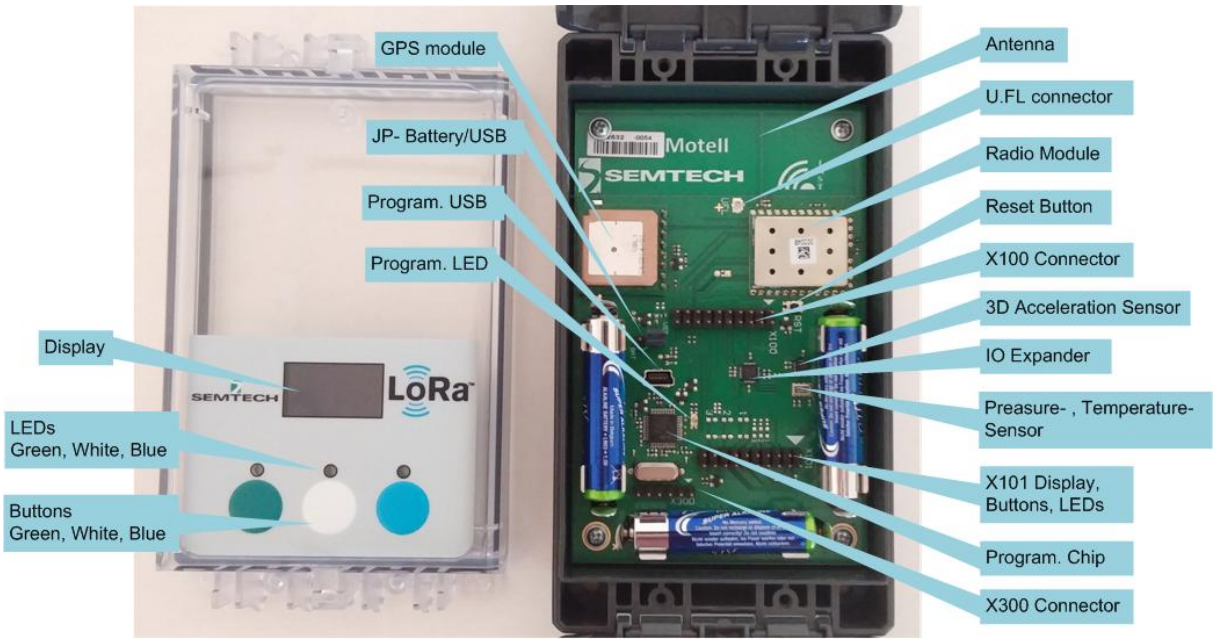


Figure 3-2: Mote II Hardware Description

3.1 Dimensions of Mote II

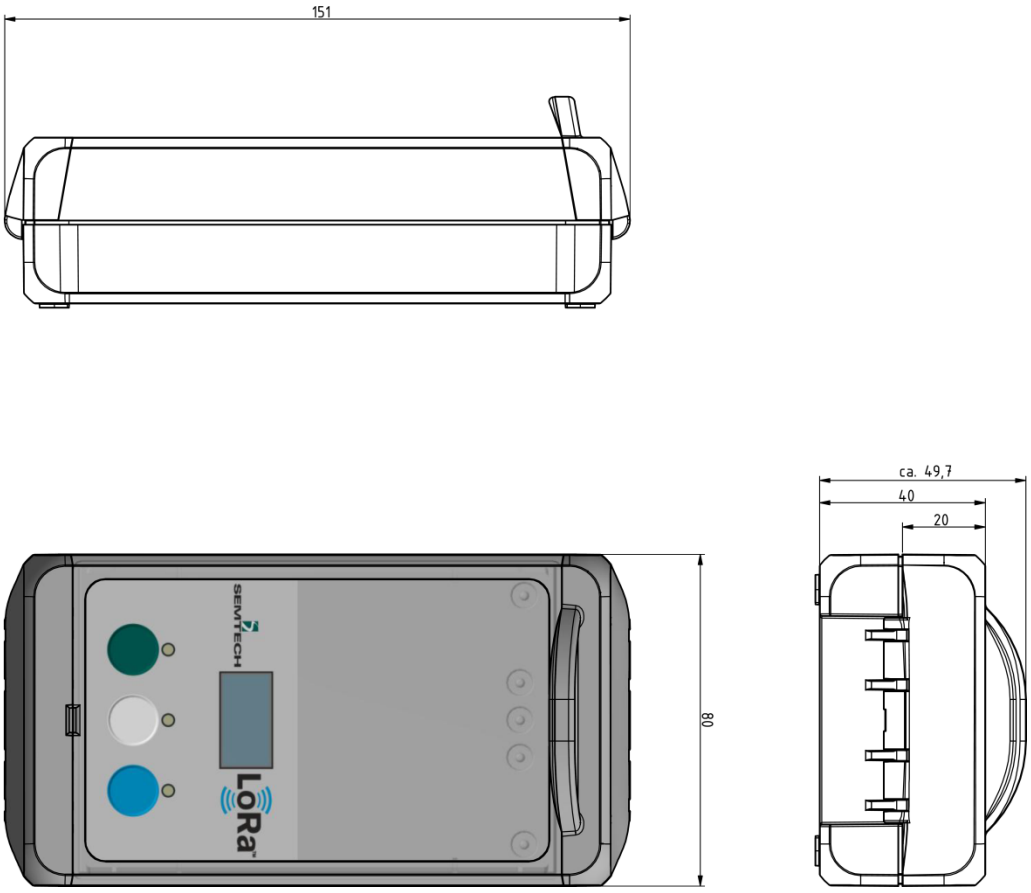


Figure 3-3: Mote II Mechanical Dimension in mm

4. LoRa® Modulation Technique

The Mote II 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 sensitivities 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 Mote II 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 4-1: 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 Mote II 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 4-2: Coding Rate of Mote II

5. Firmware

The Mote II is normally pre-programmed with a firmware from the open source project github/LoRa-net.

5.1 Integrated Programmer

On the Mote II a direct programming and debugging interface is implemented (see Figure 3-2, Program.USB and Program.Chip). The programmer (Program.Chip) is connected with an USB standard A to Mini- B cable and is compatible to ST-LINK/V2. Therefore the STM tool chain can be used for programming and debugging the radio module.

For more detailed information about the programming interface refer to STMicroelectronics and ST-Link/V2.

Note: The radio module is connected to the integrated debug-interface (Program.Chip) by SWD without the reset-line (see Figure 6-3). This is done to achieve lower current consumption.

5.1.1 Programmer Status LED

The programmer LED (dual color) shows the status of the Program.Chip, see Figure 3-2. The LED shows the following behavior (using default firmware within the Program.Chip):

- LED is blinking RED: the first USB enumeration with the PC is taking place.
- LED is RED: communication between the PC and programmer is established (end of enumeration).
- LED is blinking GREEN/RED: data is being exchanged between radio module and the PC.
- LED is GREEN: the last communication with the radio module has been successful.
- LED is ORANGE: communication with the radio module has failed.

5.2 Firmware Update

To update the firmware of the radio module no additional tools are needed. Please follow the given instructions:

1) Set Jumper to “USB” to power supply the Mote II by USB.
2) Connect the Mote II to your PC.
3) Your Windows PC will detect Mote II as an additional flash drive.
4) You can copy the corresponding binary file directly to this flash drive.
5) Wait until programmers LED is permanently green.
6) Do a power cycle of the Mote II or press the reset button near the radio module.

Optionally: Install the drivers for the ST-LINK/V2, if debugging or UART connection to the radio module is needed.

6. Schematics & BOM

6.1 Schematics

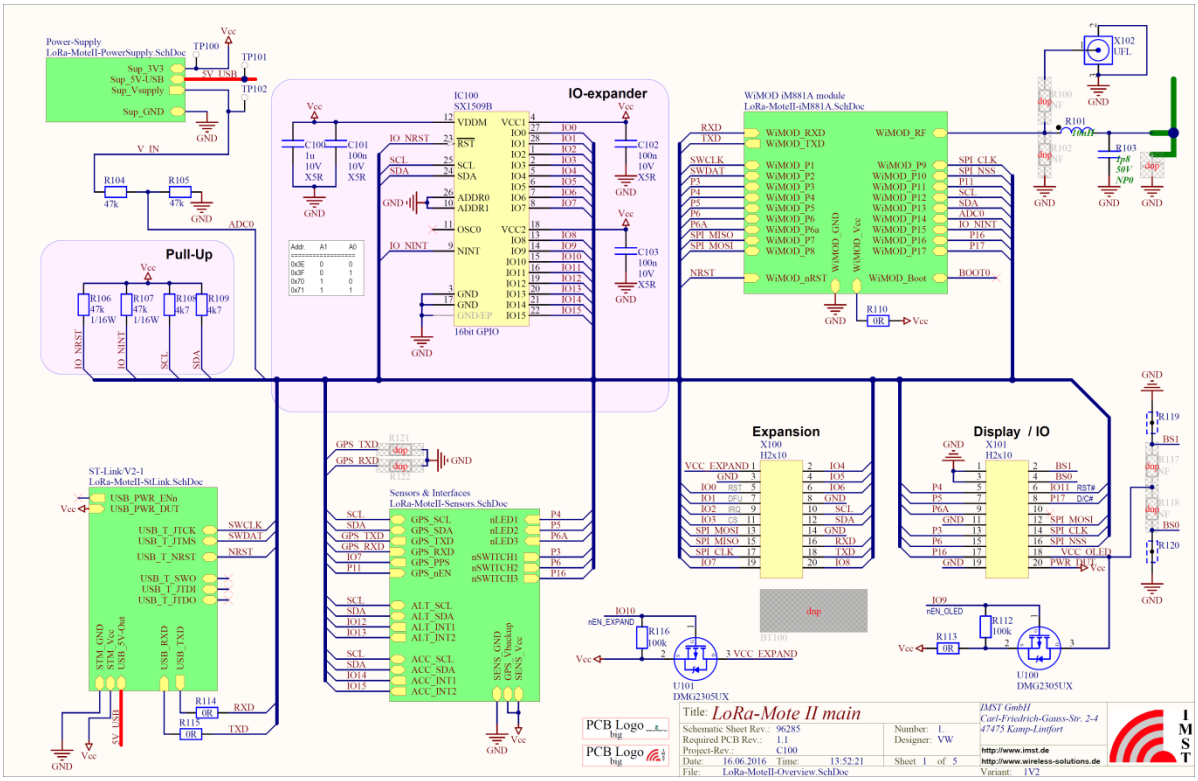


Figure 6-1: Mote II Overview.

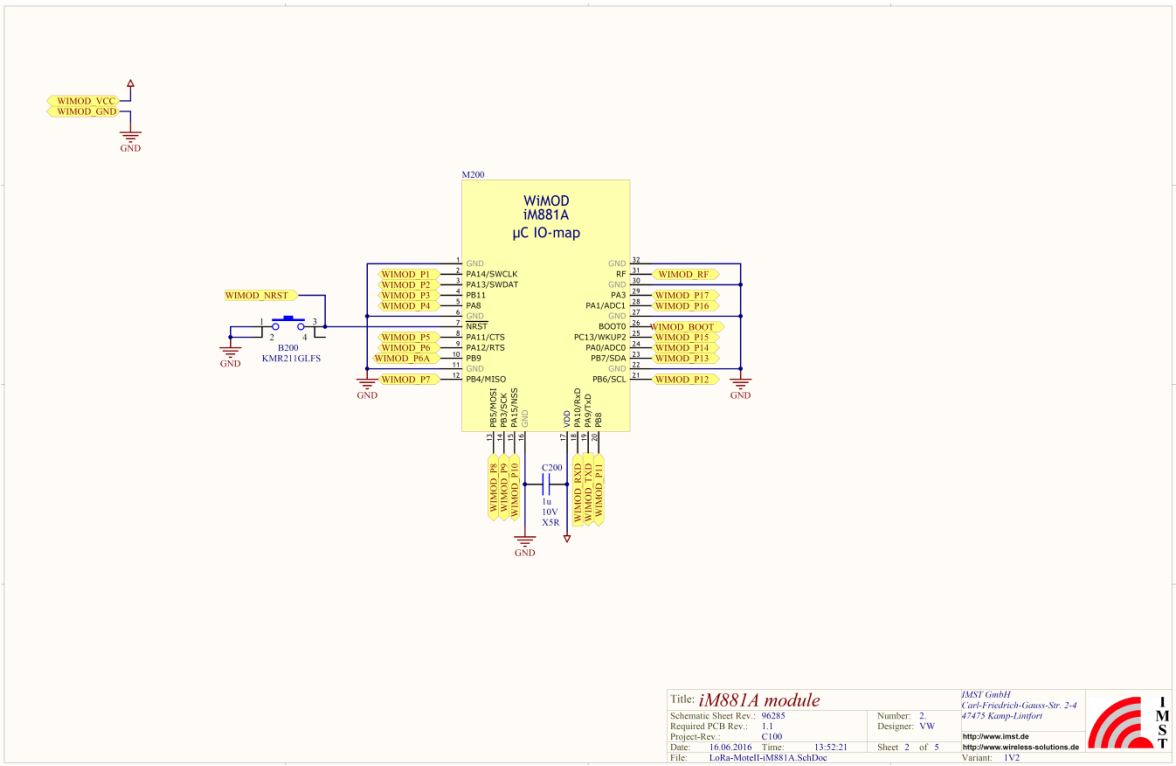


Figure 6-2: Schematic iM881A

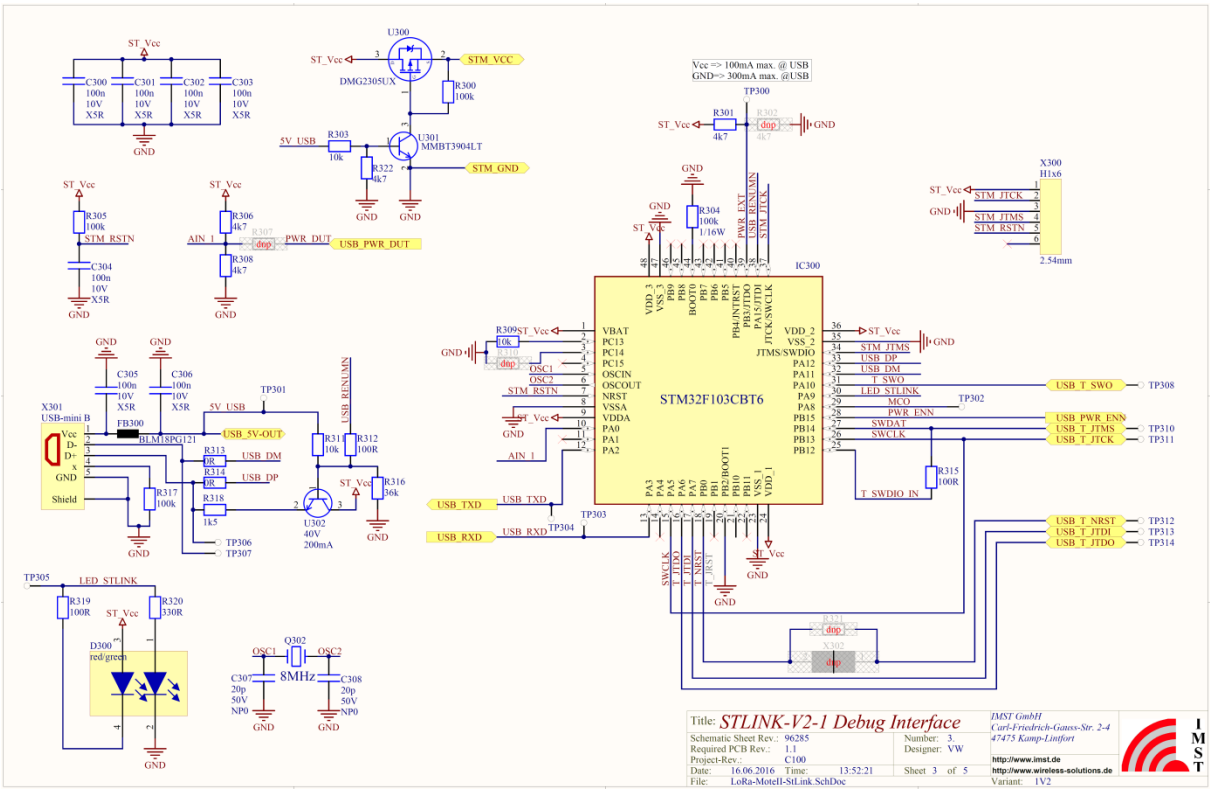


Figure 6-3: ST Link Programming Interface

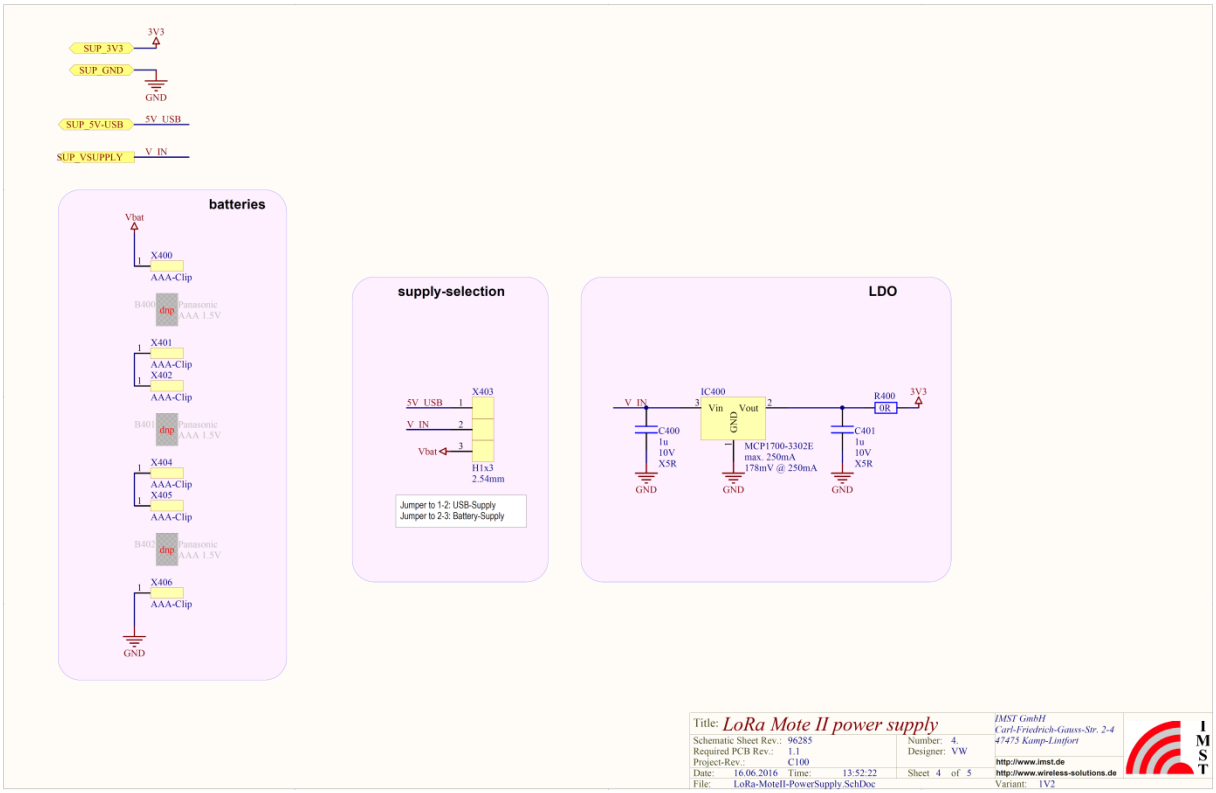


Figure 6-4: Power Supply

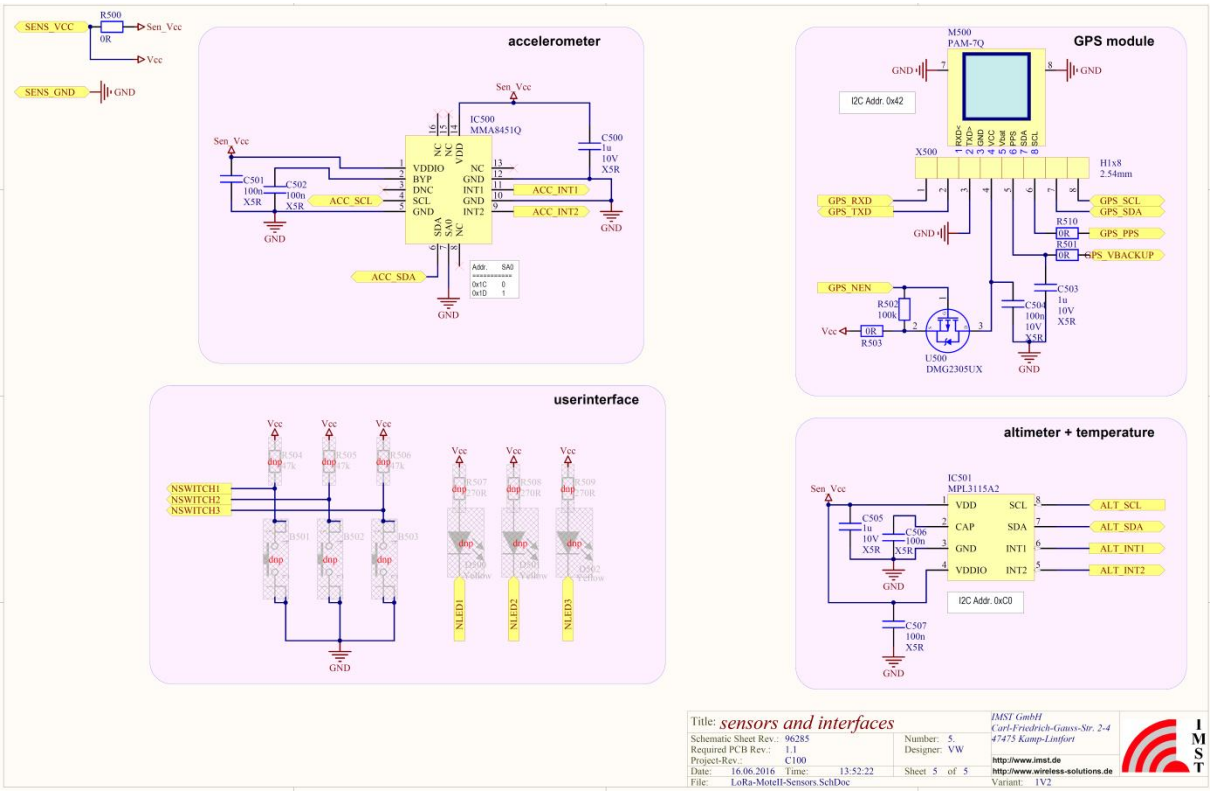


Figure 6-5: Mote II Sensors

6.2 BOM

The main components of Mote II are listed within the following table.

Designator	Description	Manufacturer	Productname
IC100	16-bit I2C controlled level shifting GPIO expander	Semtech	SX1509BIULTRT
IC300	ARM 32-bit Cortex-M3 CPU	STM	STM32F103CBT6
IC500	Digital, tri-axial acceleration sensor	Freescale Semiconductor	MMA8451Q
IC501	Digital pressure and temperature sensor	Freescale Semiconductor	MPL3115A2
M200	WiMOD iM881A with RF pad	IMST GmbH	iM881A
M500	GPS module with patch-antenna	uBlox	PAM-7Q-0-000
n.a.	OLED display	EastRising	ER-OLED0.96-1B

Table 6-1: Main Components of Mote II

7. Antenna

The Mote II is equipped with a planar inverted F antenna (PIFA). This antenna is connected to the radio module by default. Additionally Mote II provides an U.FL connector to make use of an external antenna.

7.1 Dimension of the Planar Inverted F-Antenna

The following picture shows the dimensions of the planar inverted F-antenna and the PCB of Mote II.

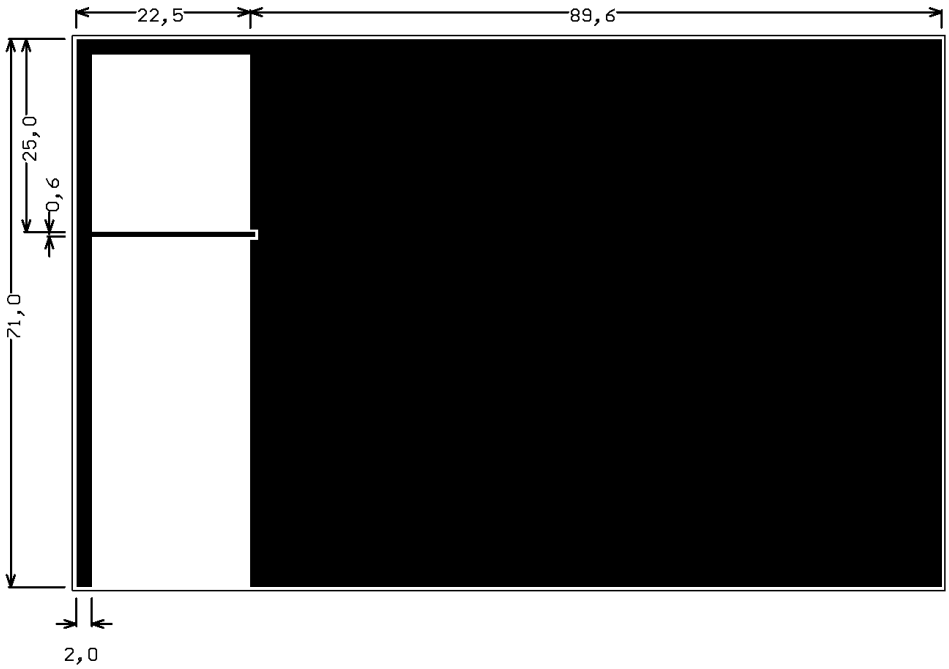


Figure 7-1: Dimensions in mm of PIFA

7.2 U.FL Connector

For using an external antenna the U.FL connector can be connected to the output of the iM881A radio module. To do this R101 (10nH inductor) has to be removed and a zero ohm resistor has to be soldered to the position of R100.

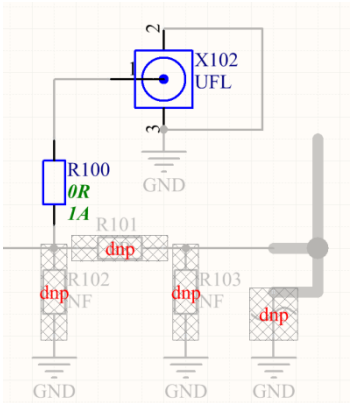


Figure 7-2: Zero Ohm Resistor for connecting external Antennas

8. Electrical Characteristics

In the following different electrical characteristics of the Mote II are listed. Furthermore details and other parameter ranges are available on request.

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

8.1 Absolute Maximum Ratings

Parameter	Condition	Min	Typ.	Max	Unit
Supply Voltage (VDD)		+3.6		+6	V
Storage Temperature		-40		+80	°C
Operating Temperature		-30		+65	°C
RF Input Power				+10	dBm
ESD contact discharge				±4	kV
ESD air discharge				±8	kV
Notes: 1) Unless otherwise noted, all voltages are with respect to GND					

Table 8-1: Absolute Maximum Ratings

8.2 Global Electrical Characteristics

T = 25°C, VDD = 4.5 V (typ.) if nothing else stated

Parameter	Condition	Min	Typ.	Max	Unit
Supply Voltage (VDD)	Three standard AAA batteries		4.5V		V
Current Consumption Low Power Mode	IO-expander (SX1509B)		~3*1		µA
	GPS-module (PAM-7Q)		~15*1		µA
	Accelerometer (MMA8451Q)		~2*1		µA
	Altimeter (MPL3115A2)		~2*1		µA
	Radio-Module (iM881A)		~1*1		µA
	OLED Display		~2*1		µA
Current Consumption Active Mode	IO-expander (SX1509B)		365*1,2	460*1	µA
	GPS-module (PAM-7Q)	6.0*1,2	21.5*1,2	71*1	mA
	Accelerometer (MMA8451Q)	<0.01*1,2	0.085*1,2	1*1	mA
	Altimeter (MPL3115A2)	<0.01*1,2	0.04*1,2	2*1	mA
	Radio-Module (iM881A) µC active, TRX off			7*1,2	mA
	OLED Display			32*1,2	mA
Current Consumption RECEIVE LoRa	iM881A receive mode, µC sleep mode		11*1		mA
Current Consumption TRANSMIT	iM881A transmit mode, µC sleep mode, all µC units off, power level 14dBm @3.0V		39*1		mA
MCU operation frequency	iM881A		16		MHz
			32.768		kHz
Memory (Flash)	iM881A		64		kByte
Memory (RAM)	iM881A		8		kByte
EEPROM	iM881A		2		kByte

Notes:
*1: values are taken from the corresponding components datasheet
*2: depending on device/sensor settings

Table 8-2: General Characteristics

8.3 Transmitter RF Characteristics

Mote II includes an iM881A radio module which provides an excellent transmitter performance as given by Table 8-3. For further details please refer to the data sheet of iM881A.

T = 25°C, VDD = 3.3 V (typ. module supply voltage on Mote II), f=868MHz

Parameter	Condition	Min	Typ.	Max	Unit
Frequency Range		863	-	870	MHz
RF Output Power	868 MHz Band		14.0		dBm
Modulation Techniques	LoRa™and FSK				
TX Frequency Variation vs. Temperature	-40 to +85°C	-	±10	-	kHz
TX Power Variation vs. Temperature		-	±0.5	-	dB

Table 8-3: Transmitter RF Characteristics of iM881A

8.3.1 Radiation Performance

The Total Radiated Power (TRP), the maximum Equivalent Isotropically Radiated Power (EIRP) and Total Isotropic Sensitivity (TIS) of Mote II are shown within the following table.

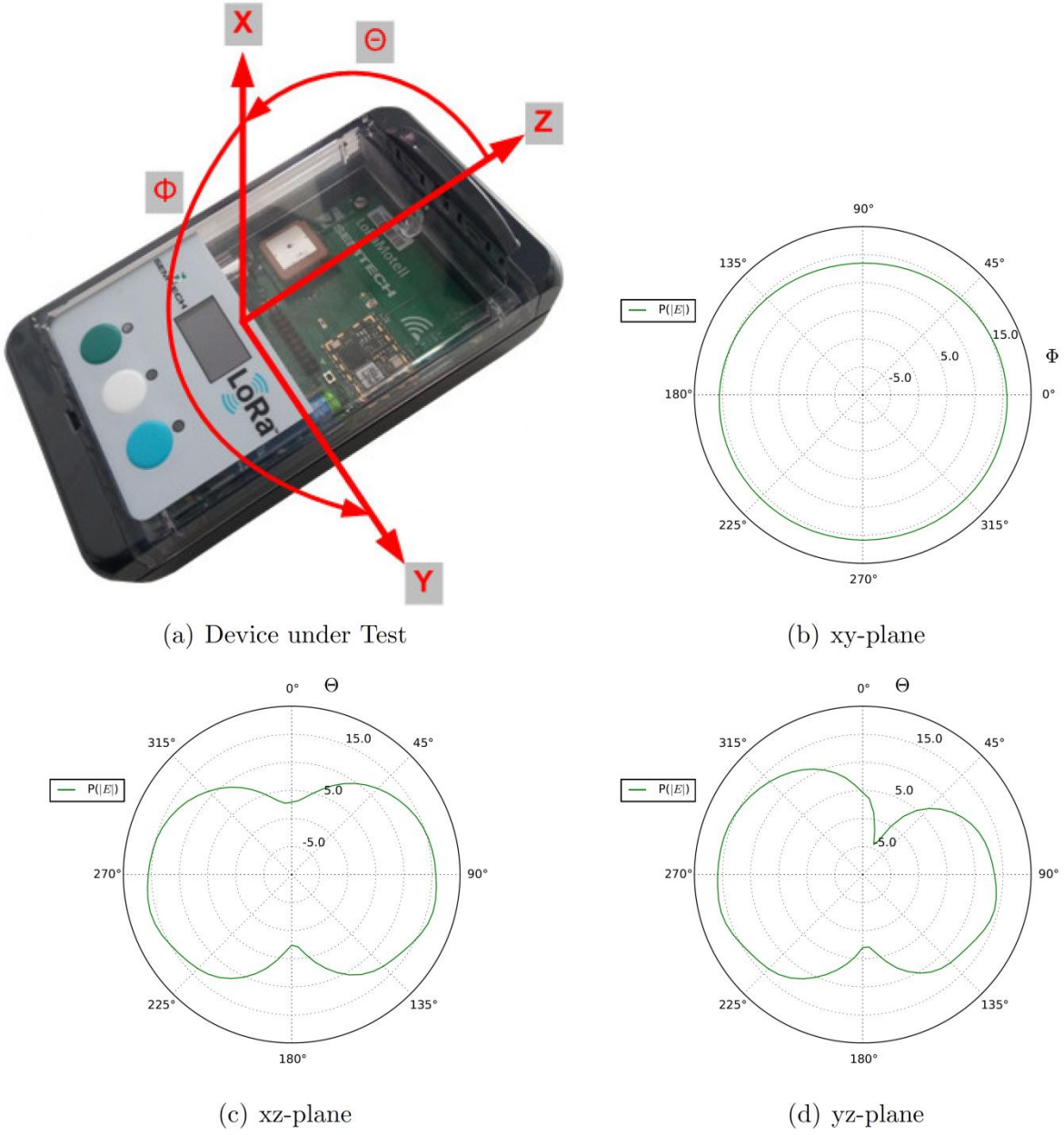
T = 25°C, VDD = 3.3 V (typ. module supply voltage on Mote II), f=868MHz

Parameter	Typical Performance	Unit
Total Radiated Power (TRP)	13	dBm
Max. EIRP	16	dBm
Total Isotropic Sensitivity (TIS) TIS-SF7-BW125kHz TIS-SF7-BW250kHz TIS-SF10-BW125kHz TIS-SF12-BW125kHz	 -123 -120 -130 -136	dBm

Table 8-4: Typical Radiation Performance Parameter

8.3.2 Antenna Characteristic

Following the measured 2D radiation pattern of Mote II are given.



(a) Device under Test (b) xy-plane

(c) xz-plane (d) yz-plane

Figure 8-1: 2D Radiation Pattern

8.4 Interface Characteristics

For a detailed interface description for the IO's at the expansion connector X100 (please refer to chapter 10.2) refer to the actual datasheet of the GPIO expander SX1509B and radio module iM881A. The supply voltage on Mote II is regulated to 3.3V.

9. 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 9-1: 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.

10. Pin-out Description

This chapter describes the different connectors and Jumper of Mote II. These are the Jumper X403, the connector X100, X101 and X300.

10.1 Jumper X403

The Jumper can be used to switch the power supply between battery and USB. Setting a jumper between Pin1 and Pin2 the device is supplied by the USB interface. Setting a jumper between Pin2 and Pin3 the device is supplied by batteries.

Pin-Nr.	Name	Connected to
X403.1	5V_USB	5V supply voltage from USB connector
X403.2	Vin	Input pin voltage regulator for suppliing the Mote II
X403.3	Vbat	4.5V supply voltage from the batteries

Table 10-1: X403 Jumper

10.2 X100 Connector

X100 is the expansion header. It is mainly connected with the IO expander IC 100 (SX1509B) and the radio module (iM881A).

Pin-Nr.	Name	Connected to
X100.1	VCC_EXPAND	switched Vcc (activated by IO expander IO10, low active)
X100.2	IO4	IO expander IO4
X100.3	GND	Ground
X100.4	IO5	IO expander IO5
X100.5	IO0	IO expander IO0
X100.6	IO6	IO expander IO6
X100.7	IO1	IO expander IO1
X100.8	GND	Ground
X100.9	IO2	IO expander IO2
X100.10	SCL	IO expander SCL
X100.11	IO3	IO expander IO3
X100.12	SDA	IO expander SDA
X100.13	SPI_MOSI	SPI MOSI of iM881A (Pin name P8)
X100.14	GND	Ground
X100.15	SPI_MISO	SPI MISO of iM881A (Pin name P7)
X100.16	RxD	USART Rx of iM881A (Pin name RxD)
X100.17	SPI_CLK	SPI Clock of iM881A (Pin name P9)
X100.18	TxD	USART Tx of iM881A (Pin name TxD)
X100.19	IO7	IO expander IO7
X100.20	IO8	IO expander IO8

Table 10-2: X100 Connector

10.3 X101 Connector

X101 is the header to connector the display, the three buttons, and the three LEDs installed within the cover of Mote II.

Pin-Nr.	Name	Connected to Mote II PCB	Connected to Display PCB
X101.1	GND	Ground	Ground
X101.2	BS1	Ground	OLED BS1 (interface selection)
X101.3	GND	Ground	Ground
X101.4	BS0	Ground	OLED BS0 (interface selection)
X101.5	P4	iM881A (Pin name 48)	LED1 (green)
X101.6	IO11	IO expander IO11	OLED RST#
X101.7	P5	iM881A (Pin name P5)	LED2 (white)
X101.8	P17	iM881A (Pin name P17)	OLED D/C#
X101.9	P6A	iM881A (Pin name P6a)	LED3 (blue)
X101.10	NC	Not connected	OLED D2
X101.11	GND	Ground	Ground
X101.12	SPI_MOSI	iM881A (Pin name P8)	OLED D1
X101.13	P3	iM881A (Pin name P3)	Button1 (green)
X101.14	SPI_CLK	iM881A (Pin name P9)	OLED D0
X101.15	P6	iM881A (Pin name P6)	Button2 (white)
X101.16	SPI_NSS	iM881A (Pin name P10)	OLED CS#
X101.17	P16	iM881A (Pin name P16)	Button3 (blue)
X101.18	VCC_OLED	Switched Vcc (activated by IO expander IO9, low active)	Display Vcc
X101.19	GND	Ground	Ground
X101.20	VCC	Supply voltage	Vcc for Buttons and LEDs

Table 10-3: X101 Connector

10.4 X300 Connector

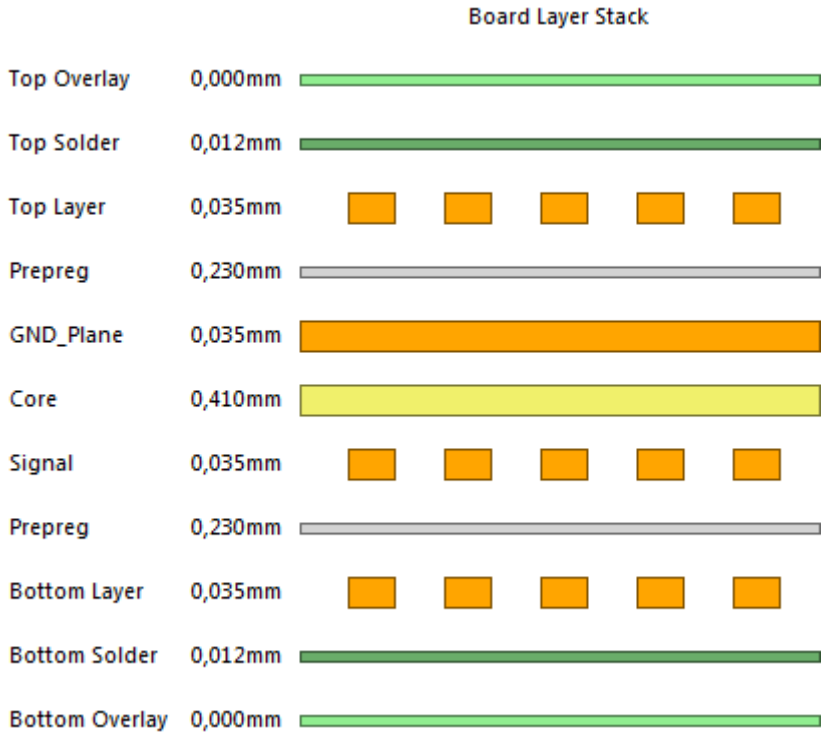
X300 connector is only used for programming the debug/programmer interface IC (Program.Chip). Please do not re-program the Program.Chip.

Pin-Nr.	Connected to	Description
X300.1	Vcc for IC300	Supply voltage sense line for external programmer
X300.2	IC300 Pin 37	JTCK for initial programming of programmer interface IC
X300.3	GND	Ground
X300.4	IC300 Pin 34	JTMS for initial programming of programmer interface IC
X300.5	IC300 Pin 7	nRST for initial programming of programmer interface IC
X300.6	n.c.	Not connected

Table 10-4: X300 Connector

11. PCB Design

The PCB design is based on a 4-layer stack-up with internal ground plane. The used material is FR4 with TG 150 and is RoHS compliant.



Layer	Name	Material	Thickness	Constant	Board Layer Stack
1	Top Overlay				
2	Top Solder	Solder Resist	0,012mm	3,6	
3	Top Layer	Copper	0,035mm		
4	Prepreg	2x2116	0,230mm	3,9	
5	GND_Plane	Copper	0,035mm		
6	Core	FR-4	0,410mm	4,3	
7	Signal	Copper	0,035mm		
8	Prepreg	2x2116	0,230mm	3,9	
9	Bottom Layer	Copper	0,035mm		
10	Bottom Solder	Solder Resist	0,012mm	3,6	
11	Bottom Overlay				

Table 11-1: PCB Layers

12. Ordering Information

Ordering Part Number	Description	Weight	Distributor
Mote II (Art.Nr.: 40810)	Demonstration platform for LoRaWAN	230g net.	sales@imst.de webshop.imst.de
iM881A-M	Radio Module iM881A 64 KB Flash, 8 KB RAM, 2 KB EEPROM, 16 MHz MCU crystal	Tbd.	sales@imst.de webshop.imst.de
SK – iM881A	Starter Kit for the iM881A radio module	Tbd.	sales@imst.de webshop.imst.de

Table 12-1: Ordering Information

13. Appendix

13.1 List of Abbreviations

ADC	Analog-to-Digital Converter
BER	Bit Error Rate
BSC	Basic Spacing between Centers
CPWG	Coplanar Waveguide Grounded
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

13.2 List of Figures

13.3 List of Tables

13.4 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 9th October 2012

[3] iM881A_Datasheet from www.wireless-solutions.de

14. Regulatory Compliance Information

The use of radio frequencies may be limited by national regulations. The device has been designed to comply with the European Union R&TTE (Radio & Telecommunications Terminal Equipment) directive 1999/5/EC and can be used license free within the European Union. Nevertheless, restrictions in terms of maximum allowed RF power or duty cycle may apply.

A declaration of conformity for the device is available from IMST GmbH on request.

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 Test Center or to consult the local authorities of the relevant countries.

15. Important Notice

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