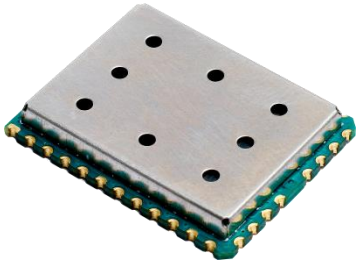
WiMOD iM980B-MBand

Datasheet



Document ID: 4100/40140/0174

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Document Information

File name	iM980B-MBand_Datasheet.docx
Created	2021-11-17
Total pages	30

Revision History

Version	Note
0.1	Created
0.2	Chapter 0
0.3	Document name changed
0.4	Adapted SF for ProLink operation mode
0.5	Updated max. conducted output power
1.0	Update to fit FCC / IC requirements
1.1	• Labelling Requirements for Host Device moved to chapter 7.1 • Chapter 7.2 added • Chapter 7 and 8.1 updated

Aim of this Document

The aim of this document is to give a detailed product description including interfaces, features and performance of component iM980B-MBand. iM980B-MBand supports Multiple Bands

- LoRaWAN US902-928 MHz and ProLink US903.0-914.2 MHz
- LoRaWAN AU915-928 MHz and ProLink AU915.9-927.1 MHz

It is a combination of the radio module iM980B with the firmware ProLink_LoRaWAN_EndNode_Modem_MBAND_iM980B_V3_0.hex

Table of Contents

1. INTRODUCTION 4
1.1 Key Features 4
1.2 Applications 4
2. MODULE OVERVIEW 5
3. LORA MODULATION TECHNIQUE 6
3.1 Channel Frequencies, Data Rates and Output Power 6
3.1.1 LoRaWAN US902-928MHz 6
3.1.2 LoRaWAN AU915-928MHz 7
3.1.3 ProLink 902-928MHz 8
4. ELECTRICAL CHARACTERISTICS 9
4.1 Absolute Maximum Ratings 9
4.2 Global Electrical Characteristics 10
4.3 Module Interface Characteristics 11
4.4 RF Characteristics 12
4.4.1 Applicable Frequency Bands and Sub-Bands 12
4.4.2 Transmitter RF Characteristics 12
5. MODULE PACKAGE 14
5.1 Pinout Description 14
5.2 Module Dimensions 16
5.3 Recommended Footprint 16
6. MODULE INTERFACE CHARACTERISTICS 17
6.1 Programming Interface 17
7. INTEGRATION INSTRUCTIONS 18
7.1 Labelling Requirements for Host Device 18
7.2 Host Device User Manual 18
7.3 Common PCB Design Recommendations 19
7.4 Integration Procedures 19
7.5 Trace Antenna Requirements 20
7.6 Typical Application Schematic 21
7.7 Recommended Soldering Conditions 22

8. REGULATORY COMPLIANCE INFORMATION 23
8.1 FCC Regulatory Notices 23
8.2 Industry Canada Statement 24
9. ORDERING INFORMATION 26
10. APPENDIX 27
10.1 List of Abbreviations 27
10.2 List of Figures 28
10.3 List of Tables 28
10.4 References 28
11. IMPORTANT NOTICE 29
11.1 Disclaimer 29
11.2 Contact Information 29

1. Introduction

The iM980B-MBand is a compact, low power, bidirectional radio module for the 902-928 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 iM980B-MBand 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.

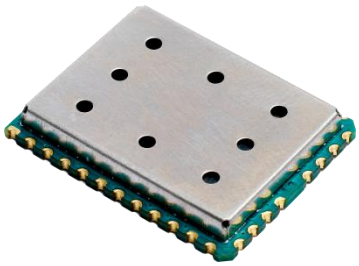

Figure 1-1: Picture of iM980B-MBand

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
- Supply voltage range from 2.4 to 3.6 V
- RF interface optimized to 50 Ω
- Integrated 20 dBm Power Amplifier
- High link budget up to 155 dB
- Range up to 15000m (Line of Sight)
- STM32L151CxU6Axx
- Certified according to FCC ID:
- Supporting: LoRaWAN US902-915MHz, AU915-928MHz and ProLink 902-928MHz

1.2 Applications

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

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

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

2. Module Overview

The iM980B-MBand is an ultra-long range, high-performance, pre-certified module for wireless communication. It operates in the license free 902-928 MHz ISM frequency band and includes all necessary passive components for wireless communication as depicted in the following figure.

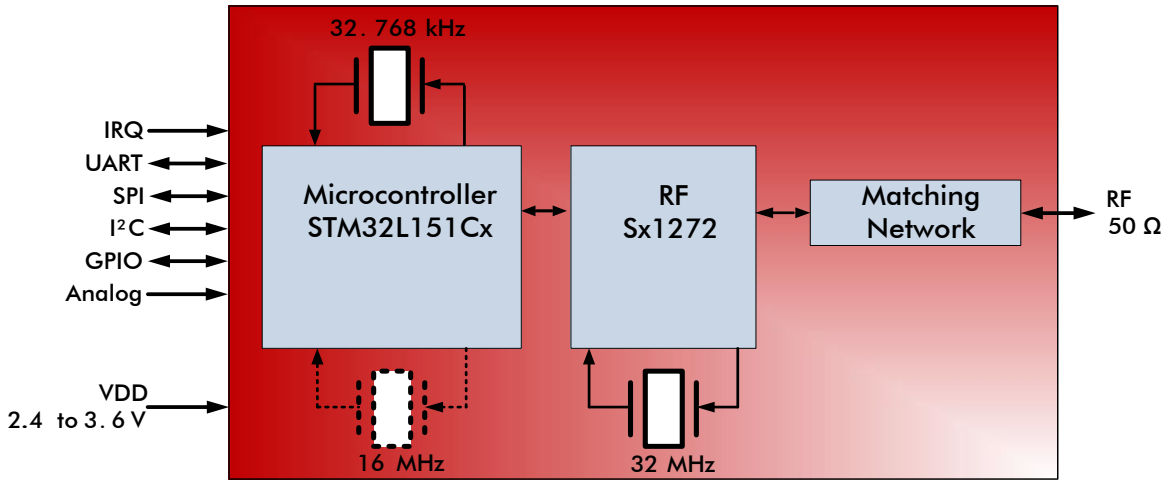

Figure 2-1: Block Diagram of Radio Module iM980B-MBand

The iM980B-MBand 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 iM980B-MBand receive performances are given in the following table.

Signal Bandwidth/[kHz]	Spreading Factor	Sensitivity/[dBm]
125	7	-123
125	12	-137
500	7	-115
500	12	-130

Table 2-1: Typically Radio Performance of iM980B-MBand

This high sensitivity combined with the integrated 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, qualified in accordance to FCC Part 15 and ISED's licence-exempt RSSs.

3. LoRa Modulation Technique

The iM980B-MBand 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.

3.1 Channel Frequencies, Data Rates and Output Power

The iM980B-MBand uses the following channel set up.

3.1.1 LoRaWAN US902-928MHz

- Uplink (Tx) – 64 channels numbered 0 to 63 utilizing LoRa 125 kHz BW varying from DR0 to DR3, using coding rate 4/5, starting at 902.3 MHz and incrementing linearly by 200 kHz to 914.9 MHz. Those channels can be used with max. RF output power.
- Uplink (Tx) – 8 channels numbered 64 to 71 utilizing LoRa 500 kHz BW at DR4 starting at 903.0 MHz and incrementing linearly by 1.6 MHz to 914.2 MHz. Those channels can be used with max. RF output power.
- Downlink (Rx) – 8 channels numbered 0 to 7 utilizing LoRa 500 kHz BW at DR8 to DR13 starting at 923.3 MHz and incrementing linearly by 600 kHz to 927.5 MHz

Data Rate	Settings	Physical Bit Rate [bit/s]
0	LoRa: SF10 / 125 kHz	980
1	LoRa: SF9 / 125 kHz	1760
2	LoRa: SF8 / 125 kHz	3125
3	LoRa: SF7 / 125 kHz	5470
4	LoRa: SF8 / 500 kHz	12500
5:7	For future use	
8	LoRa: SF12 / 500 kHz	980
9	LoRa: SF11 / 500 kHz	1760
10	LoRa: SF10 / 500 kHz	3900
11	LoRa: SF9 / 500 kHz	7000
12	LoRa: SF8 / 500 kHz	12500
13	LoRa: SF7 / 500 kHz	21900
14:15	For future use	

3.1.2 LoRaWAN AU915-928MHz

- Uplink (Tx) – 64 channels numbered 0 to 63 utilizing LoRa 125 kHz BW varying from DR2 to DR5, using coding rate 4/5, starting at 915.2 MHz and incrementing linearly by 200 kHz to 927.8 MHz. Those channels can be used with max. RF output power[1].
- Uplink (Tx) – 8 channels numbered 64 to 71 utilizing LoRa 500 kHz BW at DR6 starting at 915.9 MHz and incrementing linearly by 1.6 MHz to 927.1 MHz. Those channels can be used with max. RF output power.
- Downlink (Rx) – 8 channels numbered 0 to 7 utilizing LoRa 500 kHz BW at DR8 to DR13 starting at 923.3 MHz and incrementing linearly by 600 kHz to 927.5 MHz

Data Rate	Settings	Physical Bit Rate [bit/s]
0	Not used	
1	Not used	
2	LoRa: SF10 / 125 kHz	980
3	LoRa: SF9 / 125 kHz	1760
4	LoRa: SF8 / 125 kHz	3125
5	LoRa: SF7 / 125 kHz	5470
6	LoRa: SF8 / 500 kHz	12500
7	Not used	
8	LoRa: SF12 / 500 kHz	980
9	LoRa: SF11 / 500 kHz	1760
10	LoRa: SF10 / 500 kHz	3900
11	LoRa: SF9 / 500 kHz	7000
12	LoRa: SF8 / 500 kHz	12500
13	LoRa: SF7 / 500 kHz	21900
14:15	Not used	

[1] The highest channel is reduced by 2.6dB

3.1.3 ProLink 902-928MHz

ProLink is a proprietary link. It can be used in P2P or P2multiPoint communication between end devices and can be used in addition to the US902-915MHz and the AU915-928MHz LoRaWAN operating mode.

- Prolink US: Uplink/Downlink (Tx/Rx) – 8 channels LoRa 500 kHz BW with SF7 to SF8 starting at 903.0 MHz and incrementing linearly by 1.6 MHz to 914.2 MHz. Those channels can be used with max. RF output power.
- Prolink AU: Uplink/Downlink (Tx/Rx) – 8 channels LoRa 500 kHz BW with SF7 to SF8 starting at 915.9 MHz and incrementing linearly by 1.6 MHz to 927.1 MHz. Those channels can be used with max. RF output power.

4. Electrical Characteristics

In the following different electrical characteristics of the iM980B-MBand 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

> **Note:** With RF output power level above +16 dBm a minimum distance between two devices should be 1 m for avoiding too large input level.

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)		2.4	3.0	3.6	V
Current Consumption Low Power Mode	RTC off		800		nA
	RTC on		1.85		µA
Current Consumption System IDLE	TRX idle mode, µC idle mode		5		mA
Current Consumption RECEIVE LoRa @500kHz	TRX receive mode, µC sleep mode		13.2		mA
Current Consumption TRANSMIT	TRX transmit mode, µC sleep mode, all µC units off, max. RF power level, 915 MHz		110		mA
MCU operation frequency			32		MHz
			32.768		kHz
Memory (Flash)	iM980B		128		kByte
Flash Memory Endurance	Program memory	10k			Erase/ Write Cycles
	Data memory	300k			
Memory (RAM)	iM980B		32		kByte

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)	2.4 V < VDD < 2.7 V, 4 mA (max)	VDD -0.45	-	-	V
	2.7 V < VDD < 3.6 V, 8 mA (max)	VDD -0.4			
Digital output voltage (low level)	2.4 V < VDD < 2.7 V, 4 mA (max)	-	-	0.45	V
	2.7 V < VDD < 3.6 V, 8 mA (max)	-		0.4	
Digital input voltage (high level)	VDD = 2.4 V to 3.6 V, CMOS	0.45 VDD+0.38	-	-	V
	VDD = 2.4 V to 3.6 V, CMOS, 5 V tolerant	0.39 VDD+0.59	-	-	V
	BOOT0	0.15 VDD+0.56	-	-	V
Digital input voltage (low level)	VDD = 2.4 V to 3.6 V	-	-	0.3 VDD	V
	BOOT0	-	-	0.14 VDD	V
UART baud rate			115.2		kbps
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

Please refer to chapter 3.1

4.4.2 Transmitter RF Characteristics

The iM980B has an excellent transmitter performance as given by Table 4-4. 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.), 915 MHz if nothing else stated

Parameter	Condition	Min	Typ.	Max	Unit
Frequency Range		902	-	928	MHz
RF Output Power (conducted)	915 MHz Band		18.5	19.5	dBm
Modulation Techniques	LoRa®				
TX Frequency Variation vs. Temperature	-40 to +85°C	-	±12	-	kHz
TX Power Variation vs. Temperature		-	±0.5	-	dB

Table 4-4: Transmitter RF Characteristics

Note: The antenna has to be matched with a maximum VSWR of 3:1.

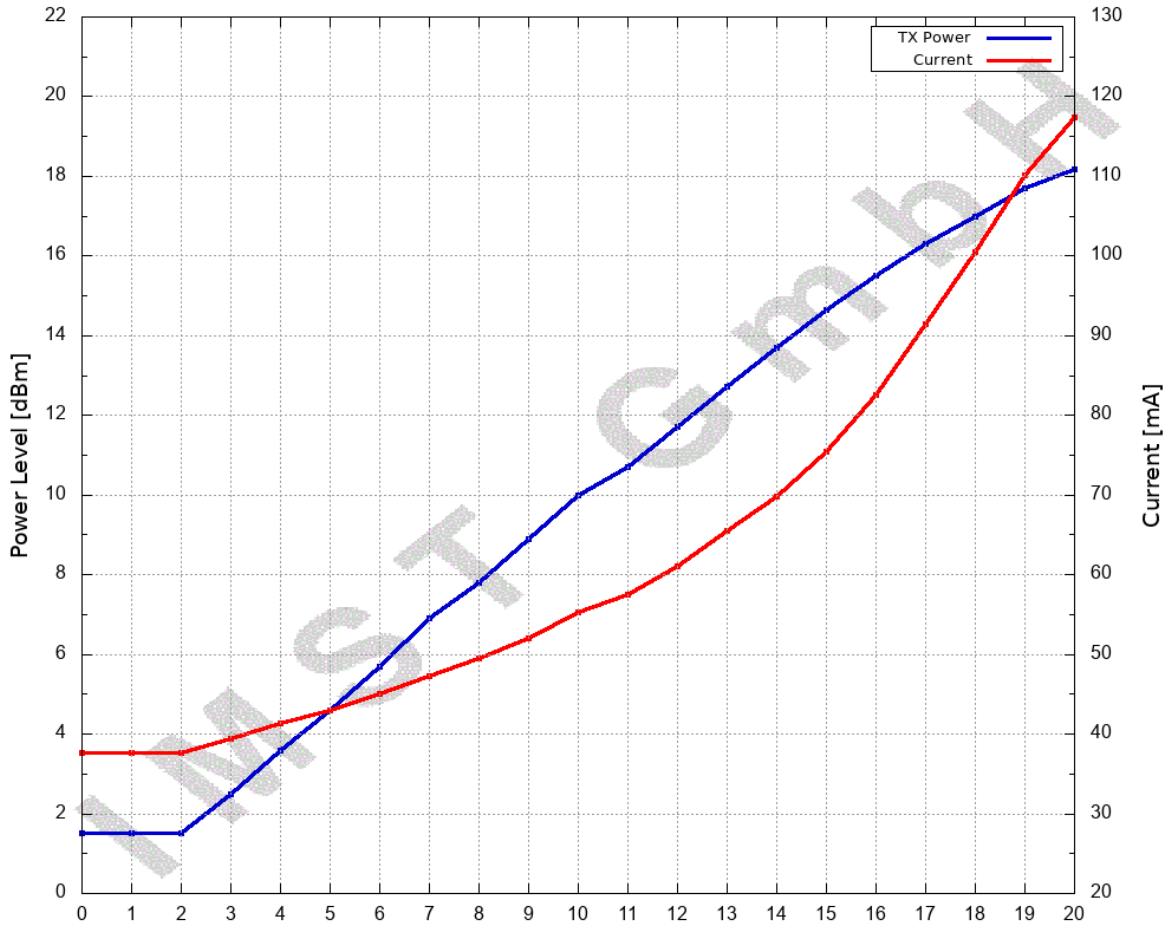

Figure 4-1: RF output power level and current consumption versus power stages from 1 to 20 @ room temperature and 915 MHz

5. Module Package

In the following the iM980B-MBand module package is described. This description includes the iM980B-MBand 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 iM980B-MBand'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.

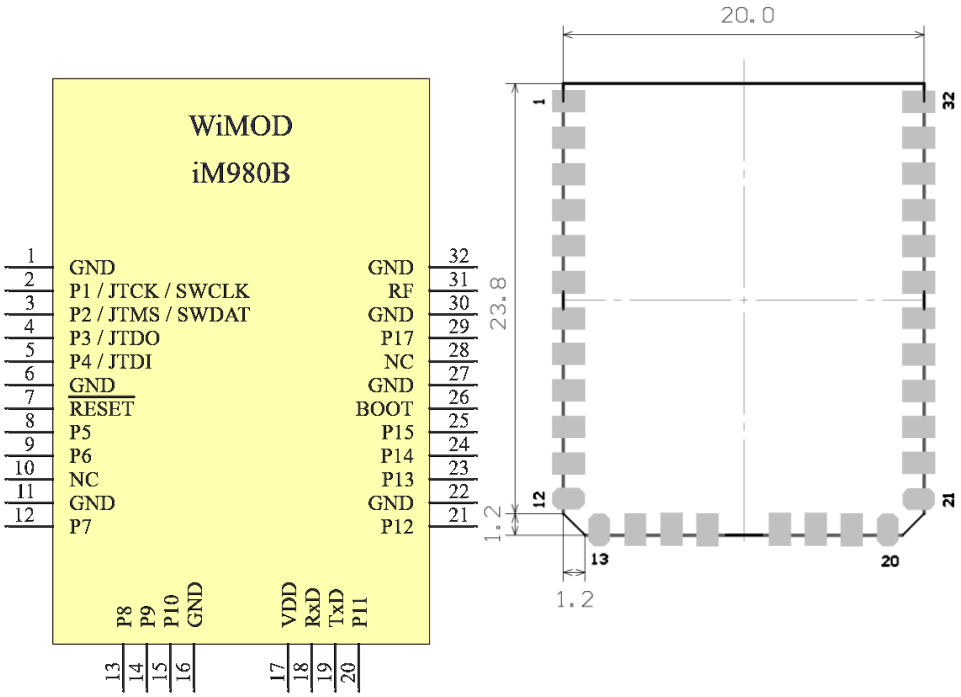

Figure 5-1: Description of iM980B-MBand module pins and top view

PIN	PIN Name	PIN Type	MCU Pin (number)	5 V Tolerance	Description
1	GND	Supply		-	Ground connection
2	P1	D IN/OUT	PA_14 (P37)	Yes	Digital IO / JTCK / SWCLK
3	P2	D IN/OUT	PA_13 (P34)	Yes	Digital IO / JTMS / SWDIO
4	P3	D IN/OUT	PB_3 (P39)	Yes	Digital IO / JTDO
5	P4	D IN/OUT	PA_15 (P38)	Yes	Digital IO / JTDI
6	GND	Supply		-	Ground connection
7	nReset	D IN	NRST (P7)	No	NReset, internally pulled-up by 47 kΩ
8	P5	D IN/OUT	PA_11 (P32)	Yes	Digital IO / USART1-CTS
9	P6	D IN/OUT	PA_12 (P33)	Yes	Digital IO / USART1-RTS
10	NC	NC		-	Should be NC
11	GND	Supply		-	Ground connection
12	P7	D IN/OUT, A IN	PB_14 (P27)	Yes	Digital IO / SPI2_MISO / ADC_IN20
13	P8	D IN/OUT, A IN	PB_15 (P28)	Yes	Digital IO / SPI2_MOSI / ADC_IN21
14	P9	D IN/OUT, A IN	PB_13 (P26)	Yes	Digital IO / SPI2_CLK / ADC_IN19
15	P10	D IN/OUT, A IN	PB_12 (P25)	Yes	Digital IO / SPI2_NSS / ADC_IN18
16	GND	Supply		-	Ground connection
17	VDD	Supply		-	Supply voltage
18	RxD	D IN/OUT	PA_10 (P31) PB_6 (P42)	Yes	Digital IO / USART1-RX
19	TxD	D IN/OUT	PA_9 (P30)	Yes	Digital IO / USART1-TX
20	P11	D IN/OUT	PA_8 (P29)	Yes	Digital IO
21	P12	D IN/OUT	PB_8 (P45)	Yes	Digital IO / I2C1-SCL
22	GND	Supply		-	Ground connection
23	P13	D IN/OUT	PB_9 (P46)	Yes	Digital IO / I2C1-SDA
24	P14	D IN/OUT, A IN	PA_1 (P11)	Yes	Digital IO / ADC_IN1
25	P15	D IN/OUT, A_IN	PA_0 (P10)	Yes	Digital IO / WKUP1 / ADC_IN0
26	P16	D IN	BOOT0 (P44)	No	Bootloader Pin 0, internally pulled-down by 47 kΩ
27	GND	Supply		-	Ground connection
28	NC	NC		-	This pin should be left unconnected
29	P17	D IN/OUT, A IN	PA_3 (P13)	No	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: iM980B-MBand Pinout Table

5.2 Module Dimensions

The outer dimensions of the iM980B-MBand are given by Figure 5-2 and Figure 5-3.

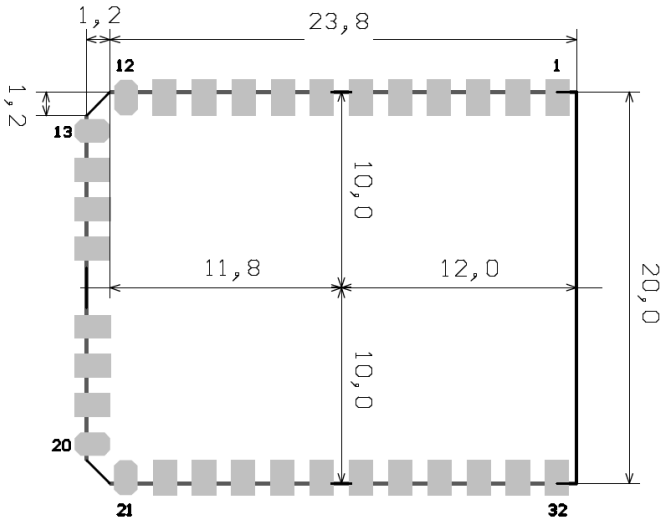

Figure 5-2: Outer Dimensions of the iM980B-MBand (top view)

5.3 Recommended Footprint

According to Chapter 5.2, a recommendation for the footprint of the iM980B-MBand is given by Figure 5-3.

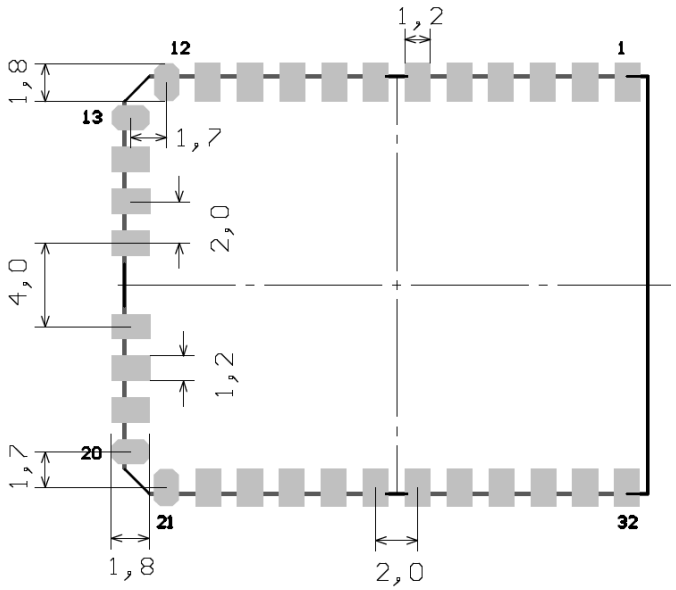

Figure 5-3: Recommended footprint of the iM980B-MBand (top view)

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.

Note: The module offers some IOs that are connected to the JTAG On-chip Debug system. Currently this interface is unavailable[1].

[1] Currently there is a silicon limitation for the MCU of the module. For more information please see: http://www.st.com/resource/en/errata_sheet/dm00097022.pdf (ES0224, V7.0, chapter 2.1.2)

7. Integration Instructions

The iM980B-MBand provides 32 pins as described in Chapter 5. For integrating the iM980B-MBand into an environment, a typically circuit as given in Figure 7-3 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 7.7.

For the host manufacturer it is highly recommended to follow the “Module Integration Guide” (KDB 996369 D04) which is available at the OET Knowledge Database (KDB).

Since the iM980B-MBand is only FCC authorized for the rule parts given by the present document (also listed one the grant), the host manufacturer is responsible for compliance to any other FCC rules that apply to the host including additional testing requirements.

7.1 Labelling Requirements for Host Device

The host device shall be properly labelled to identify the modules within the host device. The certification label of the module shall be clearly visible at all times when installed in the host device, otherwise the host device must be labelled to display the FCC ID/IC ID of the module, preceded by the words "Contains transmitter module", or the word "Contains", or similar wording expressing the same meaning, as follows:

Contains FCC ID: Q9B-IM980B

Contains IC: 10740A-IM980B

7.2 Host Device User Manual

The host device manufacturer need add additional information in their user manual. These need to contain:

- The antenna should be installed and operated with minimum distance of 20 cm between the radiator and your body.
- This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.
- If the host device is being Part 15 Subpart B compliant, the user manual of the host device need to provide a notice, that the final host product still requires Part 15 Subpart B compliance testing with the iM980B-MBand.

7.3 Common PCB Design Recommendations

The Top Layer of the carrier board should be kept free of Tracks and Vias under the iM980B-MBand 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.

RF Impedance need to follow the recommendations and is typically based on 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 7-1). The target impedance is 50 Ohms.

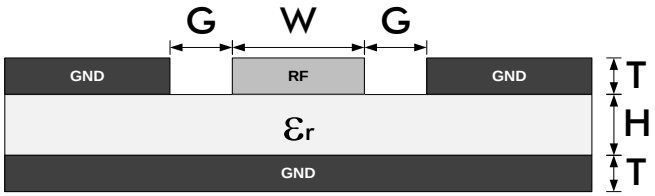

Figure 7-1: Structure of a grounded CPWG

The parameters need to be as follows:

- G = 0.15 mm
- W = 0.6 mm
- Layer-Stack dimensions according to Table 5-1
- All Vias shall be characterized by a diameter of 0.6 mm and hole size of 0.3 mm

Layer	Name	Material	Thickness	Constant
	Silkscreen Top			
	Top Solder	Solder Resist (tol. +/- 10um)	0,020mm	3,5
1	Top Layer	Copper	0,035mm	
	FR4	(eps-r tol. +/- 0.3; thickness tol. +/- 40um)	1,500mm	4,3
2	Bottom Layer	Copper	0,035mm	
	Bottom Solder	Solder Resist (tol. +/- 10um)	0,020mm	3,5
	Silkscreen Bottom			

Table 7-1: Dimensions of PCB Layer Stack

7.4 Integration Procedures

The integrator need to follow exactly the design requirements hereunder:

- A power supply regulator for the radio module, to supply the radio module with a voltage as required by Table 4-1 as shown in the reference schematic Figure 7-3
- Trace antenna requirements according to chapter 7.5

Otherwise the integrator needs to do a "Change-In-ID", which needs to be initially requested at IMST GmbH via the contact data at the end of the document. The procedure need to be followed by a "Class II Permissive Change" application.

7.5 Trace Antenna Requirements

This module can only be used with a host antenna circuit trace layout design in strict compliance with the OEM instructions provided. Modular approval considers a mono-pole-antenna design described by the parameters hereunder:

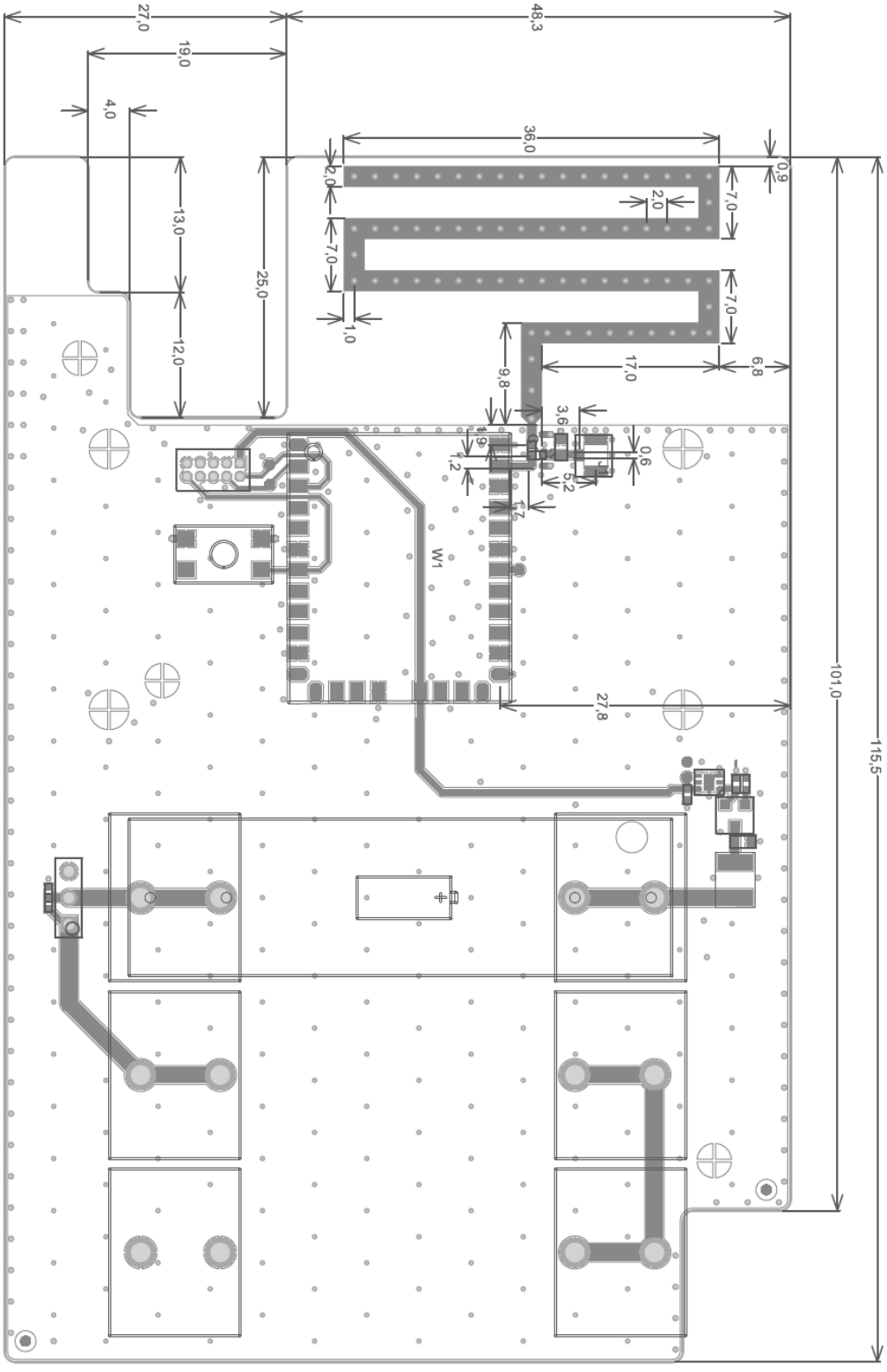

Figure 7-2: Dimensions (in mm) of the antenna

Component	Type	Manufacturer	P/N
C1	Capacitor	Murata	GCM31A5C3A680FX01D
C2	Capacitor	Murata	GCM31A5C3A680FX01D
J1	U.FL Connector	Hirose	U.FL-R-SMT-1(10)

Table 7-2: Part List (BOM) for the antenna circuit

Integrator need to verify radiation parameters (TRP, effective gain) in the host device to verify antenna characteristics. Therefore, the test functions of the provided firmware can be used as described in [3]. The document is available on request.

7.6 Typical Application Schematic

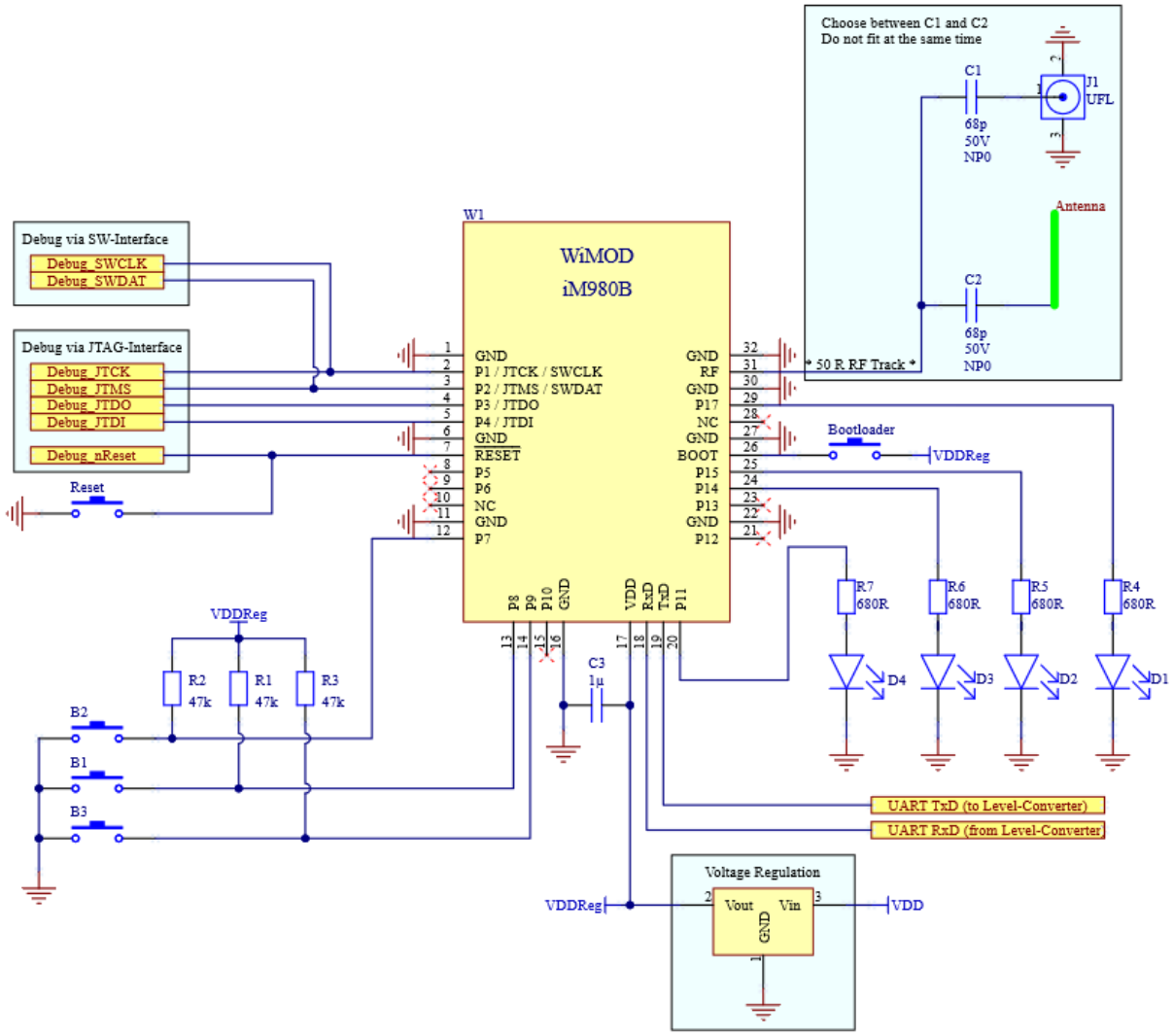

Figure 7-3: Typical Application Schematic for iM980B-MBand

7.7 Recommended Soldering Conditions

An example of the temperature profile for the soldering process of the iM980B-MBand is depicted in Figure 7-4 with the corresponding values as given by Table 7-3. The temperature values should not exceed the limits.

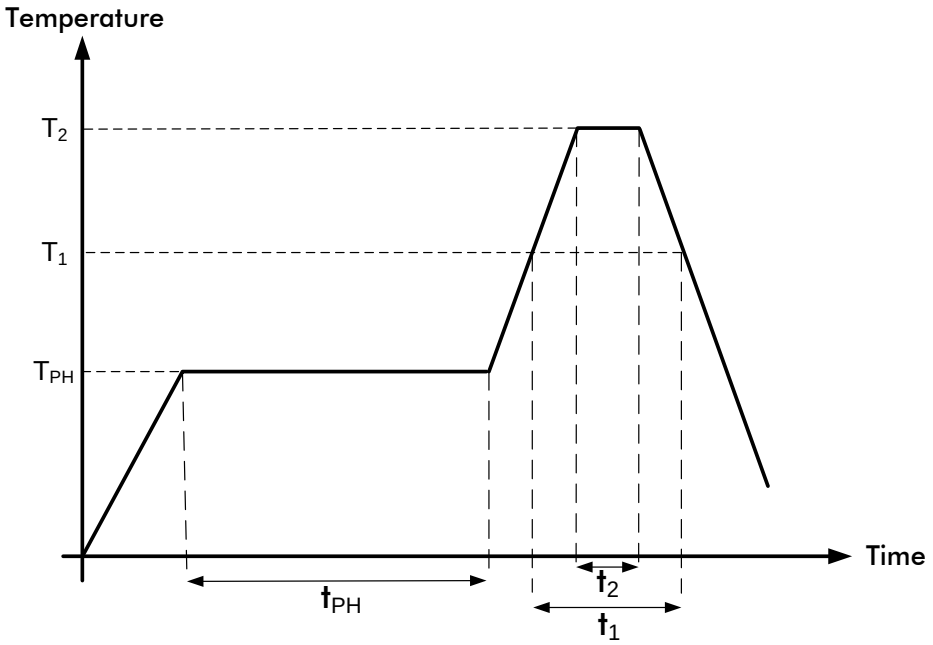

Figure 7-4: Soldering Profile

Phase	Pb-Free Conditions
Preheating	t_{PH} = 120s T_{PH} = 160~180°C
Primary heat	t_1 = 60s T_1 = 220°C
Peak	t_2 = 10s (max) T_2 = 255°C

Table 7-3: 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. Regulatory Compliance Information

The iM980B-MBand complies with part 15 of the FCC rules and Industry Canada license-exempt RSS standards.

8.1 FCC Regulatory Notices

The iM980B-MBand module has received Federal Communications Commission (FCC) CFR47 Telecommunications, Part 15 Subpart C modular approval in accordance with Part 15.212 Modular Transmitter Statement about FCC.

The iM980B-MBand is authorized for FCC rules of Part §15.247 for specific band access.

Modification Statement

IMST GmbH has not approved any changes or modifications to this device by the user. Any changes or modifications could void the user's authority to operate the equipment.

Interference Statement

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Wireless Notice

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. The antenna should be installed and operated with minimum distance of 20 cm between the radiator and your body. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

Permitted Antenna

This radio transmitter iM980B-MBand has been approved by FCC to operate with the antenna types listed below with the maximum permissible gain indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Type	Max Gain
PCB maeander-antenna	1.7 dBi

8.2 Industry Canada Statement

This device complies with ISED's licence-exempt RSSs. Operation is subject to the following two conditions:

1. This device may not cause harmful interference, and
2. this device must accept any interference received, including interference that may cause undesired operation.

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be chosen so that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication.

Radiation Exposure Statement

This equipment complies with ISED radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with greater than 20 cm between the radiator & your body.

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.

Le présent appareil est conforme aux CNR d' ISED applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes:

1. le dispositif ne doit pas produire de brouillage préjudiciable, et
2. ce dispositif doit accepter tout brouillage reçu, y compris un brouillage susceptible de provoquer un fonctionnement indésirable.

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radio électrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante.

Déclaration d'exposition aux radiations

Cet équipement est conforme aux limites d'exposition aux rayonnements ISED établies pour un environnement non contrôlé. Cet équipement doit être installé et utilisé à plus de 20 cm entre le radiateur et votre corps.

9. Ordering Information

Ordering Part Number	Description	Distributor
iM980B-MBand	Radio Module 128 KB Flash, 32 KB RAM, 16 MHz MCU crystal	sales@imst.de
AB – iM980B-MBand	2x Adapter Board with iM980B-MBand	sales@imst.de

Table 9-1: Ordering Information

10. Appendix

10.1 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

10.2 List of Figures

Figure 1-1: Picture of iM980B-MBand 4
Figure 2-1: Block Diagram of Radio Module iM980B-MBand 5
Figure 4-1: RF output power level and current consumption versus power stages from 1 to 20 @ room temperature and 915 MHz 13
Figure 5-1: Description of iM980B-MBand module pins and top view 14
Figure 5-2: Outer Dimensions of the iM980B-MBand (top view) 16
Figure 5-3: Recommended footprint of the iM980B-MBand (top view) 16
Figure 7-1: Structure of a grounded CPWG 19
Figure 7-2: Dimensions (in mm) of the antenna 20
Figure 7-3: Typical Application Schematic for iM980B-MBand 21
Figure 7-4: Soldering Profile 22

10.3 List of Tables

Table 2-1: Typically Radio Performance of iM980B-MBand 5
Table 4-1: Absolute Maximum Ratings 9
Table 4-2: General Characteristics 10
Table 4-3: Module Interface Characteristics 11
Table 4-4: Transmitter RF Characteristics 12
Table 5-1: iM980B-MBand Pinout Table 15
Table 7-1: Dimensions of PCB Layer Stack 19
Table 7-2: Part List (BOM) for the antenna circuit 21
Table 7-3: Recommended Soldering Parameter for Temperature and Timing 22
Table 9-1: Ordering Information 26

10.4 References

[1] Semtech Sx1272 Data Sheet from www.semtech.com
[2] LoRaWAN_Regional_Parameters from www.lora-alliance.org
[3] WiMOD LoRaWAN EndNode Modem Test Mode HCI Specification

11. Important Notice

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