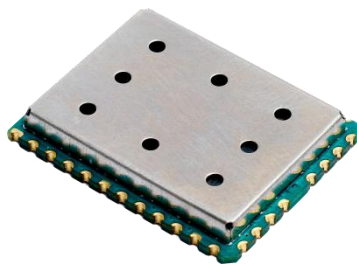# WiMOD iM282A

Datasheet Version 1.0

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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 iM282A.

Table of Contents

1.   Introduction

The iM282A is a compact, low power, bidirectional radio module for the 2.4 GHz 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 iM282A 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.
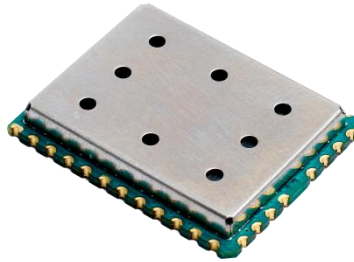
Figure 1-1: Picture of iM282A

1.1   Key Features

- Compact module 20.0 x 25.0 x 3.3 mm
- LoRa™, FLRC, FSK modulation
- Sensitivity down to -130 dBm
- UART, SPI and I²C interface
- Digital inputs and outputs
- Analog inputs
- Supply voltage range from 1.8 to 3.6 V
- RF interface optimized to 50 Ω
- Output power level up to +12 dBm
- High link budget up to 142 dB
- Range more than 12,000 m (LoS[1])
- Powerful Cortex M3
- Pre-Certified according to EN 300 328

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.

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[1] LoS: Line of Sight

2.   Module Overview

The iM282A is an ultra-long range, high-performance, pre-certified module for wireless communication. It operates in the license free 2.4 GHz ISM frequency band and includes all necessary passive components for wireless communication as depicted in the following figure.
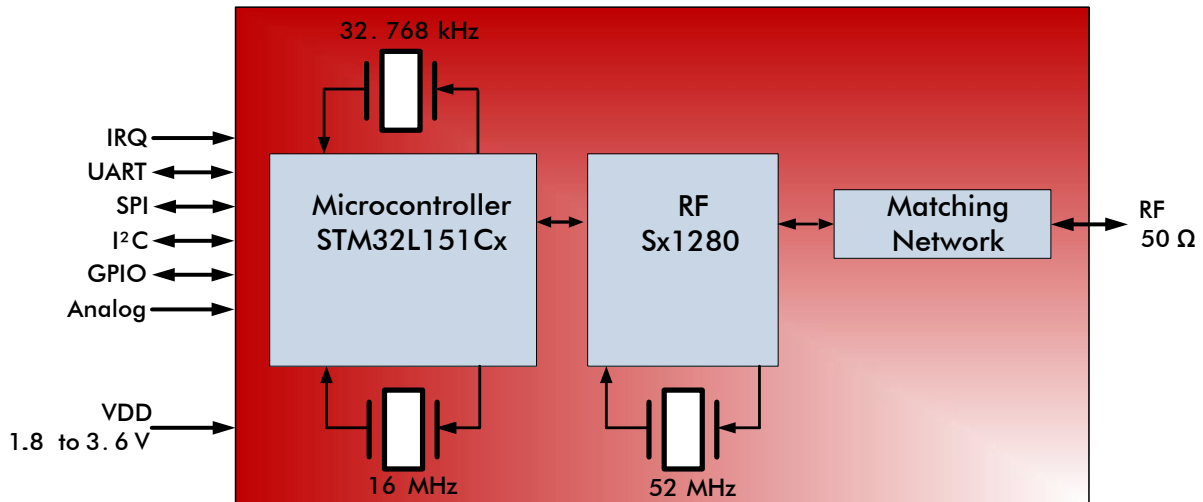
Figure 2-1: Block Diagram of Radio Module iM282A

The iM282A uses Semtech's LoRa^{TM} as well as FLRC (Fast Long Range Communication) modulation technique which combine 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 iM282A receive performances are given in the following table.

Signal Bandwidth [kHz]	Spreading Factor	Sensitivity [dBm]
203	5	-109
203	12	-130
406	5	-105
406	12	-127
812	5	-103
812	12	-126
1,625	5	-99
1,625	12	-120

Table 2-1: Typically Radio Performance of iM282A

Additionally to the LoRa^{TM} and FLRC modulation it is possible to use (G)FSK modulation.
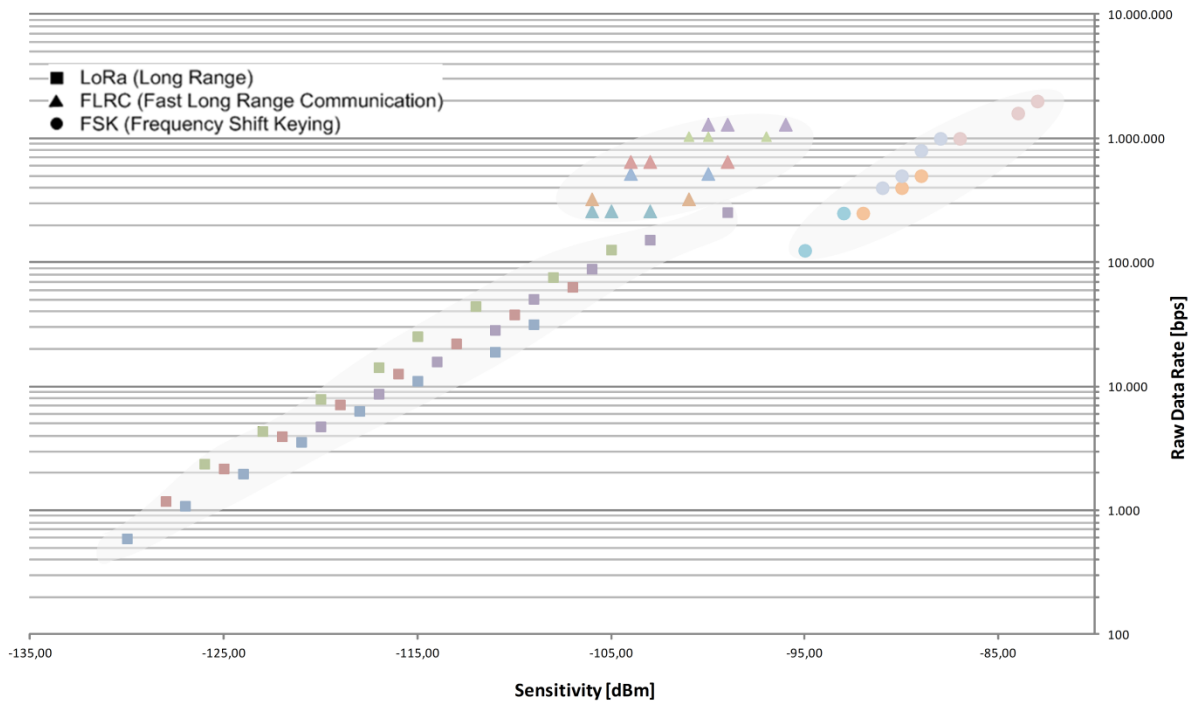
Figure 2-2: Raw Data Rate and Sensitivity for different operation modes

The high sensitivity combined with the maximum output power of +12 dBm yields an 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 EN 300 328.

The wide range of capabilities provided by the iM282A can be tested by using the WiMOD Demo Board (part of the WiMOD Starter Kit).

3.   LoRa Modulation Technique

The iM282A 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 increases the range and robustness of radio communication compared to traditional FSK and OOK modulation.

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

In LoRa^{TM} mode the iM282A offers four bandwidth options of 203 kHz, 406 kHz, 812 kHz and 1,625 kHz with spreading factors ranging from 5 to 12.

The spread spectrum LoRa^{TM} 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 (R_s), 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 is given in the following tables.

Spreading Factor	Chips/Symbol	SNR/[dB]
5	32	Tbd
6	64	Tbd
7	128	Tbd
8	256	Tbd
9	512	Tbd
10	1024	Tbd
11	2048	Tbd
12	4096	Tbd

Table 3-1: Spreading Factors of SX1280

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^{TM} receiver.

To further improve the robustness of the radio link iM282A 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 iM282A

4.   FLRC Modulation Technique

The Fast Long Range Communication (FLRC) modem uses coherent demodulation of GMSK signals with additional forward error correction (FEC) and interleaving techniques. The modulation parameters are accessible by the user and allow high speed communication with an improved link budget of up to 10dB compared to FSK modulation at the same data rate.

4.1   FLRC Modem Bandwidth and Data Rates

The FLRC modem covers data rates from 260 kbps up to 1.3 Mbps with modulation bandwidths from 0.3 MHz to 2.4 MHz. In Table 4-1 the valid combinations of possible data rates and bandwidth are shown.

Symbol	RAW Bit Rate [Mbps]	Bandwidth [MHz]
FLRC_BR_1_300_BW_1_2	1.3	1.2
FLRC_BR_1_040_BW_1_2	1.04	1.2
FLRC_BR_0_650_BW_0_6	0.65	0.6
FLRC_BR_0_520_BW_0_6	0.52	0.6
FLRC_BR_0_325_BW_0_3	0.325	0.3
FLRC_BR_0_260_BW_0_3	0.26	0.3

Table 4-1: Valid FLRC Data Rate and Bandwidth Combinations of iM282A[1]

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[1] Values given by SX1280 datasheet

Optionally a FEC can be used to improve communication performance which leads to the effective bit rates and sensitivities listed in Table 4-2.

Symbol	RAW Bit Rate [Mbps]	Coding Rate	Effective Bit Rate [Mbps]	Sensitivity[1] [dBm]
FLRC_BR_1_300_BW_1_2	1.3	1	1.300	-96
		¾	0.975	-100
		½	0.650	-99
FLRC_BR_1_040_BW_1_2	1.04	1	1.040	-97
		¾	0.780	-100
		½	0.520	-101
FLRC_BR_0_650_BW_0_6	0.65	1	0.650	-99
		¾	0.488	-103
		½	0.325	-104
FLRC_BR_0_520_BW_0_6	0.52	1	0.520	-100
		¾	0.390	-104
		½	0.260	-104
FLRC_BR_0_325_BW_0_3	0.325	1	0.325	-101
		¾	0.195	-106
		½	0.130	-106
FLRC_BR_0_260_BW_0_3	0.26	1	0.260	-103
		¾	0.195	-105
		½	0.130	-106

Table 4-2: Data Rates and Sensitivity of FLRC with FEC of iM282A

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[1] Sensitivity values given by SX1280 datasheet

5.   FSK Modulation Technique

- FSK Modem which supports FSK, GFSK, MSK and GMSK modulations
- Physical layer compatible to BT-LE
- Data rates from 125 kbps to 2 Mbps

Symbol	RAW Bit Rate [Mbps]	Bandwidth [MHz]	Sensitivity[1] [dBm]
FSK_BR_2_000_BW_2_4	2.0	2.4	-83
FSK_BR_1_600_BW_2_4	1.6	2.4	-84
FSK_BR_1_000_BW_2_4	1.0	2.4	-87
FSK_BR_1_000_BW_1_2	1.0	1.2	-88
FSK_BR_0_800_BW_2_4	0.8	2.4	-87
FSK_BR_0_800_BW_1_2	0.8	1.2	-89
FSK_BR_0_500_BW_1_2	0.5	1.2	-90
FSK_BR_0_500_BW_0_6	0.5	0.6	-89
FSK_BR_0_400_BW_1_2	0.4	1.2	-91
FSK_BR_0_400_BW_0_6	0.4	0.6	-90
FSK_BR_0_250_BW_0_6	0.25	0.6	-92
FSK_BR_0_250_BW_0_3	0.25	0.3	-93
FSK_BR_0_125_BW_0_3	0.125	0.3	-95

Table 5-1: Valid FSK Data Rate and Bandwidth Combinations with Sensitivity of iM282A

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[1] Sensitivity values given by SX1280 datasheet

6. Electrical Characteristics

In the following different electrical characteristics of the iM282A are listed. Furthermore details and other parameter ranges are available on request.

> **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.

6.1 Absolute Maximum Ratings

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

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				+0	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 6-1: Absolute Maximum Ratings

6.2　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			0.8		μA
	RTC on			2.0		μA
Current Consumption System IDLE	TRX off mode, μC idle mode			5.0		mA
Current Consumption RECEIVE LoRa	TRX receive mode, μC sleep mode			9.0		mA
Current Consumption TRANSMIT	TRX transmit mode, μC sleep mode	Power Setting 8		25		mA
		Power Setting 11		31		mA
		Power Setting 13		34		mA
MCU operation frequency	HSE Clock			16		MHz
	HSE Clock with PLL Multiplex			32		MHz
	LSE Clock			32.768		kHz
Memory (Flash)	iM282A-L			128		kByte
Flash Memory Endurance	Program memory		10k			Erase/ Write Cycles
	Data memory		300k			
Memory (RAM)	iM282A-L			32		kByte
Notes: 1) If not other stated, all measurement values are obtained based on firmware "WiMOD LRBase+"						

Table 6-2: General Characteristics

6.3   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 < 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)	1.8 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)	BOOT0	0.15 VDD+0.56	-	-	V
	5 V tolerant IOs	0.39 VDD+0.59	-	-	V
	Other IOs	0.45 VDD+0.38	-	-	V
Digital input voltage (low level)	BOOT0	-	-	0.14 VDD	V
	Other IOs	-	-	0.3 VDD	V
UART baud rate			115.2		kbps
Notes: 1) Unless otherwise noted, all voltages are with respect to GND					

Table 6-3: Module Interface Characteristics

6.4   RF Characteristics

6.4.1   Transmitter RF Characteristics

The iM282A has an excellent transmitter performance as given by Table 6-4. For further details, refer to Figure 6-1 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.), 2440 MHz if nothing else stated

Parameter	Condition	Min	Typ.	Max	Unit
Frequency Range		2400	-	2482	MHz
RF Output Power[1]	Power Setting 8		8		dBm
	Power Setting 11		10		dBm
	Power Setting 13		12		dBm
Modulation Techniques	LoRa™, FLRC, FSK				
TX Frequency Variation vs. Temperature	-40 to +85°C	-	±20	-	kHz
TX Power Variation vs. Temperature		-	±0.8	-	dB

Table 6-4: Transmitter RF Characteristics

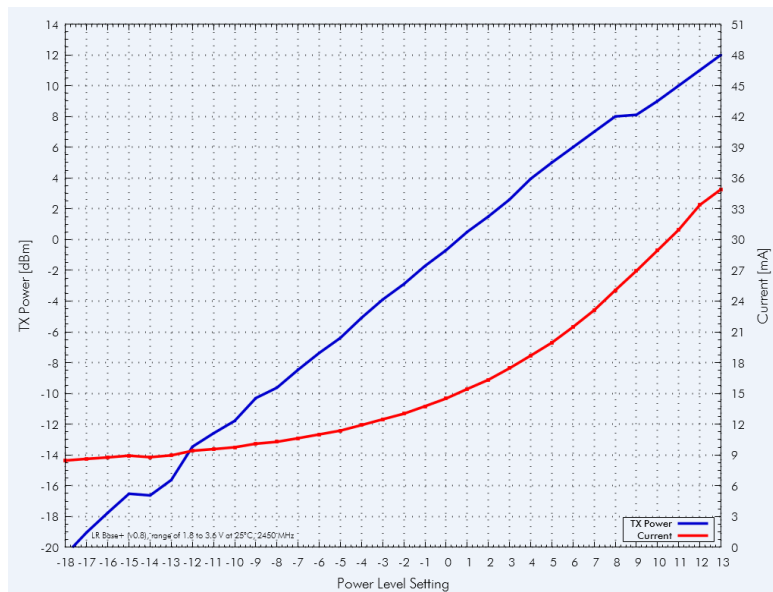**Note:** The antenna has to be matched with a maximum VSWR of 3:1.

Figure 6-1: RF output power level and current consumption[2] versus power stages from -18 to 13 @ 25°C

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[1] For RED compliance the maximum radiated power has to be limited, see chapter 9.2

[2] Current consumption is a mean value of currents though the whole voltage supply range

7. Module Package

In the following the iM282A module package is described. This description includes the iM282A 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.

7.1 Pinout Description

Figure 7-1 depicts a description of the iM282A'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 7-1: iM282A Pinout Table.
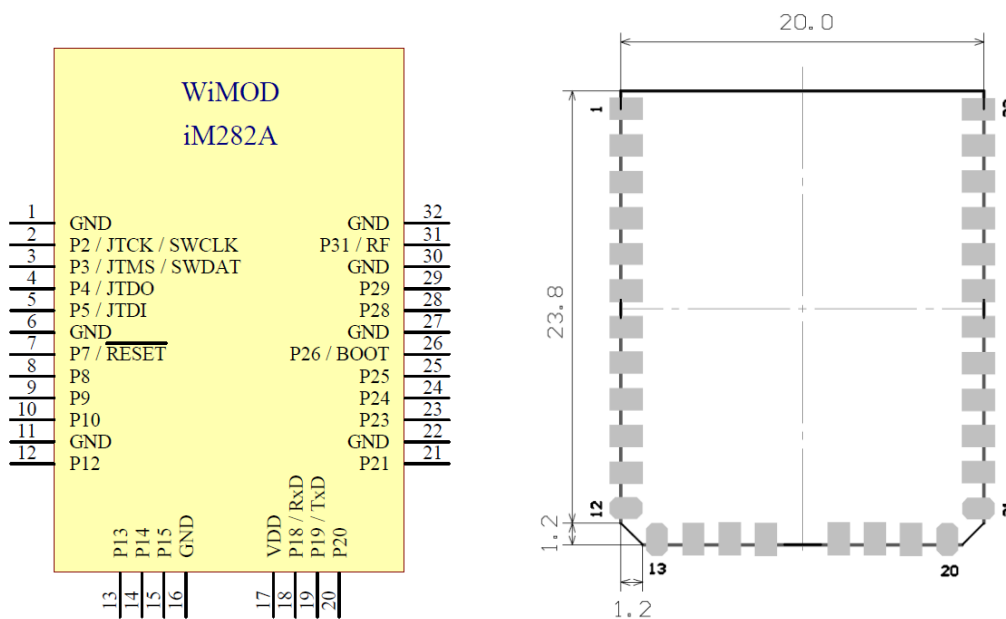
Figure 7-1: Description of iM282A module pins and top view

PIN	PIN Name	PIN Type	MCU Pin (number)	5 V Tolerance	Description
1	GND	Supply		-	Ground connection
2	P2	D IN/OUT	PA_14 (P37)	Yes	Digital IO / JTCK / SWCLK
3	P3	D IN/OUT	PA_13 (P34)	Yes	Digital IO / JTMS / SWDIO
4	P4	D IN/OUT	PB_3 (P39)	Yes	Digital IO / JTDO
5	P5	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	P8	D IN/OUT	PA_11 (P32)	Yes	Digital IO / USART1-CTS
9	P9	D IN/OUT	PA_12 (P33)	Yes	Digital IO / USART1-RTS
10	P10	D IN/OUT	PB7 (P43)	Yes	Digital IO / TIM4_Ch2
11	GND	Supply		-	Ground connection
12	P12	D IN/OUT, A IN	PB_14 (P27)	Yes	Digital IO / SPI2_MISO / ADC_IN20
13	P13	D IN/OUT, A IN	PB_15 (P28)	Yes	Digital IO / SPI2_MOSI / ADC_IN21
14	P14	D IN/OUT, A IN	PB_13 (P26)	Yes	Digital IO / SPI2_CLK / ADC_IN19
15	P15	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	P20	D IN/OUT	PA_8 (P29)	Yes	Digital IO
21	P21	D IN/OUT	PB_8 (P45)	Yes	Digital IO / I2C1-SCL
22	GND	Supply		-	Ground connection
23	P23	D IN/OUT	PB_9 (P46)	Yes	Digital IO / I2C1-SDA
24	P24	D IN/OUT, A IN	PC_13 (P2)	Yes	Digital IO / ADC_IN1
25	P25	D IN/OUT, A_IN	PA_0 (P10)	Yes	Digital IO / WKUP1 / ADC_IN0
26	P26	D IN	BOOT0 (P44)	No	Bootloader Pin 0, internally pulled-down by 47 kΩ
27	GND	Supply		-	Ground connection
28	P28	D IN/OUT, A_IN	PA_2 (P12)	Yes	Digital IO / ADC_IN2, USART2-TX
29	P29	D IN/OUT, A IN	PA_3 (P13)	No	Digital IO / ADC_IN3
30	GND	Supply		-	Ground connection
31	P31	RF		-	External 50 Ω port for monostatic antenna connection
32	GND	Supply		-	Ground connection

Table 7-1: iM282A Pinout Table

7.2   Module Dimensions

The outer dimensions of the iM282A are given by Figure 7-2 and Figure 7-3. The height of the iM282A is typically 3.3 mm.
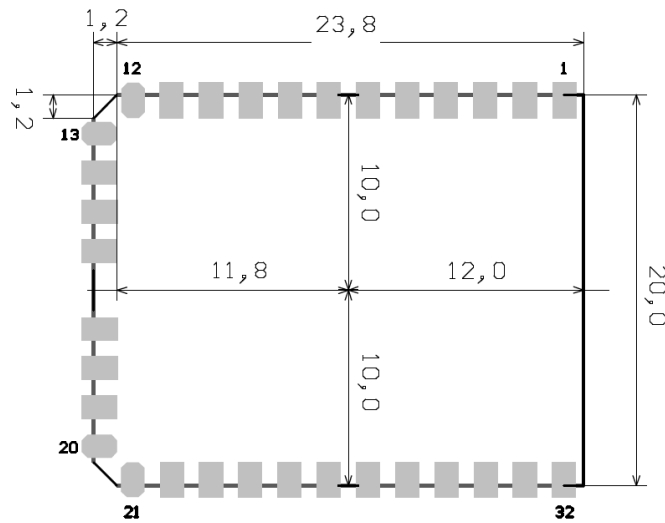
Figure 7-2: Outer Dimensions of the iM282A (top view)

7.3   Recommended Footprint

According to Chapter 7.2, a recommendation for the footprint of the iM282A is given by Figure 7-3.
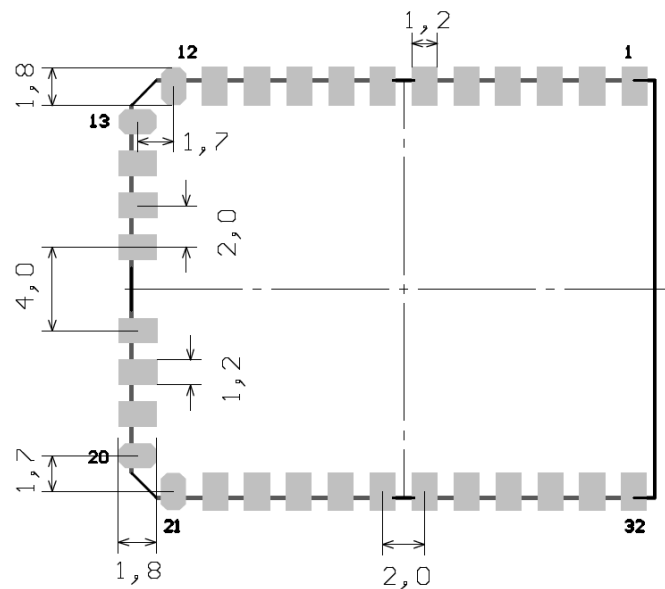
Figure 7-3: Recommended footprint of the iM282A (top view)

8. Module Interface Characteristics

8.1 Programming Interface

For programming the module with special firmware versions, there are two types of interfaces supported: A SWD/JTAG-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].

9. Integration Guide

The iM282A provides 32 connectors as described in Chapter 7. For integrating the iM282A into an environment, a typically circuit as given in Chapter 9.1 can be used. While designing the PCB Layout, the recommendations of Chapter 9.3 should be applied, as well as the recommendation for soldering in Chapter 9.4.

9.1 Typical Application Schematic
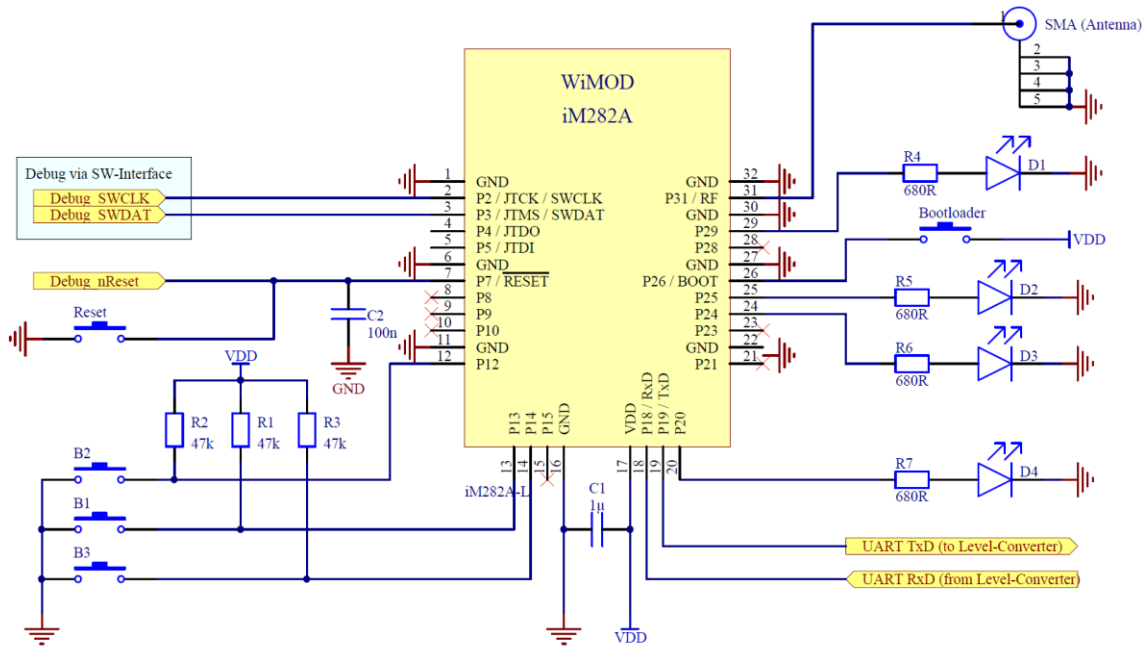
Figure 9-1: Typical Application Schematic for iM282A

9.2 RED-Compliant Settings

RED pre-certification was done based on the WiMOD SK-282A Starter Kit with an antenna giving 0 dBi gain. Due to special requirements of the RED certification the current output power is limited by software to +8 dBm with respect to extreme conditions. The usage of higher output power of up to +12 dBm can be achieved in improving the current software.

9.3   PCB Design Recommendation

The Top Layer of the carrier board should be kept free of tracks and vias under the iM282A 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 iM282A'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 coplanar waveguide with lower ground plane (CPWG) structure, to reduce effects of electromagnetic fields. The impedance of transmission lines 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 9-2).
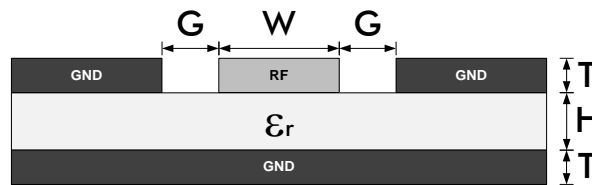

Figure 9-2: Structure of a grounded CPWG

Assuming a frequency of approx. 2.4 GHz, FR4 ($\varepsilon_r \approx 4.3$) as substrate material, copper as conductor material, G = 0.4 mm and T = 35 μm, the recommended width of the transmission line is given by Table 9-1.

H [mm]	W [mm]
1.0	1.4
1.6	1.8

Table 9-1: Recommended width of transmission line[2] for CPWG and 2.4 GHz

For exact dimension definition please contact your PCB supplier.

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

[2] The calculation is only valid if the transmission line is not routed below the iM282A

9.4 Recommended Soldering Conditions

An example of the temperature profile for the soldering process of the iM282A is depicted in Figure 9-3 with the corresponding values as given by Table 9-2. The temperature values should not exceed the limits.
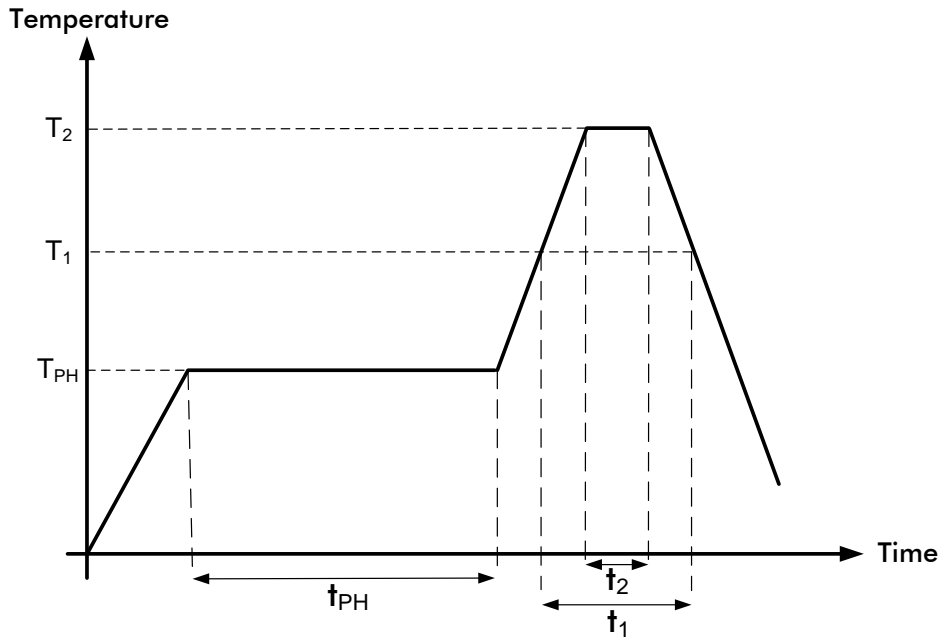

Figure 9-3: Soldering Profile

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

Table 9-2: 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,…

10.   Ordering Information

Ordering Part Number	Description	Distributor
iM282A-L	Radio Module 128 KB Flash, 32 KB RAM, 16 MHz MCU crystal	sales@imst.de
SK – iM282A	Starter Kit for the iM282A. See Notes.	sales@imst.de
AB – iM282A	2x Adapter Board with iM282A	sales@imst.de
Notes: The Starter Kit contains two Demo Boards, two Adapter Boards with iM282A, two antennas, and a CD or USB memory stick with documentation.		

Table 10-1: Ordering Information

11. Appendix

11.1 List of Abbreviations

ADC   Analog-to-Digital Converter

BER   Bit Error Rate

BSC   Basic Spacing between Centers

CPWG   Coplanar Waveguide with Lower Ground Plane

CW   Continuous Wave

FEC   Forward Error Correction

FLRC   Fast Long Range Communication

FSK   Frequency Shift Keying

GFSK   Gaussian Frequency Shift Keying

GMSK   Gaussian Minimum Shift Keying

GND   Ground

GPIO   General Purpose Input/Output

I^2C Inter-Integrated Circuit

MCU   Microcontroller Unit

MSK   Minimum Shift Keying

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

11.2   List of Figures

11.3   List of Tables

11.4   References

[1]   Semtech SX1280 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

12.   Restrictions and Limitations

12.1   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.

12.2   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.

12.3   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.

12.4   Disclaimer

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