WiMOD iM871A

Datasheet

Document ID: 4100/6404/0047

Document Information

File name	iM871A_Datasheet.docx
Created	2011-06-10
Total pages	29

Revision History

Version	Note
0.8	Created, Preliminary Version
0.9	Table 3-2 updated
1.0	Table 4-2 and Chapter 6.3 updated
1.1	Table 3-5 updated
1.2	Table 4-1and Figure 4-2 updated
1.3	Table 3-1and Table 3-3 updated
1.4	Table 3-2and Table 3-4 updated
1.5	Figure 6.1updated, Chapter 7.3 added

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 iM871A.

Table of Contents

1.   Introduction

The iM871A is a compact, ultra low power, bidirectional radio module for the 868 MHz frequency band. Using the iM871A 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.

Especially in combination with the Wireless M-Bus Stack [1], the iM871A is optimal suited for use in Smart Metering Applications, which are compliant to EN 13757 part 4 [2].
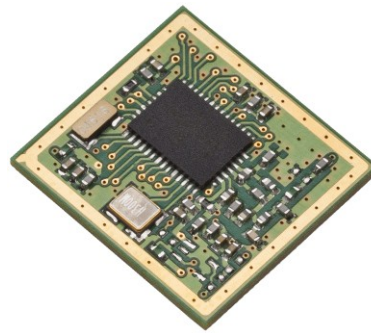
Figure 1-1: Picture of iM871A

1.1   Key Features

- Compact module 16.8 x 18.6 x 2 mm for SMD mounting
- Ultra low power modes for extended battery lifetime
- Communication/Configuration via UART, SPI and I^{2}C 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 +14 dBm
- High link budget up to 130 dB
- Range up to 3000 m (line of sight)
- 64 kByte Flash + 4 kByte RAM Memory
- Pre-Certified according to EN 300 220

1.2   Applications

- Wireless networks
- Metering systems
- Home-, building-, industrial automation
- Remote control
- Wireless sensors
- Telemetry
- …

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

2. Module Overview

The iM871A is an ultra-low-power, high-performance, pre-certified module for wireless communication. It operates in the 868 MHz ISM frequency band and includes all necessary passive components for wireless communication as depicted in Figure 2-1.
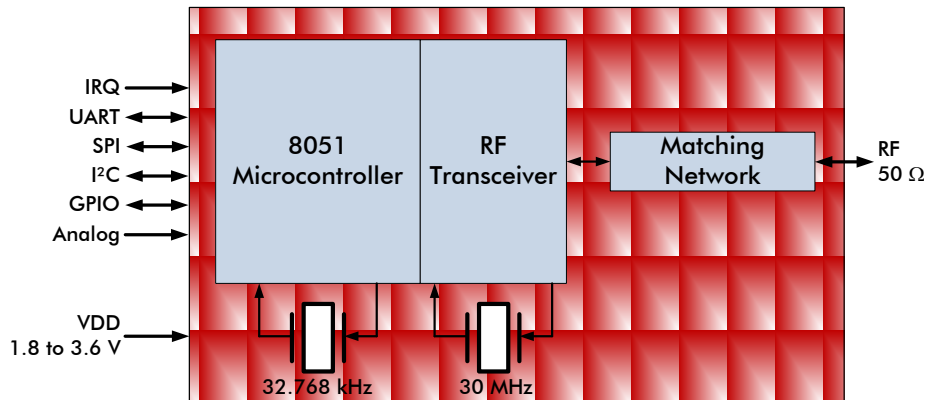

Figure 2-1: Block Diagram of Radio Module iM871A

The iM871A is able to transmit at RF power levels up to +14 dBm with a current consumption of less than 39 mA. In receive mode, the maximum current consumption is less than 19 mA with a sensitivity down to -116 dBm. With a standby current of less than 0.1 μA, the iM871A is optimal suited for battery powered devices while providing an excellent RF performance.

The iM871A provides several useable application interfaces[1]. For serial communication it provides interfaces like UART and SPI. Furthermore it offers up to 17 GPIOs (if not using other interfaces). Except one of the 17 GPIOs, all pins have the capability to be used as analog input to the 10 bit ADC or additionally one external interrupt signal.

For low power consumption, the module supports the capability to periodically wake up from sleep mode to listen for incoming RF packets. The RF data rate of the module is adjustable up to 256 kbps. Decreasing the data rate will increase the sensitivity which results in a longer RF range.

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 300 220-2 V2.1.2. Moreover, with the available firmware for Wireless M-Bus [1], the module is conform to EN 13757-4:2011 D [2].

The wide range of capabilities provided by the iM871A can be tested by using the WiMOD Demo Board (part of the WiMOD Starter Kit).

---

[1] Usability depends on combinational use with the other interfaces

3. Electrical Characteristics

In the following different electrical characteristics of the iM871A 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.

3.1 Absolute Maximum Ratings

Parameter	Condition	Min	Typ.	Max	Unit
Supply Voltage (VDD)		-0.3	-	4.0	V
Storage Temperature		-40	-	+85	°C
Operating Temperature		-20	-	+70	°C
Voltage on any Px-Pin	VDD > 2.2 V VDD ≤ 2.2 V	-0.3 -0.3	-	5.8 VDD + 3.6	V
Voltage on all Reserved Pins		-0.3	-	VDD + 0.3	V
Voltage on P15 acting as external ADC reference voltage (VREF)		0	-	3.6	V
Instantaneous peak voltage on RF Pin		-0.3	-	+8.0	V
Sustained peak Voltage on RF Pin		-0.3	-	+6.5	V
RF Input Power		-	-	+10	dBm
Total Current through VDD or GND		-	-	500	mA
Output Current sunk by $\overline{\text{RST}}$ or any Px Pin		-	-	100	mA
Total Current through all Px Pins		-	-	200	mA
ESD (Human Body Model)	All pins except RF	-	-	2	kV
	RF	-	-	1	kV
ESD (Machine Model)	All pins except RF	-	-	150	V
	RF	-	-	45	V
Notes: 1) Unless otherwise noted, all voltages are with respect to GND					

Table 3-1: Absolute Maximum Ratings

3.2 Global Electrical Characteristics

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

Parameter	Condition	Min	Typ.	Max	Unit
Supply Voltage (VDD)		1.8	3.0	3.6	V
Current Consumption μC IDLE	TRX shut down, μC idle mode,		2.8		mA
Current Consumption Systen SLEEP	TRX shut down, μC sleep mode, RTC off		200		nA
	TRX shut down, μC sleep mode, RTC on		850		nA
Current Consumption System IDLE	TRX idle mode, μC idle mode		4.2		mA
Current Consumption RECEIVE	TRX receive mode, μC sleep mode, all μC units off		18.8		mA
Current Consumption TRANSMIT(Note 4)	TRX transmit mode, μC sleep mode, all μC units off, max. RF power level				
	VDD = 1.8 V		27.5		mA
	VDD = 3.0 V		34.1		mA
	VDD = 3.6 V		36.7		mA
MCU operation frequency			24.5		MHz
			20		MHz
			32.768		kHz
Memory (Flash)			64		kByte
Flash Memory Endurance		1k	30k		Erase/ Write Cycles
Memory (RAM)			4		kByte
Notes: 1) Unless otherwise noted, all voltages are with respect to GND 2) MCT clock frequency equals 24.5 MHz 3) Transmitting of CW at 868.3 MHz 4) Refer to chapter 7 to get details about trasmitted RF power levels					

Table 3-2: General Characteristics

3.3   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) (Note 2)	I = -3 mA	VDD - 0.7	-	-	V
Digital output voltage (low level) (Note 2)	I = -3 mA	-	-	0.6	V
Digital input voltage (high level)	VDD = 1.8 to 2.0 V	0.7 x VDD	-	-	V
	VDD = 2.0 to 3.6 V	VDD - 0.6	-	-	V
Digital input voltage (low level)	VDD = 1.8 to 2.0 V	-	-	0.3 x VDD	V
	VDD = 2.0 to 3.6 V	-	-	0.6	V
Pulse width on $\overline{RST}$ pin	Low active pin	15	-	-	μs
Power on reset delay	VDD = 1.8 to 3.6 V	7	-	15	ms
UART baud rate		-	57.6	57.6	kbps
SPI baud rate	Acting as master	-	6.125	12500	kbps
ADC resolution		-	8 10	-	Bit Bit
Internal Reference Voltage (VREF)		-	1.68	-	V
ADC Input Resistance		-	5	-	kΩ
Notes: 1) Unless otherwise noted, all voltages are with respect to GND 2) High drive strength, Port I/O push-pull					

Table 3-3: Module Interface Characteristics

3.4 RF Characteristics

3.4.1 Receiver RF Characteristics

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

Parameter	Condition	Min	Typ.	Max	Unit
Frequency Range	g1 subband	868.0	-	868.6	MHz
	g2 subband	868.7	-	869.2	MHz
Modulation Techniques	2-FSK				
Sensitivity	BER ≤ 1% 1 kbps, 2-FSK, Deviation: ±30 kHz		-116		dBm
	BER ≤ 1% 4.8 kbps, 2-FSK, Deviation: ±7.2 kHz		-109		dBm
	BER ≤ 1% 10 kbps, 2-FSK, Deviation: ±20 kHz		-108		dBm
	BER ≤ 1% 32.768 kbps, 2-FSK, Deviation: ±80 kHz		-105		dBm
	BER ≤ 1% 100 kbps, 2-FSK, Deviation: ±80 kHz		-102		dBm
	BER ≤ 1% 256 kbps, 2-FSK, Deviation: ±120 kHz		-98		dBm
Notes: 1) The RF perfomance can be affected by the layout of the target board 2) Supporting RF datarates equal to 4.8, 32.768 and 100 kbps the iM871A can operate in all modes of wireless m-Bus [2]					

Table 3-4: Receiver RF Characteristics

3.4.2   Transmitter RF Characteristics

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

Parameter	Condition	Min	Typ.	Max	Unit
Frequency Range	g1 subband	868.0	-	868.6	MHz
	g2 subband	868.7	-	869.2	MHz
RF Output Power (Note 1)	VDD = 3.6 V	+12.5	+13	+14	dBm
RF Data Rate			4.8		kbps
			32.768		kbps
			100		kbps
Modulation Techniques	2-FSK				
Modulation Deviation			±4.8..±7.2		kHz
			±40..±80		kHz
TX Frequency Variation vs. Temperature	-20 to +70°C			±10	ppm
Notes: 1) Depends on output power settings of TRX register 0x6D. RF output power vary over temperature and frequency					

Table 3-5: Transmitter RF Characteristics

4. Module Package

In the following the iM871A module package is described. This description includes the iM871A 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.

4.1 Pinout Description

Figure 4-1 depicts a description of the iM871A's pads on the bottom side. The figure shows the module with its pinout in top view (left figure) and with the module viewed from the bottom side. A detailed description of the individual pins can be found in Table 4-1.
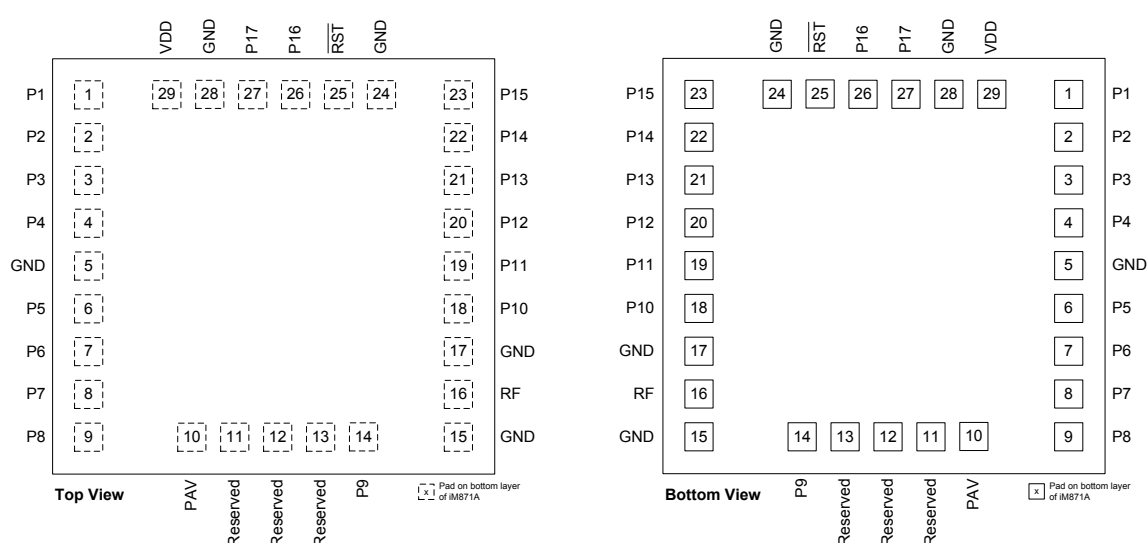

Figure 4-1: Description of iM871A module pins in top (left) and bottom view (right)

PIN	PIN Name	PIN Type	Description
1	P1	D IN/OUT A IN	Digital input or output Analogue input
2	P2	D IN/OUT A IN	Digital input or output Analogue input
3	P3	D IN/OUT A IN	Digital input or output Analogue input
4	P4	D IN/OUT A IN	Digital input or output Analogue input
5, 15, 17, 24 , 28	GND	Supply	Ground connection
6	P5	D IN/OUT A IN	Digital input or output Analogue input
7	P6	D IN/OUT A IN	Digital input or output Analogue input
8	P7	D IN/OUT A IN	Digital input or output Analogue input

9	P8	D IN/OUT A IN	Digital input or output Analogue input
10	PAV	NC	This pin should be left unconnected or tied to GND
11/12/13	Reserved		Pins for special testing
14	P9	D IN/OUT A IN	Digital input or output Analogue input
16	RF	A IN/OUT	External 50 Ω port for monostatic antenna connection
18	P10	D IN/OUT A IN	Digital input or output Analogue input
19	P11	D IN/OUT A IN	Digital input or output Analogue input
20	P12	D IN/OUT A IN	Digital input or output Analogue input
21	P13	D IN/OUT A IN	Digital input or output Analogue input
22	P14	D IN/OUT A IN A GND	Digital input or output Analogue input Analogue GND for ADC
23	P15	D IN/OUT A IN A IN	Digital input or output Analogue input Reference voltage input
25	$\overline{RST}$	D IN/OUT IN/OUT	Open-Drain output of internal POR. A device reset will be initiated by driving this pin low for at least 15 μs. Internally pulled-up to VDD by 4.7 kΩ. C2 Debug Interface (Clock signal)
26	P16	D IN/OUT D IN/OUT	Digital input or output C2 Debug Interface (Data signal)
27	P17	D IN/OUT A IN	Digital input or output Analogue input
29	VDD	Positive supply voltage	Supply

Table 4-1: iM871A Pinout Table

4.2   Internal Module Connection Diagram

The iM871A is based on the Silicon Labs Si1002 single chip microcontroller with an integrated RF transceiver for low power applications. The logical routing between the iM871A pads and the Si1002-Chip is depicted in Figure 4-2. Excepting the Si1002-signals *P1.5* and *P0.6*, all pins *Px.y* can be used as configured by the appropriate firmware.
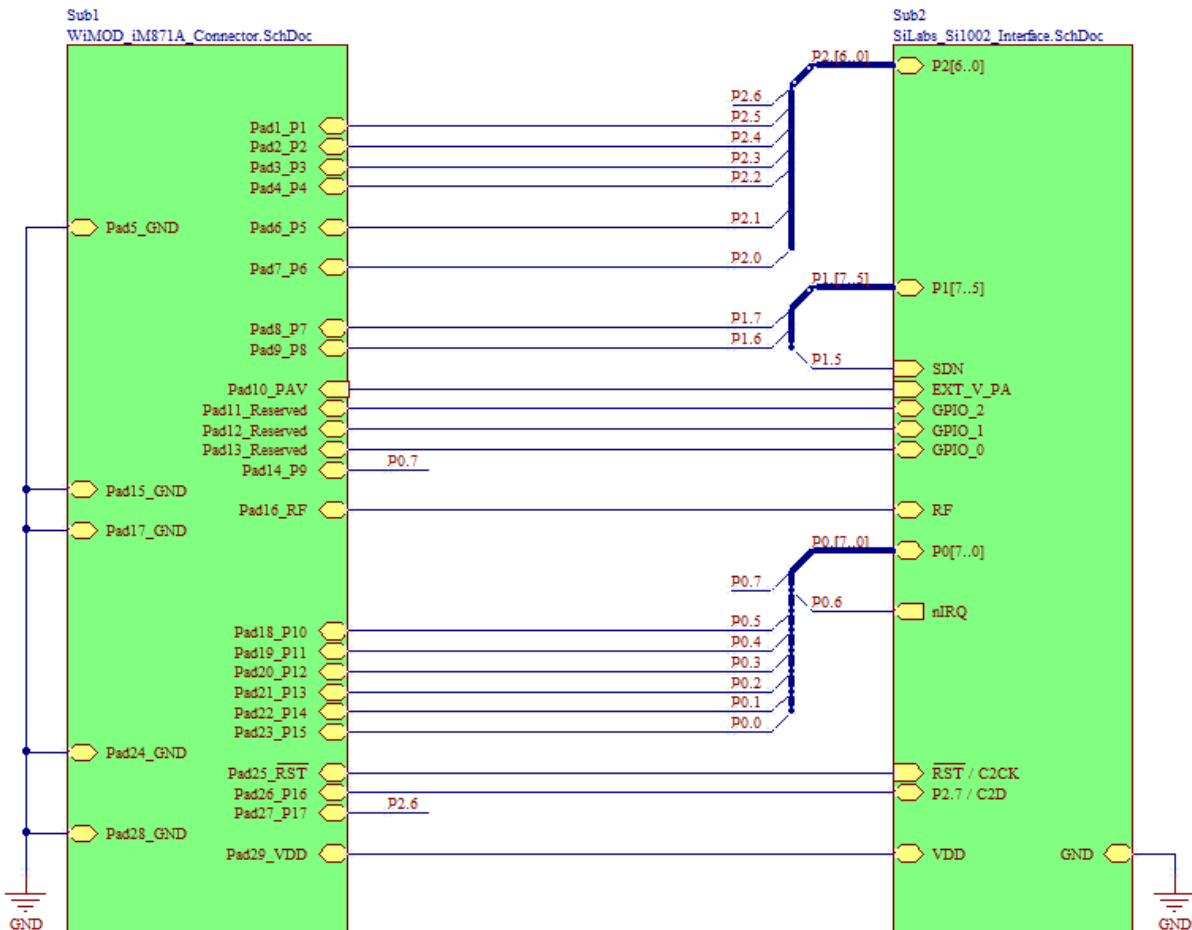

Figure 4-2: Logical routing of the iM871A to the Si1002 single chip

Using the iM871A with special firmware, the Si1002 signal *P1.5* should be used to control the shutdown state of the transceiver. The signal *nIRQ* indicates special events of the transceiver (interrupt signal), which is directly routed to the Si1002-pin *P0.6*.

4.3 Module Dimensions

The outer dimensions of the iM871A are given by Figure 4-3 and Table 4-2. The left figure shows the iM871A in top view, at the right side an overview of the pad arrangement on the bottom side of the module is given. The weight of the iM871A is typically 1 g.

Figure 4-3: iM871A Package Drawing in top (left) and bottom view (right)

Dimension	Min	Typ.	Max.
B	1.2	1.3	1.4
D	16.6	16.8	17.0
D1		15.1 BSC	
D2		10.5 BSC	
D3		8.4 BSC	
e		2.1 BSC	
E	18.4	18.6	18.8
E1		16.8 BSC	
L	1.2	1.3	1.4
L1		0.3	
L2		0.3	
H	-	1.8	-
Notes: 1) All dimensions are in mm, unless otherwise noted 2) All pitches are represented by (e) unless otherwise noted			

Table 4-2: Module Dimensions

4.4   Recommended Footprint

According to Chapter 4.3, a recommendation for the footprint of the iM871A is given by Figure 4-4 and Table 4-3.
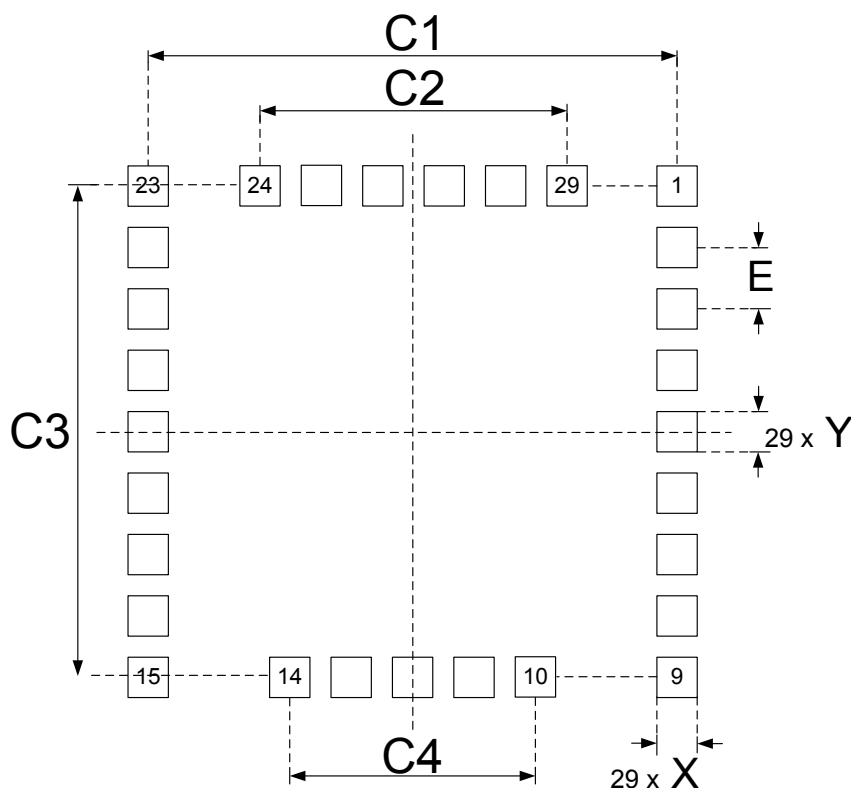
Figure 4-4: iM871A Package Drawing in top (left) and bottom view (right)

Dimension	Value
C1	15.1
C2	10.5
C3	16.8
C4	8.4
E	2.1
X	1.3
Y	1.3
Notes: 1) All dimensions are in mm unless otherwise noted 2) All pitches are represented by (E) unless otherwise noted	

Table 4-3: Dimensions of the recommended land pattern

5. Module Interface Characteristics

5.1 Programming Interface

For updating the firmware of the iM871A, the module provides a special debug interface. Programming of the iM871A requires the Silicon Laboratories USB Debug Adapter[1], which can be connected with a 10-pin ribbon cable to the target board.

Programming the iM871A using the debug adapter requires a connection as depicted in Figure 5-1. Therefore signal P16 should be applied directly to pin 4 and signal $\overline{RST}$ to pin 7 of the programming adapter. The pins 2, 3 and 9 should be GND. All others should be unconnected.
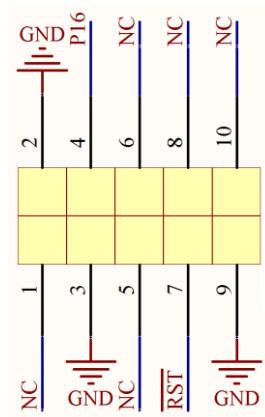
Figure 5-1: Connection of programming connector

5.2 Input / Output Ports

The iM871A provides up to 17 externally usable I/O ports (Px). These ports can be defined as digital inputs or outputs, or analog inputs (except P16). All I/O ports are 5 V tolerant, if used as digital input port or open drain output.

In dependency on the port configuration, the digital I/O ports can be assigned to special digital functions such as digital communication interfaces, hardware timer, counter or comparators.

The integrated 10-bit ADC can be used for converting applied analog signals to the defined ports with up to 300 ksps.

---

[1] For detailed information refer to http://www.silabs.com

5.3   Communication Interfaces

As configured by the appropriate firmware, different communication interfaces are available to use with the defined digital I/O ports. By using some of the following interfaces, the number of useable I/O Ports respectively of analog inputs will decrease.

With the Serial Peripheral Interface (**SPI**) the iM871A is able to communicate with other devices via 3-wire bus (SCK, MISO, MOSI). By using the additional NSS signal for selecting master or slave mode, the iM871A is also able to work in 4-wire mode.

Next a Universal Asynchronous Receiver Transmitter (**UART**) is available to use. This interface supports full duplex mode and is able to act in 8-bit or 9-bit operational mode.

With the **SMBus I/O interface**, the module supports two wire bi-directional serial bus communication. The SMBus is compliant with the **I²C** serial bus and the System Management Bus Specification (Version 1.1).

6.   Integration Guide

The iM871A provides 29 pads on its bottom side as described in Chapter 4. For integrating the iM871A into an environment, a typically circuit as given in Chapter 6.1 can be used. While designing the PCB Layout, the recommendations of Chapter 6.2 should be applied, as well as the recommendation for soldering in Chapter 6.3.
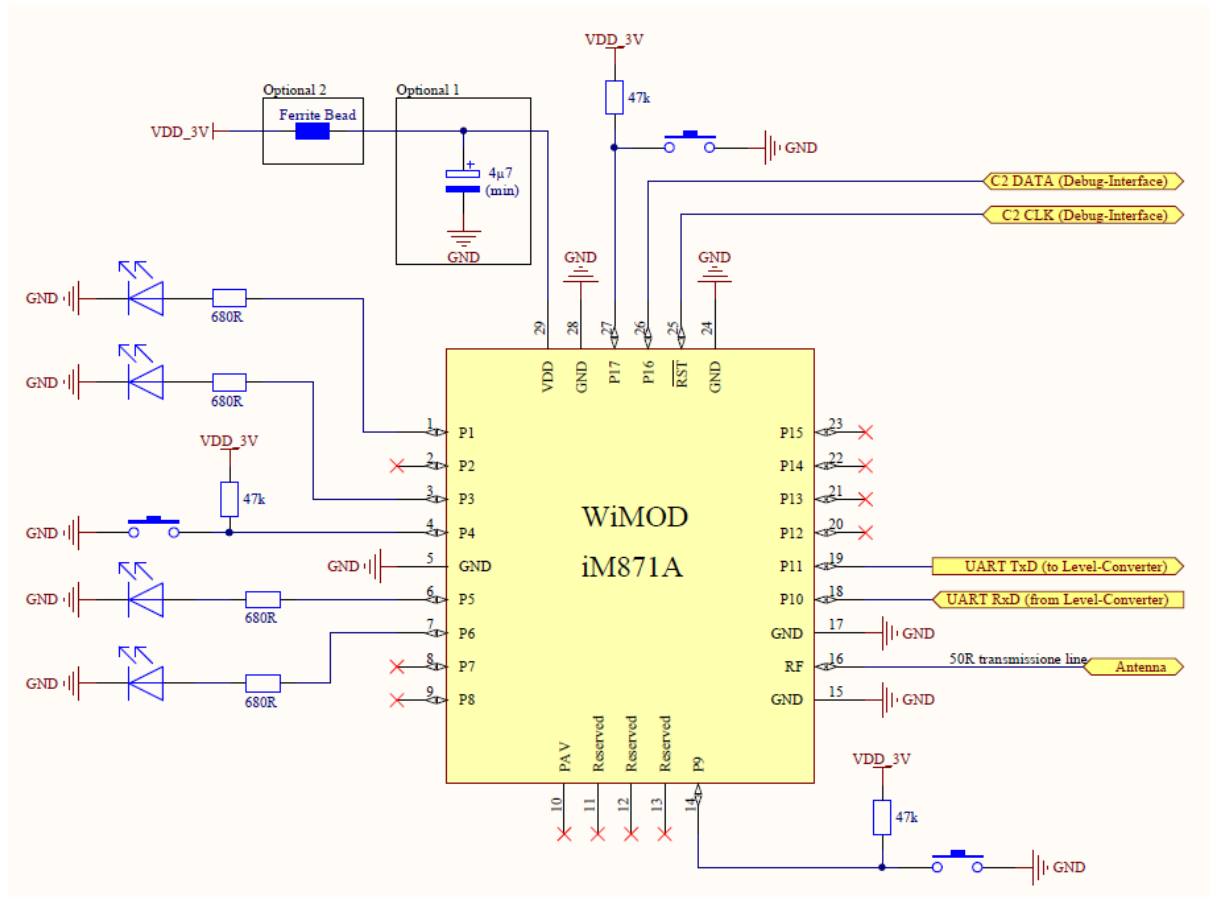
6.1   Typical Application Schematic

Figure 6-1: Schematic of an Example Application

Figure 6-1 shows a schematic of a typical application (e.g. Starter Kit Application). P10 and P11 are used as serial interface and must be connected to a host controller or to a host PC (via a level converter).

P1, P3, P5 and P6 are used as outputs. It must be ensured that the total maximum DC current is not exceeded. P4, P9 and P17 are used as digital inputs.

The RF interface of the module is matched to 50 Ω. By using a 50 Ω antenna, it can be directly connected to module without any additional matching components. In other case, it is recommended to use a special matching network.

P16 and $\overline{RST}$ can be used for updating and debugging the firmware of the iM871A as described in chapter 5.1.

Optional 1: The iM871A is designed for a maximum ripple of the supply voltage of less than 30 mV peak-to-peak. For stable operation mode, the voltage should be stabilized by appropriate circuits and a parallel capacity minimum of 4.7 μF.

Optional 2: In accordance to ESD protection, which is required by R&TTE certification, the usage of a ferrite bead is recommended.

6.2   PCB Design Recommendation

The Top Layer of the carrier board should be kept free of Tracks and Visa under the iM871A 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 iM871A'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 6-2).
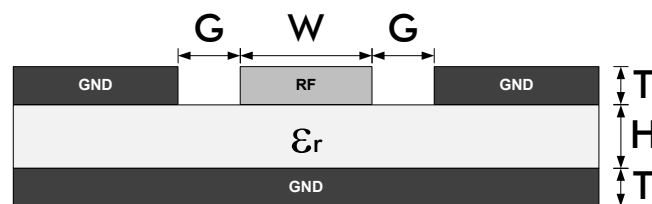

Figure 6-2: Structure of a grounded CPWG

---

[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 μm, the width of transmission line is given by Table 6-1.

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

Table 6-1: Recommended width of transmission line for CPWG and 868 MHz

6.3   Recommended Soldering Conditions

An example of the temperature profile for the soldering process of the iM871A is depicted in Figure 6-3 with the corresponding values as given by Table 6-2. The temperature values should not exceed the limits.
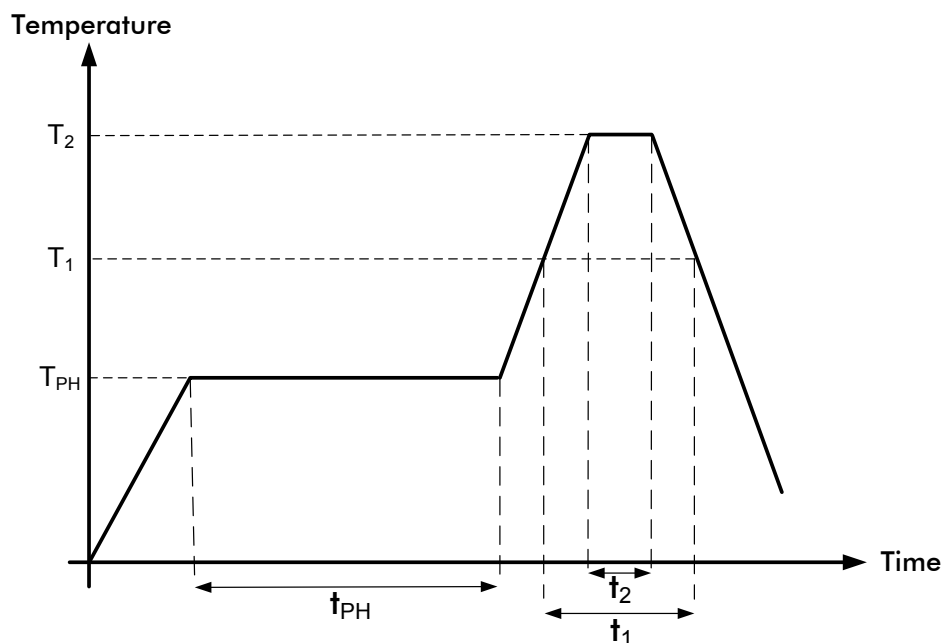
Figure 6-3: Soldering Profile

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

Table 6-2: 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,...

7.   Measurements

7.1   RF Power

Using the iM871A with appropriate firmware and configuration, different simple measurements can be used to measure (RF) performance data of the module.

Configuring the iM871A's transceiver for transmitting a CW signal, the RF output power level and the appendant current consumption can be measured.
Depending on the supply voltage of the iM871A and the configuration of the *TX-Power* register (0x6D) of the Si1002 for different output power level, the results of Figure 7-1 can be measured[1].
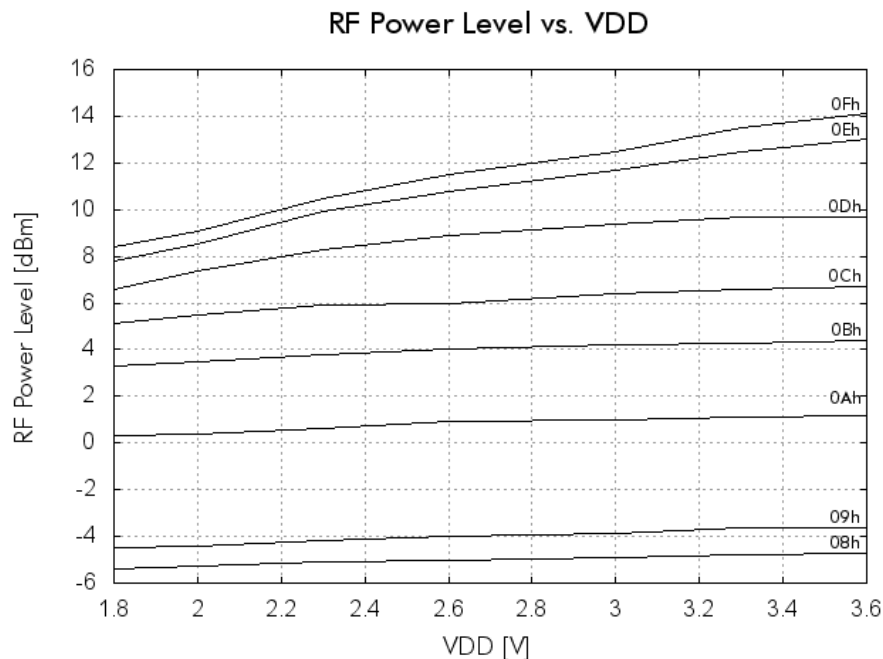
Figure 7-1: Output Power of the iM871A vs. VDD for different TX-Power-Register settings

---

[1] It is required to set the LNA_SW-Bit in transmit-mode

7.2   Current Consumption

While measuring the RF output power level, the current consumption can be obtained as well. Therefore the μC should be set to standby mode. As depicted in Figure 7-2, the iM871A current consumption is less than 38 mA while transmitting a CW with an output power level up to +14 dBm.
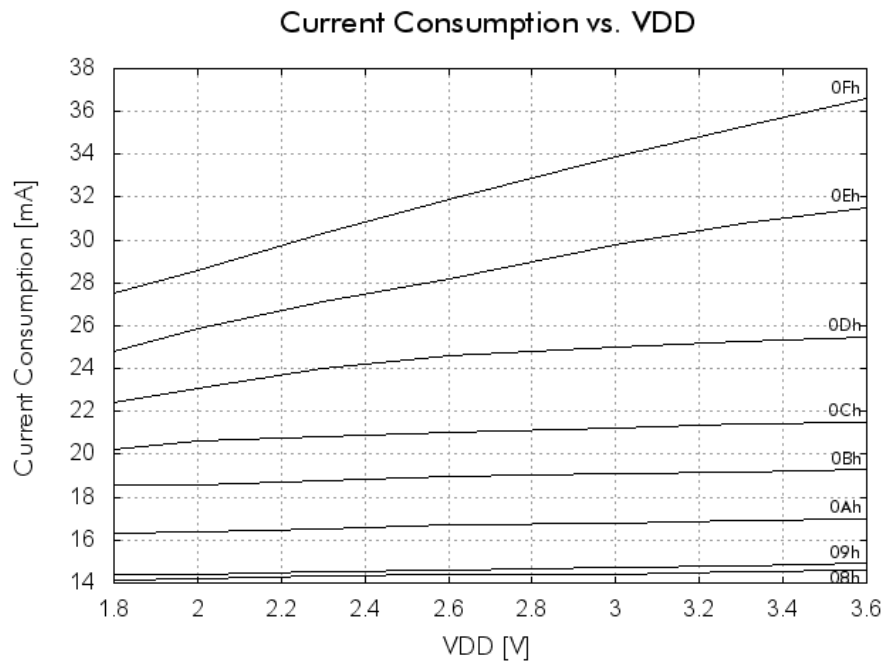
Figure 7-2: Current consumption the iM871A vs. VDD for different TX-Power-Register settings

7.3   RSSI

The RSSI values which can optionally be attached to the HCI messages on received RF telegrams originate from register 0x26 of the radio transceiver. Figure 7-3 shows the relationship between these register rssi values and input power in dBm. Note: the values are not exact, they represent only an estimation. Please refer to the Si1002 datasheet [3] for further details.
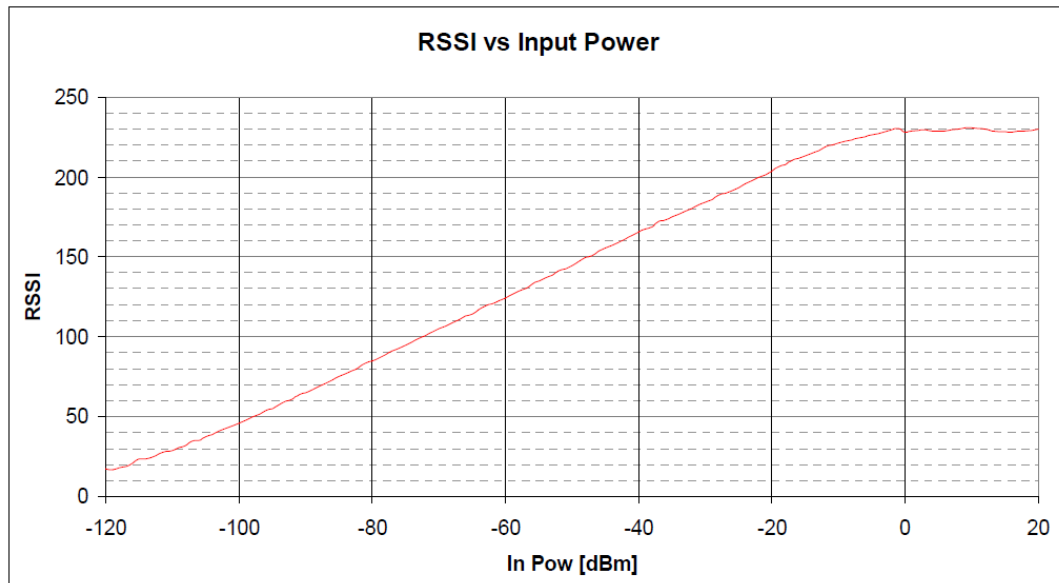
Figure 7-3: RSSI vs. Input Power (Silicon Labs Si1002 datasheet [3])

8.   Ordering Information

Ordering Part Number	Description	Distributor
iM871A	Radio module iM871A	wimod@imst.de
SK – iM871A	Starter Kit for the iM871A. See Notes.	wimod@imst.de
AB – iM871A	2x Adapter Board with iM871A	wimod@imst.de
Notes: The Starter Kit contains two Demo Boards, two Adapter Boards with iM871A, 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]   iM871A Wireless M-Bus User Guide, 2011

[2]   EN13575-4 : 2011
         Communication systems for meters and remote reading of meters

[3]   Silicon Labs Si1000/1/2/3/4/5 datasheet

10. Regulatory Compliance Information

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

The radio module has been designed to be embedded into other products (referred as "final products"). According to the R&TTE directive, the declaration of compliance with essential requirements of the R&TTE directive is within the responsibility of the manufacturer of the final product. A declaration of conformity for the radio module 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 accredited Test Center or to consult the local authorities of the relevant countries.

11. Important Notice

11.1 Disclaimer

IMST GmbH points out that all information in this document is given on an "as is" basis. No guarantee, neither explicit nor implicit is given for the correctness at the time of publication. IMST GmbH reserves all rights to make corrections, modifications, enhancements, and other changes to its products and services at any time and to discontinue any product or service without prior notice. It is recommended for customers to refer to the latest relevant information before placing orders and to verify that such information is current and complete. All products are sold and delivered subject to "General Terms and Conditions" of IMST GmbH, supplied at the time of order acknowledgment.

IMST GmbH assumes no liability for the use of its products and does not grant any licenses for its patent rights or for any other of its intellectual property rights or third-party rights. It is the customer's duty to bear responsibility for compliance of systems or units in which products from IMST GmbH are integrated with applicable legal regulations. Customers should provide adequate design and operating safeguards to minimize the risks associated with customer products and applications. The products are not approved for use in life supporting systems or other systems whose malfunction could result in personal injury to the user. Customers using the products within such applications do so at their own risk.

Any reproduction of information in datasheets of IMST GmbH is permissible only if reproduction is without alteration and is accompanied by all given associated warranties, conditions, limitations, and notices. Any resale of IMST GmbH products or services with statements different from or beyond the parameters stated by IMST GmbH for that product/solution or service is not allowed and voids all express and any implied warranties. The limitations on liability in favor of IMST GmbH shall also affect its employees, executive personnel and bodies in the same way. IMST GmbH is not responsible or liable for any such wrong statements.

Copyright © 2011, IMST GmbH

11.2 Contact Information

IMST GmbH

Carl-Friedrich-Gauss-Str. 2-4
47475 Kamp-Lintfort
Germany

T +49 2842 981 0
F +49 2842 981 299
E wimod@imst.de
I www.wireless-solutions.de