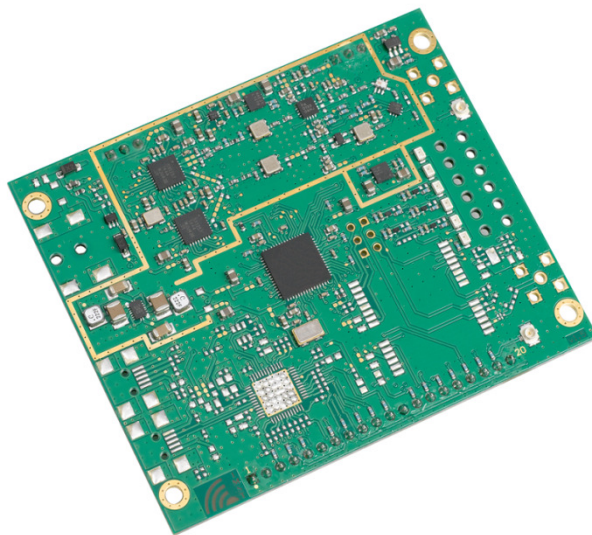


WiMOD iC880A

DATASHEET



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Aim of this Document

The aim of this document is to give a product description including interfaces, features and performance of the concentrator module iC880A-SPI.

Important Note

Caution: Operating the iC880A outside the given specification may harm the device.



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1. Introduction

The concentrator module iC880A is targeted for a huge variety of applications like Smart Metering, IoT and M2M applications. It is a multi-channel high performance transmitter/receiver module designed to receive several LoRa packets simultaneously using different spreading factors on multiple channels. The concentrator module iC880A can be integrated into a gateway as a complete RF front end of this gateway. It provides the possibility to enable robust communication between a LoRa gateway and a huge amount of LoRa end-nodes spread over a wide range of distance. The iC880A needs a host system for proper operation. This host system can be a PC or MCU that will be connected to iC880A via SPI-Interface.

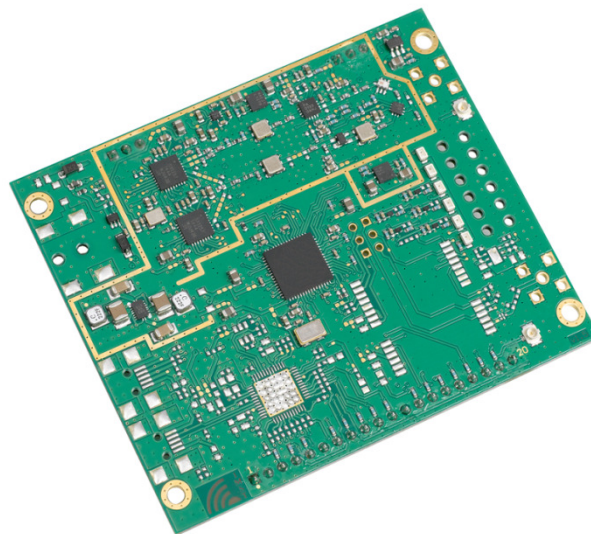


Figure 1-1: Picture of iC880A-SPI

The iC880A is able to receive up to 8 LoRa[®] packets simultaneously sent with different spreading factors and also on different channels. This unique capability allows to implement innovative network architectures advantageous over other short range systems:

- End-point nodes (e.g. sensor nodes) can change frequency with each transmission in a random pattern. This provides vast improvement of the system robustness in terms of interferer immunity and radio channel diversity.
- End-point nodes can dynamically perform link rate adaptation based (by adapting their spreading factors) on their link margin without adding complexity to the protocol. There is no need to maintain a table of which end point uses which data rate, because all data is demodulated in parallel.
- The capacity of the air interface can be increased due to orthogonal spreading factors.
- Due to the high range a star topology can be used. This results in simple implementation avoiding complex network layers, wireless routers and additional network protocol traffic.

1.1 Key Features

- Compact size 79.8 x 67.3 mm
- LoRa® modulation technology
- Frequency band 868 MHz
- Orthogonal spreading factors
- Sensitivity down to -137 dBm
- SPI interface
- SX1301 base band processor
- Emulates up to 49 x LoRa demodulators
- 10 parallel demodulation paths
- 1 (G)FSK demodulator
- 2 x SX1257 Tx/Rx front-ends
- Supply voltage 5 V
- RF interface optimized to 50 Ω
- Output power level up to 20 dBm
- GPS receiver (optional)
- Range up to 15 km (Line of Sight)
- Range of several km in urban environment¹
- Status LEDs
- HAL is available from https://github.com/Lora-net/lora_gateway

1.2 Applications

- Smart Metering
- Wireless Star Networks
- Home-, Building-, Industrial automation
- Remote Control
- Wireless Sensors
- M2M, IoT
- Wireless Alarm and Security Systems
- LoRaWAN™
- ...

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

¹ Depending on the environment

2. LoRa Modulation Technique

The iC880A uses Semtech's LoRa[®] 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.

LoRa also provides significant advantages in both blocking and selectivity, solving the traditional design compromise between range, interference immunity and energy consumption, please refer to [1].

Semtech's LoRa[®] technology transceivers support several bandwidth options and 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 payload information is sent is referred to as the nominal symbol rate (R_s), the ratio between the nominal symbol rate and chip rate is the spreading factor and represents the number of modulation symbols sent per bit of information. Note that the spreading factor must be normally 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.

For further information on LoRa[®] please refer to [2].

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3. Module Overview

The Concentrator Module is currently available as “iC880A-SPI”. An overview about designation of the key components is given by the following picture

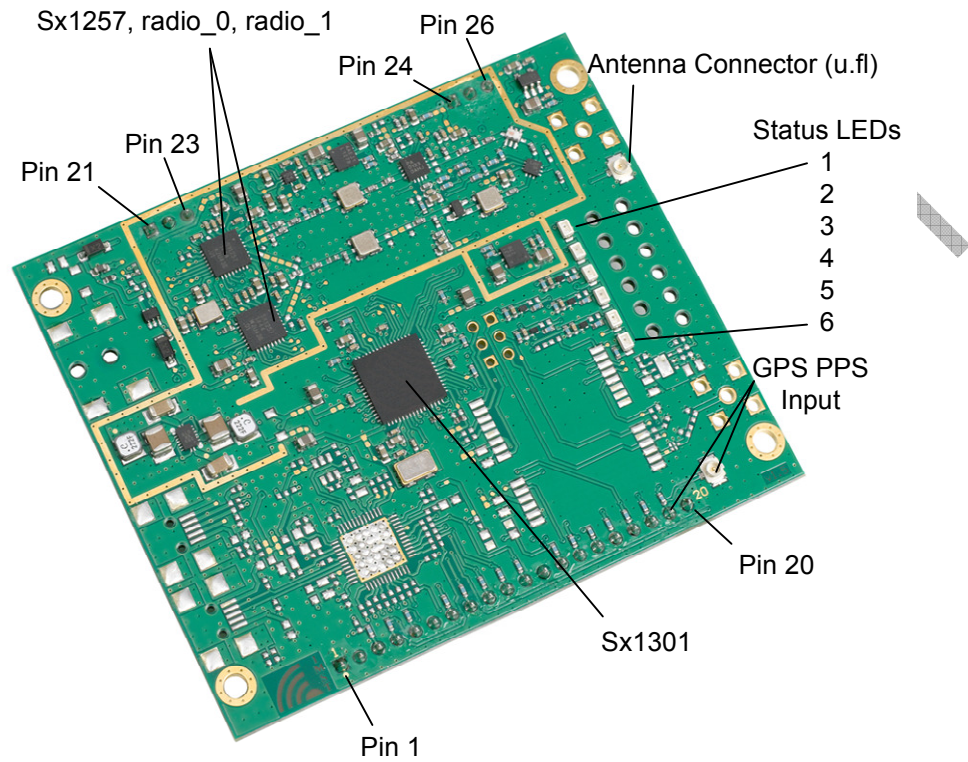


Figure 3-1: Component Overview iC880A-SPI

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3.1 SX1301

The iC880A includes Semtech's SX1301 which is a digital baseband chip including a massive digital signal processing engine specifically designed to offer breakthrough gateway capabilities in the ISM bands worldwide. It integrates the LoRa concentrator IP.

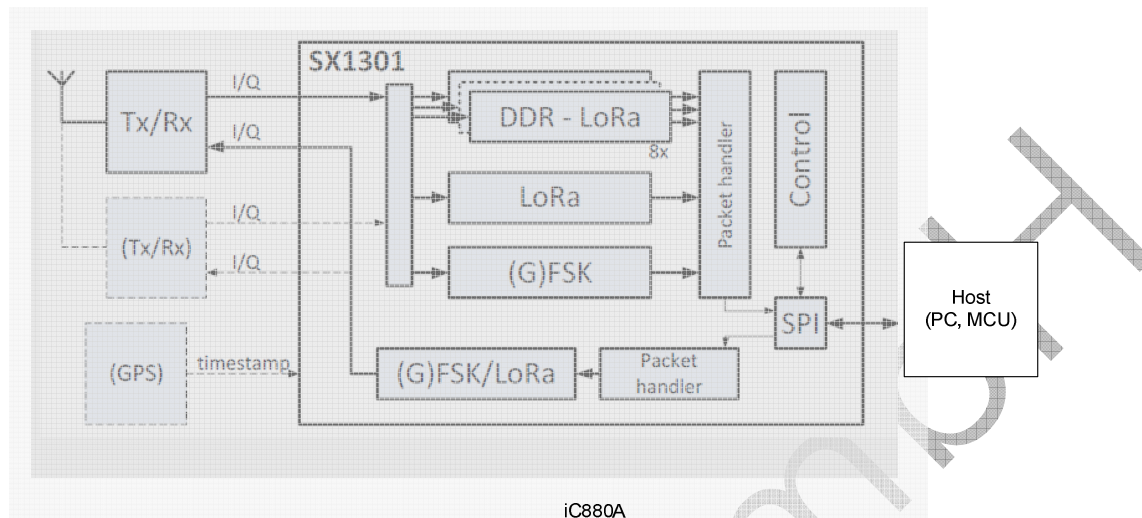


Figure 3-2: Block Diagram of iC880A with SX1301 Base Band Processor.

The SX1301 is a smart baseband processor for long range ISM communication. In the receiver part, it receives I and Q digitized bit stream for one or two receivers (SX1257), demodulates these signals using several demodulators, adapting the demodulators settings to the received signal and stores the received demodulated packets in a FIFO to be retrieved from a host system (PC, MCU). In the transmitter part, the packets are modulated using a programmable (G)FSK/LoRa modulator and sent to one transmitter (SX1257). Received packets can be time-stamped using a GPS PPS input.

The SX1301 has an internal control block that receives microcode from the host system (PC, MCU). The microcode is provided by Semtech as a binary file to load into the SX1301 at power-on (see Semtech application support for more information).

The control of the SX1301 by the host system (PC, MCU) is made using a Hardware Abstraction Layer (HAL). The Hardware Abstraction Layer source code is provided by Semtech and can be adapted by the host system developers.

It is highly recommended to fully re-use the latest HAL as provided by Semtech on <https://github.com/Lora-net>.

3.1.1 Block Diagram

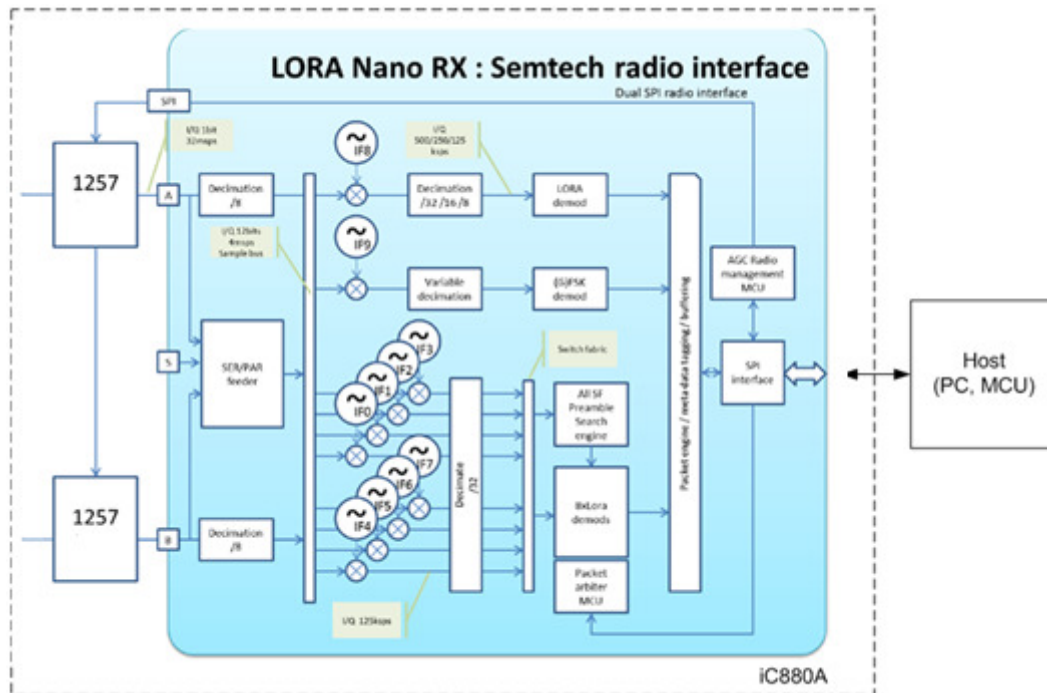


Figure 3-3: Detailed Block Diagram of SX1301 taken from [5].

The SX1301 digital baseband chip contains 10 programmable reception paths. Those paths have differentiated levels of programmability and allow different use cases. It is important to understand the differences between those demodulation paths to make the best possible use from the system.

3.1.2 IF8 LORA channel

This channel is connected to one SX1257 using any arbitrary intermediate frequency within the allowed range. This channel is LoRa only. The demodulation bandwidth can be configured to be 125, 250 or 500 kHz. The data rate can be configured to any of the LoRa available data rates (SF7 to SF12) but, as opposed to IF0 to IF7, ONLY the configured data rate will be demodulated. This channel is intended to serve as a high speed backhaul link to other gateways or infrastructure equipment. This demodulation path is compatible with the signal transmitted by the SX1272 (iM880B, iM881A) and SX1276 chip family.

3.1.3 IF9 (G) FSK channel

The IF9 channel is connected to a GFSK demodulator. The channel bandwidth and bit rate can be adjusted. This demodulator offers a very high level of configurability, going well beyond the scope of this document. The demodulator characteristics are essentially the same than the GFSK demodulator implemented on the SX1232 and SX1272 (iM880B, iM881A) Semtech chips. This demodulation path can demodulate any legacy FSK or GFSK formatted signal.

3.1.4 IF0 to IF7 LORA channels

Those channels are connected to one SX1257. The channel bandwidth is 125 kHz and cannot be modified or configured. Each channel IF frequency can be individually configured. On each of those channels any data rate can be received without prior configuration.

Several packets using different data rates (different spreading factors) may be demodulated simultaneously even on the same channel. Those channels are intended to be used for a massive asynchronous star network of 10000's of sensor nodes. Each sensor may use a random channel (amongst IF0 to IF7) and a different data rate for any transmission.

Sensors located near the gateway will typically use the highest possible data rate in the fixed 125 kHz channel bandwidth (e.g. 6 kbit/s) while sensors located far away will use a lower data rate down to 300 bit/s (minimum LoRa data rate in a 125 kHz channel).

The SX1301 digital baseband chip scans the 8 channels (IF0 to IF7) for preambles of all data rates at all times.

The chip is able to demodulate simultaneously up to 8 packets. Any combination of spreading factor and intermediate frequency for up to 8 packets is possible (e.g. one SF7 packet on IF0, one SF12 packet on IF7 and one SF9 packet on IF1 simultaneously).

The SX1301 can detect simultaneously preambles corresponding to all data rates on all IF0 to IF7 channels. However, it cannot demodulate more than 8 packets simultaneously. This is because the SX1301 architecture separates the preamble detection and signal acquisition task from the demodulation process. The number of simultaneously demodulated packets (in this case 8) is an arbitrary system parameter and may be set to other values for a customer specific circuit.

The unique multi data-rate multi-channel demodulation capacity SF7 to SF12 and of channels IF0 to IF7 allows innovative network architectures to be implemented.

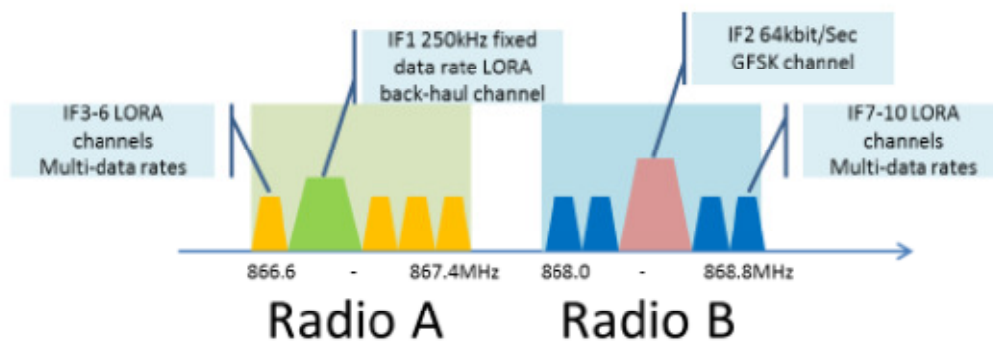


Figure 3-4: Possible use of radio spectrum taken from [5].

3.2 RF Interface

The iC880A supports an RF interface for the 868 MHz frequency band. By connecting an appropriate antenna¹ to the antenna connector, the iC880A is fully ready for communication.

3.3 External Module Connector

For easy integration into a target system and mounting of the iC880A on a carrier board, the headers on the module's bottom side can be used for these purposes (refer to Table 6-1 for the pin description).

3.3.1 SPI

The connector on the bottom side provides an SPI connection, which allows direct access to the Sx1301 SPI interface. This gives the target system the possibility to use existing SPI interfaces to communicate to the iC880A.

After powering up the iC880A it is required to reset SX1301 via PIN 13, refer to Table 6-1.

3.3.2 GPS PPS

In case of available PPS signals in the target system, it is possible to connect this available signal to the appropriate pin at the connector.

3.3.3 UART

The bottom connector provides a UART interface. This interface is for future use.

3.3.4 Digital IOs

There are five GPIOs of the Sx1301 available, which gives the user some possibilities to get information about the system status. These pins are the same, as they are used for the LEDs on the iC880A.

The functions of the LED are depending on the software used for operating the concentrator. The intentional use of the LEDs is as follows:

- 1) Backhaul packet
- 2) TX packet
- 3) RX Sensor packet
- 4) RX FSK packet
- 5) RX buffer not empty
- 6) Power

¹ Recommended antenna is CTA868/2/DR/SM/S2, available at CompoTEK GmbH, Germany

4. LoRa Systems, Network Approach

The use of LoRa® technology can be distinguished in “Public” and “Private” networks. In both cases the usage of a concentrator module can be reasonable. Public networks are operator (e.g. telecom) managed networks whereas private networks are individually managed networks.

LoRa networks are typically star or multiple star networks where a gateway relays the packets between the end-nodes and a central network server, see Figure 4-1. For private network approaches the server can also be implemented on the gateway host.

Due to the possible high range the connection between end-nodes and the concentrator iC880A is always a direct link. There are no repeaters or routers within a LoRa network.

Depending on the used spreading factor and signal bandwidth different data rates¹ (0.3 kbps to ~22 kbps) and sensitivities down to -137 dBm are possible. Spreading factor and signal bandwidth are a trade-off between data rate and communication range.

4.1 Overview

The iC880A is able to receive on different frequency channels at the same time and is able to demodulate the LoRa signal without knowledge of the used spreading factor of the sending node.

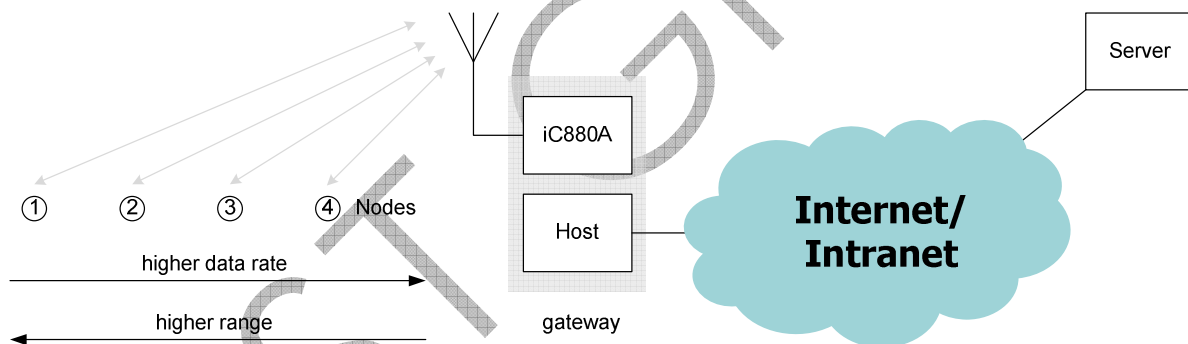


Figure 4-1: Public LoRa Network Approach

Due to the fact that the combination of spreading factors and signal bandwidths results in different data rates the use of “Dynamic Data-Rate Adaption” becomes possible. That means that LoRa nodes with high distances from the iC880A must use higher spreading factors and therefore have a lower data rate. LoRa nodes which are closer to the concentrator can use lower spreading factors and therefore can increase their data rate.

Due to the fact that spreading factors are orthogonal and iC880A supports up to 10 demodulations paths the channel capacity of a LoRa cell can be increased using iC880A compared to conventional modulation techniques.

¹ Equivalent bit rate.

4.2 Firmware

The LoRaWAN specification is currently driven by the LoRa Alliance™. Currently all available software, firmware and documentation can be found and downloaded from the open source project LoRa-net hosted on <https://github.com/Lora-net>

This project considers all parts that are needed to run a network based on LoRa technology. It includes the node firmware (several hardware platforms are supported), the gateway host software (HAL driver for SX1301, packet forwarder) and a server implementation.

It is highly recommended to re-use the latest HAL as provided. The "iC880A_QuickStartGuide.pdf" is available on request.

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5. Electrical Characteristics & Timing specifications

In the following different electrical characteristics of the iC880A 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.

5.1 Absolute Maximum Ratings

Parameter	Condition	Min	Typ.	Max	Unit
Supply Voltage (VDD)		-0.3	5.0	5.5	V
Operating Temperature		-5		+55	°C
Operating Temperature (extended)		-40		+85°C	°C
RF Input Power				-15	dBm
Max Pin on Hot-Switching RF-Switch				+20	dBm
VSWR on any RF connector				3:1	
Notes:					

Table 5-1: Absolute Maximum Ratings

Note: With RF output power level above +15 dBm a minimum distance to a transmitter should be 1 m for avoiding too large input level.

5.2 Global Electrical Characteristics

T = 25°C, VDD = 5 V (typ.) if nothing else stated

Parameter	Condition	Min	Typ.	Max	Unit
Supply Voltage (VDD)		4.5	5.0	5.5	V
Receiver Current Consumption	medium activity (2 radios, 4 active paths)		288		mA
	high activity (2 radios, 10 active paths)		428		

Table 5-2: General Characteristics

T = 25°C, VDD = 5 V (typ.) if nothing else stated

Parameter	Condition	Min	Typ.	Max	Unit
Logic low input threshold (VIL)	"0" logic input			0.4	V
Logic high input threshold (VIH)	"1" logic input	2.9		3.3	V
Logic low output level (VOL)	"0" logic output, 2 mA sink			0.4	V
Logic high output level (VOH)	"1" logic output, 2 mA source	2.9		3.3	V

Notes:

Table 5-3: Electrical characteristics of IOs

5.3 SPI Interface Characteristics

T = 25°C, VDD = 5 V (typ.) if nothing else stated

Parameter	Condition	Min	Typ.	Max	Unit
SCK frequency				10	MHz
SCK high time		50			ns
SCK low time		50			ns
SCK rise time			5		ns
SCK fall time			5		ns
MOSI setup time	From MOSI change to SCK rising edge	10			ns
MOSI hold time	From SCK rising edge to MOSI change	20			ns
NSS setup time	From NSS falling edge to SCK rising edge	40			ns
NSS hold time	From SCK falling edge to NSS rising edge, normal mode	40			ns
NSS high time between SPI accesses		40			ns

Table 5-4: Timing characteristics of SPI Interface

5.4 RF Characteristics

5.4.1 Transmitter RF Characteristics

The iC880A has an excellent transmitter performance, which generally give a lot of possible settings for the power amplifier of the iC880A. It is highly recommended, to use an optimized configuration for the power level configuration. An application note called AN22 “iC880A Power Amplifier Settings” [6] is available, which describes optimized settings for the transmitter configuration. It is available on request.

The iC880A is specified for a max. RF output power of +20 dBm. Long-term operating of the iC880A with more than +20 dBm can destroy the internal power amplifier of iC880A. Especially in case of operating the iC880A with the github software it need to be ensured, that the maximum RF output power of +20 dBm is not exceeded. Therefore the settings of the global_conf.json might need to be changed accordingly.

T = 25°C, VDD = 5 V (typ.), 866.5 MHz if nothing else stated

Parameter	Condition	Min	Typ.	Max	Unit
Frequency Range		863	-	870	MHz
Modulation Techniques	FSK / LoRa™				
TX Frequency Variation vs. Temperature	-5°C to +55°C	-	+/- 3	-	kHz
TX Power Variation vs. Temperature ¹	Max. power level, -5°C to +55°C	-	+/- 2.4	-	dB
	Max. power level, -40°C to +85°C		+/-4.9	-	dB
TX Power Variation vs. Frequency	Max. power level	-	+/- 2	-	dB
TX Power Variation (initial)	Max. power level	-	+/- 1.5	-	dB
TX Current Consumption	Gain setting for nom. +14 dBm -5°C to +55°C PA=2; DAC=3; Mix=10; Dig=2	-	260	-	mA
	Gain setting for nom. +20 dBm -5°C to +55°C PA=2; DAC=3; Mix=12; Dig=0	-	300	-	mA
Notes: All values are based on settings given by Application Note 22 [6] which is available on request					

Table 5-5: Transmitter RF Characteristics

¹ Operational temperature range can be basically extended to -40°C to +85°C, but a larger power level drift vs. temperature need to be expected. In addition it is recommended, to use optimized TX settings which are also individually adapted to the temperature.

5.4.2 Receiver RF Characteristics

It is highly recommended, to use optimized RSSI calibration values. For both, Radio 1 and 2, the RSSI-Offset should be set to -169.

The following table gives typically sensitivity level of the iC880A:

Signal Bandwidth/[kHz]	Spreading Factor	Sensitivity/[dBm]
125	12	-137
125	7	-126
250	12	-136
250	7	-123
500	12	-134
500	7	-120

Table 5-6: Typically Radio Performance of iC880A

5.4.3 Certification and Compliancy Restrictions

This component has been designed to comply with the European Union's RE-Directive (Radio Equipment Directive) 2014/53/EU. As the product is a component only, the assessment is done on EMC and ERM (EN 300 220 v3.1.1) only. A declaration of conformity for this component will be available from IMST GmbH on request. 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.

RED pre-certification was done based on the LoRa Lite Gateway with an antenna giving 2.15 dBi gain. Due to special requirements of the RED certification the current output power may need to be limited by software depending on operational frequency and with respect to specified extreme conditions.

6. Module Package

In the following the iC880A module package is described. This description includes the iC880A pinout as well as the modules dimensions.

6.1 Pinout Description

The iC880A provides headers at the bottom side, which have a pitch of 2.54 mm. The description of the pins is given by Table 6-1. An additional overview gives Figure 6-1.

PIN	PIN Name	PIN Type	Description
1	GND	Power	
2	NC	NC	Reserved
3	nGPS_Reset	Input	GPS Module Reset (low active)
4	SPValid	Input	Sx1301 Radio C Sample Valid (don't connect)
5	EN_GPS_Supply	Input	GPS Module LDO: Enable Pin
6	NC	NC	Reserved
7	GPIO0	I/O	Sx1301 GPIO 0
8	GPIO1	I/O	Sx1301 GPIO 1
9	GPIO3	I/O	Sx1301 GPIO 3
10	GPIO2	I/O	Sx1301 GPIO 2
11	GPIO4	I/O	Sx1301 GPIO 4
12	GND	Power	
13	Reset	Reset	Sx1301 Reset, for a stable start-up Reset should be at high-level for 100 ns (min), once the supply voltage is stable . Internally pulled-down with 100 kΩ.
14	CLK	Input	Sx1301 SPI-Clock
15	MISO	Output	Sx1301 SPI-MISO
16	MOSI	Input	Sx1301 SPI-MOSI
17	NSS	Input	Sx1301 SPI-NSS
18	ScanMode	Input	Sx1301 ScanMode Signal
19	PPS	Input	GPS PPS Input Signal
20	GND	Power	
21	VDD	Power	+5 V Supply Voltage
22	GND	Power	
23	VDDDB	Power	GPS backup supply voltage
24	GND	Power	
25	GPS_TX	Output	GPS UART TxD
26	GPS_RX	Input	GPS UART RxD

Table 6-1: iC880A Pinout Table

Note: MISO-signal is always low impedance. Do not share with other MISO-signal by direct connection.

6.2 Module Dimensions

The outer dimensions of the iC880A are given by 79.8 x 67.3 mm ± 0.2 mm. The iC880A provide four drills for screwing the PCB to another unit each with a drill diameter of 3 mm.

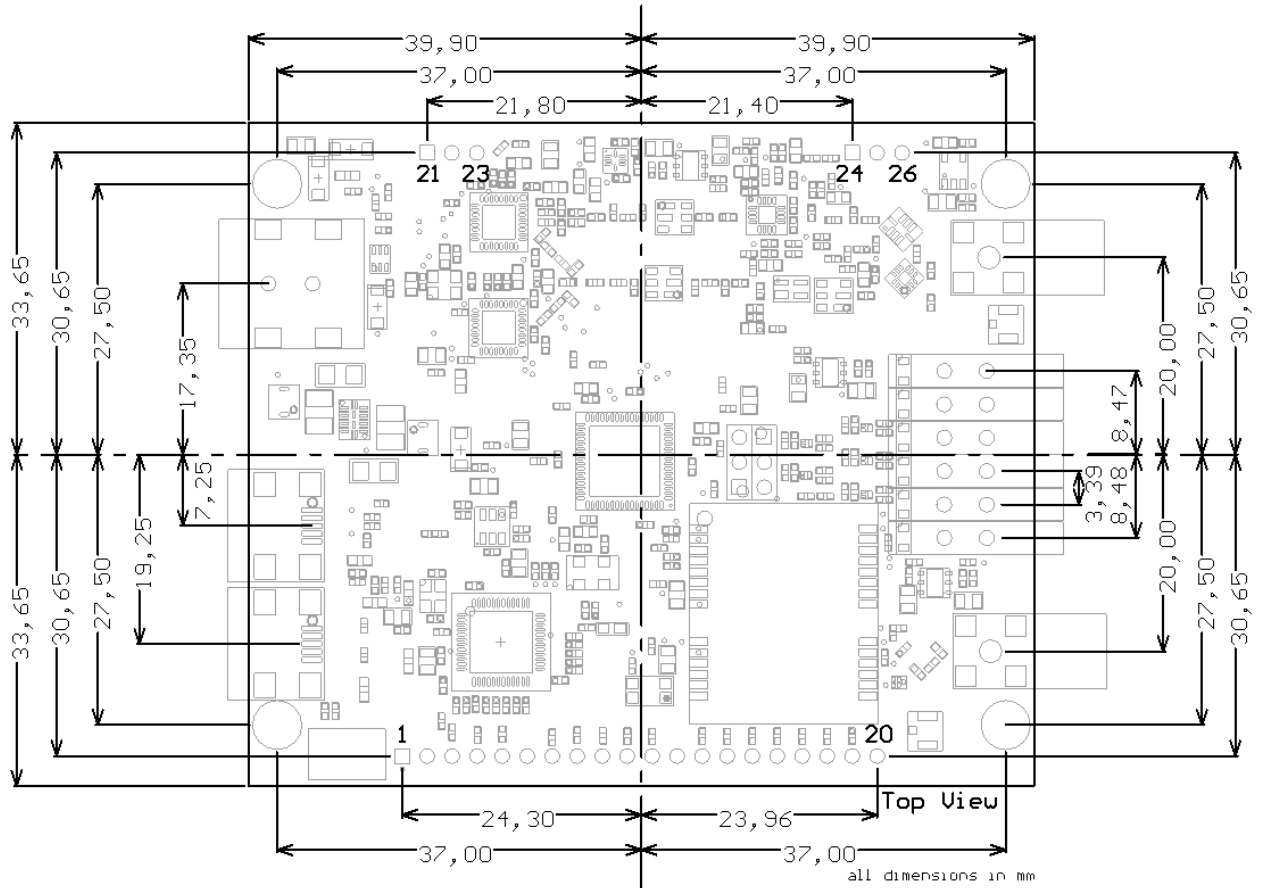


Figure 6-1: iC880A outlines and pins of bottom connector in top view

7. Ordering Information

Ordering Part Number	Description	Distributor
iC880A-SPI	Concentrator Module with SPI interface	

Table 7-1: Ordering Information

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8. Restrictions and Limitations

8.1 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.

8.2 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.

8.3 Compliancy Restrictions and Limitations

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

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

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

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

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9. Appendix

9.1 List of Abbreviations

AFA	Adaptive Frequency Agility
BER	Bit Error Rate
BSC	Basic Spacing between Centers
GND	Ground
GPIO	General Purpose Input/Output
GPS	Global Positioning System
HAL	Hardware Abstraction Layer
IF	Intermediate Frequency
IoT	Internet of Things
ISM	Industrial, Scientific and Medical
LBT	Listen Before Talk
M2M	Machine to Machine
MAC	Medium Access Control
MCU	Microcontroller Unit
MPSSE	Multi-Protocol Synchronous Serial Engine (FTDI)
PCB	Printed Circuit Board
PPS	Pulse Per Second
RAM	Random Access Memory
RF	Radio Frequency
SMT	Surface Mounted Technology
SNR	Signal to Noise Ratio
SPI	Serial Peripheral Interface
TRX	Transceiver
USB	Universal Serial Bus

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9.4 References

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