

# ISP4520

## Smart LoRa and Bluetooth

### Low Energy Module with MCU and Antennas

This highly miniaturized LGA module, 9.8 x 17.2 x 1.7 mm, is based on the new SX126x LoRa transceiver series and nRF52832 BLE chip. Using a simple user interface via the SPI connection and integrating a Cortex™ M4 CPU, flash and RAM memory combined with single optimized antenna for both LoRa and BLE standards, ISP4520 offers the perfect stand-alone module solution for large spectrum of application in IoT domains. For longer range use case, ISP4520 can be used in conjunction with an external LoRa antenna.



#### Key Features

- LoRaWAN Protocol Stack
- Single Mode BLE 5 Ready
- NFC-A Tag for OOB pairing
- Fully integrated LoRa & BLE matching and Antennas
- Integrated LoRa and BLE 32 MHz & 32.768 kHz Clocks
- LoRa section based on Semtech SX126x series transceiver
- BLE section based on Nordic Semi nRF52
- Externally Controlled or using embedded 32-bit ARM Cortex M4 CPU
- 512 kB Flash and 64 kB SRAM
- Analog and Digital peripherals
- SPI interface
- Supply Voltage 1.8V to 3.6V
- Very small size 9.8 x 17.2 x 1.7 mm
- Temperature -30 to +85 °C



#### Applications

- Smart Cities / Smart Retail
- Industrial Internet
- Big Data / Data Science
- Energy Engagement / Smart grids

#### Certifications

- FCC certification pending
- CE certification pending
- LoRaWAN certification pending
- Bluetooth SIG certification pending
- RoHS compliant

## Preliminary Data Sheet

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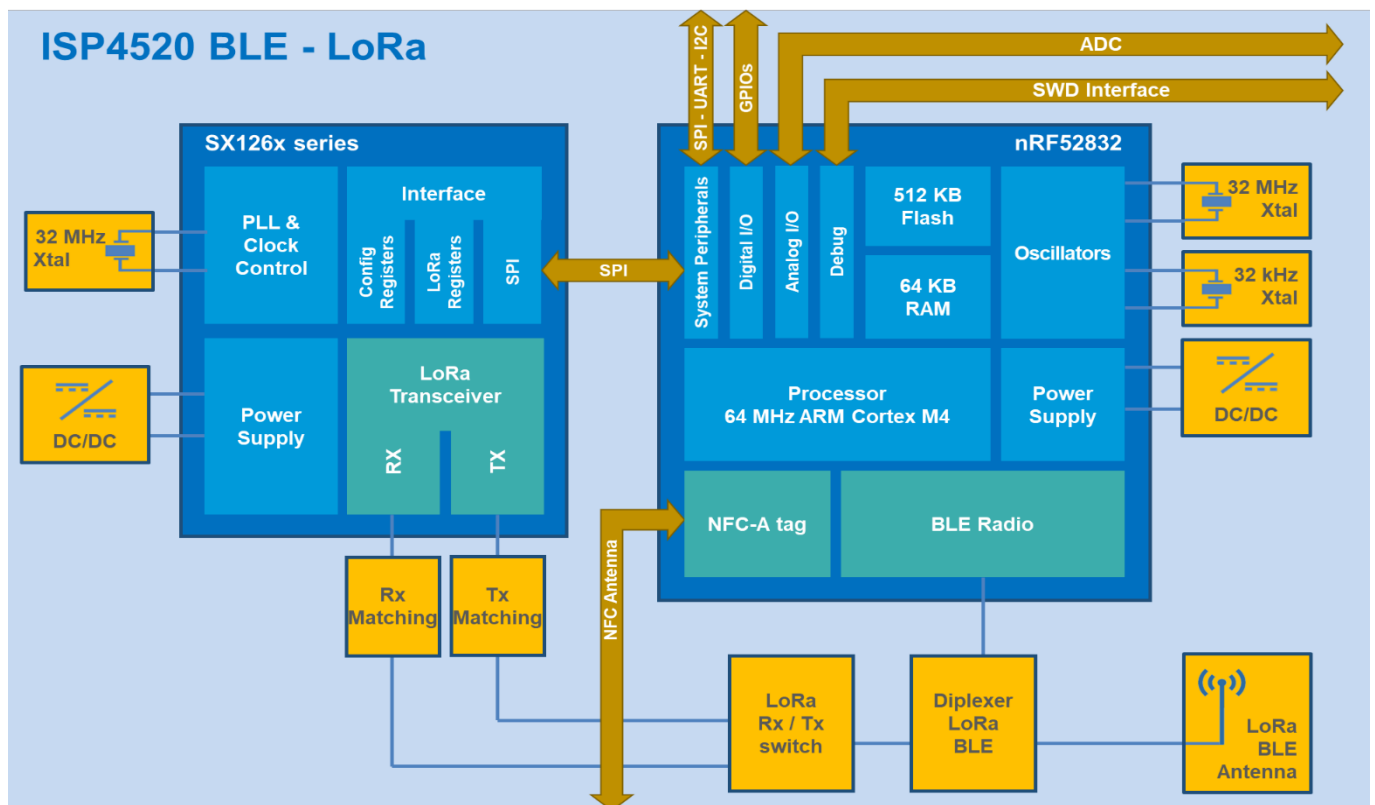
### 1. Block Diagram

This module is based on new Semtech SX126x single-chip LoRa transceiver series and nRF52832 Nordic Semiconductor 2.4GHz wireless System on Chip (SoC). It integrates a 32-bit ARM Cortex™ M4 CPU, flash memory as well as analog and digital peripherals.

ISP4520 can support LoRa connectivity compliant to LoRa Alliance standards. LoRa section can be used as stand-alone transmitting module connected to LoRaWAN (LoRa Alliance) for long range data access using a simple user interface controlled over the air by Bluetooth or by SPI connection from nRF52832 interface.

ISP4520 also integrates a BLE connectivity compliant to Bluetooth V4.2. It can be used either in Peripheral or Central roles for BLE. Fully qualified BLE stacks for nRF52832 are implemented in the S132 SoftDevice which can be freely downloaded.

Despite the small size of 9.8 x 17.2 x 1.7 mm, the module integrates decoupling capacitors, 32 MHz crystals for LoRa and BLE and 32.768 kHz crystal for BLE, DC-DC converters in addition to the wireless SoCs. On the RF side, the ISP4520 also integrates the matching circuits for low / high power transmitters and receiver (with RX SAW filter achieving out-band rejection option on LoRa part), and a multipoint switch with common antenna for LoRa or BLE operation. Ultra-low power consumption and advanced power management enables battery lifetimes up to several years on a coin cell battery.



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### 2. Specifications

#### 2.1. Important Notice

The electrical specifications of the module are directly related to the Semtech SX126x series transceiver and the Nordic Semiconductor nRF52832 specifications for chipsets. Below information is only a summary of the main parameters. For more detailed information, please refer to the up-to-date specification of chipsets available on Semtech and Nordic Semi website.

#### 2.2. Absolute Maximum Ratings

Parameter	Min	Typ	Max	Unit
Supply Voltage VCC	-0.3		3.6	V
IO & Control Pins	-0.3		3.6	V
Storage Temperature	-40		+85	°C
Moisture Sensitivity Level			5	-
Flash Endurance			10000	cycles



#### ATTENTION

CONSERVE PRECAUTION FOR HANDLING  
ELECTROSTATIC SENSITIVE DEVICES  
Human Body Model Class 3A

#### 2.3. Operating Conditions

Parameter	Min	Typ	Max	Unit
Operating Supply Voltage VCC	1.8	3.0	3.6	V
Operating Input Voltage IO Pins P0.xx / GPIO	-0.3		VCC	V
Operating Temperature Range	-30	+25	+85	°C

## Preliminary Data Sheet

### 2.4. Current Consumption

Parameter	Min	Typ	Max	Unit
LoRa receiver			10	mA
LoRa transmitter			34	mA
LoRa idle mode		1.6		mA
LoRa sleep mode		0.5		μA
LoRa deep sleep mode		160		nA
BLE Peak current, Receiver active <sup>(1)</sup>		6.1		mA
BLE Peak current, Transmitter active +4 dBm Output Power <sup>(2)</sup>		7.9		mA
BLE Peak current, Transmitter active 0 dBm Output Power <sup>(2)</sup>		5.4		mA
CPU System OFF current, no RAM retention		0.7		μA
CPU System ON base current, full RAM retention		1.5		μA
CPU Additional RAM retention current per 4 KB block		40		nA

(1) DC-DC enabled, Power supply 3V, 1 Msps

(2) DC-DC enabled, Power supply 3V

### 2.5. Clock Sources

Parameter	Min	Typ	Max	Unit
Internal High Frequency Clock for RF Stability: 32 MHz Crystal Frequency Tolerance <sup>(1)</sup>			± 40	ppm
Internal Low Frequency Clock for BLE Synchronization: 32.768 kHz Crystal Frequency Tolerance <sup>(1)</sup>			± 40	ppm
Internal Low Frequency Clock for BLE Synchronization: RC Oscillator <sup>(2)</sup>			± 250	ppm

(1) Including initial tolerance, drift, aging, and frequency pulling

(2) Frequency tolerance after calibration

### Preliminary Data Sheet

#### 2.6. LoRa Radio Specifications

Parameter - EU version	Min	Typ	Max	Unit
LoRa Frequency Band (EU)	863		870	MHz
LoRa Input at 1dB compression point			+10	dBm
LoRa Rx sensitivity Level for BER <1% <sup>(3)</sup>	-134			dBm
LoRa Output Power at transceiver output		+12	+13	dBm
LoRa Antenna Gain in band <sup>(1) (5)</sup>		-2.6		dBi
LoRa Load impedance		50		Ω
LoRa Range Open field @ 1 m height <sup>(1) (3) (5)</sup>		15		km
LoRa Range Open field @ 1 m height <sup>(2) (3)</sup>		20		km

Parameter - US version	Min	Typ	Max	Unit
LoRa Frequency Band (US)	902		928	MHz
LoRa Input at 1dB compression point			+10	dBm
LoRa Rx sensitivity Level for BER <1% <sup>(4)</sup>	-129			dBm
LoRa Output Power at transceiver output		+20		dBm
LoRa Antenna Gain in band <sup>(1) (5)</sup>		-1.9		dBi
LoRa Load impedance		50		Ω
LoRa Range Open field @ 1 m height <sup>(1) (3) (5)</sup>		17		km
LoRa Range Open field @ 1 m height <sup>(2) (3)</sup>		20		km

Parameter - JP version	Min	Typ	Max	Unit
LoRa Frequency Band (JP)	920		923	MHz
LoRa Input at 1dB compression point			+10	dBm
LoRa Rx sensitivity Level for BER <1% <sup>(3)</sup>	-134			dBm
LoRa Output Power at transceiver output		+12	+13	dBm
LoRa Antenna Gain in band <sup>(1) (5)</sup>		-1.9		dBi
LoRa Load impedance		50		Ω
LoRa Range Open field @ 1 m height <sup>(1) (3) (5)</sup>		13		km
LoRa Range Open field @ 1 m height <sup>(2) (3)</sup>		16		km

- (1) With internal LoRa antenna / Outdoor
- (2) With external LoRa antenna / Outdoor
- (3) Lower data rate DR0 SF12/125kHz (EU & JP)
- (4) Lower data rate DR0 SF10/125kHz (US)
- (5) Measured Front side of ISP4520

## Preliminary Data Sheet

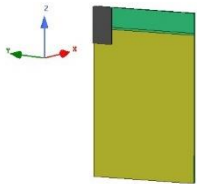
### 2.7. BLE Radio Specifications

Parameter	Min	Typ	Max	Unit
BLE Frequency Range	2402		2480	MHz
BLE Channel 0 to 39 Spacing		2		MHz
BLE Output Power Channels 0 to 39	-20		+4	dBm
BLE Rx sensitivity Level for BER <0,1% ideal Tx	-96			dBm
BLE Antenna Gain		-3.6		dBi
BLE EIRP	-23.6		0.4	dBm
BLE Range Open field @ 1m height (1)		70		m

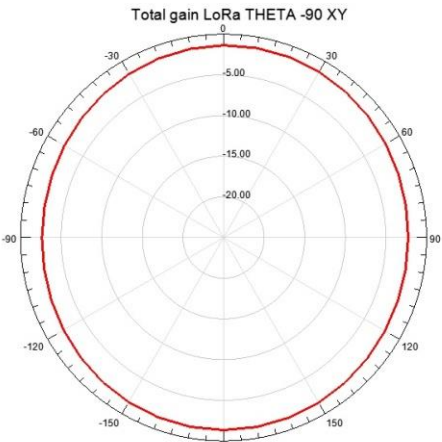
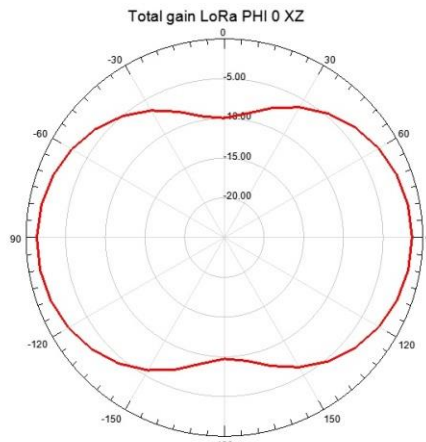
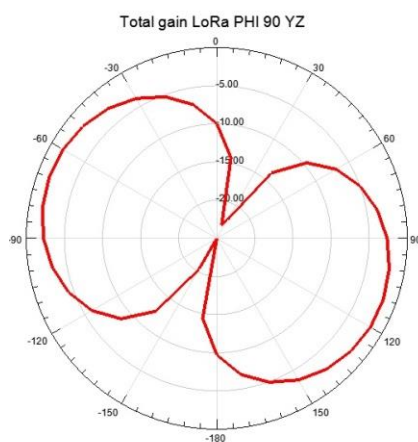
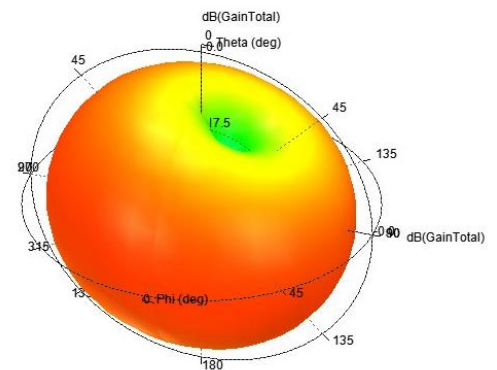
(1) Data Rate 1000 / 2000 Kbps

### 2.8. Antenna Performance

#### LoRa Radiation Pattern – Module in top left corner



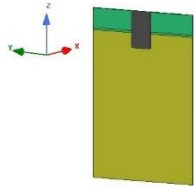
Module positioned on the top left corner of the application PCB (top view)  
Keep out zone of 50 mm length  
Ground plane of 70 x 50 mm



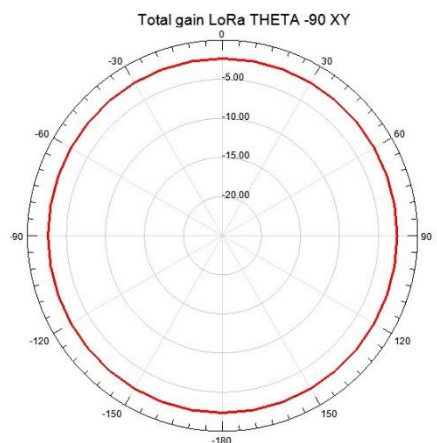
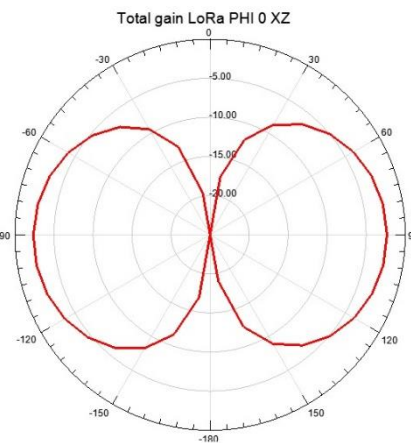
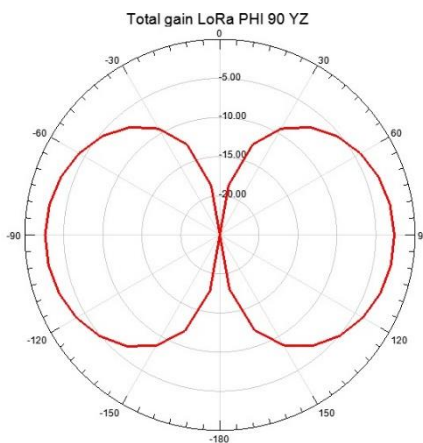
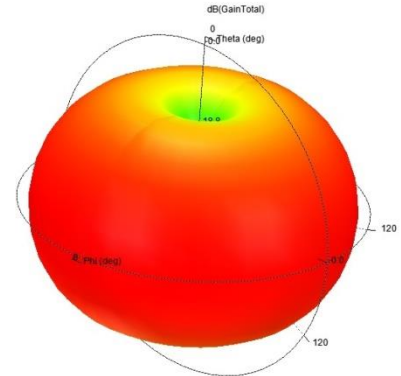


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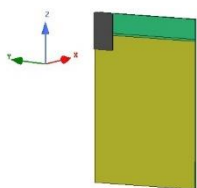
### LoRa Radiation Pattern – Module in top center edge



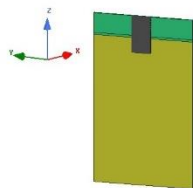
Module positioned on the center of the top edge of the application PCB (top view)  
Keep out zone of 50 mm length  
Ground plane of 70 x 50 mm



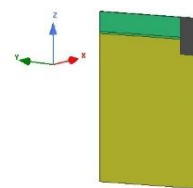
### Ground Plane Effect Simulation



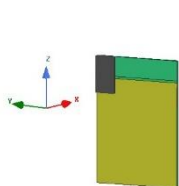
Top left position  
Ground plane  
70 x 50 mm



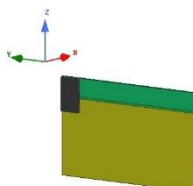
Top center position  
Ground plane  
70 x 50 mm



Top right position  
Ground plane  
70 x 50 mm



Top left position  
Ground plane  
50 x 40 mm

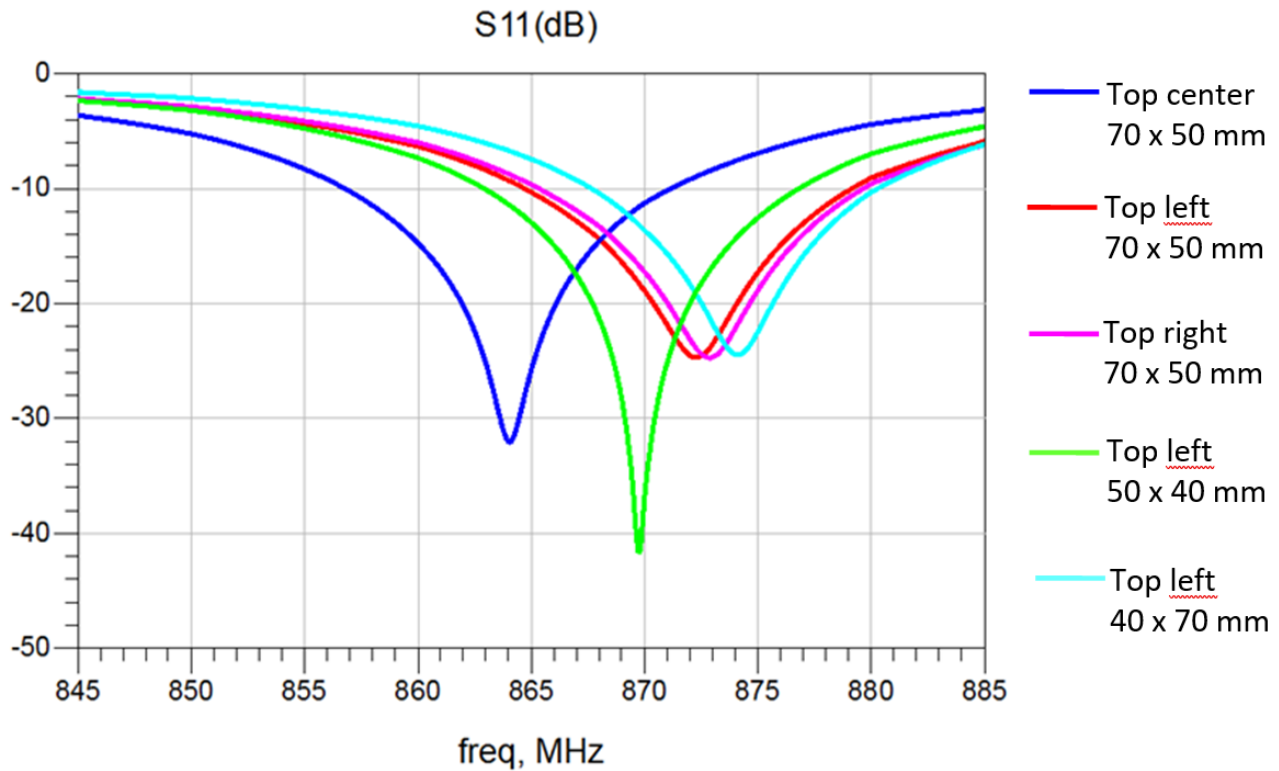


Top left position  
Ground plane  
40 x 70 mm





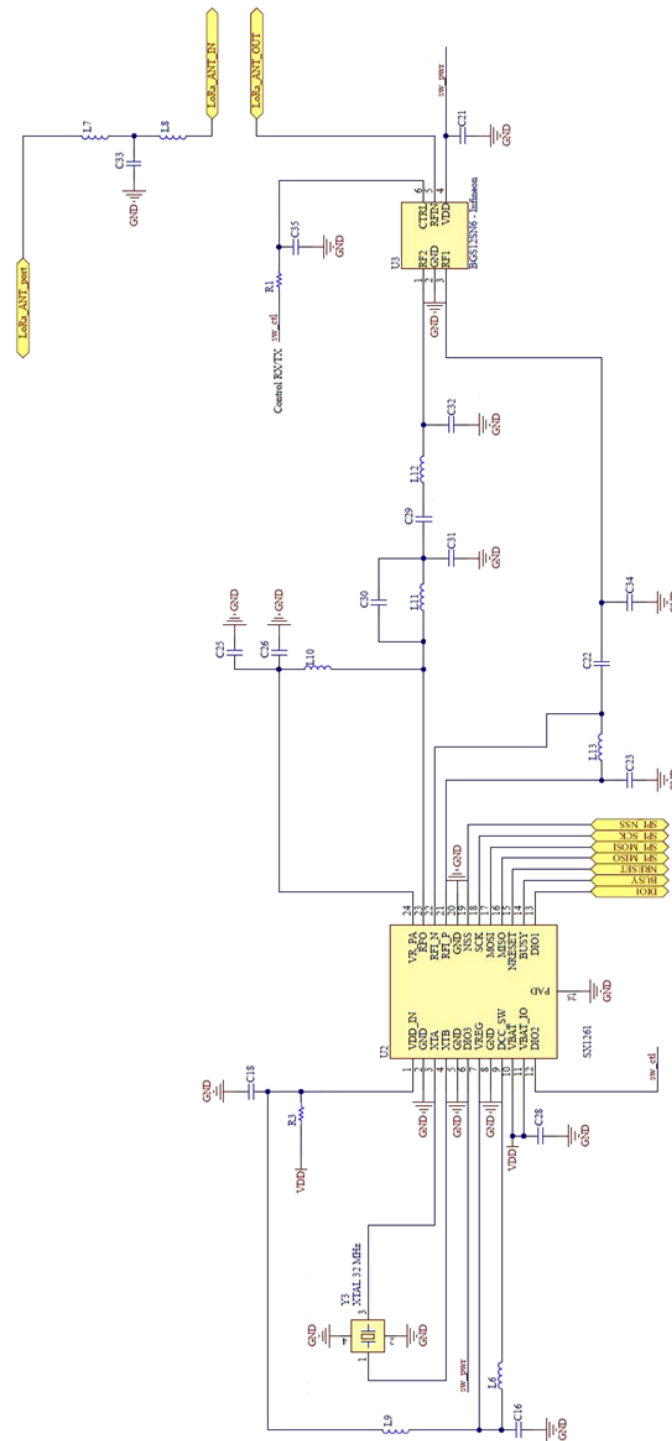
## Preliminary Data Sheet



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### 2.9. Electrical Schematic

✚ Details of Semtech LoRa transceiver connections for EU and JP version

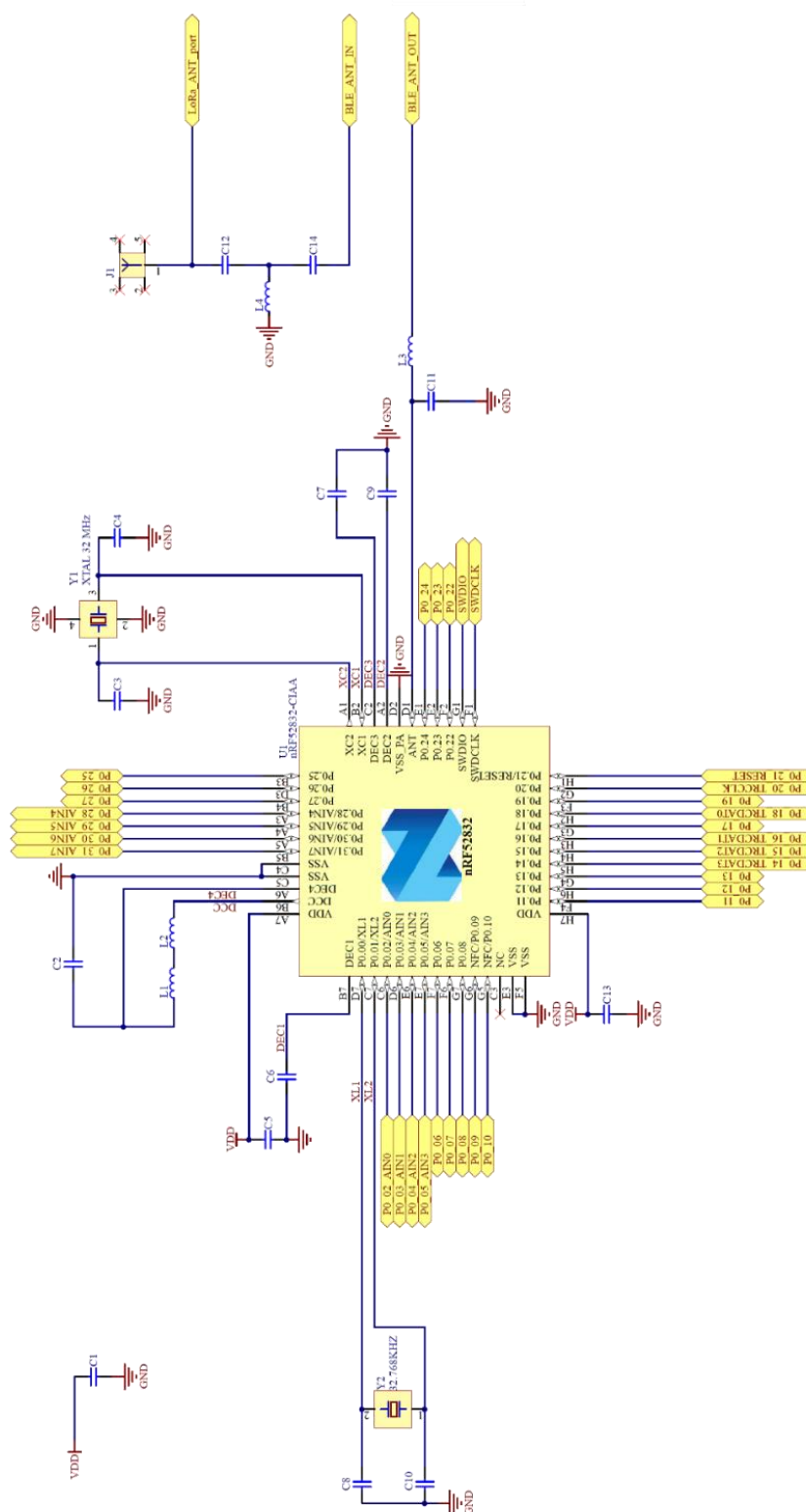




## Preliminary Data Sheet

## Preliminary Data Sheet

### Details of nRF52832 connections



## Preliminary Data Sheet

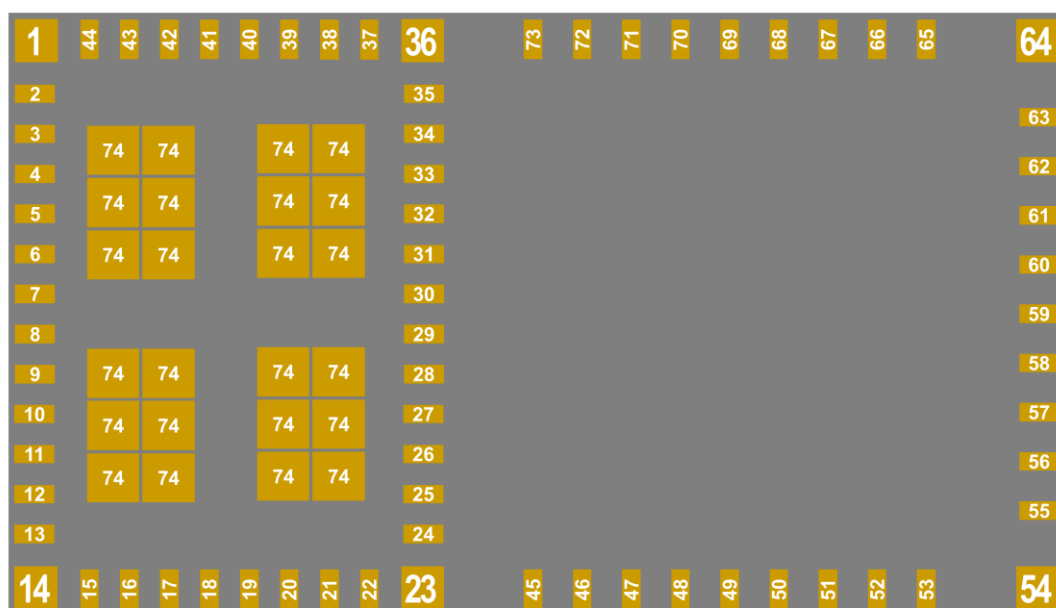
### 3. Pin Description

The module uses an LGA format. The pad layout follows the QFN Jedec standard for LGA parts. The NC pads are to be connected to isolated metal pads on the application PCB for mechanical stability and reliability (drop test).

Pin	Name	Pin function	Description
1	GND	Ground	Power Ground – Must be connected to ground on application PCB
2	P0_12	Digital I/O	nRF52 general purpose I/O pin
3	P0_10 NFC2	Digital I/O NFC Input	nRF52 general purpose I/O pin NFC antenna connection pin
4	P0_17	Digital I/O	nRF52 general purpose I/O pin
5	P0_07	Digital I/O	nRF52 general purpose I/O pin
6	P0_22	Digital I/O	nRF52 general purpose I/O pin
7	P0_09 NFC1	Digital I/O NFC Input	nRF52 general purpose I/O pin NFC antenna connection pin
8	P0_08	Digital I/O	nRF52 general purpose I/O pin
9	P0_13	Digital I/O	nRF52 general purpose I/O pin
10	P0_06	Digital I/O	nRF52 general purpose I/O pin
11	P0_05_AIN3	Digital I/O Analog Input	nRF52 general purpose I/O pin SAADC / COMP / LPCOMP input
12	P0_04_AIN2	Digital I/O Analog Input	nRF52 general purpose I/O pin SAADC / COMP / LPCOMP input
13	P0_03_AIN1	Digital I/O Analog Input	nRF52 general purpose I/O pin SAADC / COMP / LPCOMP input
14	GND	Ground	Power Ground – Must be connected to ground on application PCB
15	VDD	Power	External supply
16	P0_02_AIN0	Digital I/O Analog Input	nRF52 general purpose I/O pin SAADC / COMP / LPCOMP input
17	P0_31_AIN7	Digital I/O Analog Input	nRF52 general purpose I/O pin SAADC / COMP / LPCOMP input
18	P0_30_AIN6	Digital I/O Analog Input	nRF52 general purpose I/O pin SAADC / COMP / LPCOMP input
19	P0_29_AIN5	Digital I/O Analog Input	nRF52 general purpose I/O pin SAADC / COMP / LPCOMP input
20	P0_28_AIN4	Digital I/O Analog Input	nRF52 general purpose I/O pin SAADC / COMP / LPCOMP input
21	GND	Ground	Power Ground – Must be connected to ground on application PCB
22	GND	Ground	Power Ground – Must be connected to ground on application PCB
23	GND	Ground	Power Ground – Must be connected to ground on application PCB
24	LoRa_TR	RF I/O	LoRa RF I/O pin of the module Should be connected to Pin 25 for normal operation
25	LoRa_ANT	RF I/O	Internal LoRa antenna RF I/O pin Should be connected to Pin 24 for normal operation
26	GND	Ground	Power Ground – Must be connected to ground on application PCB
27	GND	Ground	Power Ground – Must be connected to ground on application PCB
28	GND	Ground	Power Ground – Must be connected to ground on application PCB
29	GND	Ground	Power Ground – Must be connected to ground on application PCB
30	GND	Ground	Power Ground – Must be connected to ground on application PCB

## Preliminary Data Sheet

Pin	Name	Pin function	Description
31	GND	Ground	Power Ground – Must be connected to ground on application PCB
32	GND	Ground	Power Ground – Must be connected to ground on application PCB
33	GND	Ground	Power Ground – Must be connected to ground on application PCB
34	BLE_ANT	RF I/O	Internal BLE antenna RF I/O pin Should be connected to Pin 35 for normal operation
35	BLE_TR	RF I/O	BLE RF I/O pin of the module Should be connected to Pin 34 for normal operation
36	GND	Ground	Power Ground – Must be connected to ground on application PCB
37	SWDCLK	Digital I/O	nRF52 Serial Wire Debug clock input for debug and programming
38	SWDIO	Digital I/O	nRF52 Serial Wire Debug I/O for debug and programming
39	P0_20 TRCCLK	Digital I/O	nRF52 general purpose I/O pin Trace port clock output
40	P0_21 RESET	Digital I/O	nRF52 general purpose I/O pin May be configured as nRF52 RESET pin
41	P0_18 TRCDAT0	Digital I/O	nRF52 general purpose I/O pin Trace port output
42	P0_16 TRCDAT1	Digital I/O	nRF52 general purpose I/O pin Trace port output
43	P0_15 TRCDAT2	Digital I/O	nRF52 general purpose I/O pin Trace port output
44	P0_14 TRCDAT3	Digital I/O	nRF52 general purpose I/O pin Trace port output
45 .. 73	NC	Not Connected	Isolated pad on application PCB for mechanical stability
74	GND	Ground	Segmented Ground Plane Must be connected to ground on application PCB



ISP4520 pad  
placement and pin  
assignment for the  
LGA QFN package

TOP VIEW



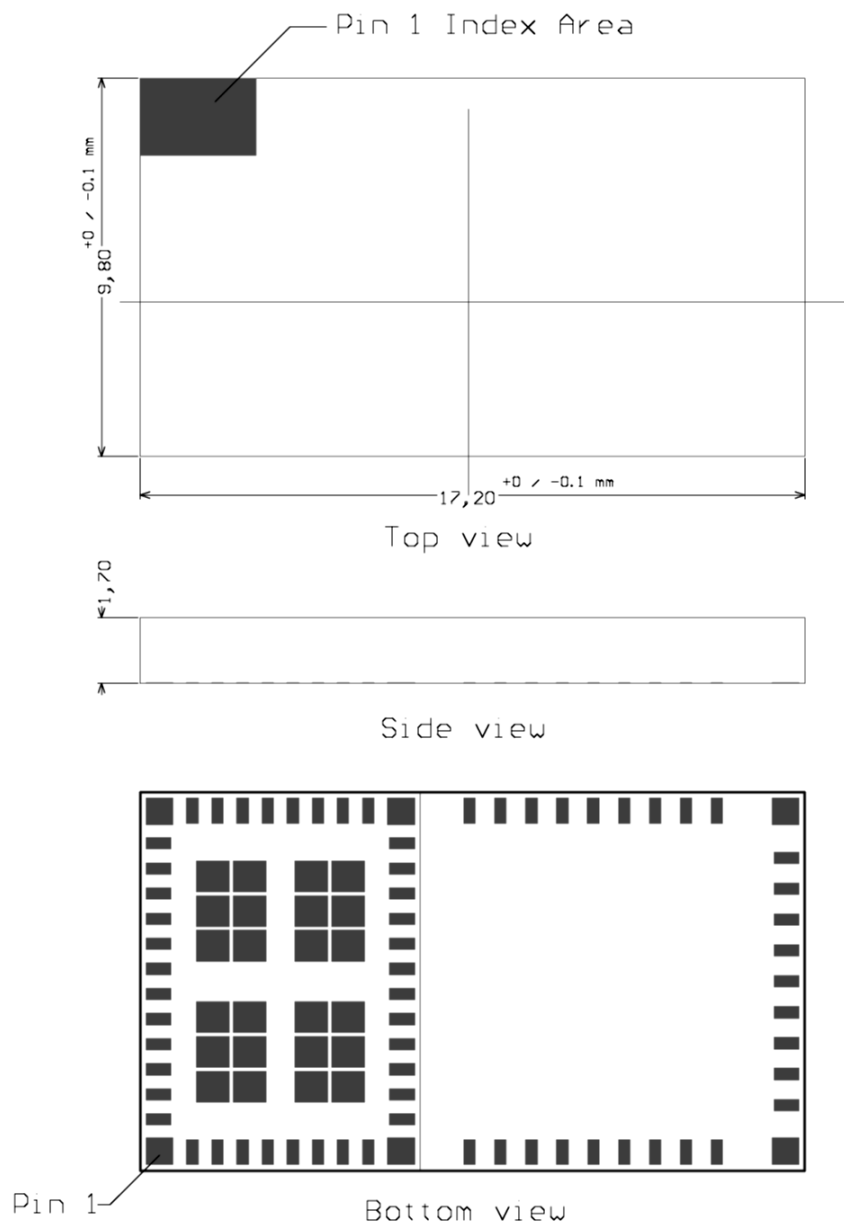


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### 4. Mechanical Outlines

#### 4.1. Mechanical Dimensions

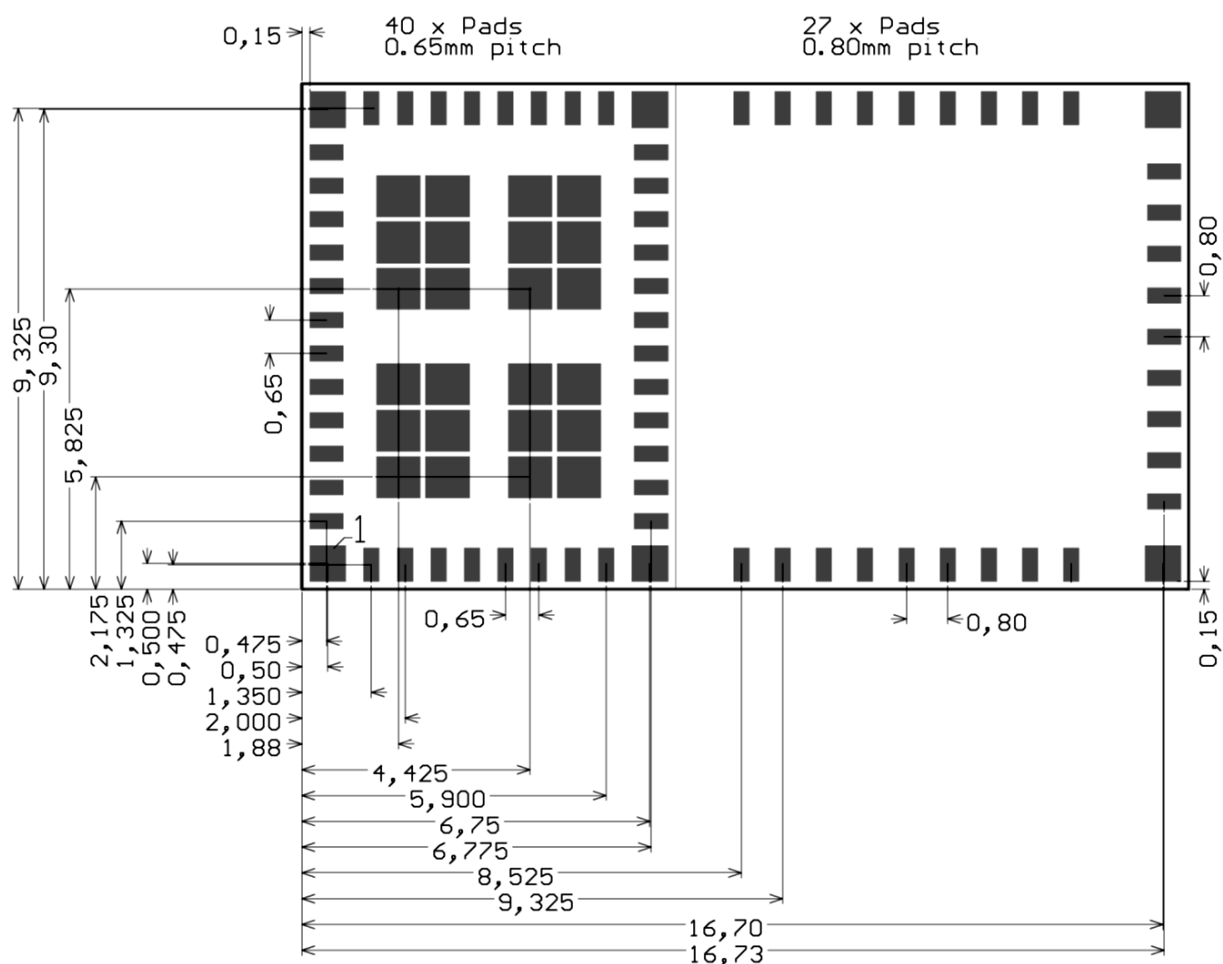
Dimensional drawing for 9.8 x 17.2 x 1.7 mm, 74-Pad LGA Package



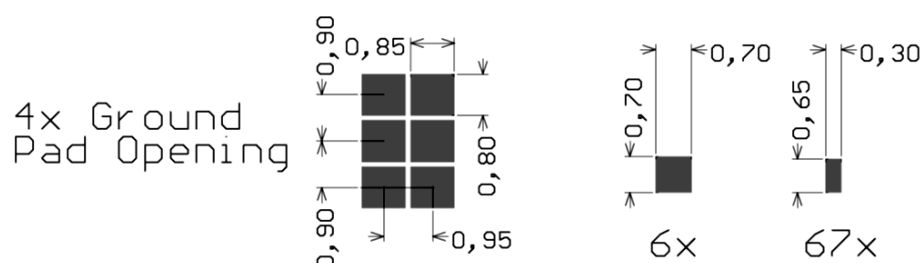
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## Preliminary Data Sheet

### Detail of LGA package pad positioning and size



Bottom view



## Preliminary Data Sheet

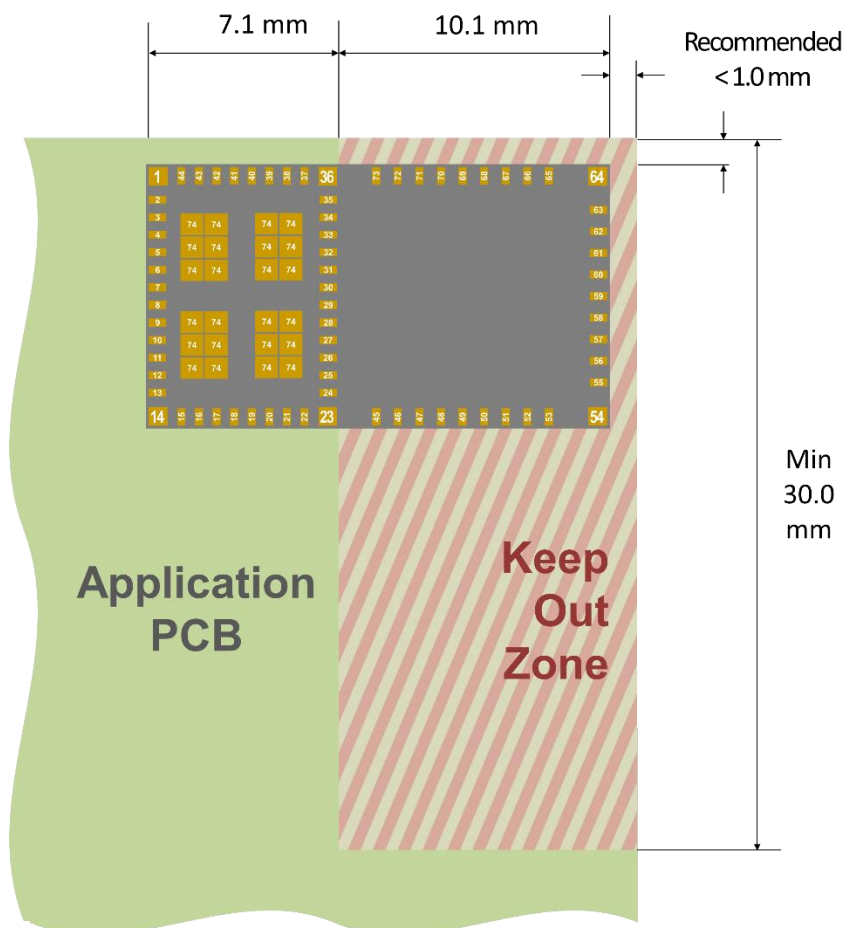
### 4.2. SMT Assembly Guidelines

For PCB Land Patterns and Solder Mask layout, Insight SiP recommends the use of the same dimensions as the module pads, i.e. 0.65 x 0.30 mm for standard pads, 0.70 x 0.70 mm for corner pads, 2.75 x 2.15 mm for mechanical pads.

Please contact Insight SiP for more detailed information.

### 4.3. Antenna Keep-Out Zone

For optimal antenna performance, it is recommended to respect a metal exclusion zone to the edge of the board: no metal, no traces and no components on any application PCB layer except mechanical LGA pads.



## Preliminary Data Sheet

### 5. Packaging & Ordering information

#### 5.1. Marking

M	/N	:	I	S	P	4	5	2	0
T	T		Y	Y	W	W	R		

ISP4520	Part Number
TT	2 letters Module Type (see section 5.5)
YY	2 digits year number
WW	2 digits week number
R	1 letter Hardware revision



#### 5.2. Prototype Packaging

For engineering samples and prototype quantities up to 99 units, deliveries are provided in thermoformed trays. Please order with "ST" code packaging suffix.

They are delivered in sealed pack with desiccant pack and humidity sensors. Please see section 6.2 for more information on moisture sensitivity.



#### 5.3. Jedec Trays

For higher quantities and volume production, ISP4520 are available in Jedec trays. They are delivered in sealed pack with desiccant pack and humidity sensors. These Jedec trays are also suitable for further baking. Please see section 6.2 for more information on moisture sensitivity.

Jedec trays are proposed in standard quantities of 100 units, 200 units and multiples of 200 units only. Please order with "J1" code packaging suffix for 100-unit tray and "J2" for 200 and multiple unit trays.

Complete information on Jedec trays is available on request.

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### 5.4. Tape and Reel

ISP4520 are also available in Tape & Reel. They are delivered in sealed pack with desiccant pack and humidity sensors. Reels are proposed in standard quantities of 500 units (180mm / 7" reel) or 2000 units (330mm / 13" reel) only. Please order with "RS" code packaging suffix for 500-unit reels and "R2" for 2000-unit reels.

Complete information is available on request.

### 5.5. Ordering Information

I	S	P	4	5	2	0	-	T	T	-	Z	Z	
								▼	▼		▼	▼	
								▼	▼		▼	▼	
								▼	▼		▼	▼	
I	S	P	4	5	2	0							Part Number
							-	E	U				LoRa EU frequency range & BLE protocol (1)
							-	U	S				LoRa US frequency range & BLE protocol (1)
							-	J	P				LoRa JP frequency range & BLE protocol (1)
							-	S	T				Unsealed Tray Packaging
							-	J	T				Jedec Tray
							-	R	S				Reel of 500 units
							-	R	2				Reel of 2000 units

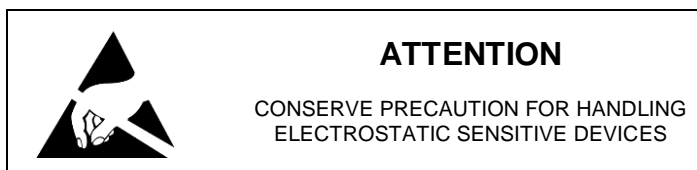
(1) Refer to section 2.6 for frequency bands

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### 6. Storage & Soldering information

#### 6.1. Storage and Handling

- ✚ Keep this product away from other high frequency devices which may interfere with operation such as other transmitters and devices generating high frequencies.
- ✚ Do not expose the module to the following conditions:
  - Corrosive gasses such as Cl<sub>2</sub>, H<sub>2</sub>S, NH<sub>3</sub>, SO<sub>2</sub>, or NO<sub>x</sub>
  - Extreme humidity or salty air
  - Prolonged exposure to direct Sunlight
  - Temperatures beyond those specified for storage
- ✚ Do not apply mechanical stress
- ✚ Do not drop or shock the module
- ✚ Avoid static electricity, ESD and high voltage as these may damage the module



#### 6.2. Moisture Sensitivity

All plastic packages absorb moisture. During typical solder reflow operations when SMDs are mounted onto a PCB, the entire PCB and device population are exposed to a rapid change in ambient temperature. Any absorbed moisture is quickly turned into superheated steam. This sudden change in vapor pressure can cause the package to swell. If the pressure exerted exceeds the flexural strength of the plastic mold compound, then it is possible to crack the package. Even if the package does not crack, interfacial delamination can occur.

Since the device package is sensitive to moisture absorption, it is recommended to bake the product before assembly. The baking process for dry packing is 24 hours at 125°C.

ISP4520 has been tested MSL-5 according to standards. After baking, modules can be exposed to ambient room conditions (approximately 30 °C/60%RH) during 48 hours before assembly on the PCB.

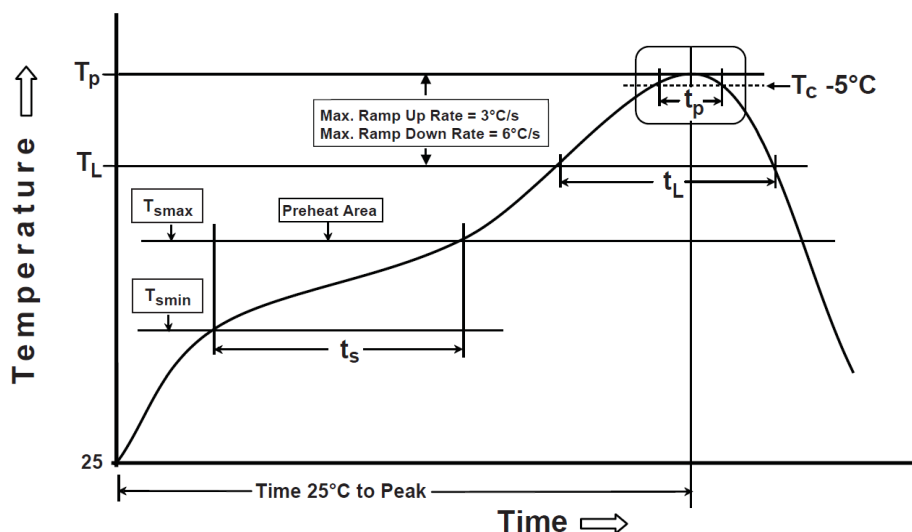




## Preliminary Data Sheet

### 6.3. Soldering information

Recommendation for RoHS reflow process is according to Jedec J-STD-020 and 033 standard profiles.



Preheat/Soak	
Temperature Min ( $T_{smin}$ )	150 °C
Temperature Max ( $T_{smax}$ )	200 °C
Time ( $t_s$ ) from ( $T_{smin}$ to $T_{smax}$ )	60-120 sec
Ramp-up rate ( $T_L$ to $T_p$ )	3 °C/sec max
Liquidous temperature ( $T_L$ )	217 °C
Time ( $t_L$ ) maintained above $T_L$	60-150 sec

Peak package body temperature ( $T_p$ )	260°C (+0/-5°C)
Classification Temperature ( $T_c$ )	260 °C
Time ( $t_p$ ) maintained above $T_c -5^\circ\text{C}$	30 sec
Ramp-down rate ( $T_p$ to $T_L$ )	6 °C/sec max
Time 25 °C to peak temperature	8 mn max

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### 7. Quality & User information

#### 7.1. Pending Certifications

- FCC Identifier tbd
- CE: Complies with 1999/5/EC, EN300328 V1.9.1 – EC DoC N° tbd
- Bluetooth SIG certified N° tbd
- RoHS compliant

#### 7.2. USA – User information

This intends to inform how to specify the FCC ID of our module “ISP4520” on the product. Based on the Public Notice from FCC, the host device should have a label which indicates that it contains our module. The label should use wording such as:

“Contains FCC ID: 2AAQS-ISP4520”

Any similar wording that expresses the same meaning may be used.

The label of the host device should also include the below FCC Statement. When it is not possible, this information should be included in the User Manual of the host device:

*“This device complies with part 15 of the FCC rules. Operation is subject to the following two conditions.  
(1) This device may not cause harmful interference  
(2) This device must accept any interference received, including interference that may cause undesired operation.  
Caution: Any Changes or modifications not expressly approved by the party responsible for compliance could void the user’s authority to operate the equipment.”*

#### 7.3. Canada – User information

This intends to inform how to specify the IC ID of our module “ISP4520” on the product. According to Canadian standards “RSS-210” and “RSS-Gen”, the host device should have a label which indicates that it contains our module. The label should use wording such as:

“Contains IC: 11306A-ISP4520”

Any similar wording that expresses the same meaning may be used.

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The label of the host device should also include the below IC Statement. When it is not possible, this information should be included in the User Manual of the host device:

*"This device complies with Industry Canada licence-exempt RSS standard(s). 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."*

*Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes : (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement."*

### 7.4. RF Exposure Information

This equipment complies with FCC/IC radiation exposure limits set forth for an uncontrolled environment and meets the FCC radio frequency (RF) Exposure Guidelines in Supplement C to OET65 and RSS-102 of the IC radio frequency (RF) Exposure rules. This equipment has very low levels of RF energy that it deemed to comply without maximum permissive exposure evaluation (MPE).

### 7.5. Informations concernant l'exposition aux fréquences radio (RF)

La puissance de sortie émise par l'appareil de sans fil est inférieure à la limite d'exposition aux fréquences radio d'Industry Canada (IC). Ce module a également été évalué et démontré conforme aux limites d'exposition aux RF d'IC dans des conditions d'exposition à des appareils mobiles et/ou portables.

### 7.6. Discontinuity

Normally a product will continue to be manufactured as long as all of the following are true:

- The manufacturing method is still available.
- There are no replacement products.
- There is demand for it in the market.

In case of obsolescence, Insight SiP will follow Jedec Standard JSD-48. A Product Discontinuation Notice (PDN) will be sent to all distributors and made available on our website. After this, the procedure goes as follows:

- Last Order Date will be 6 months after the PDN was published.
- Last Shipment Date will be 6 months after Last Order Date, i.e. 12 months after PDN.

**Preliminary Data Sheet****7.7. Disclaimer**

Insight SiP's products are designed and manufactured for general consumer applications, so testing and use of the product shall be conducted at customer's own risk and responsibility. Please conduct validation and verification and sufficient reliability evaluation of the products in actual condition of mounting and operating environment before commercial shipment of the equipment. Please also pay attention (i) to apply soldering method that don't deteriorate reliability, (ii) to minimize any mechanical vibration, shock, exposure to any static electricity, (iii) not to overstress the product during and after the soldering process.

The products are not designed for use in any application which requires especially high reliability where malfunction of these products can reasonably be expected to result in personal injury or damage to the third party's life, body or property, including and not limited to (i) aircraft equipment, (ii) aerospace equipment, (iii) undersea equipment, (iv) power plant control equipment, (v) medical equipment, (vi) transportation equipment, (vii) traffic signal equipment, (viii) disaster prevention / crime prevention equipment.

The only warranty that Insight SiP provides regarding the products is its conformance to specifications provided in datasheets. Insight SiP hereby disclaims all other warranties regarding the products, express or implied, including without limitation any warranty of fitness for a particular purpose, that they are defect-free, or against infringement of intellectual property rights. Insight SiP customers agree to indemnify and defend Insight SiP against all claims, damages, costs and expenses that may be incurred, including without any limitation, attorney fees and costs, due to the use of products.