LANTRONIX®

# SARA-R500S-01B

## LTE-M / NB-IoT modules Data sheet

# Document information

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|---|---|
| **Title** | **SARA-R500S-01B** |
| **Subtitle** | LTE-M / NB-IoT modules |
| **Document type** | Data sheet |

| **Product status** | **Corresponding content status** | |
|---|---|---|
| **Functional sample** | Draft | For functional testing. Revised and supplementary data will be published later. |
| **In development / Prototype** | Objective specification | Target values. Revised and supplementary data will be published later. |
| **Engineering sample** | Advance information | Data based on early testing. Revised and supplementary data will be published later. |
| **Initial production** | Early production information | Data from product verification. Revised and supplementary data may be published later. |
| **Mass production / End of life** | Production information | Document contains the final product specification. |

# 1 Functional description

## 1.1 Overview

- SARA-R500S-01B, general purpose LTE Cat M1 / LTE Cat NB2 product designed for multi-regional deployments

The miniature SARA LGA form factor (26.0 x 16.0 mm, 96-pin) allows an easy integration into compact designs and a seamless drop-in migration from other LTRX cellular module families.

SARA-R5 series modules are form-factor compatible with the LTRX LISA, LARA and TOBY cellular module families and they are pin-to-pin compatible with the u-blox SARA-R4, SARA-N2, SARA-N3, SARA-N4, SARA-G3, SARA-G4 and SARA-U2 cellular modules families. This facilitates migration from other LTRX LPWA modules as well as from other LTRX GSM/GPRS, CDMA, UMTS/HSPA and higher LTE categories modules, maximizing customer investments, simplifying logistics, and enabling very short time-to-market.

SARA-R500S-01B modules provide software-based multi-band configurability enabling international multi-regional coverage in LTE Cat M1 / NB2 radio access technologies, supporting a comprehensive set of 3GPP Rel. 14 features that are relevant for IoT applications.

SARA-R500s modules offer data communications up to 1200 kbit/s over an extended operating temperature range of –40 °C to +85 °C, with low power consumption, and with coverage enhancement for deeper range into buildings and basements (and underground with NB2).

## 1.2 Block diagram

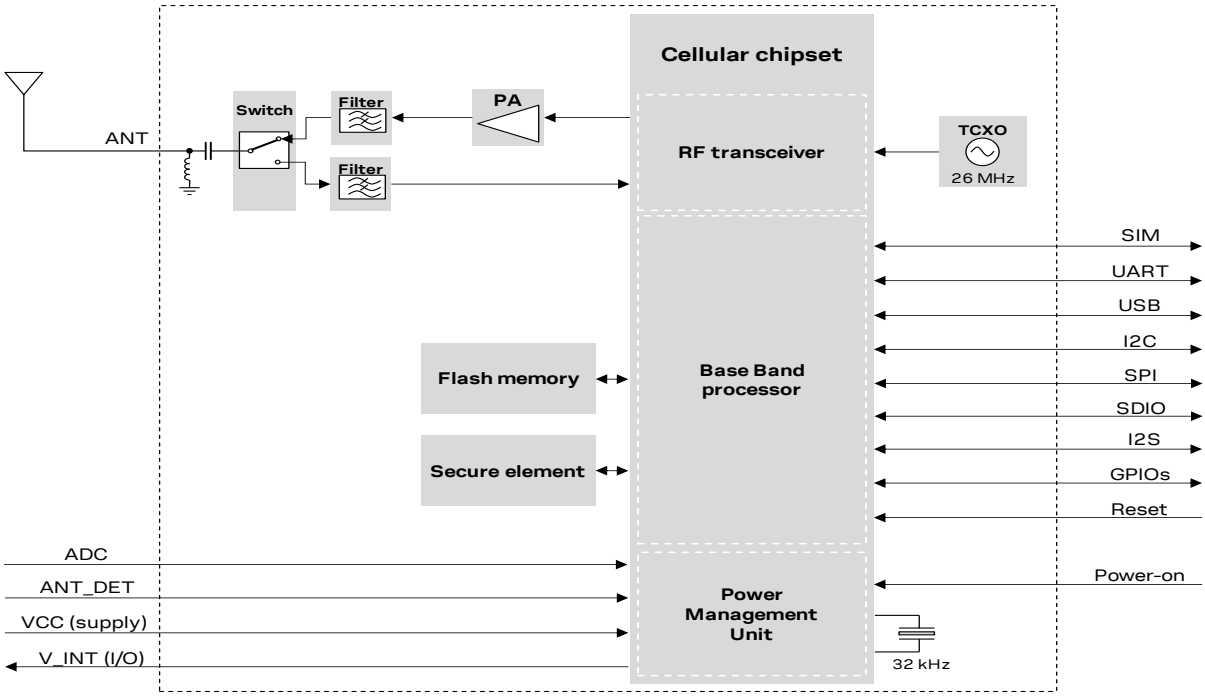


**Figure 1: SARA-R500 block diagram**

## 1.4 Product description

| Item | SARA-R500S-01B |
|---|---|
| Cellular protocol stack | 3GPP Rel.13 LTE Cat M1 and NB1<br>3GPP Rel.14 LTE Cat M1: Coverage Enhancement Mode B, Uplink TBS of 2984b<br>3GPP Rel.14 LTE Cat NB2: Higher data rate (TBS of 2536b), Mobility enhancement (RRC connection re-establishment), E-Cell ID, two HARQ processes, Release Assistant, Random access on Non-Anchor Carrier |
| Cellular RAT | LTE Cat M1 Half-Duplex<br>LTE Cat NB2 Half-Duplex |
| Cellular operating bands | LTE FDD band 1 (2100 MHz)<br>LTE FDD band 2 (1900 MHz)<br>LTE FDD band 3 (1800 MHz)<br>LTE FDD band 4 (1700 MHz)<br>LTE FDD band 5 (850 MHz)<br>LTE FDD band 8 (900 MHz)<br>LTE FDD band 12 (700 MHz)<br>LTE FDD band 13 (750 MHz)<br>LTE FDD band 18 (850 MHz)<br>LTE FDD band 19 (850 MHz)<br>LTE FDD band 20 (800 MHz)<br>LTE FDD band 25 (1900 MHz)<br>LTE FDD band 26 (850 MHz)<br>LTE FDD band 28 (700 MHz)<br>LTE FDD band 66 (1700 MHz)<br>LTE FDD band 71 (600 MHz)<br>LTE FDD band 85 (700 MHz) |
| Cellular power class | LTE power class 3 (23 dBm) |
| Cellular data rate | LTE category M1:<br>up to 1200 kbit/s UL, up to 375 kbit/s DL<br>LTE category NB2:<br>up to 140 kbit/s UL, up to 125 kbit/s DL |

## 1.5 AT command support

The SARA-R500s modules support AT commands according to the 3GPP standards TS 27.007 [4], TS 27.005 [5], TS 27.010 [6].

☞ For the complete list of all supported AT commands and their syntax, see SARA-R5 series AT commands manual [1].

## 1.6 Supported features

Table 3 lists some of the main features supported by SARA-R500s modules. For more details, see the SARA-R5 series system integration manual [2] and SARA-R5 series AT commands manual [1].

| Feature | Description |
|---|---|
| Device security | An immutable chip ID and hardware-based Root of Trust (RoT) embedded in a dedicated Common Criteria EAL5+ high certified Secure Element[1] provide foundational security and a unique device identity.<br>Device security features include:<br>• Secure boot: software authenticity and integrity<br>• Secure update: secure delivery of the correct FW to the module<br>• Anticloning detection and rejection[1]: system automatically identifies and blocks clones that use the same RoT |
| Data security[1] | Secure libraries allow generation of hardware-backed crypto functions and keys for local encryption to secure local file storage and for end-to-end encryption.<br>Data security features include:<br>• Local data protection: symmetric crypto functions via AT command to locally encrypt / decrypt and authenticate data (e.g. certificates, tokens) on the device. Allows also secure local storage of sensitive information in a non-secure location (e.g. in “standard” device memory)<br>• Local chip-to-chip (C2C) security: unique cryptographic pairing between the MCU of the device and u-blox module by providing confidentiality, integrity, mutual authentication for their communication channel (e.g. UART interface)<br>• E2E symmetric KMS: highly scalable method to provision and manage a session unique PSK available in cloud via REST API. Up to 8 times reduction in secure communication data overhead reducing data power consumption and cost<br>• E2E data protection: minimize data traffic and power encrypting data on a device and decrypting asynchronously in cloud independent of protocols, servers, platforms or time before reaching final destination<br>• E2E data integrity[2]: sign data on a device and verify the signature asynchronously in cloud |
| Secure access management[1] | Allow only authenticated access to device and features, safely manage changes of device ownership and provide out-of-the-box, simple, secure and cost effective zero touch onboarding to popular IoT cloud platforms.<br>Access management features include:<br>• Change of ownership: efficient way to change the ownership and to apply the policies / authorizations of the new owner, even if the device is already in the field<br>• Zero touch provisioning for AWS and Azure: out-of-the-box, simple, secure and cost effective AWS and Azure onboarding |
| MQTT Anywhere[3], MQTT Flex[3] | With u-blox’s communication services – MQTT Anywhere or MQTT Flex – data overhead, time spent on-the-air, and energy consumption can be reduced, thus enabling users to extend device life cycles, lower costs, and improve ROI. |
| Integrated GNSS receiver[4] | SARA-R510M8S modules are pre-integrated with a u-blox UBX-M8030 concurrent GNSS chipset with SPG 3.01 firmware version, comprehensive of a dedicated GNSS antenna interface, additional LNA and SAW filter for a highly reliable, accurate positioning data.<br>The GNSS system is totally independent from the LTE system and can run concurrently to a LTE communication. |

| Feature | Description |
|---|---|
| External GNSS control via modem [5] | Access to external u-blox GNSS positioning chips and modules through I2C interface.<br>This means that any external host processor can control the SARA-R500E, SARA-R500S or SARA-R510S cellular module and the u-blox GNSS chip / module through a single serial port. |
| Embedded AssistNow Software | Embedded AssistNow Online and AssistNow Offline clients are available to provide better GNSS performance and faster Time-to-First-Fix. An AT command can enable / disable the clients. |
| CellLocate® | Enables the estimation of device position based on the parameters of the mobile network cells visible to the specific device based on the CellLocate® database.<br>CellLocate® is available via a set of AT commands for CellLocate® service configuration and position request. |
| Hybrid Positioning | Provides the module's current position using a u-blox positioning chip or module (external for SARA-R500E / SARA-R500S / SARA-R510S, integrated UBX-M8 chip for SARA-R510M8S) or the estimated position from CellLocate®, depending on which positioning method provides the best and fastest solution according to the user configuration.<br>Hybrid positioning is implemented through a set of AT commands that allow the configuration and the position request. |
| CellTime | Returns accurate timing retrieved from the LTE network and/or from the u-blox positioning chip or module (external for the SARA-R500E / SARA-R500S / SARA-R510S cellular modules, integrated UBX-M8 chip for the SARA-R510M8S modules).<br>Can be used to provide periodic time-stamps to an external application processor or to output a time indication associated to an interrupt detected on a GPIO (e.g. coming from an external sensor connected to the module).<br>The implementation of CellTime can be extended to control and maintain timing info in a network of sensors (each one integrating a SARA-R5 module). |
| Antenna dynamic tuning | Control via two GPIOs an external antenna matching IC according to the LTE band used by the module. |
| Embedded TCP and UDP stack | Embedded TCP/IP and UDP/IP stack including direct link mode for TCP and UDP sockets.<br>Sockets can be set in Direct Link mode to establish a transparent end-to-end communication with an already connected TCP or UDP socket via the serial interface. |
| HTTP, HTTPS<br>(v1.0 for +UHTTP,<br>v1.1 for LwM2M client) | Hyper-Text Transfer Protocol as well as Secure Hyper-Text Transfer Protocol (SSL encryption) functionalities are supported via AT commands. |
| FTP, FTPS | File Transfer Protocol as well as Secure File Transfer Protocol (SSL encryption of FTP control channel) functionalities are supported by means of AT commands. |
| CoAP<br>(RFC 7252) [11] | Embedded Constrained Application Protocol (CoAP) datagram-based client/server application protocol designed to easily translate from HTTP for simplified integration with the web. |
| MQTT (v3.1.1) and MQTT-SN (v1.2) | Embedded Message Queuing Telemetry Transport (MQTT) and MQTT for Sensor Networks (MQTT-SN) publish-subscribe messaging protocols designed for lightweight M2M communications over TCP (MQTT) or over UDP (MQTT-SN). These allow one-to-one, one-to-many and many-to-one communications over a TCP or UDP connection. |
| LwM2M with dynamically loaded objects (v1.0) | The LwM2M is a light and compact communication protocol designed for managing IoT machine-to-machine communication between a LwM2M Server and a LwM2M Client located in lightweight, low power or resource-constrained LwM2M devices, with object data model.<br>SARA-R5 series modules allow customers to configure dynamically loaded run time objects, defining necessary custom objects, creating instances of those objects as appropriate, managing module LwM2M protocol stack to interact with the LwM2M server. |
| TLS (v1.0, v1.1, v1.2, v1.3) and DTLS (v1.2) | Transport Layer Security (TLS) provides security for HTTP, FTP, MQTT and TCP communications.<br>Embedded Datagram Transport Layer Security (DTLS) provides security for CoAP, LwM2M, MQTT-SN and UDP communications. |
| Jamming detection | Detects "artificial" interference that obscures the operator's carrier entitled to give access to the radio service and automatically reports the start and stop of such conditions to the application processor that can react accordingly. |

| Feature | Description |
|---|---|
| Smart temperature supervisor | Constant monitoring of the module board temperature:<br>• Warning notification when the temperature approaches an upper or lower predefined threshold (see section 4.2.16)<br>• Shutdown notified and forced when the temperature value is outside the specified range (shutdown suspended in case of an emergency call in progress)<br>The smart temperature supervisor feature can be enabled or disabled through an AT command (see the SARA-R5 series AT commands manual [1], +USTS AT command). |
| Last gasp | In case of power supply outage (i.e. main supply interruption, battery removal, battery voltage below a certain threshold) the cellular module can be configured to send an alarm notification to a remote entity. The feature can be enabled and configured through the +ULGASP AT command. |
| Network status indication | GPIO configured to indicate the network status: registered home network, registered roaming, data call enabled, no service. The feature can be enabled through the +UGPIOC AT command. |
| Antenna detection | The **ANT_DET** pin provides antenna presence detection capability, evaluating the resistance from the **ANT** pin to GND by means of an external antenna detection circuit implemented on the application board. The antenna supervisor (i.e. antenna detection) feature can be enabled through the +UANTR AT command. |
| BIP | Bearer Independent Protocol for over-the-air SIM provisioning. |
| Dual stack IPv4/Ipv6 | Capability to move between Ipv4 and dual stack network infrastructures.<br>Ipv4 and Ipv6 addresses can be used. |
| Firmware update Over AT commands (FOAT) | Firmware module update over AT command interface.<br>The feature can be enabled and configured through the +UFWUPD AT command. |
| u-blox Firmware update Over The Air (uFOTA) | u-blox firmware module update over the LTE air interface client/server solution using LwM2M. |
| Power Saving Mode (PSM) | The Power Saving Mode (PSM) feature, defined in 3GPP Rel.13, allows further reduction of the module current consumption maximizing the amount of time a device can remain in PSM low power deep-sleep mode during periods of data inactivity. It can be activated and configured by the +CPSMS AT command. |
| eDRX | Extended mode DRX, based on 3GPP Rel.13, reduces the amount of signaling overhead decreasing the frequency of scheduled measurements and/or transmissions performed by the module in idle mode (for eDRX cycles shorter than 327.68 s) or in deep-sleep mode (for eDRX cycles equal or longer than 327.68 s). This in turn leads to a reduction in the module power consumption while maintaining a perpetual connection with the base station. |
| Coverage Enhancement (mode A and mode B) | Coverage Enhancement modes introduced in 3GPP Rel.13 are used to improve the cell signal penetration. |
| LTE-M and NB-IoT 3GPP release 14 features | |

# 2 Interfaces

## 2.1 Power management

### 2.1.1 Module supply input (VCC)

SARA-R500S-01B modules must be supplied through the **VCC** pins by a proper external DC power supply providing a nominal voltage within the normal operating range (see Table 11). Voltage must be stable, because during operation the current drawn from **VCC** may vary significantly, based on the power consumption profile of the LTE Cat M1 and LTE Cat NB2 radio access technologies (described in the SARA-R5 series system integration manual [2]).

The three **VCC** pins of SARA-R5 series modules are internally connected to both the internal Power Amplifier and the internal Power Management Unit, which integrates voltage regulators generating all the internal supply voltages needed by the module for the designed operations, as the supply voltage for the generic digital interfaces (**V_INT**), the supply voltage for the SIM interface (**VSIM**), and the supply voltage for the internal GNSS receiver.

It is important that the system power supply circuit is able to withstand the maximum pulse current during a transmit burst at maximum power level (see Table 13).

### 2.1.2 Generic digital interfaces supply output (V_INT)

SARA-R5 series modules provide a 1.8 V supply rail output on the **V_INT** pin, which is internally generated when the module is switched on. The same voltage domain is used internally to supply the generic digital interfaces of the module. The **V_INT** supply output can be used in place of an external discrete regulator.

☞ It is recommended to provide accessible test point directly connected to the **V_INT** pin.

## 2.2 Antenna interface

### 2.2.1 Cellular antenna RF interface (ANT)

The **ANT** pin is the cellular RF antenna I/O interface, designed with 50 Ω characteristic impedance.

### 2.2.2 GNSS antenna RF interface (ANT_GNSS)

☞ The GNSS antenna RF interface is not supported by SARA-R500E, SARA-R500S, SARA-R510S.

The **ANT_GNSS** pin represents the GNSS RF input of the SARA-R510M8S modules, designed with 50 Ω characteristic impedance and with an internal DC block, suitable for both active and/or passive GNSS antennas due to the built-in SAW filter followed by an LNA in front of the integrated high performing LTRX M8 concurrent positioning engine.

### 2.2.3 Antenna detection (ANT_DET)

The **ANT_DET** pin is an Analog to Digital Converter (ADC) input with a current source provided by SARA-R5 series modules to sense the external antenna presence (as an optional feature), evaluating the DC resistance to GND by means of an externally implemented circuit (for more details, see the LTRX SARA-R5 series system integration manual [2] and the SARA-R5 series AT commands manual [1]).

## 2.3 System functions

### 2.3.1 Module power-on

When the SARA-R500E, SARA-R500S and SARA-R510M8S modules are not powered, they can be switched on as following:

- Rising edge on the **VCC** supply input to a valid voltage for modules supply: the modules switch on applying **VCC** supply starting from a voltage value lower than 2.15 V, providing a fast enough **VCC** voltage slope, as it must ramp from 2.15 V to 3.0 V within 300 ms, and reach a regular nominal **VCC** voltage value within the operating range (see Table 11).

When the SARA-R510S modules are not powered, they can be switched on as following:

- Applying a voltage at the **VCC** module supply input within the operating range (see Table 11), and then forcing a low level at the **PWR_ON** input pin, which is normally set high by an internal pull-up, for a valid time period (see section 4.2.9, module switch-on).

When the SARA-R5 series modules are in power-off mode (i.e. switched off, but with a valid voltage present at the **VCC** module supply input within the operating range reported in Table 11), they can be switched on as following:

- Forcing a low level at the **PWR_ON** input pin, which is normally set high by an internal pull-up, for a valid time period (see section 4.2.9, module switch-on).

When the SARA-R5 series modules are in low power PSM / eDRX[6] deep-sleep mode, with a valid voltage present at the **VCC** module supply input within the operating range reported in Table 11, they can be woken up as following:

- Forcing a low level at the **PWR_ON** input pin, which is normally set high by an internal pull-up, for a valid time period (see section 4.2.9, module early wake-up from PSM / eDRX deep-sleep).

The **PWR_ON** line is intended to be driven by open drain, open collector or contact switch.

☞ It is recommended to provide accessible test point directly connected to the **PWR_ON** input pin.

### 2.3.2 Module power-off

The proper graceful power-off of the SARA-R5 series modules, with storage of the current parameter settings in the module's non-volatile memory and a clean network detach, can be triggered by:

- AT+CPWROFF command (see the SARA-R5 series AT commands manual [1])

A faster and safe power-off procedure of the modules, with storage of the current parameter settings in the module's non-volatile memory and without a clean network detach, can be triggered by:

- AT+CFUN=10 command (see the SARA-R5 series AT commands manual [1])
- Toggling the GPIO input configured with the faster and safe power-off function (see section 2.7)

An abrupt emergency hardware shutdown of the modules, without saving current parameter settings in the module's non-volatile memory and without clean network detach, can be executed by:

- Forcing a low pulse at the **PWR_ON** and **RESET_N** input pins, in the proper sequence described in section 4.2.9 with details in Figure 6

An abrupt under-voltage shutdown occurs on SARA-R5 series modules when the **VCC** supply is removed. If this occurs, it is not possible to store the current parameter settings in the module's non-volatile memory or to perform the proper network detach.

An over-temperature or an under-temperature shutdown occurs on the SARA-R5 series modules when the temperature measured within the module reaches the dangerous area (see section 4.2.16), if the optional "Smart temperature supervisor" feature is enabled and configured by the dedicated AT command (see the SARA-R5 series AT commands manual [1], +USTS AT command).

### 2.3.3 Module reset

SARA-R5 series modules can be reset (re-booted), saving current parameter settings in the module's non-volatile memory and performing a proper network detach, by:

- AT+CFUN=16 command (for other options and further details, see the SARA-R5 series AT commands manual [1]). This causes a graceful software reset of the module.

An abrupt software reset of the module is executed by applying a low pulse at the **RESET_N** input pin, which is normally set high by an internal pull-up, for a valid time period (see section 4.2.10). The current parameter settings are not saved in the module's non-volatile memory and a proper network detach is not performed.

The **RESET_N** line is intended to be driven by open drain, open collector or contact switch.

☞ It is recommended to provide accessible test point directly connected to the **RESET_N** input pin.

## 2.4 SIM

☞ The external SIM interface is not supported by the SARA-R500E modules.

### 2.4.1 SIM interface

SARA-R5 series modules provide the **VSIM**, **SIM_IO**, **SIM_CLK**, **SIM_RST** pins as an interface to connect an external SIM card/chip. Both 1.8 V and 3.0 V SIM types are supported. Activation and deactivation with an automatic voltage switch from 1.8 V to 3.0 V is implemented according to the ISO-IEC 7816-3 specifications.

### 2.4.2 SIM detection

The **GPIO5** pin of SARA-R5 series modules is a 1.8 V digital input which can be configured as an external interrupt to detect the SIM card presence (as a feature which can be optionally used), as intended to be properly connected to the mechanical switch of an external SIM card holder.

For more details, see the SARA-R5 series system integration manual [2] and the SARA-R5 series AT commands manual [1].

## 2.5 Serial communication

The SARA-R5 series provides the following serial communication interfaces:

- UART interfaces, available for communications with host application processor (2.5.1)
- USB 2.0 compliant interface, available for diagnostics only (2.5.2)
- SPI interfaces, available for communications with external SPI devices and for diagnostic (2.5.3)
- SDIO interface, available for communications with external SDIO devices (2.5.4)
- I2C bus compatible interface, available for communications with external I2C devices (2.5.5)

### 2.5.1 UART interfaces

The SARA-R5 series modules include 1.8 V unbalanced asynchronous serial interfaces (UART) for communication with external application host processor(s).

UART can be configured by dedicated AT command in the following variants:

- **Variant 0** (default configuration), consists of a single UART interface that supports AT commands, data communication, multiplexer protocol functionality, FW update by means of FOAT or by means of the u-blox EasyFlash tool, and provides the following lines:
  - data lines (**RXD** as output, **TXD** as input),
  - hardware flow control lines (**CTS** as output, **RTS** as input),
  - modem status and control lines (**DTR** as input, **RI** as output)
- **Variant 1**, consists of a single UART interface that supports AT commands, data communication, multiplexer protocol functionality, FW update by means of FOAT or by means of the u-blox EasyFlash tool, and provides the following lines:
  - data lines (**RXD** as output, **TXD** as input),
  - hardware flow control lines (**CTS** as output, **RTS** as input),
  - modem status and control lines (**DTR** as input, **DSR** as output, **DCD** as output, **RI** as output)
- **Variants 2, 3 and 4**, consists of two UART interfaces plus ring indicator function:
  - First primary UART interface supports AT commands, data communication, multiplexer protocol functionality, FW update by means of FOAT or by means of the u-blox EasyFlash tool, and provides the following lines:
    - data lines (**RXD** as output, **TXD** as input),
    - hardware flow control lines (**CTS** as output, **RTS** as input),
  - Second auxiliary UART interface supports AT commands (variant 2 only), data communication (variant 2 only), FW update by means of FOAT (variant 2 only), diagnostic trace logging (variant 3 only), and GNSS tunneling (variant 4 only), and provides the following lines:
    - data lines (**DCD** as data output, **DTR** as data input),
    - hardware flow control lines (**RI** as flow control output, **DSR** as flow control input),
  - Ring indicator function over the GPIO pin configured with RI function (see section 2.7)

UART general features, valid for all variants, are:

- Serial port with RS-232 functionality conforming to the ITU-T V.24 recommendation [8], with CMOS compatible levels (0 V for low data bit or ON state, and 1.8 V for high data bit or OFF state)
- Hardware flow control (default value) or none flow control are supported
- UART power saving indication available on the hardware flow control output, if hardware flow control is enabled: the line is driven to the OFF state when the module is not prepared to accept data by the UART interface
- One-shot autobauding is supported and it is enabled by default: automatic baud rate detection is performed only once, at module start up. After the detection, the module works at the fixed baud rate (the detected one) and the baud rate can only be changed via AT command (see SARA-R5 series AT commands manual [1])
- Following baud rates are supported and can be auto detected: 9600 bit/s, 19200 bit/s, 38400 bit/s, 57600 bit/s, 115200 bit/s, 230400 bit/s, 460800 bit/s, 921600 bit/s
- Following baud rates are supported but cannot be auto detected: 3000000 bit/s, 3250000 bit/s
- The default frame format is 8N1 (8 data bits, no parity, 1 stop bit)
- Following frame formats are supported: 8N1 (8 data bits, no parity, 1 stop bit), 8N2 (8 data bits, no parity, 2 stop bit), 8E1 (8 data bits, even parity, 1 stop bit), 8O1 (8 data bits, odd parity, 1 stop bit), 7N1 (7 data bits, no parity, 1 stop bit), 7E1 (7 data bits, even parity, 1 stop bit), 7O1 (7 data bits, odd parity, 1 stop bit)

The UART interfaces can be conveniently configured through AT commands. For more details, see the SARA-R5 series AT commands manual [1] and SARA-R5 series system integration manual [2].

☞ It is highly recommended to provide accessible test points directly connected to the **TXD** and **RXD** pins for FW upgrade purpose.

☞ It is recommended to provide accessible test points directly connected to the **DCD** and **DTR** pins for diagnostic purpose.

#### 2.5.1.1 Multiplexer protocol

SARA-R5 series modules include multiplexer functionality as per 3GPP TS 27.010 [6] on the UART interfaces physical link. This is a data link protocol which uses HDLC-like framing and operates between the module (DCE) and the application processor (DTE), allowing a number of simultaneous sessions over the physical link (UART).

When USIO variant 0 or 1 is set, the following virtual channels are defined:

- Channel 0: control channel
- Channel 1 – 3: AT commands / data communication
- Channel 4: GNSS tunneling

When USIO variant 2 is set, AT commands and data communication are available on the second auxiliary UART, and the following virtual channels are defined on the primary UART:

- Channel 0: control channel
- Channel 1 – 2: AT commands / data communication
- Channel 3: GNSS tunneling

When USIO variant 3 is set, diagnostic trace log is available on the second auxiliary UART, and the following virtual channels are defined on the primary UART:

- Channel 0: control channel
- Channel 1 – 3: AT commands / data communication
- Channel 4: GNSS tunneling

When USIO variant 4 is set, GNSS tunneling is available on the second auxiliary UART, and the following virtual channels are defined on the primary UART:

- Channel 0: control channel
- Channel 1 – 3: AT commands / data communication

### 2.5.2 USB interface

SARA-R5 series modules include a high-speed USB 2.0 compliant interface with a maximum 480 Mbit/s data rate according to the USB 2.0 specification [9]. The module itself acts as a USB device and can be connected to any USB host equipped with compatible drivers.

The USB interface is available for diagnostic purpose only.

The **USB_D+** / **USB_D-** lines carry the USB data and signaling, while the **VUSB_DET** pin represents the input to enable the USB interface by applying an external valid USB VBUS voltage (5.0 V typical).

☞ It is highly recommended to provide accessible test points directly connected to the USB interface pins (**VUSB_DET**, **USB_D+**, **USB_D-**) for diagnostic purpose.

### 2.5.3 SPI interfaces

☞ The SPI interfaces are not supported by the “00B”, “01B”, “61B”, and “71B” products versions of SARA-R5 series modules, except for diagnostic purpose.

SARA-R5 series modules include 1.8V Serial Peripheral Interfaces available for communications with external SPI target devices, or with the module acting as SPI controller, for diagnostic purpose.

### 2.5.4 SDIO interface

☞ The SDIO interface is not supported by the “00B”, “01B”, “61B”, and “71B” products versions of SARA-R5 series modules.

SARA-R5 series modules include a 1.8V 4-bit Secure Digital Input Output interface over the **SDIO_D0**, **SDIO_D1**, **SDIO_D2**, **SDIO_D3**, **SDIO_CLK** and **SDIO_CMD** pins, with the module acting as an SDIO controller, available for communications with compatible external SDIO devices, and for diagnostic purpose.

☞ Accessible test points directly connected to the **SDIO_D0**, **SDIO_D1**, **SDIO_D2** and **SDIO_D3** pins may be provided for diagnostic purpose, alternatively to the highly recommended accessible test points provided on the USB interface pins.

### 2.5.5 I2C interface

☞ Communication with an external GNSS receiver is not supported by SARA-R510M8S modules.

SARA-R5 series modules include a 1.8V I2C-bus compatible interface over the **SDA** and **SCL** pins, available to communicate with an external u-blox GNSS receiver and with external I2C devices as for example an audio codec: the SARA-R5 series module acts as an I2C controller that can communicate with I2C target devices in accordance with the I2C bus specifications [10].

## 2.6 Audio

☞ Audio is not supported by SARA-R5 series modules.

SARA-R5 series modules include a 1.8V I2S digital audio interface over the **I2S_TXD**, **I2S_RXD**, **I2S_CLK** and **I2S_WA** pins, not supported by any product version.

## 2.7 ADC

☞ ADC is not supported by the “00B” products version of SARA-R5 series modules.

SARA-R5 series modules include an Analog-to-Digital Converter input pin, **ADC**, configurable via a dedicated AT command (for further details, see the SARA-R5 series AT commands manual [1]).

## 2.8 GPIO

SARA-R5 series modules include pins that can be configured as general-purpose input/output or to provide custom functions as summarized in Table 4. For further details, see the SARA-R5 series system integration manual [2] and the SARA-R5 series AT commands manual [1], +UGPIOC, +UGPIOR, +UGPIOW AT commands).

| Function | Description | Default GPIO | Configurable GPIOs |
|---|---|---|---|
| General purpose output | Output to set high or low digital level | - | GPIO1, GPIO2, GPIO3, GPIO4, GPIO5, GPIO6 |
| General purpose input | Input to sense high or low digital level | - | GPIO1, GPIO2, GPIO3, GPIO4, GPIO5, GPIO6 |
| Network status indication | Output indicating cellular network status: registered, data transmission, no service | - | GPIO1, GPIO2, GPIO3, GPIO4, GPIO5, GPIO6 |
| External GNSS supply enable [7] | Output to enable/disable the supply of an external u-blox GNSS receiver connected to the cellular module by the I2C interface | - | GPIO2 [7] |
| External GNSS data ready [7] | Input to sense when an external u-blox GNSS receiver connected to the module is ready for sending data over the I2C interface | - | GPIO3 [7] |
| SIM card detection [8] | Input for SIM card physical presence detection, to optionally enable / disable SIM interface upon detection of external SIM card physical insertion / removal | - | GPIO5 [8] |
| Module status indication | Output indicating module status: power-off or deep-sleep mode versus idle, active or connected mode | - | GPIO1, GPIO2, GPIO3, GPIO4, GPIO5, GPIO6 |
| Module operating mode indication | Output indicating module operating mode: power-off, deep-sleep or idle mode versus active or connected mode | - | GPIO1, GPIO2, GPIO3, GPIO4, GPIO5, GPIO6 |
| Ring indicator | Output providing events indicator | - | GPIO1, GPIO2, GPIO3, GPIO4, GPIO5, GPIO6 |
| Last gasp | Input to trigger last gasp notification | - | GPIO1, GPIO2, GPIO3 [9], GPIO4, GPIO6 |
| Time pulse output | Output providing accurate time reference, as a sequence with configurable[10] PPS or as single time pulse, based on the GNSS system or the LTE system (CellTime) | - | GPIO6 |
| Time stamp of external interrupt input | Input triggering via interrupt the generation of an URC time stamp over AT serial interface | - | EXT_INT |
| Faster and safe power-off | Input to trigger a faster and safe shutdown of the module (as triggered by AT+CFUN=10 command) | - | GPIO1, GPIO2, GPIO3 [9], GPIO4, GPIO6 |
| External GNSS time pulse [7] | Input to receive an accurate time reference, as a sequence with configurable[10] PPS from an external GNSS system | - | SDIO_CMD [7] |
| External GNSS time stamp of external interrupt [7] | Output triggering via interrupt the generation of an URC time stamp from an external GNSS system | - | GPIO4 [7] |
| Pin disabled | Tri-state with an internal active pull-down enabled | GPIO1, GPIO2, GPIO3, GPIO4, GPIO5, GPIO6, EXT_INT, SDIO_CMD | GPIO1, GPIO2, GPIO3, GPIO4, GPIO5, GPIO6, EXT_INT, SDIO_CMD |

**Table 4: GPIO custom functions configuration**

## 2.9 Cellular antenna dynamic tuner interface

SARA-R5 series modules include two output pins (named **I2S_TXD** and **I2S_WA**) that can optionally be used to control in real time an external antenna tuning IC, as the two pins change their output value dynamically according to the specific current LTE band in use by the module (see Table 5).

| I2S_TXD | I2S_WA | LTE frequency band in use |
|---|---|---|
| 0 | 0 | B71 ( < 700 MHz) |
| 0 | 1 | B12, B13, B28, B85 (700..800 MHz) |
| 1 | 0 | B5, B8, B18, B19, B20, B26 (800..900 MHz) |
| 1 | 1 | B1, B2, B3, B4, B25, B66 ( > 1000 MHz) |

**Table 5: SARA-R5 series modules antenna dynamic tuning truth table**

For design guidelines, see the SARA-R5 series system integration manual [2]. For details about how to enable the feature, see the SARA-R5 series AT commands manual [1], +UTEST=4 AT command.

## 2.10 GNSS peripheral outputs

☞ The GNSS peripheral output pins are not supported by SARA-R500E, SARA-R500S, SARA-R510S and SARA-R510M8S-00B product versions.

SARA-R510M8S modules provide the following 1.8 V peripheral output pins directly connected to the internal u-blox M8 GNSS chipset (as is illustrated in Figure 4):

- The ANT_ON output pin, over the **I2S_RXD** pin, can provide optional control for switching off power to an external active GNSS antenna or an external separate LNA. This facility is provided to help minimize power consumption in power save mode operation.
- The GEOFENCE output pin, over the **I2S_CLK** pin, can provide optional indication of the geofencing status and can be used, for example, to wake up a host on activation.

## 2.11 Reserved pin (RSVD)

SARA-R5 series modules have a pin reserved for future use, marked as **RSVD**. This pin is to be left unconnected on the application board.

# 3 Pin definition

## 3.1 Pin assignment

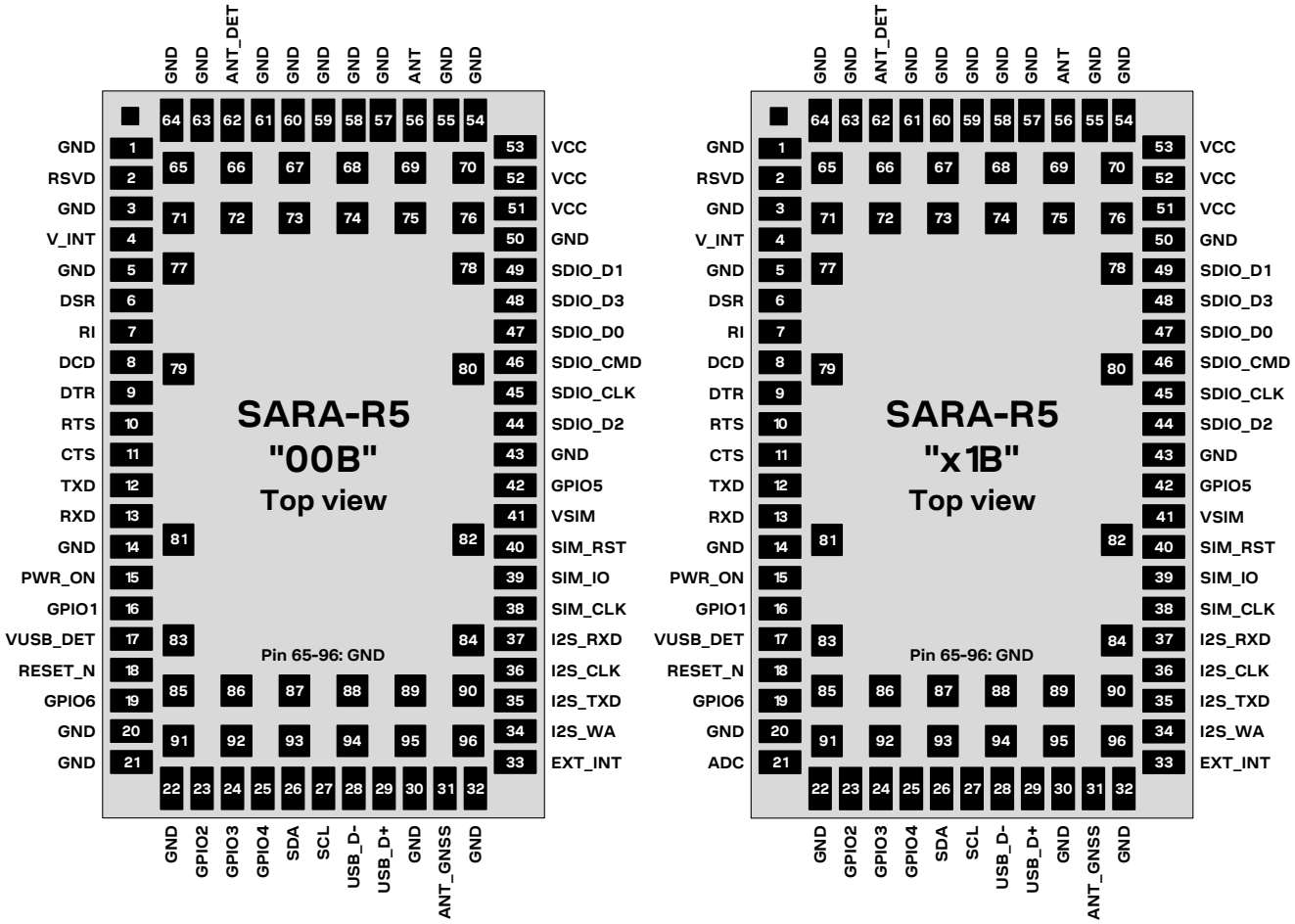


**Figure 5: SARA-R5 series modules pin assignment (top view)**

| No. | Name | Power domain | I/O | Description | Remarks |
|---|---|---|---|---|---|
| 1 | GND | - | N/A | Ground | All the GND pins must be connected to ground. |
| 2 | RSVD | - | N/A | Reserved pin | Leave unconnected. |
| 3 | GND | - | N/A | Ground | All the GND pins must be connected to ground. |
| 4 | V_INT | - | O | Generic Digital Interfaces supply output | V_INT generated by the module when is switched on.<br>See section 2.1.2 for functional description.<br>See section 4.2.3 for detailed electrical specs.<br>Provide test point for diagnostic purposes. |
| 5 | GND | - | N/A | Ground | All the GND pins must be connected to ground. |
| 6 | DSR | GDI | O / I | UART data set ready / AUX UART request to send | Circuit 107 in ITU-T V.24 (DSR output, push-pull, idle high, active low), alternatively configurable as Second Auxiliary UART RTS (HW flow control input, idle high, active low, with internal active pull-up enabled).<br>See section 2.5.1 for functional description.<br>See section 4.2.12 for detailed electrical specs. |

| No. | Name | Power domain | I/O | Description | Remarks |
|---|---|---|---|---|---|
| 7 | RI | GDI | O / O | UART ring indicator / AUX UART clear to send | Circuit 125 in ITU-T V.24 (RI output, push-pull, idle high, active low), alternatively configurable as Second Auxiliary UART CTS (HW flow control output, push-pull, idle high, active low).<br>See section 2.5.1 for functional description.<br>See section 4.2.12 for detailed electrical specs. |
| 8 | DCD | GDI | O / O | UART data carrier detect / AUX UART data output | Circuit 109 in ITU-T V.24 (DCD output, push-pull, idle high, active low), alternatively settable as Second Auxiliary UART RXD (data output, push-pull, idle high, active low).<br>Fixed push-pull.<br>See section 2.5.1 for functional description.<br>See section 4.2.12 for detailed electrical specs.<br>Provide test point for diagnostic purposes. |
| 9 | DTR | GDI | I / I | UART data terminal ready / AUX UART data input | Circuit 108/2 in ITU-T V. 24 (DTR input, idle high, active low, with internal active pull-up enabled), alternatively settable as Second Auxiliary UART TXD (data input, idle high, active low, with internal active pull-up enabled).<br>See section 2.5.1 for functional description.<br>See section 4.2.12 for detailed electrical specs.<br>Provide test point for diagnostic purposes. |
| 10 | RTS | GDI | I | UART request to send | Circuit 105 in ITU-T V.24 (RTS flow control input, idle high, active low, with internal active pull-up enabled).<br>See section 2.5.1 for functional description.<br>See section 4.2.12 for detailed electrical specs. |
| 11 | CTS | GDI | O | UART clear to send | Circuit 106 in ITU-T V.24 (CTS hardware flow control output, push-pull, idle high, active low).<br>See section 2.5.1 for functional description.<br>See section 4.2.12 for detailed electrical specs. |
| 12 | TXD | GDI | I | UART data input | Circuit 103 in ITU-T V.24 (TxD data input, idle high, active low, with internal active pull-up enabled).<br>See section 2.5.1 for functional description.<br>See section 4.2.12 for detailed electrical specs.<br>Provide test point for FW update purposes. |
| 13 | RXD | GDI | O | UART data output | Circuit 104 in ITU-T V.24 (RxD data output, push-pull, idle high, active low).<br>See section 2.5.1 for functional description.<br>See section 4.2.12 for detailed electrical specs.<br>Provide test point for FW update purposes. |
| 14 | GND | - | N/A | Ground | All the GND pins must be connected to ground. |
| 15 | PWR_ON | POS | I | Power-on input | Internal active pull-up. Active low.<br>See section 2.3.1 and 2.3.2 for functional description.<br>See section 4.2.9 for detailed electrical specs.<br>Provide test point for diagnostic purposes. |
| 16 | GPIO1 | GDI | I/O | GPIO | Configurable GPIO. Push-pull output type.<br>See section 2.8 for functional description.<br>See section 4.2.12 for detailed electrical specs. |
| 17 | VUSB_DET | USB | I | USB detect input | Input for VBUS (5 V typical) USB supply sense.<br>USB interface supported for diagnostic purpose only.<br>See section 2.5.2 for functional description.<br>See section 4.2.15 for detailed electrical specs.<br>Provide test point for diagnostic purposes. |
| 18 | RESET_N | GDI | I | External reset input | Internal active pull-up. Active low.<br>See section 2.3.3 for functional description.<br>See section 4.2.10 for detailed electrical specs.<br>Provide test point for diagnostic purposes. |

| No. | Name | Power domain | I/O | Description | Remarks |
|---|---|---|---|---|---|
| 19 | GPIO6 | GDI | I/O / O | GPIO / Time pulse output | Configurable GPIO, alternatively configurable as accurate time reference output. Push-pull output type.<br>See section 2.8 for functional description.<br>See section 4.2.12 for detailed electrical specs. |
| 20 | GND | - | N/A | Ground | All the GND pins must be connected to ground. |
| 21 | GND [11] | - | N/A | Ground | All the GND pins must be connected to ground. |
| | ADC [12] | ADC | I | ADC input | 12-bit Analog to Digital Converter input.<br>This pin can be externally connected to GND, if the ADC function is not needed in the application.<br>See section 4.2.16 for detailed electrical characteristics. |
| 22 | GND | - | N/A | Ground | All the GND pins must be connected to ground. |
| 23 | GPIO2 | GDI | I/O | GPIO | Configurable GPIO. Push-pull output type.<br>See section 2.8 for functional description.<br>See section 4.2.12 for detailed electrical specs. |
| 24 | GPIO3 | GDI | I/O | GPIO | Configurable GPIO. Push-pull output type.<br>See section 2.8 for functional description.<br>See section 4.2.12 for detailed electrical specs. |
| 25 | GPIO4 | GDI | I/O / O | GPIO / External GNSS time stamp of external interrupt [13] | Configurable GPIO, alternatively configurable as output indicating the generation of an URC time stamp. Push-pull output type.<br>See section 2.8 for functional description.<br>See section 4.2.12 for detailed electrical specs. |
| 26 | SDA | I2C | I/O | I2C bus data line | Open drain output type.<br>Internal active pull-up. Idle high, active low.<br>See section 2.5.5 for functional description.<br>See section 4.2.14 for detailed electrical specs. |
| 27 | SCL | I2C | O | I2C bus clock line | Open drain output type.<br>Internal active pull-up. Idle high, active low.<br>See section 2.5.5 for functional description.<br>See section 4.2.14 for detailed electrical specs. |
| 28 | USB_D- | USB | I/O | USB Data Line D- | 90 Ω nominal differential impedance.<br>Pull-up, pull-down and series resistors, as required by the USB 2.0 specifications [9], are part of the USB pin driver and shall not be provided externally.<br>USB interface supported for diagnostic purpose only.<br>See section 2.5.2 for functional description.<br>See section 4.2.15 for detailed electrical specs.<br>Provide test point for diagnostic purposes. |
| 29 | USB_D+ | USB | I/O | USB Data Line D+ | 90 Ω nominal differential impedance.<br>Pull-up, pull-down and series resistors, as required by USB 2.0 specifications [9], are part of the USB pin driver and shall not be provided externally.<br>USB interface supported for diagnostic purpose only.<br>See section 2.5.2 for functional description.<br>See section 4.2.15 for detailed electrical specs.<br>Provide test point for diagnostic purposes. |
| 30 | GND | - | N/A | Ground | All the GND pins must be connected to ground. |

| No. | Name | Power domain | I/O | Description | Remarks |
|---|---|---|---|---|---|
| 31 | ANT_GNSS[14] | - | I | GNSS antenna | RF input for GNSS Rx antenna.<br>50 Ω nominal impedance.<br>See section 2.2.2 and Table 2 for functional description. |
| 32 | GND | - | N/A | Ground | All the GND pins must be connected to ground. |
| 33 | EXT_INT | GDI | I | External interrupt | Configurable as interrupt input triggering the generation of an URC time stamp. Internal active pull-down enabled.<br>See section 2.8 for functional description.<br>See section 4.2.12 for detailed electrical specs. |
| 34 | I2S_WA | GDI | O / O | I2S word alignment / Pin for antenna dynamic tuning | I2S not supported by “00B”, “01B”, “61B”, “71B” versions.<br>Configurable as pin for antenna dynamic tuning. Push-pull output type.<br>See section 2.7 / 2.9 for functional description.<br>See section 4.2.12 for detailed electrical specs. |
| 35 | I2S_TXD | GDI | O / O | I2S transmit data / Pin for antenna dynamic tuning | I2S not supported by “00B”, “01B”, “61B”, “71B” versions.<br>Configurable as pin for antenna dynamic tuning. Push-pull output type.<br>See section 2.7 / 2.9 for functional description.<br>See section 4.2.12 for detailed electrical specs. |
| 36 | I2S_CLK | GDI | O | I2S clock | I2S not supported by “00B”, “01B”, “61B”, “71B” versions. |
| | GEOFENCE[15] | GNSS | O | Geofencing status indication | Configurable to provide optional indication of the geofencing status.<br>See section 4.2.13 for detailed electrical specs. |
| 37 | I2S_RXD | GDI | I | I2S receive data | I2S not supported by “00B”, “01B”, “61B”, “71B” versions. |
| | ANT_ON[15] | GNSS | O | Antenna or LNA enable | External GNSS active antenna and/or LNA on/off signal driven by u-blox M8 chipset, connected to internal LNA.<br>See section 4.2.13 for detailed electrical specs. |
| 38 | SIM_CLK | SIM | O | SIM clock | External SIM not supported by SARA-R500E modules.<br>See section 2.4.1 for functional description.<br>See section 4.2.11 for detailed electrical specs. |
| 39 | SIM_IO | SIM | I/O | SIM data | External SIM not supported by SARA-R500E modules.<br>See section 2.4.1 for functional description.<br>See section 4.2.11 for detailed electrical specs. |
| 40 | SIM_RST | SIM | O | SIM reset | External SIM not supported by SARA-R500E modules.<br>See section 2.4.1 for functional description.<br>See section 4.2.11 for detailed electrical specs. |
| 41 | VSIM | - | O | SIM supply output | External SIM not supported by SARA-R500E modules.<br>See section 2.4.1 for functional description.<br>See section 4.2.11 for detailed electrical specs. |
| 42 | GPIO5 | GDI | I/O / I | GPIO / SIM card detection [16] | Configurable GPIO, alternatively configurable as input pin for SIM card detection. Push-pull output type.<br>See sections 2.4.2 and 2.8 for functional description.<br>See section 4.2.12 for detailed electrical specs. |
| 43 | GND | - | N/A | Ground | All the GND pins must be connected to ground. |
| 44 | SDIO_D2 | GDI | I/O / O | SDIO serial data [2] / SPI_CLK | SDIO not supported by “00B”, “01B”, “61B”, “71B” versions<br>The pin is alternatively configurable as SPI_CLK, for diagnostic purpose only. Push-pull output type. |
| 45 | SDIO_CLK | GDI | O | SDIO serial clock | SDIO not supported by “00B”, “01B”, “61B”, “71B” versions |

[14] Not supported by SARA-R500S and SARA-R510S modules
[15] Not supported by “00B” products versions
[16] Not supported by SARA-R500E modules

| No. | Name | Power domain | I/O | Description | Remarks |
|---|---|---|---|---|---|
| 46 | SDIO_CMD | GDI | I/O / I | SDIO command / External GNSS time pulse input [17] | SDIO not supported by “00B”, “01B”, “61B”, “71B” versions<br>Configurable as input for external GNSS time pulse.<br>Push-pull output type.<br>See section 2.8 for functional description.<br>See section 4.2.12 for detailed electrical specs. |
| 47 | SDIO_D0 | GDI | I/O / O | SDIO serial data [0] / SPI_MOSI | SDIO not supported by “00B”, “01B”, “61B”, “71B” versions<br>The pin is alternatively configurable as SPI_MOSI, for diagnostic purpose only. Push-pull output type. |
| 48 | SDIO_D3 | GDI | I/O / O | SDIO serial data [3] / SPI_CS | SDIO not supported by “00B”, “01B”, “61B”, “71B” versions<br>The pin is alternatively configurable as SPI_CS, for diagnostic purpose only. Push-pull output type. |
| 49 | SDIO_D1 | GDI | I/O / I | SDIO serial data [1] / SPI_MISO | SDIO not supported by “00B”, “01B”, “61B”, “71B” versions<br>The pin is alternatively configurable as SPI_MISO, for diagnostic purpose only. |
| 50 | GND | - | N/A | Ground | All the GND pins must be connected to ground. |
| 51 | VCC | - | I | Module supply input | All VCC pins must be connected to external supply.<br>See section 2.1.1 for functional description.<br>See section 4.2.3 for detailed electrical specs. |
| 52 | VCC | - | I | Module supply input | All VCC pins must be connected to external supply.<br>See section 2.1.1 for functional description.<br>See section 4.2.3 for detailed electrical specs. |
| 53 | VCC | - | I | Module supply input | All VCC pins must be connected to external supply.<br>See section 2.1.1 for functional description.<br>See section 4.2.3 for detailed electrical specs. |
| 54 | GND | - | N/A | Ground | All the GND pins must be connected to ground. |
| 55 | GND | - | N/A | Ground | All the GND pins must be connected to ground. |
| 56 | ANT | - | I/O | Cellular antenna | RF input/output for Cellular Rx/Tx antenna.<br>50 Ω nominal impedance.<br>See section 2.2.1 and 4.2.6 for details. |
| 57 | GND | - | N/A | Ground | All the GND pins must be connected to ground. |
| 58 | GND | - | N/A | Ground | All the GND pins must be connected to ground. |
| 59 | GND | - | N/A | Ground | All the GND pins must be connected to ground. |
| 60 | GND | - | N/A | Ground | All the GND pins must be connected to ground. |
| 61 | GND | - | N/A | Ground | All the GND pins must be connected to ground. |
| 62 | ANT_DET | ADC | I | Antenna detection | Antenna presence detection function.<br>See section 2.2.3 for details.<br>See section 4.2.7 for detailed electrical specs. |
| 63 | GND | - | N/A | Ground | All the GND pins must be connected to ground. |
| 64 | GND | - | N/A | Ground | All the GND pins must be connected to ground. |
| 65-96 | GND | - | N/A | Ground | All the GND pins must be connected to ground. |

**Table 6: SARA-R5 series pin-out**

For more information about pin-out, see the u-blox SARA-R5 series system integration manual [2].

See appendix A for an explanation of the abbreviations and terms used.

# 4 Electrical specifications

⚠ Stressing the device above one or more of the ratings listed in the Absolute Maximum Rating section may cause permanent damage. These are stress ratings only. Operating the module at these or at any conditions other than those specified in the Operating Conditions sections (section 4.2) of the specification should be avoided. Exposure to Absolute Maximum Rating conditions for extended periods may affect device reliability.

☞ Electrical characteristics are defined according to the verification on a representative number of samples or according to the simulation.

☞ Where application information is given, it is advisory only and does not form part of the specification.

## 4.1 Absolute maximum rating

☞ Limiting values given below are in accordance with Absolute Maximum Rating System (IEC 134).

| Symbol | Description | Condition | Min. | Max. | Unit |
|---|---|---|---|---|---|
| VCC | Module supply voltage | Input DC voltage at VCC pins | -0.3 | 4.6 | V |
| VUSB_DET | USB detection pin | Input DC voltage at VUSB_DET pin | -0.3 | 5.5 | V |
| USB | USB D+/D- pins | Input DC voltage at USB interface pins | -0.3 | 3.6 | V |
| GDI | Generic digital interfaces | Input DC voltage at Generic digital interfaces pins | -0.3 | 2.3 | V |
| I2C | I2C interface | Input DC voltage at I2C interface pins | -0.3 | 2.3 | V |
| GNSS | GNSS digital interfaces | Input DC voltage at GNSS digital interfaces pins | -0.3 | 2.3 | V |
| SIM | SIM interface | Input DC voltage at SIM interface pins | -0.3 | 3.5 | V |
| POS | Power-on input | Input DC voltage at PWR_ON pin | -0.3 | 4.6 | V |
| ADC | ADC signal | Input DC voltage at ANT_DET and ADC pins | -0.3 | 2.3 | V |
| P_RF | RF power | Input RF power at ANT pin | | 3 | dBm |
| | | Input RF power at ANT_GNSS pin | | 0 | dBm |
| Rho_ANT | Antenna ruggedness | Output RF load mismatch ruggedness at ANT pins | | 10:1 | VSWR |
| Tstg | Storage temperature | | -40 | +85 | °C |

**Table 7: Absolute maximum ratings**

⚠ The product is not protected against overvoltage or reversed voltages. If necessary, voltage spikes exceeding the voltage specifications given in the table above, must be limited to values within the specified boundaries by using appropriate protection devices.

### 4.1.1 Maximum ESD

| Parameter | Min | Max | Unit | Remarks |
|---|---|---|---|---|
| ESD sensitivity for all pins | | 1000 | V | Human Body Model according to JS-001-2017 |
| | | 500 | V | Charged Device Model according to JS-002-2018 |

**Table 8: Maximum ESD ratings**

⚠ LTRX cellular modules are electrostatic sensitive devices and require special precautions when handling. See section 7.3 for ESD handling instructions.

## 4.2 Operating conditions

Unless otherwise indicated, all operating condition specifications are at an ambient temperature of +25 °C.

Operation beyond the operating conditions is not recommended and extended exposure beyond them may affect device reliability.

### 4.2.1 Operating temperature range

| Parameter | Min. | Typ. | Max. | Unit | Remarks |
|---|---|---|---|---|---|
| Normal operating temperature | -20 | +25 | +65 | °C | Operating within 3GPP / ETSI specifications |
| Extended operating temperature | -40 | | +85 | °C | Operating with possible slight deviation in RF performance outside normal operating range |

**Table 9: Environmental conditions**

### 4.2.2 Thermal parameters

| Symbol | Parameter | Min. | Typ. | Max. | Unit | Remarks |
|---|---|---|---|---|---|---|
| $\Psi_{M-A}$ | Module-to-Ambient thermal parameter | | 10 | | °C/W | Thermal characterization parameter $\Psi_{M-A} = (T_M - T_A) / P_H$ proportional to the delta between internal module temperature ($T_M$) and ambient temperature ($T_A$), due to heat power dissipation ($P_H$), with the module mounted on a 79 x 62 x 1.41 mm 4-Layer PCB with a high coverage of copper, in still air conditions |
| $\Psi_{M-C}$ | Module-to-Case thermal parameter | | 2 | | °C/W | Thermal characterization parameter $\Psi_{M-C} = (T_M - T_C) / P_H$ proportional to the delta between internal module temperature ($T_M$) and ambient temperature ($T_C$), due to heat power dissipation ($P_H$), with the module mounted on a 79 x 62 x 1.41 mm 4-Layer PCB with a high coverage of copper, with a robust aluminum heat-sink and with forced air ventilation, i.e. reducing to a value close to 0 °C/W the thermal resistance from the case of the module to the ambient |

**Table 10: Thermal characterization parameters of the module**

### 4.2.3 Supply/power pins

| Symbol | Parameter | Min. | Typical | Max. | Unit |
|---|---|---|---|---|---|
| VCC | Module supply normal operating input voltage [18] | 3.3 | 3.8 | 4.4 | V |
| | Module supply extended operating input voltage [19] | 3.0 | | 4.5 | V |

**Table 11: Input characteristics of the Supply/Power pins**

| Symbol | Parameter | Min. | Typical | Max. | Unit |
|---|---|---|---|---|---|
| VSIM | SIM supply output voltage with 1.8 V external SIM | | 1.8 | | V |
| | SIM supply output voltage with 3.0 V external SIM | | 3.0 | | V |
| V_INT | Generic Digital Interfaces supply output voltage | | 1.8 | | V |
| | Generic Digital Interfaces supply output current capability | | | 70 | mA |

**Table 12: Output characteristics of the Supply/Power pins**

[18] Operating within 3GPP / ETSI specifications.
[19] Operating with possible slight deviation in RF performance outside normal operating range. The input voltage has to be above the extended operating range minimum limit to switch-on the module and to avoid possible switch-off of the module.
[20] Typical values with matched antenna, VCC = 3.8 V

### 4.2.4 Current consumption

| Mode | Condition | Tx power | Module | Min | Typ[20] | Max | Unit |
|---|---|---|---|---|---|---|---|
| Power-off mode | Average current value (power-off mode) | -- | SARA-R510S | | 0.5 | | µA |
| | | | SARA-R500E SARA-R500S SARA-R510M8S | | 62 | | µA |
| PSM deep-sleep mode | Average current value (PSM deep-sleep mode) | -- | SARA-R510S | | 0.5 | | µA |
| | | | SARA-R500E SARA-R500S SARA-R510M8S | | 62 | | µA |
| Cyclic deep-sleep / active mode (+UPSV: 1) | Average current value (eDRX deep-sleep mode[21] rock bottom floor current) | -- | SARA-R510S | | 0.5 | | µA |
| | | | SARA-R500E SARA-R500S SARA-R510M8S | | 62 | | µA |
| | Average current value (DRX = 2.56 s, PTW = 20.48 s, eDRX = 655.36 s, +UPSMVER: 8[22]) | -- | SARA-R510S | | 180 | | µA |
| | | | SARA-R500E SARA-R500S SARA-R510M8S | | 250 | | µA |
| Cyclic idle / active mode (+UPSV: 1) | Average current value (low power idle mode rock bottom floor current) | -- | All | | 0.7[23] | | mA |
| | Average current value (DRX = 2.56 s, PTW = 20.48 s, eDRX = 655.36 s, +UPSMVER: 0) | -- | All | | 0.7[23] | | mA |
| | Average current value (DRX = 2.56 s, no eDRX) | -- | All | | 1.1[23] | | mA |
| | Average current value (DRX = 1.28 s, no eDRX) | -- | All | | 1.5[23] | | mA |
| Idle mode (+UPSV: 1) | Average current value (airplane mode, +CFUN: 0) | -- | All | | 0.7[23] | | mA |
| Active mode (+UPSV: 0) | Average current value (DRX = 1.28 s) | -- | All | | 25 | | mA |
| LTE Cat M1 connected mode | Average current value (Tx / Rx data transfer) | Minimum | All | | 95 | | mA |
| | | 0 dBm | All | | 100 | | mA |
| | | 8 dBm | All | | 115 | | mA |
| | | 14 dBm | All | | 140 | | mA |
| | | 20 dBm | All | | 170 | | mA |
| | | Maximum | All | | 195 | | mA |
| | Maximum current value (during Tx only) | Maximum | All | | 395 | | mA |
| LTE Cat NB2 connected mode | Average current value (Tx / Rx data transfer) | Minimum | All | | 85 | | mA |
| | | 0 dBm | All | | 90 | | mA |
| | | 8 dBm | All | | 100 | | mA |
| | | 14 dBm | All | | 110 | | mA |
| | | 20 dBm | All | | 125 | | mA |
| | | Maximum | All | | 135 | | mA |
| | Maximum current value (during Tx only) | Maximum | All | | 395 | | mA |

**Table 13: VCC current consumption of SARA-R5 series modules with GNSS off**

| Mode / Condition | Min | Typ[24] | Max | Unit |
|---|---|---|---|---|
| Average current value with power saving enabled (+UPSV: 1),<br>UBX-R5 in PSM, UBX-M8 in cyclic tracking mode with 1 s update period (GPS) | | 13 | | mA |
| Average current value with power saving enabled (+UPSV: 1),<br>UBX-R5 in PSM, UBX-M8 in cyclic tracking mode with 1 s update period (GPS & GLONASS) | | 14 | | mA |
| Average current value with power saving enabled (+UPSV: 1),<br>UBX-R5 in PSM, UBX-M8 in continuous tracking mode (GPS & GLONASS) | | 41 | | mA |
| Average current value with power saving enabled (+UPSV: 1),<br>UBX-R5 in DRX = 1.28 s, UBX-M8 in cyclic tracking mode with 1 s update period (GPS) | | 14 | | mA |
| Average current value with power saving enabled (+UPSV: 1),<br>UBX-R5 in DRX = 1.28 s, UBX-M8 in cyclic tracking mode with 1 s update period (GPS & GLONASS) | | 15 | | mA |
| Average current value with power saving enabled (+UPSV: 1),<br>UBX-R5 in DRX = 1.28 s, UBX-M8 in continuous tracking mode (GPS & GLONASS) | | 42 | | mA |
| Average current value with power saving disabled (+UPSV: 0),<br>UBX-R5 in DRX = 1.28 s, UBX-M8 in continuous tracking mode (GPS & GLONASS) | | 64 | | mA |
| Average current value with power saving disabled (+UPSV: 0),<br>UBX-R5 in DRX = 1.28 s, UBX-M8 in acquisition mode (GPS & GLONASS) | | 72 | | mA |
| Peak current value with power saving disabled (+UPSV: 0),<br>UBX-R5 in DRX = 1.28 s, UBX-M8 in acquisition mode (GPS & GLONASS) | | 100 | | mA |

**Table 14: Indicative VCC current consumption of the SARA-R510M8S module with GNSS on**

### 4.2.5 GNSS characteristics

| Parameter | Condition | Value | | | | |
|---|---|---|---|---|---|---|
| Receiver type | | 72-channel u-blox M8 engine<br>GPS L1C/A, SBAS L1C/A, QZSS L1C/A, QZSS L1-SAIF,<br>GLONASS L1OF, BeiDou B1I, Galileo E1B/C | | | | |
| Operational limits[25] | Dynamics | ≤ 4 g | | | | |
| | Altitude | 50'000 m | | | | |
| | Velocity | 500 m/s | | | | |
| Velocity accuracy[26] | | 0.05 m/s | | | | |
| Heading accuracy[26] | | 0.3 degrees | | | | |
| **GNSS** | | **GPS & GLONASS** | **GPS** | **GLONASS** | **BeiDou** | **Galileo** |
| Horizontal position accuracy[27] | | 2.5 m | 2.5 m | 4 m | 3 m | 3 m |
| Max navigation update rate | | 10 Hz | 18 Hz | 18 Hz | 18 Hz | 18 Hz |
| Time-To-First-Fix[28] | Cold start | 26 s | 29 s | 30 s | 34 s | 45 s |
| | Aided starts[29] | 2 s | 2 s | 2 s | 3 s | 7 s |
| Sensitivity | Tracking & Navigation | -167 dBm | -166 dBm | -166 dBm | -160 dBm | -159 dBm |
| | Reacquisition | -160 dBm | -160 dBm | -156 dBm | -157 dBm | -153 dBm |
| | Cold start | -148 dBm | -148 dBm | -145 dBm | -143 dBm | -138 dBm |

**Table 15: GNSS characteristics and performance of the SARA-R510M8S module**

[24] Typical values with matched antenna, VCC = 3.8 V
[25] Assuming Airborne < 4 g platform
[26] 50% @ 30 m/s
[27] CEP, 50%, 24 hours static, -130 dBm, > 6 SVs
[28] All satellites at -130 dBm, except Galileo at -127 dBm
[29] Dependent on aiding data connection speed and latency
[30] Time pulse / time stamp is always generated by the UBX-R5 cellular chipset after the process of the GNSS time pulse signal.

### 4.2.6 LTE RF characteristics

The LTE Cat M1 / NB2 bands supported by SARA-R5 series modules are defined in Table 2, while the following Table 16 describes the frequency ranges for each LTE band as per 3GPP TS 36.521-1 [7].

| Parameter | | Min. | Max. | Unit | Remarks |
|---|---|---|---|---|---|
| Frequency range FDD band 71 (600 MHz) | Uplink | 663 | 698 | MHz | Module transmits |
| | Downlink | 617 | 652 | MHz | Module receives |
| Frequency range FDD band 12 (700 MHz) | Uplink | 699 | 716 | MHz | Module transmits |
| | Downlink | 729 | 746 | MHz | Module receives |
| Frequency range FDD band 28 (700 MHz) | Uplink | 703 | 748 | MHz | Module transmits |
| | Downlink | 758 | 803 | MHz | Module receives |
| Frequency range FDD band 85 (700 MHz) | Uplink | 698 | 716 | MHz | Module transmits |
| | Downlink | 728 | 746 | MHz | Module receives |
| Frequency range FDD band 13 (750 MHz) | Uplink | 777 | 787 | MHz | Module transmits |
| | Downlink | 746 | 756 | MHz | Module receives |
| Frequency range FDD band 20 (800 MHz) | Uplink | 832 | 862 | MHz | Module transmits |
| | Downlink | 791 | 821 | MHz | Module receives |
| Frequency range FDD band 26 (850 MHz) | Uplink | 814 | 849 | MHz | Module transmits |
| | Downlink | 859 | 894 | MHz | Module receives |
| Frequency range FDD band 18 (850 MHz) | Uplink | 815 | 830 | MHz | Module transmits |
| | Downlink | 860 | 875 | MHz | Module receives |
| Frequency range FDD band 5 (850 MHz) | Uplink | 824 | 849 | MHz | Module transmits |
| | Downlink | 869 | 894 | MHz | Module receives |
| Frequency range FDD band 19 (850 MHz) | Uplink | 830 | 845 | MHz | Module transmits |
| | Downlink | 875 | 890 | MHz | Module receives |
| Frequency range FDD band 8 (900 MHz) | Uplink | 880 | 915 | MHz | Module transmits |
| | Downlink | 925 | 960 | MHz | Module receives |
| Frequency range FDD band 4 (1700 MHz) | Uplink | 1710 | 1755 | MHz | Module transmits |
| | Downlink | 2110 | 2155 | MHz | Module receives |
| Frequency range FDD band 66 (1700 MHz) | Uplink | 1710 | 1780 | MHz | Module transmits |
| | Downlink | 2110 | 2200 | MHz | Module receives |
| Frequency range FDD band 3 (1800 MHz) | Uplink | 1710 | 1785 | MHz | Module transmits |
| | Downlink | 1805 | 1880 | MHz | Module receives |
| Frequency range FDD band 2 (1900 MHz) | Uplink | 1850 | 1910 | MHz | Module transmits |
| | Downlink | 1930 | 1990 | MHz | Module receives |
| Frequency range FDD band 25 (1900 MHz) | Uplink | 1850 | 1915 | MHz | Module transmits |
| | Downlink | 1930 | 1995 | MHz | Module receives |
| Frequency range FDD band 1 (2100 MHz) | Uplink | 1920 | 1980 | MHz | Module transmits |
| | Downlink | 2110 | 2170 | MHz | Module receives |

**Table 16: LTE operating RF frequency bands**

SARA-R5 series modules include a UE Power Class 3 LTE Cat M1 / NB2 transmitter (see Table 2) and an LTE receiver, with output power and characteristics according to 3GPP TS 36.521-1 [7].

☞ The "00B" products version of SARA-R5 series modules and SARA-R500E modules do not support the LTE NB-IoT Radio Access Technology.

☞ The "00B" products version of SARA-R5 series modules do not support LTE FDD bands 66, 71, 85.

SARA-R5 series modules LTE receiver characteristics are compliant to 3GPP TS 36.521-1 [7], with LTE conducted receiver sensitivity performance described in Table 17 and Table 18.

| Parameter | Min. | Typical | Max. | Unit | Remarks |
|---|---|---|---|---|---|
| Receiver input sensitivity<br>Band 71 (600 MHz) | | –108.0 | | dBm | Without repetitions |
| Receiver input sensitivity<br>Band 12 / 28 / 85 (700 MHz) | | –108.0 | | dBm | Without repetitions |
| Receiver input sensitivity<br>Band 13 (750 MHz) | | –108.0 | | dBm | Without repetitions |
| Receiver input sensitivity<br>Band 20 (800 MHz) | | –108.0 | | dBm | Without repetitions |
| Receiver input sensitivity<br>Band 5 / 18 / 19 / 26 (850 MHz) | | –107.0 | | dBm | Without repetitions |
| Receiver input sensitivity<br>Band 8 (900 MHz) | | –107.0 | | dBm | Without repetitions |
| Receiver input sensitivity<br>Band 3 (1800 MHz) | | –107.0 | | dBm | Without repetitions |
| Receiver input sensitivity<br>Band 2 / 25 (1900 MHz) | | –107.0 | | dBm | Without repetitions |
| Receiver input sensitivity<br>Band 1 / 4 / 66 (2100 MHz) | | –107.0 | | dBm | Without repetitions |
| Condition: 50 Ω, throughput > 95%, QPSK modulation, other settings as per clause 7.3EA of 3GPP TS 36.521-1 [7] | | | | | |

**Table 17: LTE Cat M1 receiver sensitivity performance**

| Parameter | Min. | Typical | Max. | Unit | Remarks |
|---|---|---|---|---|---|
| Receiver input sensitivity<br>Band 71 (600 MHz) | | -116.0 | | dBm | Without repetitions |
| Receiver input sensitivity<br>Band 12 / 28 / 85 (700 MHz) | | -116.0 | | dBm | Without repetitions |
| Receiver input sensitivity<br>Band 13 (750 MHz) | | -116.0 | | dBm | Without repetitions |
| Receiver input sensitivity<br>Band 20 (800 MHz) | | -115.5 | | dBm | Without repetitions |
| Receiver input sensitivity<br>Band 5 / 18 / 19 / 26 (850 MHz) | | -115.5 | | dBm | Without repetitions |
| Receiver input sensitivity<br>Band 8 (900 MHz) | | -115.0 | | dBm | Without repetitions |
| Receiver input sensitivity<br>Band 3 (1800 MHz) | | -114.0 | | dBm | Without repetitions |
| Receiver input sensitivity<br>Band 2 / 25 (1900 MHz) | | -115.0 | | dBm | Without repetitions |
| Receiver input sensitivity<br>Band 1 / 4 / 66 (2100 MHz) | | -115.0 | | dBm | Without repetitions |
| Condition: 50 Ω, throughput > 95%, other settings as per clause 7.3F of 3GPP TS 36.521-1 [7] | | | | | |

**Table 18: LTE Cat NB2 receiver sensitivity performance**

## 4.2.7 ANT_DET pin

| Pin Name | Parameter | Min. | Typ. | Max. | Unit | Remarks |
|---|---|---|---|---|---|---|
| ANT_DET | Output DC current pulse value | | 3 | | µA | |
| | Output DC current pulse time length | | 20 | | ms | |

**Table 19: ANT_DET pin characteristics**

## 4.2.8 Time pulse

| Parameter | | Specification | | Unit |
|---|---|---|---|---|
| Accuracy of time pulse / time stamp | GNSS source [30] | RMS | 50 | ns |
| | | 99% | 100 | ns |
| | LTE source | RMS | 500 | ns |
| | | 99% | 1 | µs |
| Configurable[31] period of time pulse | | 0.5, 1.0, 2.0, 3.0 or 4.0 | | s |

**Table 20: Time pulse / time stamp characteristics**

## 4.2.9 PWR_ON pin

| Parameter | Module | Min. | Typical | Max. | Unit | Remarks |
|---|---|---|---|---|---|---|
| Low-level input | All | -0.3 | | 0.3 | V | |
| Pull-up resistance | All | | 10 | | kΩ | Integrated pull-up to internal rail |
| Low-level input current | All | | -300 | | µA | |
| PWR_ON low time | SARA-R510S | 1 | | 2 | s | Low time to trigger module switch-on from power-off mode |
| | | 1 | | 2 | s | Low time to trigger module early wake-up from PSM / eDRX[32] deep-sleep |
| | SARA-R500E SARA-R500S SARA-R510M8S | 0.1 | | 2 | s | Low time to trigger module switch-on from power-off mode |
| | | 0.1 | | 2 | s | Low time to trigger module early wake-up from PSM / eDRX[32] deep-sleep |

**Table 21: PWR_ON pin characteristics**

The **PWR_ON** and **RESET_N** input lines have to be driven as described in Figure 6 to perform an abrupt emergency hardware shutdown of the SARA-R5 series modules:

- First, **PWR_ON** line has to be set to the LOW level
- Then, **RESET_N** line has to be set to the LOW level, keeping the **PWR_ON** line set to the LOW level
- Then, after at least 23 s (minimum) since the **PWR_ON** line has been set to the LOW level, the **PWR_ON** line has to be released to the HIGH level, keeping the **RESET_N** line set to the LOW level
- Then, after at least 1.5 s (minimum) since the **PWR_ON** line has been released to the HIGH level, the **RESET_N** line has to be released to the HIGH level

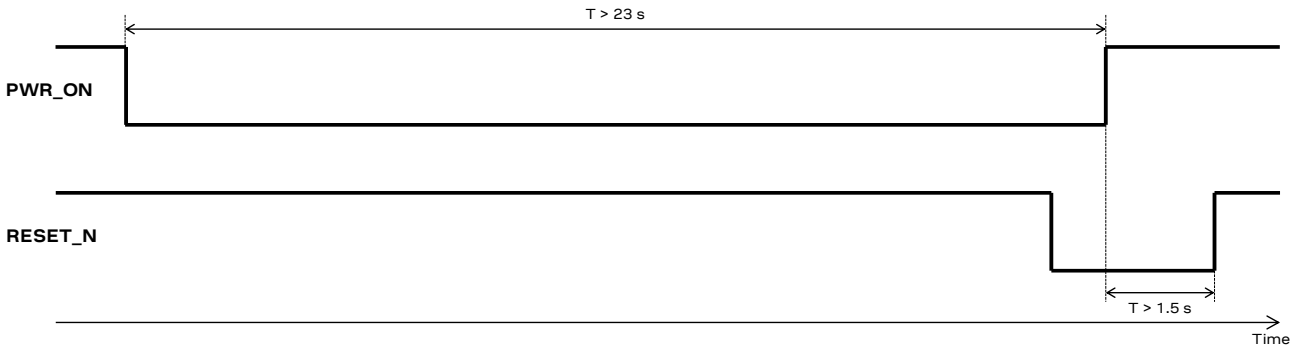


**Figure 6: PWR_ON and RESET_N lines waveforms timings to perform an abrupt emergency hardware shutdown**

[30] Time pulse / time stamp is always generated by the UBX-R5 cellular chipset after the process of the GNSS time pulse signal.
[31] Configurability not supported by "00B" products version; period is fixed to 1.0 s
[32] eDRX deep-sleep is not supported by "00B" products version

### 4.2.10 RESET_N pin

| Parameter | Min. | Typical | Max. | Unit | Remarks |
|---|---|---|---|---|---|
| Internal supply | | 1.8 | | | Digital I/O Interfaces supply (V_INT) |
| Low-level input | -0.3 | | 0.5 | V | |
| Low-level input current | -18 | -32 | -56 | µA | |
| RESET_N low time | 100 | | | ms | Low time to trigger module reset / reboot |

**Table 22: RESET_N pin characteristics**

### 4.2.11 SIM pins

The SIM pins are a dedicated interface to the external SIM card/chip. The electrical characteristics fulfill the regulatory specification requirements. The values in Table 23 are for information only.

| Parameter | Min. | Typ. | Max. | Unit | Remarks |
|---|---|---|---|---|---|
| Internal supply domain for SIM interface | | 1.8 | | V | VSIM, with external 1.8 V SIM type |
| | | 3.0 | | V | VSIM, with external 3.0 V SIM type |
| Low-level input | -0.3 | | 0.2*VSIM | V | |
| High-level input | 0.6*VSIM | | VSIM+0.3 | V | |
| Low-level output | | 0.0 | | V | |
| High-level output | | VSIM | | V | |
| Internal pull-up resistor on SIM_IO | | 4.7 | | kΩ | Internal pull-up to VSIM supply |
| Clock frequency on SIM_CLK | | 3.13 | | MHz | |

**Table 23: SIM pin characteristics**

### 4.2.12 Generic Digital Interfaces pins

| Parameter | Min | Typical | Max | Unit | Remarks |
|---|---|---|---|---|---|
| Internal supply for GDI domain | | 1.8 | | V | Digital I/O Interfaces supply (V_INT) |
| Low-level input | -0.3 | | 0.5 | V | |
| High-level input | 1.3 | | 2.1 | V | |
| Low-level output | | 0.0 | 0.4 | V | |
| High-level output | 1.4 | 1.8 | | V | |
| Input leakage current | | | 1 | µA | 0 V < $V_{IN}$ < 1.8 V |
| Output high driver strength | 3.28 | 5.22 | 7.92 | mA | $V_{OUT}$ = 1.4 |
| Output low driver strength | 3.02 | 5.41 | 8.63 | mA | $V_{OUT}$ = 0.4 |
| Pull-up input current | -18 | -32 | -56 | µA | |
| Pull-down input current | 15 | 30 | 56 | µA | |

**Table 24: GDI pin characteristics**

### 4.2.13 GNSS digital interfaces pins

| Parameter | Min | Typical | Max | Unit | Remarks |
|---|---|---|---|---|---|
| Internal supply for GNSS domain | | 1.80 | | V | |
| Low-level output | | 0.00 | 0.40 | V | |
| High-level output | 1.40 | 1.80 | | V | |

**Table 25: GNSS pins characteristics**

### 4.2.14 I2C pins

I2C lines (**SCL** and **SDA**) are compliant to the I2C-bus standard mode specification. See the I2C-bus specification [10] for detailed electrical characteristics.

| Parameter | Min | Typical | Max | Unit | Remarks |
|---|---|---|---|---|---|
| Internal supply for I2C domain | | 1.8 | | V | Digital I/O Interfaces supply (V_INT) |
| Low-level input | -0.3 | | 0.5 | V | |
| High-level input | 1.3 | | 2.1 | V | |
| Low-level output | | 0.0 | | V | |
| Pull-up input current | | -450 | | µA | |

**Table 26: I2C pin characteristics**

### 4.2.15 USB pins

USB data lines (**USB_D+** / **USB_D–**) are compliant with the USB 2.0 high-speed specification. See the Universal Serial Bus specification revision 2.0 [9] for detailed electrical characteristics. The values in Table 27 related to USB 2.0 high-speed physical layer specifications are for information only.

| Parameter | Min. | Typical | Max. | Unit | Remarks |
|---|---|---|---|---|---|
| VUSB_DET pin, High-level input | 4.40 | 5.00 | 5.25 | V | |
| High-speed squelch detection threshold (input differential signal amplitude) | 100 | | 150 | mV | |
| High speed disconnect detection threshold (input differential signal amplitude) | 525 | | 625 | mV | |
| High-speed data signaling input common mode voltage range | –50 | | 500 | mV | |
| High-speed idle output level | –10 | | 10 | mV | |
| High-speed data signaling output high level | 360 | | 440 | mV | |
| High-speed data signaling output low level | –10 | | 10 | mV | |
| Chirp J level (output differential voltage) | 700 | | 1100 | mV | |
| Chirp K level (output differential voltage) | –900 | | –500 | mV | |

**Table 27: USB pins characteristics**

### 4.2.16 ADC pin

| Parameter | Min. | Typical | Max. | Unit | Remarks |
|---|---|---|---|---|---|
| Resolution | | 12 | | Bits | |
| Input voltage range | 0 | | 1.2 | V | |
| Input resistance | | 5 | | MΩ | With respect to GND |

**Table 28: Analog to Digital Converter input pin (ADC) characteristics**

## 4.2.17 Smart temperature supervisor

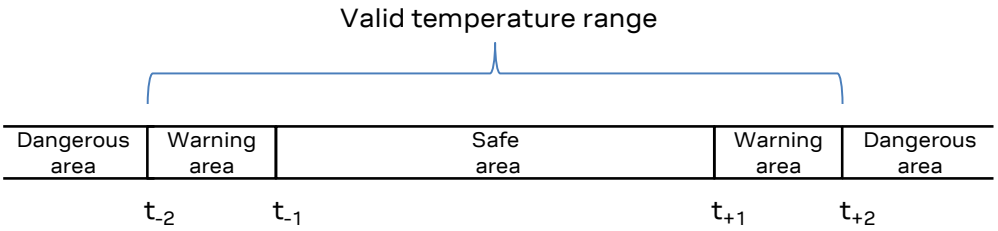


**Figure 7: Temperature range and limits**

| Symbol | Parameter | Temperature |
|---|---|---|
| $t_{-2}$ | Low temperature shutdown | –40 °C |
| $t_{-1}$ | Low temperature warning | –30 °C |
| $t_{+1}$ | High temperature warning | +77 °C |
| $t_{+2}$ | High temperature shutdown | +97 °C |

**Table 29: Thresholds definition for the "Smart temperature supervisor" feature on the SARA-R5 series modules**

☞ The sensor measures the board temperature inside the shield, which can differ from the ambient temperature.

## 4.3 Parameters for ATEX applications

This section provides useful parameters and information to integrate SARA-R5 series modules in applications intended for use in areas with potentially explosive atmospheres (ATEX), including:

- Total internal capacitance and inductance of the modules (see Table 30)
- Maximum RF output power at the antenna (**ANT**) pin of the modules (see Table 31)

☞ For any device integrating the SARA-R5 series modules and intended for use in potentially explosive atmospheres, check the detailed requisites on the pertinent normative for the application, as for example the IEC 60079-0 [12], IEC 60079-11 [13], and IEC 60079-26 [14] standards. The requirements must be fulfilled according to the exact applicable standards.

☞ The certification of the application device that integrates a SARA-R5 series module and the compliance of the application device with all the applicable certification schemes, directives and standards required for use in potentially explosive atmospheres are the sole responsibility of the application device manufacturer.

Table 30 describes the maximum total internal capacitance and the maximum total internal inductance, considering internal parts tolerance, of the SARA-R5 series modules.

| Module | Parameter | Description | Value | Unit |
|---|---|---|---|---|
| SARA-R500E, SARA-R500S | Ci | Maximum total internal capacitance | 373 | µF |
| | Li | Maximum total internal inductance | 10.7 | µH |
| SARA-R510S | Ci | Maximum total internal capacitance | 379 | µF |
| | Li | Maximum total internal inductance | 10.7 | µH |
| SARA-R510M8S | Ci | Maximum total internal capacitance | 385 | µF |
| | Li | Maximum total internal inductance | 10.7 | µH |

**Table 30: SARA-R5 series maximum total internal capacitance and maximum total internal inductance**

Table 31 describes the maximum RF output power transmitted by SARA-R5 series modules from the antenna (**ANT**) pin as Power Class 3 User Equipment for the LTE bands.

| Module | Parameter | Description | Value | Unit |
|---|---|---|---|---|
| All | ANT Pout | Maximum RF output power from ANT pin | 25.00 | dBm |

**Table 31: SARA-R5 series maximum RF output power**

☞ SARA-R5 series modules do not contain internal blocks that increase the input voltage (such as step-up, duplicators, or boosters) except for the antenna (**ANT**) pin, for which the maximum RF output power shown in Table 31.

# 5 Mechanical specifications

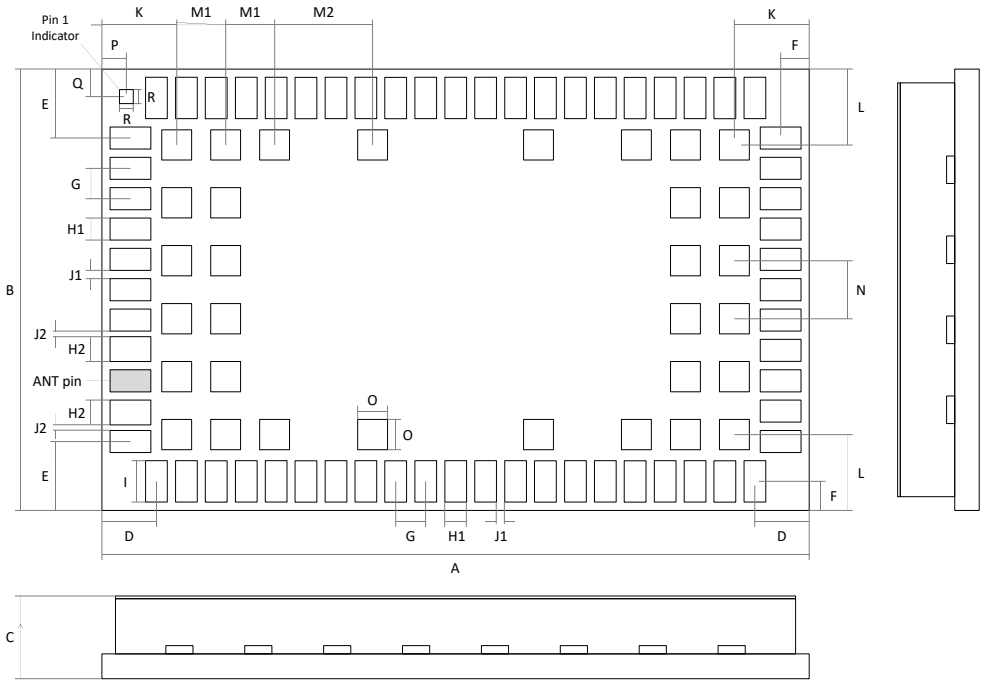


**Figure 8: SARA-R5 series dimensions (bottom and side views)**

| Parameter | Description | Typical | | Tolerance | |
|---|---|---|---|---|---|
| A | Module height [mm] | 26.0 | (1023.6 mil) | +0.20/-0.20 | (+7.9/-7.9 mil) |
| B | Module width [mm] | 16.0 | (629.9 mil) | +0.20/-0.20 | (+7.9/-7.9 mil) |
| C | Module thickness [mm] | 2.2 | (86.6 mil) | +0.25/-0.15 | (+9.8/-5.9 mil) |
| D | Horizontal edge to lateral pin pitch [mm] | 2.0 | (78.7 mil) | +0.20/-0.20 | (+7.9/-7.9 mil) |
| E | Vertical edge to lateral pin pitch [mm] | 2.5 | (98.4 mil) | +0.20/-0.20 | (+7.9/-7.9 mil) |
| F | Edge to lateral pin pitch [mm] | 1.05 | (41.3 mil) | +0.20/-0.20 | (+7.9/-7.9 mil) |
| G | Lateral pin to pin pitch [mm] | 1.1 | (43.3 mil) | +0.05/-0.05 | (+2.0/-2.0 mil) |
| H1 | Lateral pin height [mm] | 0.8 | (31.5 mil) | +0.05/-0.05 | (+2.0/-2.0 mil) |
| H2 | Lateral pin close to ANT height [mm] | 0.9 | (35.4 mil) | +0.05/-0.05 | (+2.0/-2.0 mil) |
| I | Lateral pin width [mm] | 1.5 | (59.1 mil) | +0.05/-0.05 | (+2.0/-2.0 mil) |
| J1 | Lateral pin to pin distance [mm] | 0.3 | (11.8 mil) | +0.05/-0.05 | (+2.0/-2.0 mil) |
| J2 | Lateral pin to pin close to ANT distance [mm] | 0.2 | (7.9 mil) | +0.05/-0.05 | (+2.0/-2.0 mil) |
| K | Horizontal edge to central pin pitch [mm] | 2.75 | (108.3 mil) | +0.20/-0.20 | (+7.9/-7.9 mil) |
| L | Vertical edge to central pin pitch [mm] | 2.75 | (108.3 mil) | +0.20/-0.20 | (+7.9/-7.9 mil) |
| M1 | Central pin to pin horizontal pitch [mm] | 1.8 | (70.9 mil) | +0.05/-0.05 | (+2.0/-2.0 mil) |
| M2 | Central pin to pin horizontal pitch [mm] | 3.6 | (141.7 mil) | +0.05/-0.05 | (+2.0/-2.0 mil) |
| N | Central pin to pin vertical pitch [mm] | 2.1 | (82.7 mil) | +0.05/-0.05 | (+2.0/-2.0 mil) |
| O | Central pin height and width [mm] | 1.1 | (43.3 mil) | +0.05/-0.05 | (+2.0/-2.0 mil) |
| P | Horizontal edge to pin 1 indicator pitch [mm] | 0.9 | (35.4 mil) | +0.20/-0.20 | (+7.9/-7.9 mil) |
| Q | Vertical edge to pin 1 indicator pitch [mm] | 1.0 | (39.4 mil) | +0.20/-0.20 | (+7.9/-7.9 mil) |
| R | Pin 1 indicator height and width [mm] | 0.5 | (19.7 mil) | +0.05/-0.05 | (+2.0/-2.0 mil) |
| Weight | Module weight [g] | < 3 | | | |

**Table 32 : SARA-R5 series dimensions**

☞ Module height tolerance +/–0.20 mm may be exceeded close to the corners of the PCB due to the cutting process: in the worst cases, the height could be +0.40 mm longer than the typical value.

☞ For information regarding Footprint and Paste Mask recommended for the application board integrating the cellular module, see the SARA-R5 series system integration manual [2].

# 6 Qualification and approvals

## 6.1 Reliability tests

Reliability tests for SARA-R5 series modules are executed according to u-blox qualification policy, based on AEC-Q104 standard.

## 6.2 Approvals

SARA-R500s modules comply with the Directive 2011/65/EU of the European Parliament and the Council on the Restriction of Use of certain Hazardous Substances in Electrical and Electronic Equipment (EU RoHS 2) and its amendment Directive (EU) 2015/863 (EU RoHS 3).

SARA-R500s modules are RoHS 3 compliant.

No natural rubbers, hygroscopic materials, or materials containing asbestos are employed.

Table 33, Table 34 and Table 35 summarize the main approvals for the “00B” and “01B” product versions of SARA-R5 series modules.

| Certification | SARA-R500S-00B |
|---|---|
| GCF | Cat M1 bands 1,2,3,4,5,8,12,13,18,19,20,25,26,28 |
| PTCRB | Cat M1 bands 1,2,3,4,5,8,12,13,18,19,20,25,26,28 |
| CE Europe | Cat M1 bands 1,3,8,20,28 |
| UKCA United Kingdom | Cat M1 bands 1,3,8,20,28 |
| FCC United States | Cat M1 bands 2,4,5,12,13,25,26 |
| ISED Canada | Cat M1 bands 2,4,5,12,13,25 |
| GITEKI Japan | Cat M1 bands 1,3,8,18,19,26 |
| NCC Taiwan | Cat M1 bands 1,3,8,28 |
| ACMA RCM Australia | Cat M1 bands 1,3,5,8,28 |
| AT&T | Cat M1 bands 2,4,5,12 |
| Verizon | Cat M1 bands 4,13 |

**Table 33: SARA-R500S-00B / SARA-R510S-00B / SARA-R510M8S-00B modules main certification approvals summary**

[33] FCC grant includes the US 900 MHz frequency spectrum within LTE band 8, enabling access to Anterix private LTE network

| Certification | SARA-R500S-01B |
|---|---|
| PTCRB | Cat M1 bands 1,2,3,4,5,8,12,13,18,19,20,25,26,28,66,71 |
| CE Europe | Cat M1 bands 1,3,8,20,28<br>Cat NB2 bands 1,3,8,20,28 |
| UKCA United Kingdom | Cat M1 bands 1,3,8,20,28<br>Cat NB2 bands 1,3,8,20,28 |
| FCC United States | Cat M1 bands 2,4,5,8[34],12,13,25,26,66,71<br>Cat NB2 bands 2,4,5,8[34],12,13,66,71,85 |
| ISED Canada | Cat M1 bands 2,4,5,12,13,25,26,66,71<br>Cat NB2 bands 2,4,5,12,13,66,71,85 |
| GITEKI Japan | Cat M1 bands 1,3,8,18,19,26,28<br>Cat NB2 bands 1,3,8,18,19,26,28 |
| NCC Taiwan | Cat M1 bands 1,3,8,28<br>Cat NB2 bands 1,3,8,28 |
| ACMA RCM Australia | Cat M1 bands 1,3,5,8,28<br>Cat NB2 bands 1,3,5,8,28 |
| KC Korea | Cat M1 bands 3,5,26 |
| AT&T | Cat M1 bands 2,4,5,12<br>FirstNet |
| Verizon | Cat M1 bands 4,13 |
| T-Mobile US | Cat M1 bands 2,4,5,12,66,71 |
| US Cellular | Cat M1 bands 2,4,5,12 |
| Rogers | Cat M1 bands 4,5,12 |
| Telus | Cat M1 bands 4,5,12,13 |
| Telstra | Cat M1 bands 3,28 |

**Table 35: SARA-R500S-01B / SARA-R510S-01B / SARA-R510M8S-01B modules main certification approvals summary**

☞ For guidelines and notices about compliance with certification approvals requirements integrating the SARA-R5 series modules in the end-device, see the SARA-R5 series system integration manual [2].

☞ For the complete list of approvals and for specific details on all country, conformance and network operators' certifications available for all the different SARA-R5 series modules' ordering numbers, including related certificates of compliancy, please contact your nearest u-blox office or sales representative. The certification approvals listed in Table 33, Table 34 and Table 35 might not be available for all the different product type numbers.

# Important Compliance Information for North American Users

The SARA-R500S-01B has been granted modular approval for mobile applications. Integrators may use the SARA-R500S-01B1 in their end products without additional FCC certification if they meet the following conditions. Otherwise, additional FCC approvals must be obtained.

1. The end product must use the RF trace design approved with the SARA-R500S-01B.The Gerber file of the trace design can be obtained upon form LANTRONIX request.
2. At least 20 cm separation distance between the antenna and the user's body must be maintained at all times.
3. To comply with FCC regulations limiting both maximum RF output power and human exposure to RF radiation, the maximum antenna gain including cable loss in a mobile-only exposure condition must not exceed the limits stipulated in below

- 7.8 dBi in 700 MHz, i.e. LTE FDD-12 band
- 9.2 dBi in 750 MHz, i.e. LTE FDD-13 band
- 9.4 dBi in 850 MHz, i.e. LTE FDD-5 band
- 7.4 dBi in 850 MHz, i.e. LTE FDD-26 band
- 6.8 dBi in 1700 MHz, i.e. LTE FDD-4 band
- 10.3 dBi in 1900 MHz, i.e. LTE FDD-2 band
- 10.4 dBi in 1900 MHz, i.e. LTE FDD-25 band

4. SARA-R500S-01B may transmit simultaneously with other collocated radio transmitters within a host device, provided the following conditions are met:
   - Each collocated radio transmitter has been certified by FCC for mobile application.
   - At least 20 cm separation distance between the antennas of the collocated transmitters and the user's body must be maintained at all times.

5. A label must be affixed to the outside of the end product into which the SARA-R500S-01B is incorporated, with a statement similar to the following: **This device contains FCC ID: R68FOX4M1BLE**

6. A user manual with the end product must clearly indicate the operating requirements and conditions that must be observed to ensure compliance with current FCC RF exposure guidelines.

The end product with an embedded SARA-R500S-01B may also need to pass the FCC Part 15 unintentional emission testing requirements and be properly authorized per FCC Part 15.

*Note: If this module is intended for use in a portable device, you are responsible for separate approval to satisfy the SAR requirements of FCC Part 2.1093.*

# Important Compliance Information for the United States and Canada

RC7611(-1), upon commercial release, will have been granted modular approval for mobile applications. Integrators may use the SARA-R500S-01B in their final products without additional FCC/ISED (Industry Canada) certification if they meet the following con-ditions. Otherwise, additional FCC/ISED approvals must be obtained.

1. At least 20 cm separation distance between the antenna and the user's body must be maintained at all times.
2. To comply with FCC/ISED regulations limiting both maximum RF output power and human exposure to RF radiation, the maximum antenna gain including cable loss in a mobile-only exposure condition must not exceed the limits
3. A label must be affixed to the outside of the end product into which SARA-R500S-01B module is incorporated, with a statement similar to the following:
   - **This device contains FCC ID: R68FOX4M1BLE**
     **Contains transmitter module ISED: 3867A-FOX4M1BLE**
4. A user manual with the end product must clearly indicate the operating requirements and conditions that must be observed to ensure compliance with current FCC/ISED RF exposure guidelines.

The end product with an embedded RC7611-1 module may also need to pass the FCC Part 15 unintentional emission testing requirements and be properly authorized per FCC Part 15.

**Note:** If this module is intended for use in a portable device, you are responsible for separate approval to satisfy the SAR requirements of FCC Part 2.1093 and ISED RSS-102.

# Industry Canada Statement

This device complies with Industry Canada license-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.

This module is intended for OEM integrator. The OEM integrator is responsible for the compliance to all the rules that apply to the product into which this certified RF module is integrated. Additional testing and certification may be necessary when multiple modules are used.

This equipment complies with ISED RSS-102 radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance 20 cm between the radiator and your body.

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.

L'intégrateur OEM doit être conscient de ne pas fournir des informations à l'utilisateur final quant à la façon d'installer ou de supprimer ce module RF dans le manuel de l'utilisateur du produit final qui intègre ce module. Le manuel de l'utilisateur final doit inclure toutes les informations réglementaires requises et avertissements comme indiqué dans ce manuel.

Cet équipement est conforme aux limites d'exposition aux rayonnements ISED établies pour un environnement non contrôlé. Cet équipement doit être installé et utilisé avec un minimum de 20 cm de distance entre la source de rayonnement et votre corps.

| Parameter | Typical value | Tolerance | Unit |
|---|---|---|---|
| $A_0$ | 16.8 | 0.2 | mm |
| $B_0$ | 26.8 | 0.2 | mm |
| $K_0$ | 3.2 | 0.2 | mm |

**Table 38 : SARA-R5 series tape dimensions (mm)**

☞ 10 sprocket hole pitch cumulative tolerance ± 0.2 mm.

☞ Pocket position relative to sprocket hole is measured as true position of pocket, not pocket hole.

☞ $A_0$ and $B_0$ are calculated on a plane at a distance "R" above the bottom of the pocket.

## 7.2 Moisture sensitivity levels

⚠ SARA-R5 series modules are moisture sensitive devices (MSD) in accordance with the IPC/JEDEC specification.

The Moisture Sensitivity Level (MSL) relates to the packaging and handling precautions required. SARA-R5 series modules are rated at MSL level 4. For more information regarding moisture sensitivity levels, labeling, storage and drying, see the u-blox package information user guide [3].

☞ For the MSL standard, see IPC/JEDEC J-STD-020 (can be downloaded from www.jedec.org).

## 7.3 Reflow soldering

Reflow profiles are to be selected according to u-blox recommendations (see the SARA-R5 series system integration manual [2]).

⚠ Failure to observe these recommendations can result in severe damage to the device!

## 7.4 ESD precautions

⚠ SARA-R5 series modules contain highly sensitive electronic circuitry and are Electrostatic Sensitive Devices (ESD). Handling SARA-R5 series modules without proper ESD protection may destroy or damage them permanently.

SARA-R5 series modules are Electrostatic Sensitive Devices (EDS) and require special ESD precautions typically applied to ESD sensitive components.

Table 8 details the maximum ESD ratings of the SARA-R5 series modules.

Proper ESD handling and packaging procedures must be applied throughout the processing, handling and operation of any application that incorporates SARA-R5 series modules.

ESD precautions should be appropriately implemented on the application board where the module is mounted, as described in the SARA-R5 series system integration manual [2].

⚠ Failure to observe these precautions can result in severe damage to the device!