Indy® RS1000
Hardware User's Guide

1 Indy® RS1000 Overview

Indy RS1000 is a completely integrated surface-mount RAIN RFID reader module. The Indy RS1000 surface-mount module improves on the Indy RS500's capabilities with a significant increase in read performance. Existing Indy RS500 users will be able to quickly offer higher performance with their existing hardware due to RS1000's drop-in compatibility. It can be easily added to an embedded system, requiring only connections to a power source, digital communication with a host, and an antenna. The package design allows it to be attached to a PCB using standard surface mount technology (SMT), with no need for additional connectors or mounting hardware. The Indy RS1000 is the easiest way to embed RAIN RFID reader capability.

This document provides hardware developers technical guidance to ensure optimal performance when using the Indy RS1000. Details on the use of the Indy RS1000 Development Kit are also included.

Air Interface Protocol	RAIN RFID (EPCglobal UHF Class 1 Gen 2 / ISO 18000-63 (formerly 18000-6C)) Supports dense reader mode (DRM)
Tx Output Power	10 to 27 dBm
Operating Frequencies	IPJ-RS1000-GX (902-928 MHz) covers all 900 MHz bands worldwide
Package	29 mm by 32 mm by 3.8 mm
Package Type	32 pin surface mount package (SMT compatible)
Rx Sensitivity	-75 dBm (1% packet error rate). Assumes a 15 dB antenna return loss at 27 dBm output power.
DC Power Supply	3.6 to 5.25 Volts
DC Power Consumption	3.5 Watts at 27 dBm output power and 5 Volt supply 3.6 Watts at 27 dBm output power and 3.6 Volt supply
Supported Regions	FCC and all equivalent regions supported.
Compliance	Certified: FCC and Canada modular operation, RoHS compliant

For technical support, visit the Impinj support portal at: support.impinj.com

For more information, contact readerchips@impinj.com
Revision 1.0

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3 RS1000 Hardware Interface

An example Indy RS1000 system-level block diagram for an embedded system is shown in Figure 1. This figure shows the electrical connections that may and must be made to control the RS1000. In the figure, the required connections are illustrated with solid lines. Recommended and optional connections are illustrated with different dotted and dashed line patterns. They are also listed below.

More details for each connection are listed in the following subsections.

Required connections:

- VDC_IN and GND are required to power the RS1000.
- RF is required to connect to the UHF RFID antenna.
- UART1 Tx and Rx are required to communicate with the system host.

Recommended connections:

- nRST is used to reset the RS1000 if UART communication is not available. This connection is highly recommended. This pin internally driven strong low during software resets, so it should only be driven externally by an open drain signal. It must not be driven strong high.
- UART2 Tx and Rx may be used to examine debug information. Their behavior is defined in the debugging section of the ITK-C user documentation.
- HEALTH indicates successful operation of the RS1000. Connection to an LED provides a visual indication of whether or not an error condition exists.
- STATUS provides an indication when the RS1000 is in active mode (for example, inventorying tags). Connection to an LED provides a visual indicator of the device's activity.

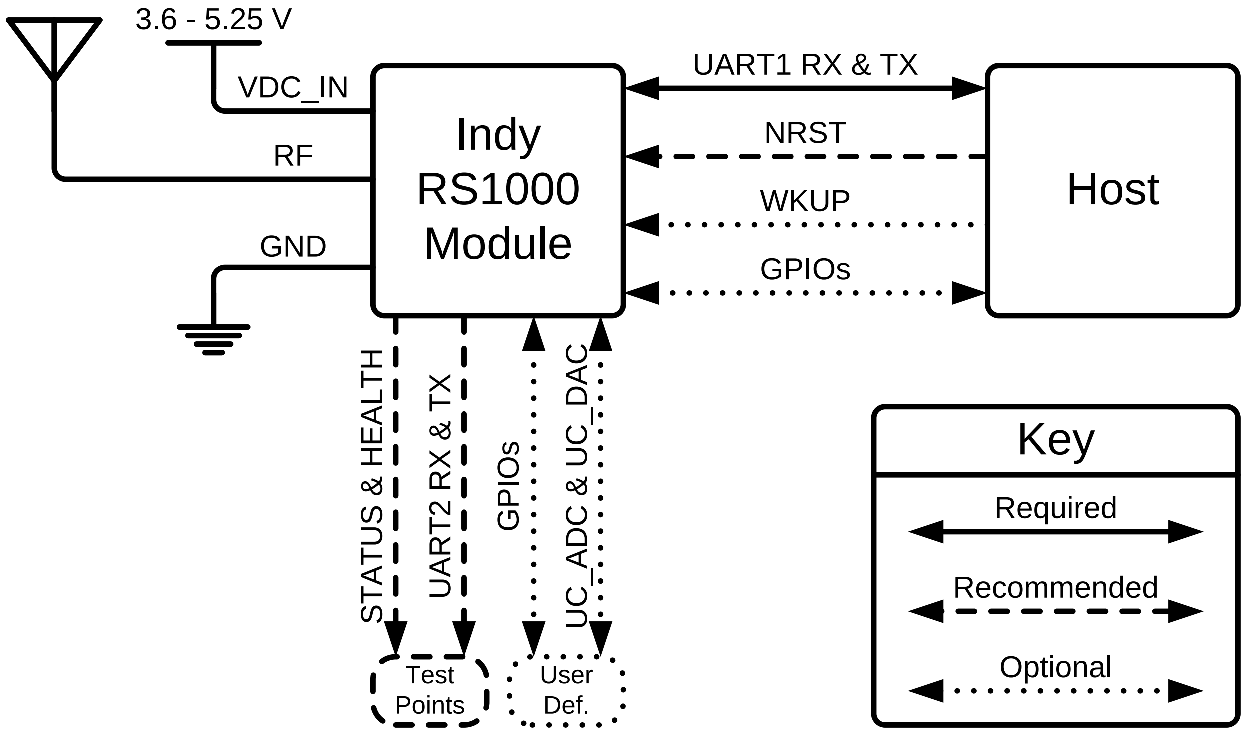
Optional connections:

- GPIOs allow interaction with the RS1000 as both digital inputs and outputs. They may be used to trigger inventory, generate events based on inventory activity, or provide general-purpose user-controlled digital I/O.
- WKUP provides a mechanism to wake up the RS1000 from the low power Sleep mode. WKUP is also used to force entry into the Impinj firmware bootstrap. If unused, this pin should be tied to logic low.
- UC_ADC allows use of an ADC to convert an analog input voltage into a digital value.
- UC_DAC allows use of a DAC to generate an analog output voltage from a digital value.

No connect:

- SWCLK and SWD connections are reserved for Impinj use only.

Figure 1 – Example RS1000 Block Diagram



3.1 Power Supply

RS1000 is powered by a voltage applied to the VDC_IN pin (pin 11) relative to the GND pins. The supply voltage operating range is 3.6 V to 5.25 V. Current consumption varies from about 1000 mA (3.6 W) to about 80 uA (0.4 mW) depending on the operating mode. The power supply is internally bypassed and regulated, and no external bypass or bulk storage capacitance is required, as long as the input voltage is stable.

If RS1000 activity is not required at all times, and power reduction is desired, the VDC_IN supply voltage may be externally gated to remove power to the device.

3.2 RF Connection

The RS1000 has a single RF pin (pin 1) which should be connected to a 50 Ω antenna via 50 Ω controlled impedance connection. This connection could simply be a microstrip transmission line to a PCB antenna or SMT antenna, or it could include a connector and coaxial cable. The RF connection is single ended, referenced to ground.

For more information about impedance matching, see section 4.1 - PCB Layout for RF.

3.3 UART Communication

The RS1000 has two full-duplex UART interfaces at the pins, accessible using pins UART1-RX, UART1-TX, UART2-RX, and UART2-TX. UART1 implements the host communication interface via IRI, and UART2 implements the debug interface. The Tx pins are outputs from the RS1000, and the Rx pins are inputs to the RS1000. Both UART interfaces are 115,200 baud, with 8 data bits, 1 stop bit, and no parity bit (8-n-1 configuration).

Each of the UART interfaces signals at 3.3 V relative to GND. The specific VIH, VIL, VOH and VOL specifications may be found in the device datasheet. The TX pins are driven strong high and low with a sink/source current of about 8 mA. If the load on a pin draws more than the 8 mA sink and source current, the pin is not guaranteed to meet the VOH and VOL specs listed in the datasheet. Excessive current sunk or sourced on the GPIO pins can also cause electrical damage to the device.

Voltages outside of the maximum IO operating voltage range of -0.3 to 4.0 V should not be applied to the UART pins. This can cause permanent damage to the device.

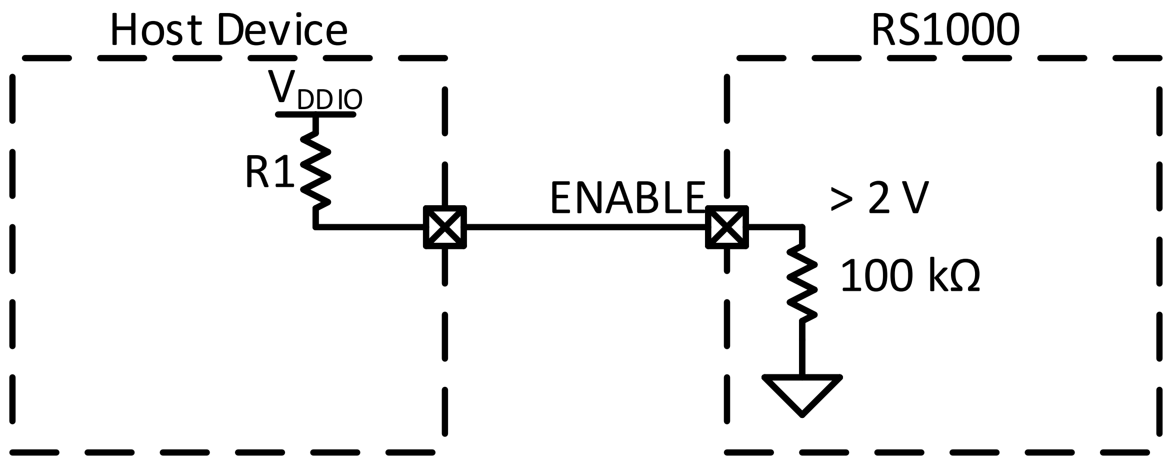
3.4 Reset Pin

The RS1000 may be reset by a logic low voltage on the NRST pin (pin 9). Usage of this pin is recommended in all designs. It may be used to reset the part if an unexpected operating state is entered. The RS1000 does have an internal watchdog circuit that will reset it if abnormal operation occurs, but the NRST pin provides a further level of reliability.

The NRST pin is pulled high (3.3 V) by an internal 100 kΩ nominal resistor. To reset the part, drive the pin strong low for at least the minimum reset pulse width as specified in the datasheet (approximately 25 µs). This pin may be driven active low to reset the part, but should not be driven strong high. Driving the pin strong high prevents the RS1000 from resetting itself in case of a watchdog reset or user requested software reset. This pin should be driven using an "open drain drives low" drive mode, which creates either a strong low voltage or a floating voltage output. If the host device has a pull-up drive mode, or a series resistor is used with a strong drive mode, the resistor value should be selected such that the NRST voltage is above 2 V. This arrangement is shown in Figure 2, and the resistor size requirement is shown in Equation 3-1.

Note Using a series resistor or resistive pull-up drive mode allows the same circuit to be used to drive the RS1000 NRST pin and the RS2000 ENABLE pin.

Figure 2 – RS1000 NRST Pin Circuit Diagram



Equation 3-1 – NRST Pin Pull-Up Resistor Size

$$R1 < 100\ k\Omega * \left(\left(\frac{V_{DDIO}}{2.0\ V}\right) - 1\right)$$

Voltages outside of the maximum IO operating voltage range of -0.3 to 4.0 V should not be applied to the NRST pin. This can cause permanent damage to the device.

3.5 Health and Status Pins

The RS1000 has two pins that indicate the state of the device through their voltages: HEALTH (pin 22) and STATUS (pin 21). Their behavior is further defined in the debugging section of the ITK-C user documentation.

Both pins are outputs operating at a logical voltage level of 3.3 V, and can sink and source 8 mA each. If the load on one of these pins draws more than the 8 mA sink and source current, the pin is not guaranteed to meet the VOH and VOL specs listed in the datasheet. Excessive current sunk or sourced on the pins can also cause electrical damage to the device.

3.5.1 Health Pin Behavior

The HEALTH pin indicates whether the RS1000 is operating in its normal mode, or if some other condition exists. The pin is cycled high and low in specific patterns to indicate the state of the RS1000. Those patterns are as follows:

Table 3-1 – Health Pin Behavior

Mode	HEALTH Pin Behavior
Reset	HEALTH pin is held low
Idle (no reads occurring)	1 second high, 1 second low
Active(reads occurring)	250 ms high, 750 ms low
Watchdog reset has occurred	HEALTH pin is held low
Recovery	Blink alternate pattern with STATUS LED

3.5.2 Status Pin Behavior

The STATUS pin indicates whether the RS1000 is operating in its active mode, or if some other condition exists. The pin is cycled high and low in specific patterns to indicate the state of the RS1000. Those patterns are as follows:

Table 3-2 – Status Pin Behavior

Mode	STATUS Pin Behavior
Reset	STATUS pin is held low
Idle (no reads occurring)	STATUS pin is held low
Active(reads occurring)	During inventory, the high time is between 150 ms and 750 ms based on the number of tags in the field. The low time is 1000 ms minus the high time. If there are no tags in the field the pin remains low.
Watchdog reset has occurred	Alternate high and low
Recovery	Toggle with a pattern of logical NOT of the HEALTH pin status

3.6 GPIO Pins

The RS1000's GPIOs can be controlled using the IRI interface. Their drive mode, direction, and state are all controllable via IRI. There are two directions: input and output. In both input and output directions, there are three possible pin states: high, low, and float. For more details on using IRI to control the GPIOs, see the IRI Toolkit (ITK) documentation.

In the output direction, the GPIOs are driven strong high and low with a source and sink current of 8 mA, and in float mode the pin is not driven either high or low, leaving the pin floating, also known as "high impedance" or "high-Z". The pins are driven to 3.3 V nominally. If the load on a pin draws more than the 8 mA sink and source current, the pin is not guaranteed to meet the VOH and VOL specs listed in the datasheet. Excessive current sunk or sourced on the GPIO pins can also cause electrical damage to the device.

In the input direction, the high and low states apply a pull-up or pull-down resistor, and in float mode the pin is not pulled either high or low, leaving the pin floating, also known as "high impedance" or "high-Z". The pull-up and pull-down resistors are about 40 kΩ nominal. See the device datasheet for more specific ratings. The inputs logic levels are proportional to 3.3 V. Specific VIH and VIL specs may be found in the device datasheet.

Voltages outside of the maximum IO operating voltage range of -0.3 to 4.0 V should not be applied to the pins, no matter their configuration. This can cause permanent damage to the device.

3.7 Wakeup Pin

The WKUP pin is used to wake the device when it is in the Standby or Sleep operating modes. This pin is edge sensitive, and will wake the device on a rising edge. The WKUP pin must be logic low in order for the device to re-enter Idle mode after a Sleep wakeup, so it should only be pulsed high to wake up the part.

The WKUP pin is also used to force the part into the Impinj bootstrap. The pin is polled at startup, and while it remains high, the device stays in the bootstrap. This allows bootloading of the part even if the bootloadable code is corrupted.

The WKUP pin operates at a 3.3 V logic level. It has a 40 kΩ typical pull-down resistor inside the RS1000. Voltages outside of the maximum IO operating voltage range of -0.3 to 4.0 V should not be applied to the WKUP pin. This can cause permanent damage to the device.

If the WKUP pin is not used, it should be left floating or tied to logic low (ground). This will prevent accidental entry into the Impinj bootstrap.

4 RS1000 Layout and Components

This section describes hardware aspects of embedded RAIN RFID readers based on the RS1000 module. For details on the dimensions, recommended PCB footprint, and reflow profile for RS1000, see the device datasheet.

4.1 PCB Layout for RF

4.1.1 50 Ohm Characteristic Impedance

As discussed in section 3.2, a properly matched RF connection is critical to achieving high performance with RS1000. An improperly matched RF connection will reduce performance in multiple ways, by both reducing the transmitted RF power, and also increasing the reflected power that interferes with RS1000's receive circuitry.

When impedance is improperly matched across a node, a signal's reflection coefficient will be proportional to the difference between the characteristic impedances on both sides of the node divided by their sum, as shown in Equation 4-1. In this equation, Z_L

represents the characteristic impedance of the transmission line, and Z_0 represents the characteristic impedance of RS1000, 50 Ohms. For example, if a 40 Ohm transmission line is used, the reflection coefficient will be = 10 / 90 = 11.1%, thus 11.1% of it will be reflected back into the RS1000, and only 88.9% of the power will be transmitted.

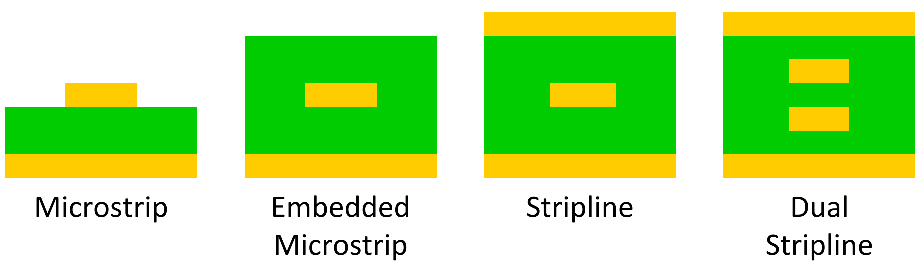
Equation 4-1 – Reflection Coefficient of a Load

$$\Gamma = \frac{Z_L - Z_0}{Z_L + Z_0}$$

RS1000 is designed to connect to a 50-Ohm characteristic impedance load. The connection between the RS1000 module and its antennas should all be designed for a 50 Ohm characteristic impedance. Because the RF connection is made via PCB traces, this requires carefully designing the PCB layout.

PCB trace characteristic impedance depends on quite a few variables, only some of which can easily be controlled by the PCB designer. The two main categories of variables are the PCB geometry, and material properties. PCB geometry includes both the transmission line type, be it microstrip, stripline, or others, and also the specific dimensions of the forward and return paths and the adjacent dielectrics. Transmission line styles are shown in Figure 3. Material properties to note include the dielectric constant of the dielectrics in the PCB, and the conductivity of the conductor used.

Figure 3 – PCB Transmission Line Types



In most PCB designs, many of the parameters of the PCB are already set, such as dielectric thickness and constant, trace conductivity and weight, etc. Usually the only variables that can be easily modified are the style of transmission line, and its dimensions. The most common, and recommended PCB transmission line scheme is to use a microstrip on the top or bottom layer of the PCB, with a ground plane on the layer immediately adjacent as a return path. The width of this microstrip can then be varied to achieve the desired characteristic impedance. Care should be taken to ensure that the microstrip trace has enough current carrying capacity. This requires designing a trace that is heavy enough to withstand the heat generated by power losses due to the resistance of the trace.

There are many online resources and tools designed to assist in designing PCB transmission lines with the correct characteristic impedances. For example, the TXLine tool from National Instruments is very useful for performing these calculations automatically. There is also an online calculator here on eeweb.com. These tools will require information about the PCB layout and also PCB characteristics, which should be obtained from the PCB manufacturer.

4.1.2 PCB Layout for Minimizing Interference

If, as recommended above, a microstrip trace is used as the RF transmission line, there are additional guidelines that can be applied to minimize interference with other signals on the PCB. Most notable are clearance between the RF traces and other nearby traces, surrounding the RF traces with a ground fill, and via stitching to connect ground fills to one another. This section provides detail.

Any conductor carrying electrical current can potentially act as an antenna, both radiating and absorbing electromagnetic signals. On a PCB, this means that signals on traces influence one another, especially if they are high power or high frequency. In order to minimize interference between traces, they should be adequately spaced. Ideally, all RF traces should be surrounded on the same layer by ground fill, at a distance of at least three times the microstrip trace width.

Unused PCB areas on the outer layers of the PCB are often filled with copper, which is connected to the ground plane. Copper pours can serve any of several useful functions including shielding of sensitive or noisy traces and reduced PCB warpage. Careless copper pours can result in undesired effects so it is important to follow some basic guidelines. Ground planes should be "stitched" together using multi-layer vias. The typical rule of thumb is to place these stitching vias at a distance of the wavelength λ divided by 10, or less. In 900 MHz UHF RFID applications, λ / 10 ~= 3.3 cm.

The Indy Module Breakout Board, a portion of which is shown in Figure 4, can be used as a reference for RF layout best practices. Details on the Indy Module Breakout Board can be downloaded here: https://support.impinj.com/hc/en-us/articles/360000537270

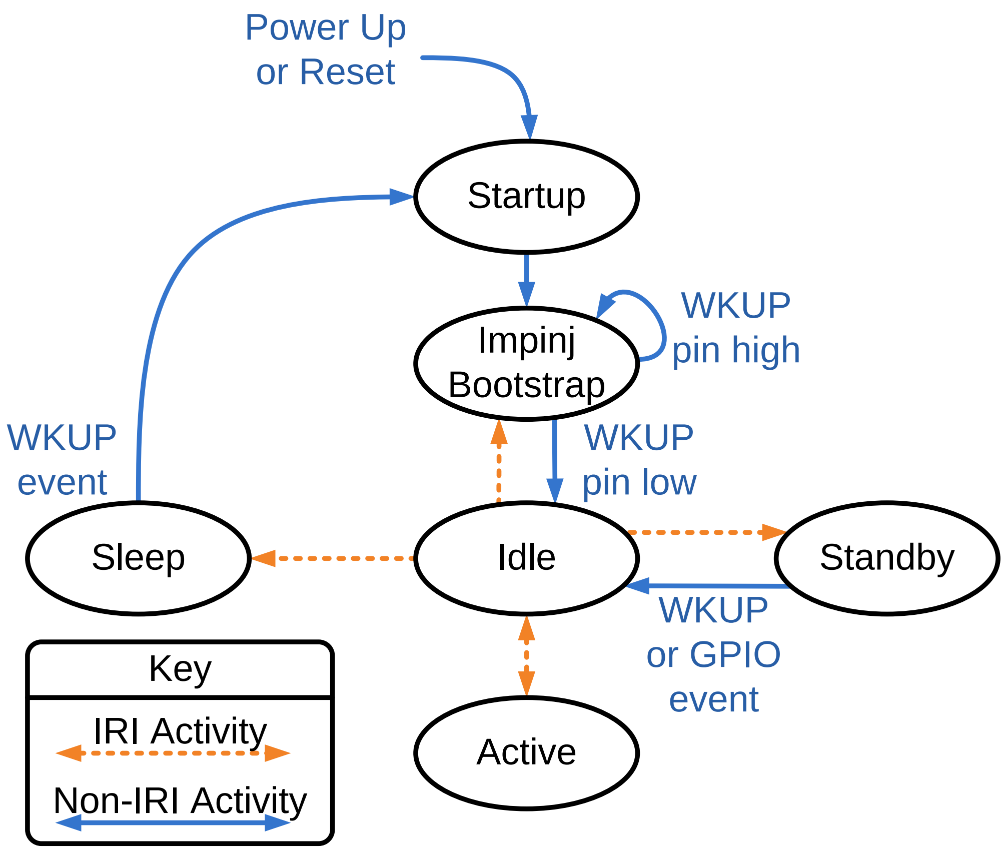
Figure 4 – RS1000 RF PCB Layout Example – Indy Module Breakout Board

5 RS1000 Operating Modes

RS1000 has five operating modes and a startup mode. The transitions between these modes are shown in Figure 5. Transitions are shown in two categories: IRI activity and non-IRI activity. IRI activity shows transitions that are caused by commands communicated over IRI. Non-IRI activity shows transitions that are caused by inputs to the part such as WKUP, NRST, and GPIOs, and power supply conditions such as power supply ramps.

More details on startup behaviour and low power modes are given in the following subsections.

Figure 5 – RS1000 Operating Mode State Diagram



5.1 Startup Behavior

Upon reset or power up, the RS1000 configures itself in the Startup mode. It automatically begins code execution in the Impinj bootstrap, which can be used to update the version of the RS1000 firmware in the device via IRI communication. It stays in this operating mode as long as the WKUP pin is held high, which allows a host to communicate with the Impinj Bootstrap via IRI. When the WKUP pin goes low, firmware execution transitions to the Idle operating mode.

5.2 Low Power Operation

The RS1000 has multiple operating modes that enable reduced power consumption. The operating modes are Active, Idle, Standby, and Sleep. The RS1000 can only perform RFID reads while in Active mode. The IRI interface is only available in Active and Idle modes. While in Idle mode, the RS1000 is ready to quickly return to Active mode and start performing RFID reads. In Standby mode, a GPIO or WKUP pin event is required to return to active mode. In Sleep mode, a WKUP pin event is required to wake the part, and will reset the part, resulting in the normal startup flow. Specifications for current consumption and wakeup time are given in the device datasheet.

Within Idle mode, there are two possible configurations: low latency and standard latency. Low latency idle mode consumes more current but returns to active mode more quickly. See the datasheet for more detailed specifications on wakeup time performance.

The NRST pin can be used in any mode to reset RS1000, eventually returning it to Idle mode via the normal startup behavior. For more detail see section 3.7: Wakeup Pin.

If the low power performance provided by these modes does not meet the requirement of a system, power may be gated to the RS1000's VDC_IN pin, allowing its current consumption to be eliminated entirely. In this configuration, voltages above 0V should not be applied to any of the pins of the device, as they can cause excessive current consumption and unexpected part behaviour.

6 Regulatory Guidelines

The RS-1000 (Impinj model number IPJ-RS1000-GX) is approved for modular certification by FCC and Industry Canada (IC) under the following ID numbers:

- FCC ID: TWYIPJRS1000
- IC: 6324A-IPJRS1000

Modular approval allows installation in different end-use products by an original equipment manufacturer (OEM) with limited or no additional testing or equipment authorization for the transmitter function provided by the RS1000. Specifically:

- No additional transmitter compliance testing is required if the module is operated with the antenna listed in the document below.
- No additional transmitter-compliance testing is required if the module is operated with the same general type of antenna (i.e. near-field segmented loop, circularly polarized patches) as those listed in this User's Guide and in the FCC filing for the RS1000. Acceptable antennas must be of equal or less far field gain than the antenna previously authorized under the same FCC ID, and must have similar in band and out of band characteristics.

In addition, the end product must comply with all applicable FCC equipment authorizations, regulations, requirements and equipment functions not associated with the RS1000. For example, compliance must be demonstrated to regulations for other transmitter components within the host product, to requirements for unintentional radiators (Part 15B), and to additional authorization requirements for the non-transmitter functions.

The OEM applying the RS1000 is required to include all FCC and/or IC statements and warnings detailed in the following sections to the end product labeling (where specified) and in the finished product manual. The OEM must also strictly adhere to antenna and installation guidelines and MPE restrictions stated in this document.

6.1 Product Labelling

A statement must be included on the exterior of the final OEM product which communicates that the device identified by the aforementioned FCC and Industry Canada ID numbers are contained within the product. For example:

> This product contains a radio module certified as FCC ID: TWYIPJRS1000 and IC: 6324A-IPJRS1000

OR

> Contains FCC ID: TWYIPJRS1000
>
> Contains IC: 6324A-IPJRS1000

The OEM must include the following statements on the exterior of the finished product unless the product is too small (e.g. less than 4 x 4 inches):

> 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, and (2) this device must accept any interference received, including any interference that may cause undesired operation.

6.2 Product Manuals

The user manual for the end product must include the following information in a prominent location:

> To comply with FCC's RF radiation exposure requirements, the antenna(s) used for this transmitter must be installed such that a minimum separation distance of 20cm is maintained between the radiator (antenna) & user's/nearby people's body at all times and must not be co-located or operating in conjunction with any other antenna or transmitter

6.3 US Requirements

The finished product manual must contain the following statement:

> WARNING: The Federal Communications Commission warns that changes or modifications of the radio module within this device not expressly approved by Impinj, Inc. could void the user's authority to operate the equipment.

In the case where an OEM seeks class B (residential) limits for the host product, the finished product manual must contain the following statement:

> Note: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no

guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

In the case where an OEM seeks the lesser category of a Class A digital device for their finished product, the following statement must be included in the manual of the finished product:

Note: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his expense.

6.4 Canadian Requirements

The OEM must include the following regulatory statements (shown in italics) in both English and French on the exterior of the finished product and/or in the product manual:

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.

The OEM must include the following regulatory statements (shown in italics) in both English and French in the finished product manual:

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication.

This radio transmitter IC: 6324A-IPJRS1000 has been approved by Industry Canada to operate with the antenna types listed below with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante.

Le présent émetteur radio IC: 6324A-IPJRS1000 a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés ci-dessous et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur.

- *Laird Technologies Model S9028PCR, CP patch antenna, 6 dBi linear far field gain*

6.5 Antenna Requirements

The RS1000 is compatible with many varieties of antennas, but for purposes of Impinj's modular certification with FCC and IC, only one antenna was tested. RS1000 users can have their own antenna and RS1000 systems certified with FCC and IC.

In order to operate the RS1000 under either FCC ID: TWYIPJRS1000 or IC: 6324A-IPJRS1000, the OEM must strictly follow these antenna guidelines:

- The OEM may operate only with the following antenna or antennas of the same type with maximum gain as shown:
  - Laird Technologies Model S9028PCR, circularly-polarized patch antenna with 6 dBi linear far field gain
- RF I/O interface to the antenna connector on the PCB shall be accomplished via a microstrip or stripline transmission line with characteristic impedance of 50 ohms +/- 10%. A custom coaxial pigtail may also be utilized to connect to the antenna in lieu of a connector.
  - The FCC and IC modular certification testing was performed using Impinj's Indy Module Breakout Board PCB, detailed documentation of which can be downloaded from Impinj's support website at the address below.
    - https://support.impinj.com/hc/en-us/articles/360000537270
  - For more information on PCB layout, see section 4.1 - PCB Layout for RF
- The connector on the OEM's PCB which interfaces to the antenna must be of a unique type to disable connection to a non-permissible antenna in compliance with FCC section 15.203. The following connectors are allowed:

  - Right angle Reverse-Polarity SMA (RP-SMA) Jack: Amphenol part number 132136RP or equivalent
  - Ultra Miniature Coaxial Connector (UMCC) Jack: Molex part number 0734120110 or equivalent
  - Custom 50 ohm coaxial pigtail from PCB to antenna
- The OEM must professionally install the RS1000 into its final environment to ensure that the conditions are met.

6.6 Maximum Power Exposure (MPE) and Usage Limitations

The minimum safe distance for people from the RS1000 has been determined by conservative calculation to be less than 20 cm for the allowable antenna types. The end product User's Guide must include the following statement in a prominent location:

> To comply with FCC's RF radiation exposure requirements, the antenna(s) used for this transmitter must be installed such that a minimum separation distance of 20 cm is maintained between the radiator (antenna) & user's/nearby people's body at all times and must not be co-located or operating in conjunction with any other antenna or transmitter.

7 Related Documentation

Table 7-1 contains a list of documentation related to this datasheet and the Indy reader products.

Table 7-1 – Related Documentation

Indy Reader Surface Mount Module Brochure
RS1000 Datasheet
RS1000 Development Kit Files
RS2000, RS1000, and RS500 STEP format 3D Models
Indy RS500 and RS2000 ETSI Compliance
Indy ITK Release (Requires support profile access)
Indy ITK Documentation
RS500 and RS2000 IRI Blog Posts
Indy Reader Chip Brochure

8 Document Change Log

Table 8-1 – Document Change Log

Version	Date	Description
1.0	3/22/2018	Production Hardware User's Guide

9 Notices

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