IPJ-RS2000-1, IPJ-RS2000-2
Electrical, Mechanical, & Thermal Specification

1   Indy® RS2000 Overview

Indy RS2000 is a completely integrated UHF reader SiP (system-in-package). 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 RS2000 is the easiest way to embed high power UHF RFID reader capability.

Air Interface Protocol	EPCglobal UHF Class 1 Gen 2 / ISO 18000-63 (formerly 18000-6C) Supports dense reader mode (DRM)
Tx Output Power	+10 to +31.5 dBm (+30 dBm in Japan)
Package	38 mm by 52 mm by 4 mm
Package Type	35 pin surface mount package (SMT compatible)
Rx Sensitivity	-74 dBm (1% packet error rate). Assumes a 15 dB antenna return loss at 31.5 dBm output power.
DC Power Supply	3.2 to 5.25 Volts
Supported Regions	Worldwide regional support. All major regions supported. See section 6.6 for a complete list.
Compliance	Certified: FCC and Canada modular operation, RoHS compliant

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

2 Table of Contents

2.1 Figures

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3   Introduction

The Indy® RS2000 reader SiP (system-in-package) is a completely integrated reader solution for EPC Gen 2 / ISO18000-63 or RAIN RFID applications. RS2000 was developed to make embedding high performance UHF RFID reader capability easy. RS2000 builds on market-leading Indy reader chip technology and integrates all of the necessary components into a small package. RS2000 requires no external reader components, is fully tested and meets regulatory requirements. RS2000 comes in a surface mount package designed to work as a SMT (surface mount technology) compatible component in a standard PCB manufacturing process, which eliminates costly mechanical hardware, RF cables and human assembly that are typically required with embedded readers on the market today. RS2000 is a turnkey solution that will enable quick and easy embedding of RFID with low development risk and fast time-to-market.

Ideal for applications requiring long read range of large tag populations, RS2000's small form factor enables a diverse range of applications, such as inventory management, portal readers, POS solutions, access control, process control in industrial automation, medical equipment, and performance handheld readers. RS2000 is capable of reading hundreds of tags per second at distances greater than 10 meters when using a 6 dBi reader antenna and far field passive tags.

This document includes interface, functional, performance, mechanical and environmental specifications. Host communication specifications (e.g. firmware upgrade and host interface protocol) and Impinj Radio Interface (IRI) documentation is provided in the latest Indy ITK Release. RS2000 uses the IRI™ (Impinj Radio Interface) to communicate with host systems. The ITK (IRI Tool Kit) enables developers to build on a variety of embedded host platforms by providing the following: documentation, image loader, IRI library, sample C code and project files. The IRI Tool Kit can be found in the latest Indy ITK Release package and can be downloaded from the restricted documents and downloads section at support.impinj.com. Please create an account and subscribe to receive automatic updates to the latest documentation and releases. Contact your local Impinj representative if you have trouble creating an account or accessing this site.

Figure 3-1: RS2000 System Integration
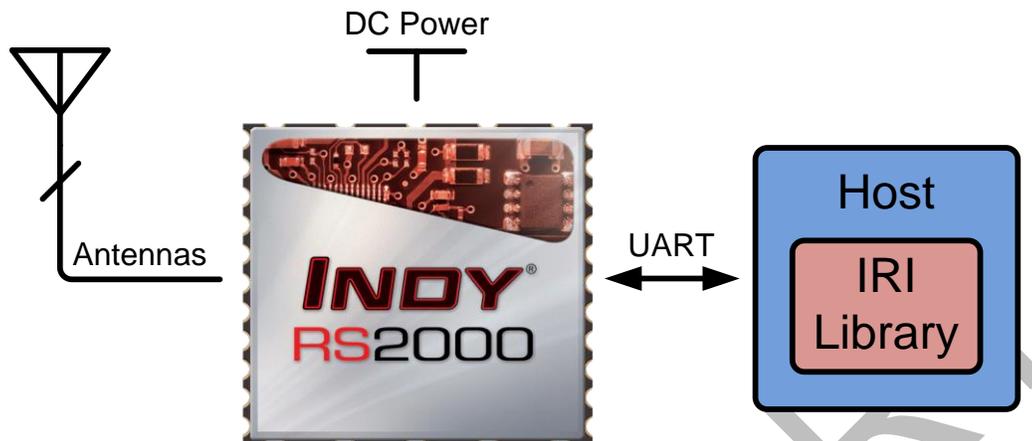
Three simple connections:
- DC Power
- UART Communication
- RF Antennas

Partners build API with IRI Tool Kit

3.1 Key features of the Indy RS2000

- Fully tested turnkey solution
- Maximum output power is 31.5 dBm
- 2 mono-static RF ports, both SMT and UFL connections
- -72 dBm Rx sensitivity, assuming 12 dB antenna return loss. The Rx performance improves with better antenna return loss.
- Inventory (FastID, Tag Population Estimate, Select, Session, Target)
- Access (Read, Write, Lock, Kill, BlockPermalock, and QT)
- Shielded to prevent unwanted radiation and provide noise immunity in embedded environments
- 38.5 mm by 52.5 mm by 4.3 mm surface mount package with SMT compatibility
- Mechanical provisions for heat dissipation
- Field upgradability via firmware updates. Gen 2 v2 will be firmware upgradable.
- Part of Impinj's platform, ensuring better performance when using Impinj's Monza® UHF RFID tag chips (enabling FastID, Tag Focus and QT)
- UART serial interface using IRI (Impinj Radio Interface)
- Test features (CW, PRBS, custom regions, channel lists, and fixed frequency)

4 System Block Diagram

An example Indy RS2000 system-level block diagram for an embedded application is shown in Figure 4-1. This figure shows the electrical connections that may and must be made to control the RS2000. 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.

For more detail on pin characteristics and behaviors, see the RS2000 Hardware User's Guide (coming soon).

Figure 4-1: Example RS2000 Block Diagram
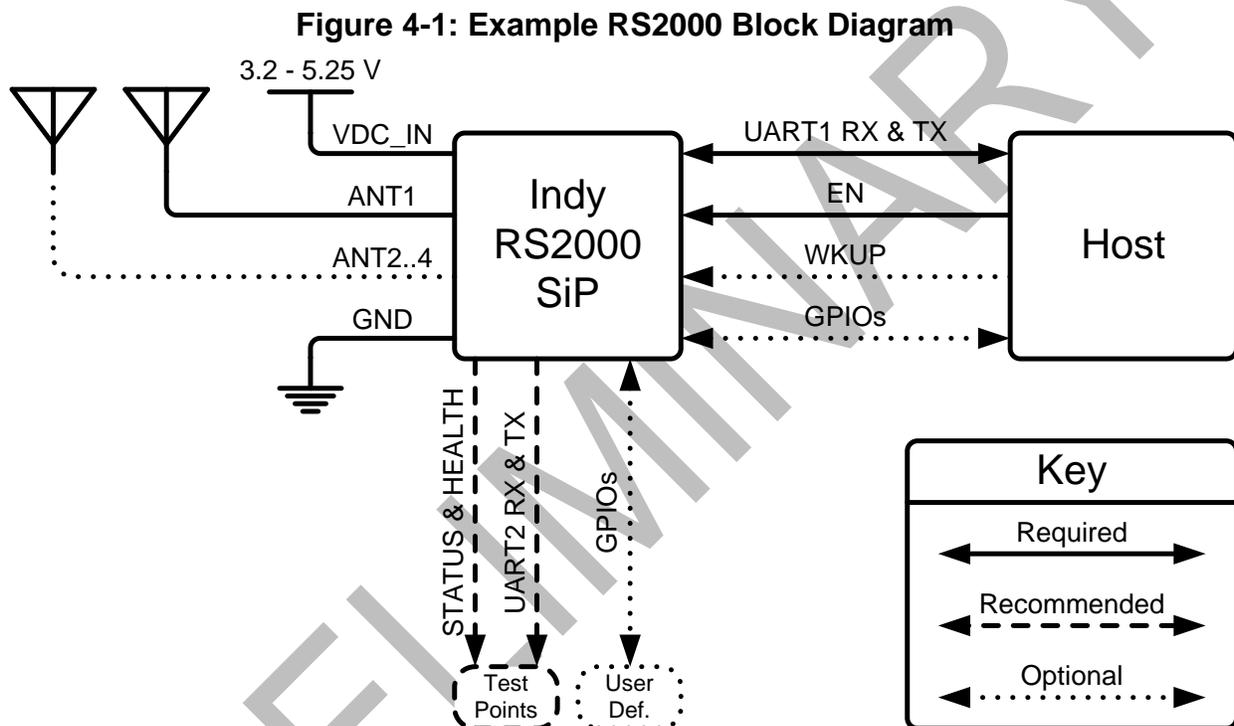
Required connections:

- VDC_IN and GND are required to power the RS2000.
- ANT1, ANT2, UFL1, or UFL2 are required to connect to UHF RFID antennas. Only one is required for RFID activity, but all four may be used.
- UART1 Tx and Rx are required to communicate with the system host.
- EN is used to enable or disable operation of the part. If this pin is driven low, the power supplies in the part will be disabled. RS2000 may be reset by toggling this pin. This pin must be driven high to enable the part.

Recommended connections:

- UART2 Tx and Rx may be used to examine debug information.
- HEALTH toggles to indicate successful operation of the RS2000. Connection to an LED provides a visual indication of whether or not an error condition exists.

- STATUS toggles to provide an indication when the RS2000 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 RS2000 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 RS2000 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.

No connect:

- CLK_OUT, DTEST0 and DTEST1 connections are reserved for Impinj use only.

5 Pin Listing and Signal Definitions

Figure 5-1: Indy RS2000 Pin Listing
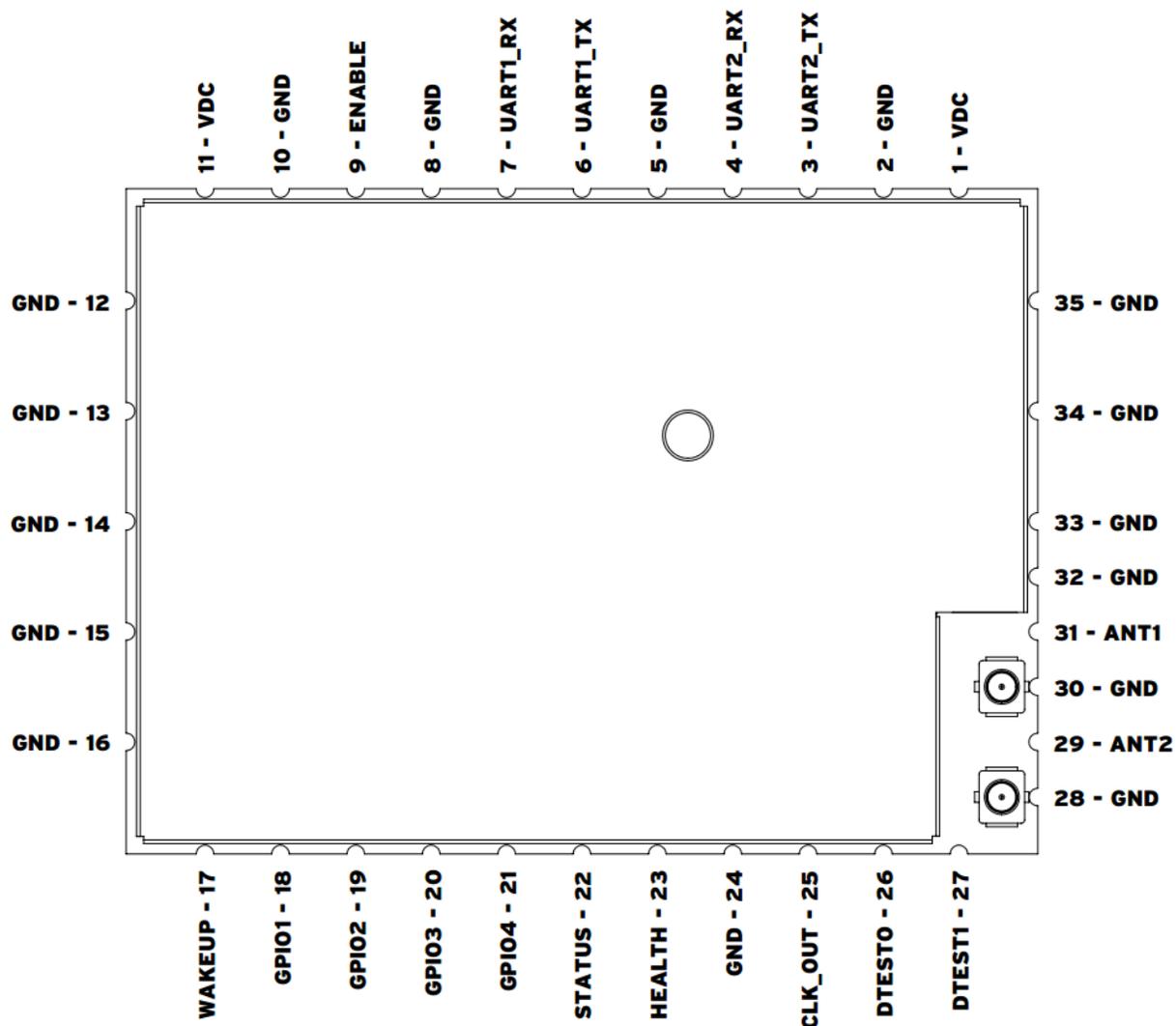
Table 5-1: Indy RS2000 – Pin Listing and Signal Definitions

Pin #	Pin Name	Pin Type	Description
1	VDC_IN	Power	DC voltage supply (3.2 – 5.25 V)
2	GND	Power	Ground
3	UART2-TX	Digital Output	RS2000 Debug UART Tx to host
4	UART2-RX	Digital Input	RS2000 Debug UART Rx from host
5	GND	Power	Ground
6	UART1-TX	Digital Output	RS2000 UART Tx to host

Pin #	Pin Name	Pin Type	Description
7	UART1-RX	Digital Input	RS2000 UART Rx from host
8	GND	Power	Ground
9	EN	Digital Input	Chip enable, active high. Puts RS2000 in Shutdown mode when logic low.
10	GND	Power	Ground
11	VDC_IN	Power	DC voltage supply (3.2 – 5.25 V)
12	GND	Power	Ground
13	GND	Power	Ground
14	GND	Power	Ground
15	GND	Power	Ground
16	GND	Power	Ground
17	WKUP	Digital Input	Wakeup from sleep on rising edge
18	GPIO1	Digital I/O	General purpose I/O
19	GPIO2	Digital I/O	General purpose I/O
20	GPIO3	Digital I/O	General purpose I/O
21	GPIO4	Digital I/O	General purpose I/O
22	STATUS	Digital Output	RS2000 status indication
23	HEALTH	Digital Output	RS2000 health indication
24	GND	Power	Ground
25	CLK_OUT	No Connect	Reserved for Impinj production test
26	DTEST0	No Connect	Reserved for Impinj production test
27	DTEST1	No Connect	Reserved for Impinj production test
28	GND	Power	Ground
29	ANT2	RF	SMT antenna port 2
30	GND	Power	Ground
31	ANT1	RF	SMT antenna port 1
32	GND	Power	Ground
33	GND	Power	Ground
34	GND	Power	Ground
35	GND	Power	Ground
UFL-1	UFL1	RF	UFL antenna port 1

Pin #	Pin Name	Pin Type	Description
UFL-2	UFL2	RF	UFL antenna port 2

6 Electrical Specifications

6.1 Absolute Maximum Ratings

The absolute maximum ratings (see Table 6-1) define limitations for electrical and thermal stresses. These limits prevent permanent damage to the Indy RS2000. Operation outside maximum ratings may result in permanent damage to the device.

Table 6-1: Indy RS2000 – Absolute Maximum Ratings

Parameter	Min.	Max.	Unit	Conditions
Supply voltage	-0.3	5.5	V	VDC_IN pin relative to GND
IO voltage, part enabled	-0.3	3.7	V	Non-VDC_IN pin voltages relative to GND
IO voltage, part disabled	-0.3	0.4	V	Non-VDC_IN pin voltages relative to GND
RF input power	-	+31.5	dBm	Incident to pin 1 (RF)
Storage temperature	-30	+100	ºC	
Humidity	-	95	% RH	Non-condensing
ESD immunity	-	2	kV	Human-body model, all I/O pads
Package moisture sensitivity level 3	-	-	-	Indy RS2000 from open trays must be baked before going through a standard solder reflow process (48 hours at 125 ºC or 24hrs at 150 ºC)

6.2 Operating Conditions

This section describes operating voltage, frequency, and temperature specifications for the Indy RS2000 during operation.

Table 6-2: Indy RS2000 – Operating Conditions

Parameter	Min.	Max.	Unit	Conditions
Supply	3.2	5.25	V	VDC_IN relative to GND
Temperature	-20	+60	ºC	Ambient Temperature
Frequency 1	902	928	MHz	IPJ-RS2000-1, See section 6.6 for regional support
Frequency 2	865	868	MHz	IPJ-RS2000-1, See section 6.6 for regional support
Frequency 1	902	928	MHz	IPJ-RS2000-2, See section 6.6 for regional support
Frequency 2	916	924	MHz	IPJ-RS2000-2, See section 6.6 for regional support

6.3   Device Functional Specifications

Table 6-3: Indy RS2000 – Supply Current Specifications

Parameter	Typ.	Unit	Description
Supply Current			Current consumed by RS2000 via VDC_IN pin
Active mode - 5V supply	1600	mA	+31.5 dBm transmit power Inventorying tags
Active mode - 5V supply	1400	mA	+30 dBm transmit power Inventorying tags
Idle mode – low latency	TBD	mA	Ready to receive IRI packets. Lower latency to return to Active mode.
Idle mode – standard latency	TBD	mA	Ready to receive IRI packets.
Standby mode	TBD	mA	GPIO activity, WKUP rising edge, or EN reset required to wakeup part.
Sleep mode	TBD	µA	WKUP rising edge or EN reset required to wakeup part.
Shutdown mode	TBD	µA	EN pin low

Table 6-4: Indy RS2000 – Startup and Wakeup Time

Parameter	Min.	Typ.	Max.	Unit	Description
Startup Time		TBD		ms	Time to receive IRI packets after power supply cycle or EN pin initiated startup
Wakeup Time					Time to receive IRI packets after wakeup event
Standby		TBD		ms	GPIO activity, WKUP rising edge, or EN reset required to wakeup part.
Sleep		TBD		ms	WKUP rising edge or EN reset required to wakeup part.

6.4   UHF Gen 2 RFID Radio Specifications

Table 6-5: Indy RS2000 – RF Receiver Specifications

Parameter	Min.	Typ.	Max.	Unit	Conditions
Frequency 1	902		928	MHz	IPJ-RS2000-1, See section 6.6 for regional support
Frequency 2	916		924	MHz	IPJ-RS2000-1, See section 6.6 for regional support
Frequency 1	902		928	MHz	IPJ-RS2000-2, See section 6.6 for regional support
Frequency 2	865		868	MHz	IPJ-RS2000-2, See section 6.6 for regional support
Input impedance		50		Ω	
Input match		-10		dB	S11

Parameter	Min.	Typ.	Max.	Unit	Conditions
Rx sensitivity		-74		dBm	1% packet error rate, assuming 15 dB antenna return loss at 31.5 dBm output

Table 6-6: Indy RS2000 – RF Transmitter Specifications

Parameter	Min.	Max.	Unit	Notes
Tx Power	+10	+31.5	dBm	Meets worldwide regulatory constraints (except Japan)
Tx Power	+10	+30	dBm	Meets Japan regulatory constraints
Tx Power Error Room temp: 30 – 31.5 dBm 27 – 30 dBm 10 – 27 dBm High/low temp: 30 – 31.5 dBm 27 – 30 dBm 10 – 27 dBm	 -0.5 -0.75 -1.0 -0.75 -1.0 -1.5	 0.5 0.75 1.0 0.75 1.0 1.5	 dB dB dB dB dB dB	Difference between desired Tx power and actual Tx power. 10 to 30 deg C -20 to 10, 30 to 60 deg C
Tx ACPR 1st Adjacent 1st Alternate 2nd Alternate		 -30 -60 -65	 dBch dBch dBch	Refer to Gen 2 dense-interrogator transmit mask spec for definition of channel bandwidths and measurement regions.
Return Loss	0	12	dB	No damage into open RF port at 31.5 dBm at any phase angle
Frequency 1	902	928	MHz	IPJ-RS2000-1, See section 6.6 for regional support
Frequency 2	916	924	MHz	IPJ-RS2000-1, See section 6.6 for regional support
Frequency 1	902	928	MHz	IPJ-RS2000-2, See section 6.6 for regional support
Frequency 2	865	868	MHz	IPJ-RS2000-2, See section 6.6 for regional support

6.5   Device Input and Output Specifications

Table 6-7: Indy RS2000 – Digital Interface Specification

Parameter	Min.	Typ.	Max.	Unit	Conditions
ENABLE					
V_{IL}	-0.3		0.8	V	
V_{IH}	2.0		3.6	V	

Parameter	Min.	Typ.	Max.	Unit	Conditions
Hysteresis voltage		200		mV	
Internal pull-down resistor		100		kΩ	
Reset pulse width	25			µs	
WKUP					
V_{IL}	-0.3		1.0	V	
V_{IH}	2.0		3.6	V	
Hysteresis voltage		200		mV	
Internal pull-down resistor		10		kΩ	
Digital inputs					
V_{IL}	-0.3		1.0	V	
V_{IH}	2.0		3.6	V	
Hysteresis voltage		200		mV	
Pull-up and pull-down resistor	25	40	55	kΩ	
Digital outputs					
V_{OL}	0.0		0.4	V	
V_{OH}	2.7		3.6	V	
Drive current (sink or source)	8			mA	
UART					
Baud rate		115.2		kbaud	
Parity		None			

6.6   Supported Regions

Table 6-8: Indy RS2000 – Regional Support

Region	Supported by SKU
Argentina	Both SKUs
Australia (920-926 MHz)	Both SKUs
Brazil (902-907 MHz)	Both SKUs
Brazil (915-928 MHz)	Both SKUs
Canada	Both SKUs
Chile	Both SKUs
Colombia	Both SKUs

Region	Supported by SKU
Costa Rica	Both SKUs
Dominican Republic	Both SKUs
Indonesia	Both SKUs
Israel	Both SKUs
Malaysia (919-923 MHz)	Both SKUs
Mexico	Both SKUs
New Zealand (921-928 MHz)	Both SKUs
Panama	Both SKUs
Peru	Both SKUs
Philippines	Both SKUs
Russian Federation (916-921 MHz)	Both SKUs
Singapore (920-925 MHz)	Both SKUs
South Africa (915-919 MHz)	Both SKUs
Taiwan (922-928 MHz)	Both SKUs
Thailand	Both SKUs
United Sates	Both SKUs
Uruguay	Both SKUs
Venezuela	Both SKUs
Vietnam (920-925 MHz)	Both SKUs
China (920-925 MHz)	IPJ-RS2000-2
Hong Kong (920-925 MHz)	IPJ-RS2000-2
Japan (916-921 MHz)	IPJ-RS2000-2
Korea (917-921 MHz)	IPJ-RS2000-2
Armenia	IPJ-RS2000-1
Austria	IPJ-RS2000-1
Azerbaijan	IPJ-RS2000-1
Belgium	IPJ-RS2000-1
Bosnia and Herzegovina	IPJ-RS2000-1
Bulgaria	IPJ-RS2000-1
Croatia	IPJ-RS2000-1

Region	Supported by SKU
Cyprus	IPJ-RS2000-1
Czech Republic	IPJ-RS2000-1
Denmark	IPJ-RS2000-1
Estonia	IPJ-RS2000-1
Finland	IPJ-RS2000-1
France	IPJ-RS2000-1
Germany	IPJ-RS2000-1
Greece	IPJ-RS2000-1
Hungary	IPJ-RS2000-1
Iceland	IPJ-RS2000-1
India	IPJ-RS2000-1
Ireland	IPJ-RS2000-1
Italy	IPJ-RS2000-1
Latvia	IPJ-RS2000-1
Lithuania	IPJ-RS2000-1
Luxembourg	IPJ-RS2000-1
Macedonia	IPJ-RS2000-1
Malta	IPJ-RS2000-1
Moldova	IPJ-RS2000-1
Netherlands	IPJ-RS2000-1
Norway	IPJ-RS2000-1
Oman	IPJ-RS2000-1
Poland	IPJ-RS2000-1
Portugal	IPJ-RS2000-1
Romania	IPJ-RS2000-1
Saudi Arabia	IPJ-RS2000-1
Serbia	IPJ-RS2000-1
Slovak Republic	IPJ-RS2000-1
Slovenia	IPJ-RS2000-1
Spain	IPJ-RS2000-1

Region	Supported by SKU
Sweden	IPJ-RS2000-1
Switzerland	IPJ-RS2000-1
Turkey	IPJ-RS2000-1
United Arab Emirates	IPJ-RS2000-1
United Kingdom	IPJ-RS2000-1

6.7   EPC Class-1 Generation-2 Operation

For details on the link profiles supported by RS2000, please see the Indy ITK Release Documentation (TBD).

Table 6-9: Indy RS2000 – Gen 2 Functionality

Parameter	Description
Select	Support for 2 Select commands
Inventory	FastID, TagFocus, Tag Population Estimate, Select, Session, and Target
Access	Read, Write, Lock, Kill, BlockPermalock, and QT

Table 6-10: Indy RS2000 – Inventory Performance

Parameter	Min.	Typ.	Max.	Unit	Conditions
Inventory Rate		TBD		Tags/sec	1 Tag with tag population estimate = 1
		TBD		Tags/sec	1 Tag with tag population estimate = 16
		TBD		Tags/sec	16 Tags with tag population estimate = 16

7   Impinj Radio Interface (IRI)

The Indy RS2000 uses IRI to enable communications; this is enabled with the IRI Tool Kit. The IRI Tool Kit includes documentation, IRI API, and sample C code. The IRI Tool Kit is intended to enable a broad set of host platforms due to its ease of use and portability.

Communication with the RS2000 via IRI occurs in two states:

1. Configuration (synchronous)
    a. All communications are commands and responses
    b. Start and Stop commands cause transition to the Listen state
2. Listen (asynchronous)
    a. Host is in a listening mode and polls to obtain tag reports

Customer applications can be enabled on a variety of embedded systems with hosts ranging in size from small microcontrollers to large microprocessors. The IRI Tool Kit is structured to ease portability by separating platform specific code from functional reader operation; this is illustrated in Figure 7-1 below.

Figure 7-1: Host and Reader Firmware Stack
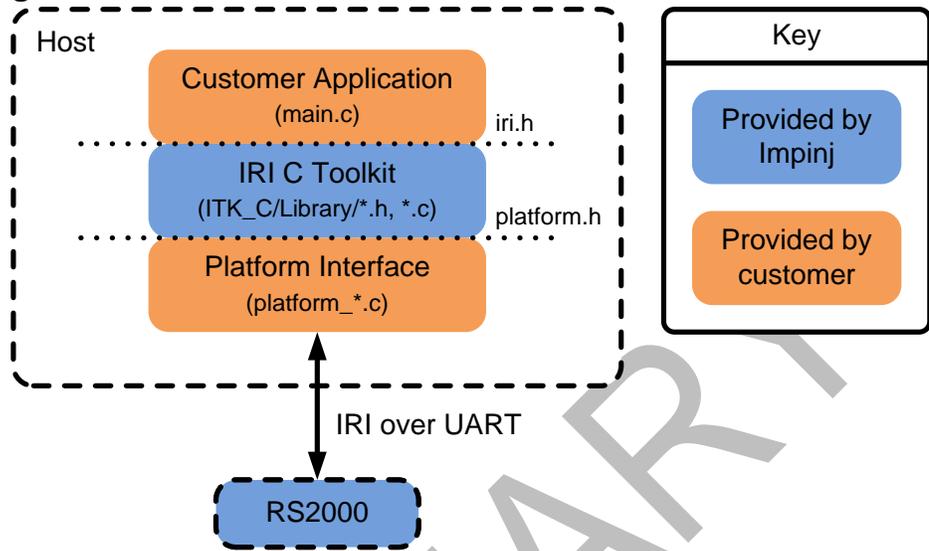
Please refer to the documentation included in the Indy ITK Release package for complete details on communicating with the Indy RS2000 using IRI. The latest Indy ITK Release package, which includes the IRI Tool Kit, can be downloaded at support.impinj.com.

8 Regulatory Information

The Indy RS2000 (IPJ-RS2000) has been certified for modular operation by FCC and Industry Canada in certain specific configurations. Use of these IDs requires specific text be added to product labeling and product Hardware User's Guides. See the Indy RS2000 Hardware User's Guide (coming soon) for more details on labeling specifics.

9 Package and Assembly Information

This section provides mechanical drawings and critical dimensions needed for PCB layout and housing design, as well as SMT assembly information.

9.1 Package Mass

The mass of the RS2000 SiP is TBD grams.

9.2 Package Dimensions

Package dimensions are shown in Figure 9-1 and Figure 9-2.

All dimensions are in millimeters.

Dimension tolerances (unless otherwise specified):

X = 1.0

X.X = 0.5

X.XX = 0.25

X.XXX = 0.125

Hole = 0.075

Angular: MACH 0.5

Bend: 1.0 Degree

Figure 9-1: RS2000 Package Dimensions, Top, Front, and Side Views
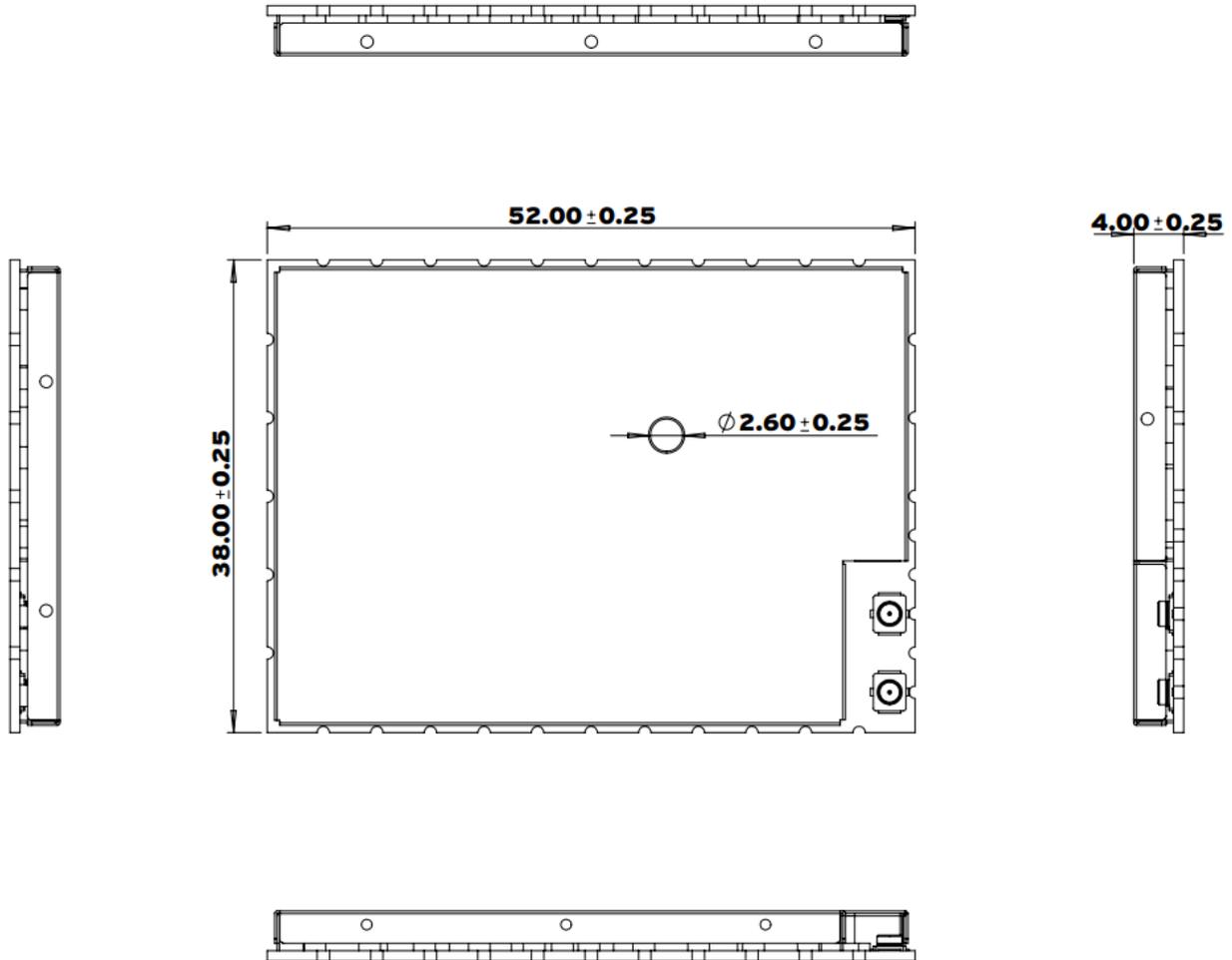
Figure 9-1 shows the dimensions of the SiP, and the markings on the top of the SiP. The serial number is printed as text and also as a 2D barcode in the center of the SiP. The serial number is made up of information about the device specific to its manufacturing. Details of the serial number makeup are shown in Table 9-1.

Table 9-1: RS2000 Serial # Makeup

Digits	Meaning
XX	SKU code: 01 = IPJ-RS2000-1 02 = IPJ-RS2000-2
ZZ	Lot number
WW	Workweek produced
YY	Year produced
AAAA	Serial number within the lot

Figure 9-2: RS2000 Pin Dimensions (viewed from underneath package)

TBD

9.3   PCB Footprint

Recommended footprint copper and pastemask dimensions are shown in Figure 9-3 and Figure 9-5. Dimensions for the individual pads are shown in Figure 9-4 and Figure 9-6.

Figure 9-3: RS2000 Recommended Etched Copper Footprint – All Pads
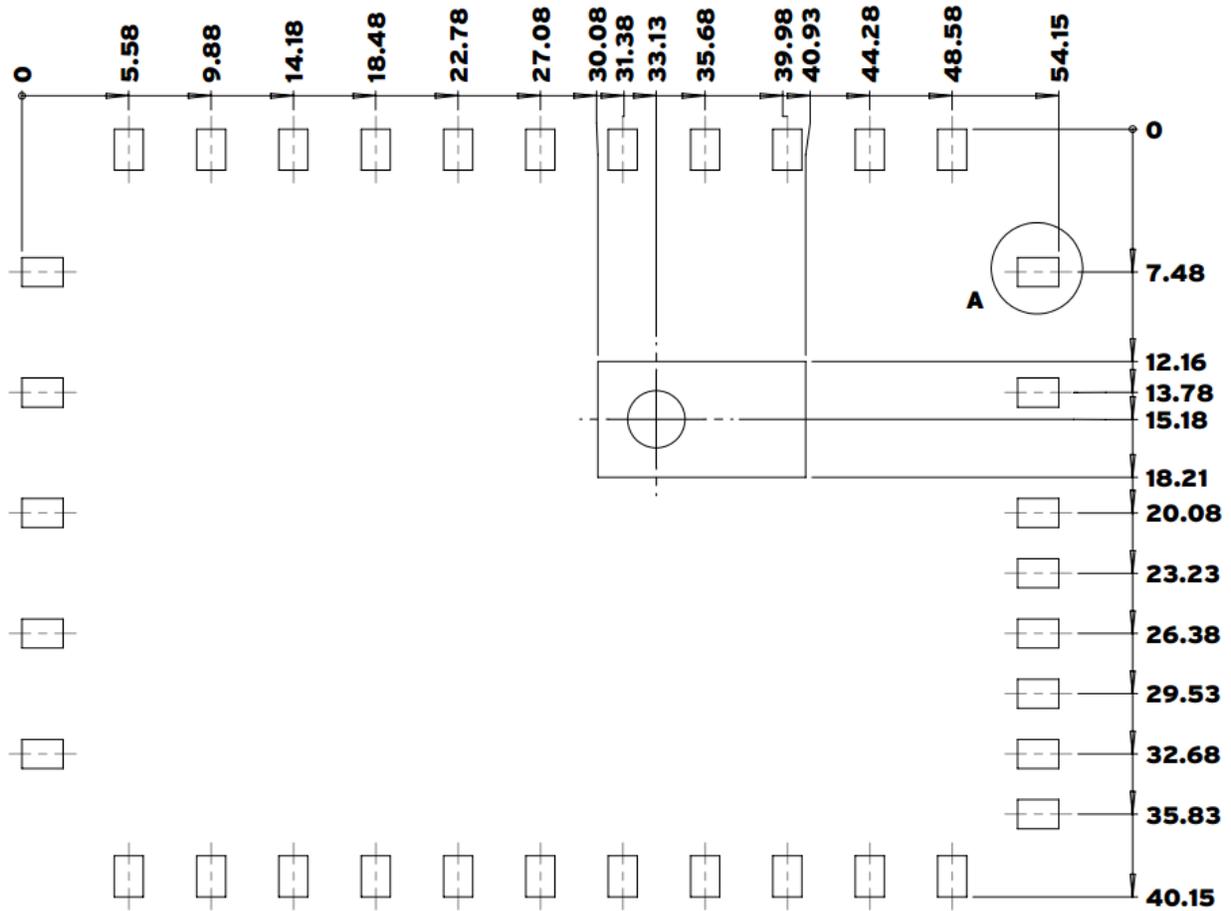
Figure 9-4: RS2000 Recommended Etched Copper Footprint – Single Pad
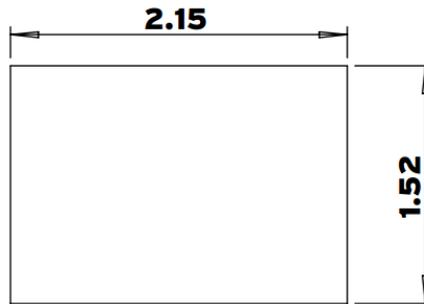
Figure 9-5: RS2000 Recommended Pastemask Footprint – All Pads
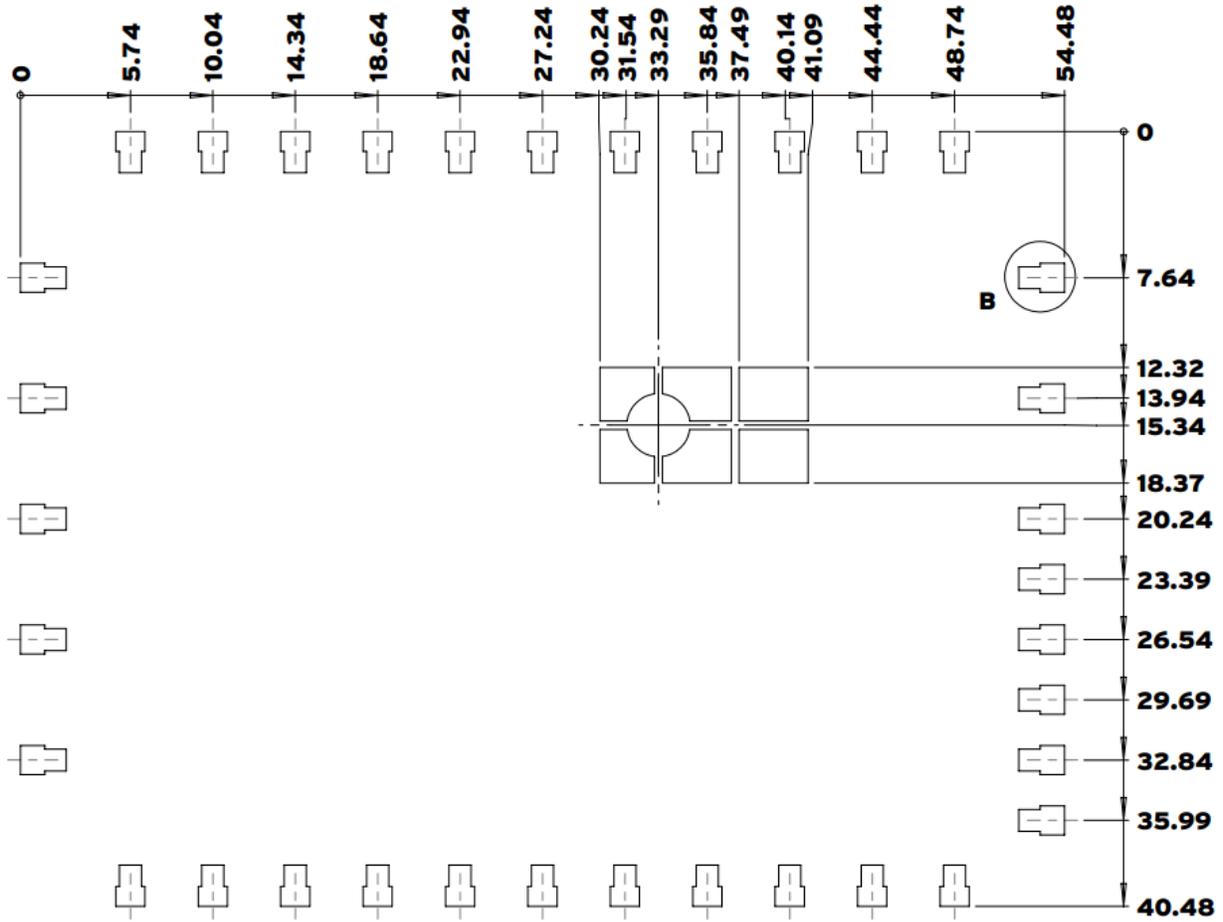
Figure 9-6: RS2000 Recommended Pastemask Footprint – Single Pad
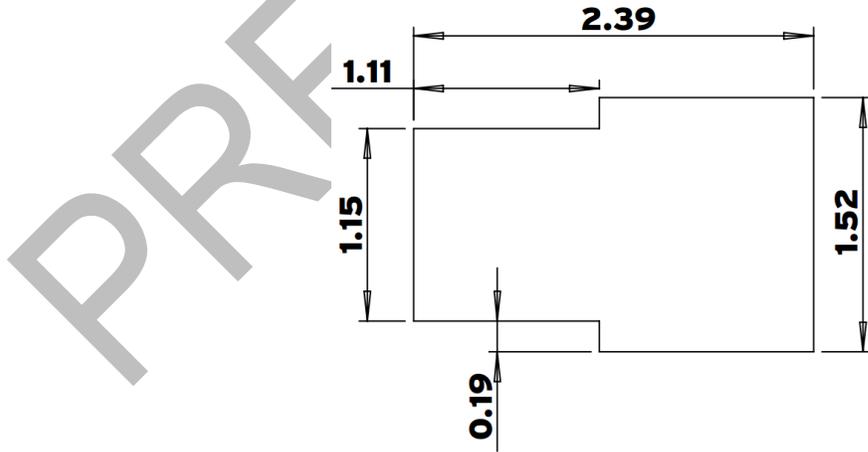
It is important to note that the optimal pad and stencil design results in a stencil aperture that is of a different shape than and that overhangs the etched pad. This design delivers the optimum amount of solder to the castellation of the SiP pad. Figure 9-7 depicts the pad/solder relationship.

Figure 9-7: Recommended Solder Stencil Opening with Etched Pad for RS2000

Red line outlines etched pad area

Narrow section of Stencil opening is under the SIP part in all pin locations.

Shaded area is Solder Paste Stencil opening

Solder Paste Stencil Extends beyond pad by .24mm (10 mils)
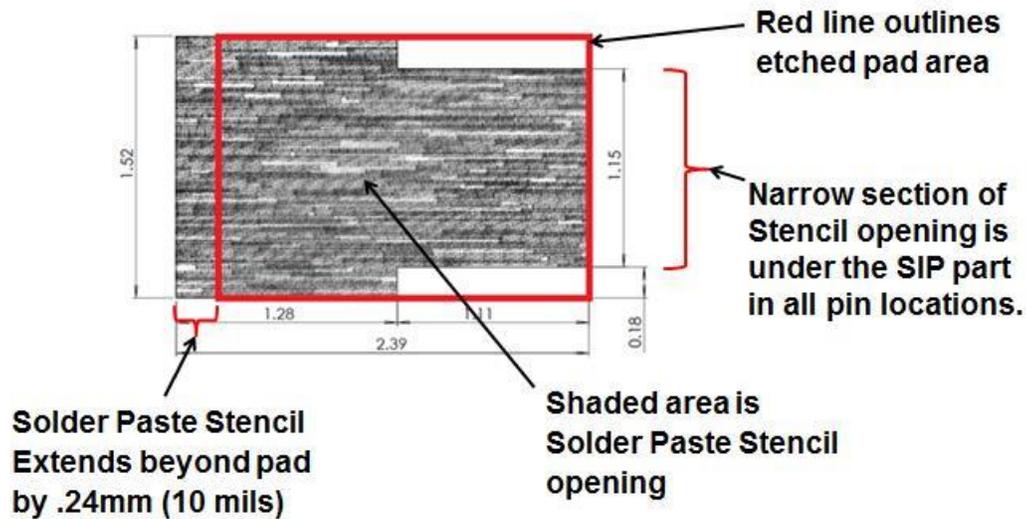
9.4 Thermal considerations

The RS2000 has two features designed to improve thermal performance. The first is a thermal pad on the underside of the SiP, which can improve the thermal connection to the PCB it is attached to. This pad should be connected to a plane on the PCB as shown in the recommended footprint in Figure 9-3. The second feature is a screw-hole through the SiP that allows improved thermal conduction to a chassis or heat-sink. This screw hole accommodates a machine screw up to metric size M2.5, or imperial size #2. It is shown in Figure 9-1.

The exposed conductive pad on the backside of the SiP is connected to the signal ground of the RS2000.

9.5 SMT Reflow Information

Recommended reflow profile is shown in Figure 9-8.

Figure 9-8: Recommended Solder Reflow Profile for the Indy RS2000

TBD

10 Document Change Log

Table 10-1: Document Change Log

Version	Date	Description
0.0		Preliminary version

11 Notices