IPJ-RS1000-GX Electrical, Mechanical, & Thermal Specification

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.

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 (902-928MHz) supports all 900MHz bands worldwide
Package	29 mm by 32 mm by 3.8 mm
Package Type	32 pin surface mount module (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
Supported Regions	FCC and all equivalent regions supported. See section 7.6 for a complete list.
Compliance	Certified: FCC and Canada modular operation, RoHS compliant

2 Table of Contents

2.1 Figures

2.2 Tables

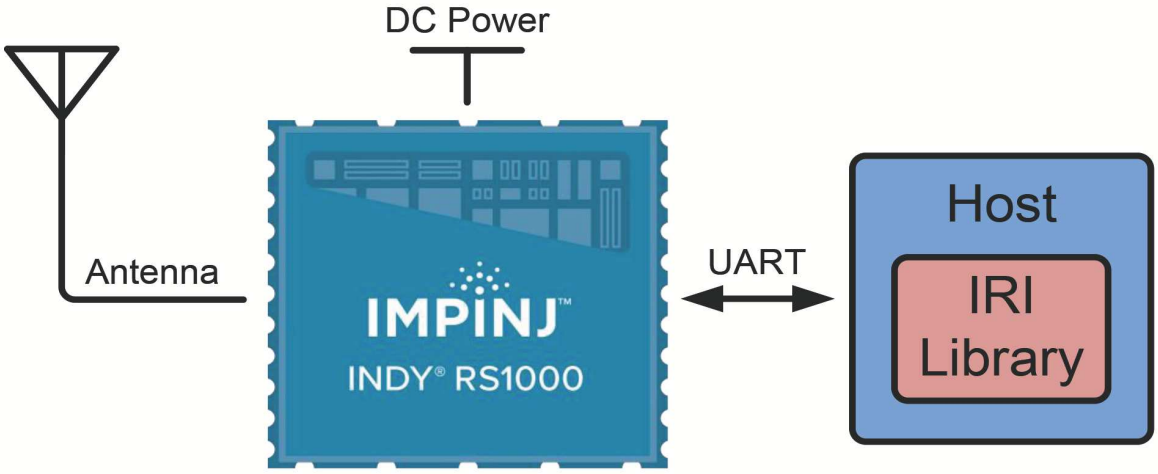
3 Introduction

The Indy® RS1000 reader surface-mount module is a completely integrated reader solution for EPC Gen 2 / ISO18000-63 (formerly 18000-6C) applications. The Indy RS1000 was developed to make embedding UHF RFID reader capability easy. The Indy RS1000 builds on market-leading Indy reader chip technology and integrates all of the necessary components into a small package. The Indy RS1000 requires no external components, is fully tested and meets regulatory requirements. The Indy RS1000 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. The Indy RS1000 is a turnkey solution that will enable quick and easy embedding of RFID with low development risk and fast time-to-market.

Ideal for moderate read range of small tag populations, the Indy RS1000's small form factor enables a diverse range of applications that need a low-cost embedded UHF Gen 2 RFID reader capability, such as consumables authentication, access control, process control, appliances, POS devices for retail, medical equipment, printers, and low-duty handheld readers. The RS1000 is capable of reading dozens of tags per second at distances greater than 6 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 RS1000 Software release package. The Indy RS1000 uses the IRI™ (Impinj Radio Interface) to communicate with host systems. The 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 Library can be found in the latest Indy Tool Kit (ITK) release package and can be downloaded from the embedded reader SDK section at support.impinj.com. Please create a support 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: RS1000 System Integration



Three simple connections:

- DC Power
- UART Communication
- RF Antenna

Partners build API with IRI Tool Kit

3.1 Key features of the Indy RS1000

- Fully tested turnkey solution
- RS500 pin compatibility
- Maximum output power is 27 dBm
- -75 dBm Rx sensitivity, assuming 15 dB 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
- 29 mm by 32 mm by 3.8 mm surface mount package with SMT compatibility
- Single mono-static RF port
- 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® RAIN 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)

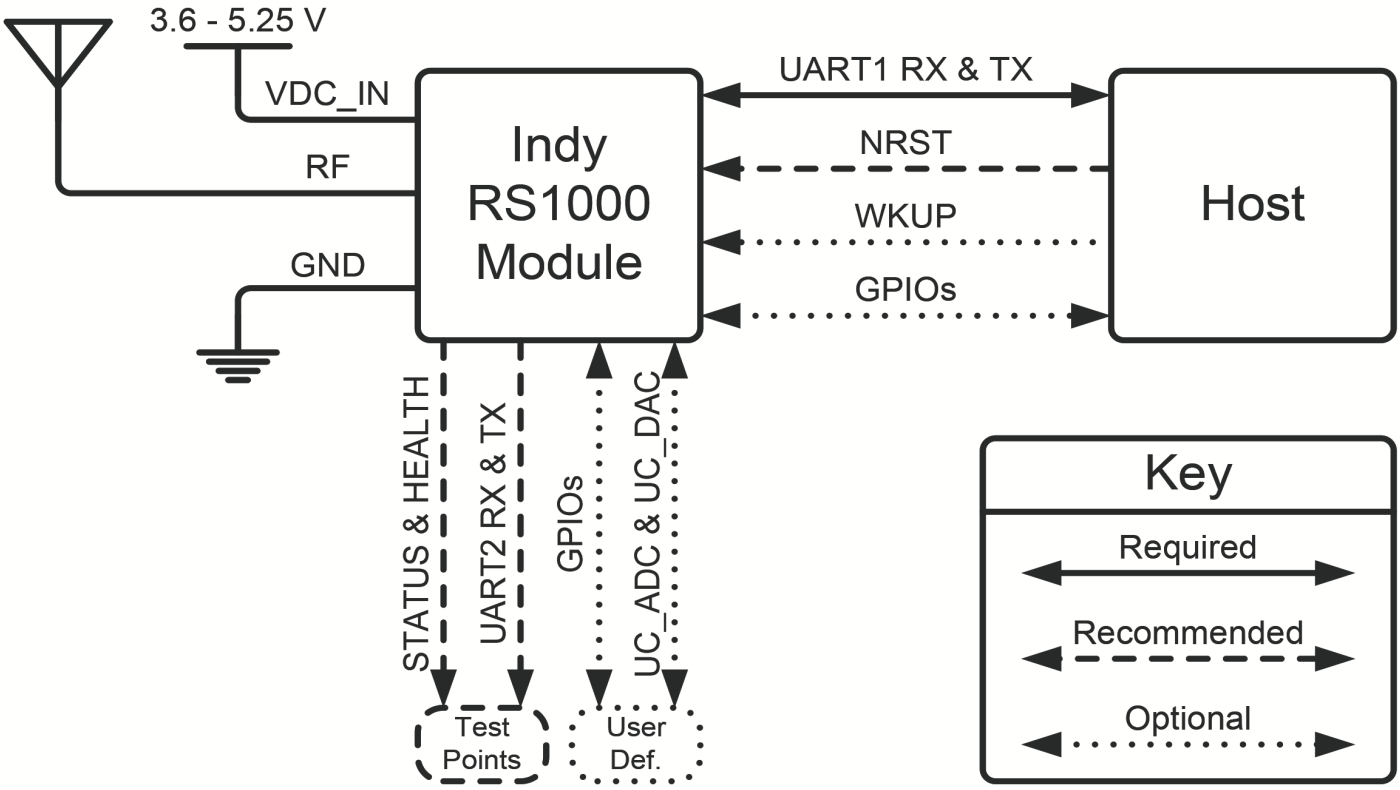
4 System Block Diagram

An example Indy RS1000 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 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.

For more detail on pin characteristics and behaviors, see the RS1000 Hardware User's Guide.

Figure 4-1: Example RS1000 Block Diagram



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:

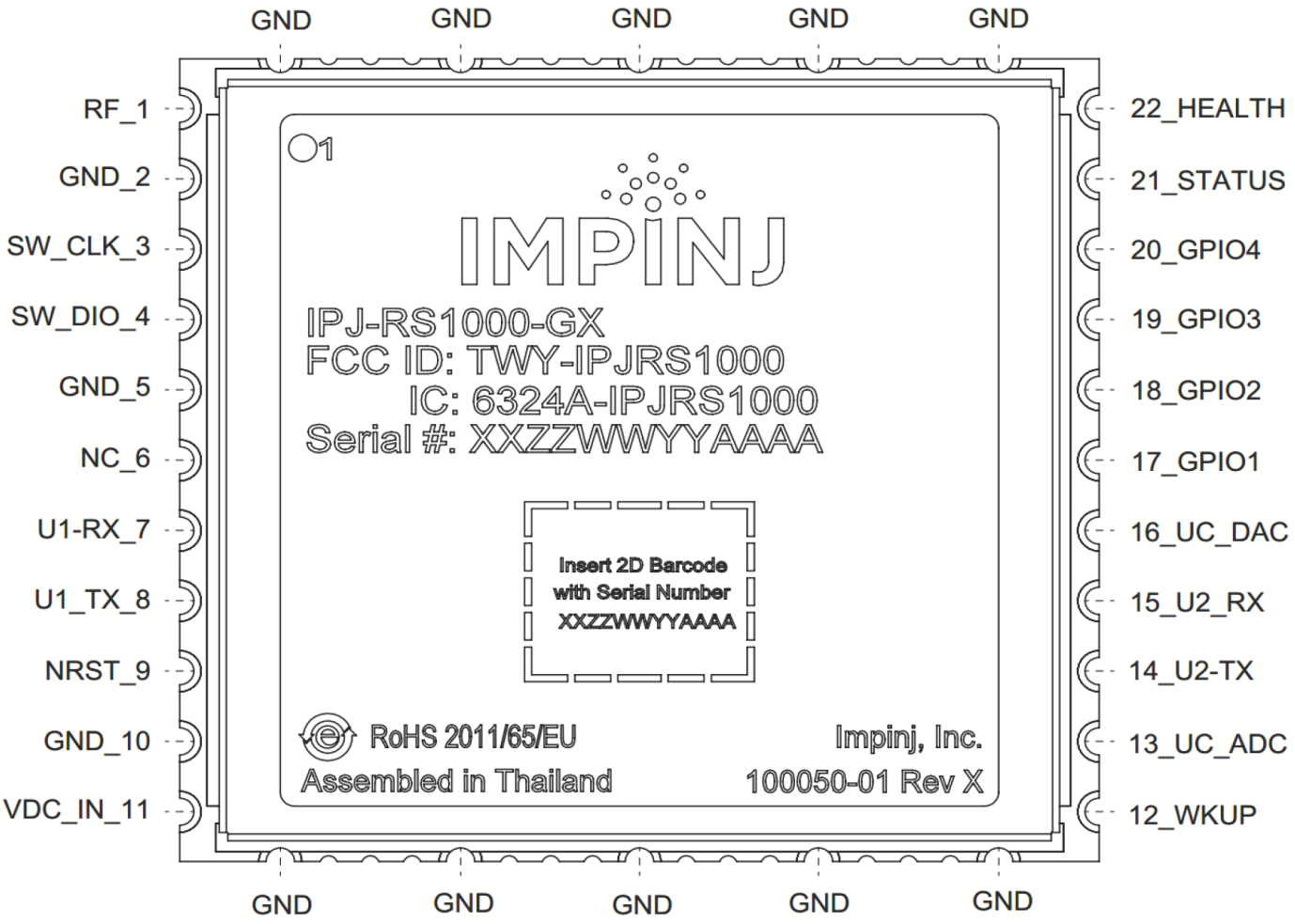
- GPIOs allow interaction with the RS1000 as both digital inputs and outputs. They may be used to trigger inventory, generate events based on inventory activity, or provide general-purpose user-controlled digital I/O.
- WKUP provides a mechanism to wake up the RS1000 from the low power Sleep mode. WKUP 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.

5 Pin Listing and Signal Definitions

Figure 5-1: Indy RS1000 Pin Listing



Note. GX markings are shown in Figure 5-1.

Table 5-1: Indy RS1000 – Pin Listing and Signal Definitions

Pin #	Pin Name	Pin Type	Description
1	RF	RF	RF antenna port
2	GND	Power	Ground
3	SW_CLK	No Connect	Reserved for Impinj production test
4	SW_DIO	No Connect	Reserved for Impinj production test
5	GND	Power	Ground
6	NC	No Connect	Leave floating or drive to ground, resistively or strong
7	UART1-RX	Digital Input	RS1000 UART Rx (Receive) from host
8	UART1-TX	Digital Output	RS1000 UART Tx (Transmit) to host
9	NRST	Digital Input	Active low reset. Connect to open drain driver. RS1000 must be able to internally pull down this signal to reset.
10	GND	Power	Ground
11	VDC_IN	Power	DC voltage supply (3.6 – 5.25 V)
12	WKUP	Digital Input	Wakeup from sleep on rising edge
13	UC_ADC	Analog Input	Analog to digital converter input
14	UART2-TX	Digital Output	RS1000 Debug UART Tx to host
15	UART2-RX	Digital Input	RS1000 Debug UART Rx from host
16	UC_DAC	Analog output	Digital to analog converter output
17	GPIO1	Digital I/O	General purpose I/O
18	GPIO2	Digital I/O	General purpose I/O
19	GPIO3	Digital I/O	General purpose I/O
20	GPIO4	Digital I/O	General purpose I/O
21	STATUS	Digital Output	RS1000 status indication
22	HEALTH	Digital Output	RS1000 health indication
23-32	GND	Power	Ground pins on the top and bottom edge of the package

6 Impinj Radio Interface (IRI)

The Indy RS1000 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

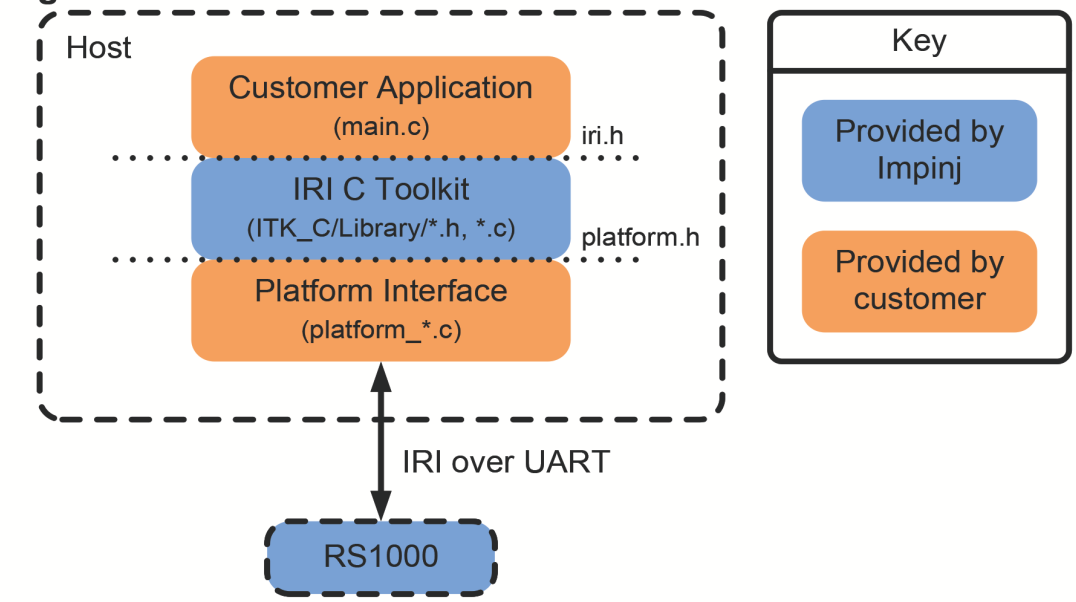
Kit is intended to enable a broad set of host platforms due to its ease of use and portability.

Communication with the RS1000 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 6-1 below.

Figure 6-1: Host and Reader Firmware Stack



Please refer to the documentation included in the RS1000 release package for complete details on communicating with the Indy RS1000 using IRI. The latest Indy RS1000 release package, which includes the IRI Tool Kit, can be downloaded at support.impinj.com.

7 Electrical Specifications

7.1 Absolute Maximum Ratings

The absolute maximum ratings (see Table 7-1) define limitations for electrical and thermal stresses. These limits prevent permanent damage to the Indy RS1000. Operation outside maximum ratings may result in permanent damage to the device.

Table 7-1: Indy RS1000 – Absolute Maximum Ratings

Parameter	Min.	Max.	Unit	Conditions
Supply voltage	-0.3	5.5	V	VDC_IN pin relative to GND
IO voltage	-0.3	4.0	V	Non-VDC_IN pin voltages relative to GND
RF input power	-	+27	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 RS1000 from open trays must be baked before going through a standard solder reflow process (48 hours at 125 ºC or 24hrs at 150 ºC)

7.2 Operating Conditions

This section describes operating voltage, frequency, and temperature specifications for the Indy RS1000 during operation.

Table 7-2: Indy RS1000 – Operating Conditions

Parameter	Min.	Max.	Unit	Conditions
Supply	3.6	5.25	V	VDC_IN relative to GND
Temperature	-20	+70	ºC	Ambient Temperature
Frequency	902	928	MHz	IPJ-RS1000-GX, See section 7.6 for regional support

7.3 Device Functional Specifications

Table 7-3: Indy RS1000 – Supply Current Specifications

Parameter	Typ.	Unit	Description
Supply Current			Current consumed by RS1000 via VDC_IN pin
Active mode - 5V supply – GX	700	mA	+27 dBm transmit power Inventorying tags
Active mode - 3.6V supply	1000	mA	+27 dBm transmit power Inventorying tags
Idle mode – low latency	55	mA	Ready to receive IRI packets. Lower latency to return to Active mode.
Idle mode – standard latency	10	mA	Ready to receive IRI packets.
Standby mode	0.45	mA	GPIO activity or WKUP rising edge required to wakeup part.

Parameter	Typ.	Unit	Description
Sleep mode	80	µA	WKUP rising edge required to wakeup part.

Table 7-4: Indy RS1000 – Startup and Wakeup Time

Parameter	Min.	Typ.	Max.	Unit	Description
Startup Time		20		ms	Time to receive IRI packets after power supply or nRST pin initiated startup
Wakeup Time					Time to receive IRI packets after wakeup event
Standby		50		ms	GPIO activity or WKUP rising edge required to wakeup part.
Sleep		60		ms	WKUP rising edge required to wakeup part.

7.4 UHF Gen 2 RFID Radio Specifications

Table 7-5: Indy RS1000 – RF Receiver Specifications

Parameter	Min.	Typ.	Max.	Unit	Conditions
Frequency	902		928	MHz	IPJ-RS1000-GX, See section 7.6 for regional support
Input impedance		50		Ω	
Input match		-10		dB	S11
Rx sensitivity		-75		dBm	1% PER, assuming 15 dB antenna RL at 27 dBm output
RX sensitivity		-80		dBm	1% PER, assuming 20 dB antenna RL at 27 dBm output

Table 7-6: Indy RS1000 – RF Transmitter Specifications

Parameter	Min.	Max.	Unit	Notes
Tx Power	10	27	dBm	Meets FCC and equivalent regulatory constraints
Tx Power Error Room temp: $23 \le P_{TX} < 27$ dBm $10 \le P_{TX} < 23$ dBm High temp: $23 \le P_{TX} < 27$ dBm $10 \le P_{TX} < 23$ dBm Low temp: $23 \le P_{TX} < 27$ dBm $10 \le P_{TX} < 23$ dBm	 -0.5 -1.0 -0.75 -1.5 -1.0 -1.75	 0.5 1.0 0.75 1.5 1.0 1.75	 dB dB dB dB dB dB	Difference between desired Tx power and actual Tx power at a given ambient temperature 10 to 30 °C 30 to 60 °C -20 to 10 °C

Parameter	Min.	Max.	Unit	Notes
Tx ACPR 1st Adjacent 1st Alternate 2nd Alternate		 -25 -55 -65	 dBch dBch dBch	Refer to Gen 2 dense-interrogator transmit mask spec for definition of channel bandwidths and measurement regions.
Return Loss	0		dB	No damage into open RF port at 27 dBm at any phase angle
Frequency	902	928	MHz	IPJ-RS1000-GX, See section 7.6 for regional support

7.5 Device Input and Output Specifications

Table 7-7: Indy RS1000 – Digital Interface Specification

Parameter	Min.	Typ.	Max.	Unit	Conditions
nRST					
V_{IL}	-0.3		0.8	V	
V_{IH}	2		3.6	V	
Hysteresis voltage		200		mV	
Internal pull-up resistor	25	40	55	kΩ	
Reset pulse width	25			µs	
WKUP					
V_{IL}	-0.3		1.0	V	
V_{IH}	1.8		3.6	V	
Hysteresis voltage		200		mV	
Internal pull-down resistor	25	40	55	kΩ	
Digital inputs					
V_{IL}	-0.3		1.0	V	
V_{IH}	1.8		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					

Parameter	Min.	Typ.	Max.	Unit	Conditions
Default baud rate		115.2		kbaud	
Configurable baud rate	9.6		921.6	kbaud	
Data bits		8		bits	
Parity bit		None			
Stop bits		1		bits	

Table 7-8: Indy RS1000 – Analog Interface Specification

Parameter	Min.	Typ.	Max.	Unit	Conditions
ADC (Pin 13)					
Resolution		12		Bits	
Conversion voltage range	1		3.3	V	
Sampling rate	0.05		1	MSPs	
Total conversion time	1		18	µsec	
Power-up time			1	µsec	
External input impedance			50	kΩ	
Sampling switch resistance			1	kΩ	
Internal sample and hold capacitance			8	pF	
Total unadjusted error		±3.3	±4	LSB	
Offset error		±1.9	±2.8	LSB	
Gain error		±2.8	±3	LSB	
DNL error		±0.7	±1.3	LSB	
INL error		±1.2	±1.7	LSB	
DAC (Pin 16)					
Resolution		12		Bits	
Resistive load with buffer ON	5			kΩ	
Impedance output with buffer OFF			15	kΩ	When the buffer is OFF, the minimum resistive load between DAC_OUT and V_{SS} to achieve 1% accuracy is 1.5 MΩ.
Capacitive load			50	pF	Maximum capacitive load at the DAC_OUT pin when the buffer is ON

Parameter	Min.	Typ.	Max.	Unit	Conditions
Output voltage range	0.2		3.1	V	
DNL			±2	LSB	
INL			±4	LSB	
Offset			±10	mV	
Gain error			±0.5	%	
Settling time		3	4	µsec	C_{LOAD} < 50 pF & R_{LOAD} > 5 kΩ

7.6 Supported Regions

Table 7-9: Indy RS1000 – Regional Support

Region	SKU
Argentina	IPJ-RS1000-GX
Brazil (902-907 MHz)	IPJ-RS1000-GX
Brazil (915-928 MHz)	IPJ-RS1000-GX
Canada	IPJ-RS1000-GX
Chile	IPJ-RS1000-GX
Colombia	IPJ-RS1000-GX
Costa Rica	IPJ-RS1000-GX
Dominican Republic	IPJ-RS1000-GX
Indonesia	IPJ-RS1000-GX
Israel	IPJ-RS1000-GX
Mexico	IPJ-RS1000-GX
Panama	IPJ-RS1000-GX
Peru	IPJ-RS1000-GX
Philippines	IPJ-RS1000-GX
Russian Federation (916-921 MHz)	IPJ-RS1000-GX
South Africa (915-919 MHz)	IPJ-RS1000-GX
Thailand	IPJ-RS1000-GX
United Sates	IPJ-RS1000-GX
Uruguay	IPJ-RS1000-GX
Venezuela	IPJ-RS1000-GX

7.7 EPC Class-1 Generation-2 Operation

Table 7-10: Indy RS1000 Link Profiles

Link Profile	Forward Link Parameter			Reverse Link Parameter		
	R2T Modulation	Tari	RTCAL	Link Frequency	T2R Modulation	TRCAL
1	PR-ASK	25 µs	62.5 µs	250 kHz	M4	85.333 µs
2	PR-ASK	25 µs	62.5 µs	300 kHz	M4	71.111 µs
3	DSB-ASK	6.25 µs	15.625 µs	400 kHz	FM0	20 µs
4	DSB-ASK	25 µs	75 µs µs	40 kHz	FM0	200 µs

Note For more detail on the Link Profiles, see the ITK-C user documentation on the key E_IPJ_KEY_RF_MODE.

Table 7-11: Indy RS1000 – 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 7-12: Indy RS1000 – Inventory Performance

Parameter	Min.	Typ.	Max.	Unit	Conditions
Inventory Rate (RF Mode 1)		146		Tags/sec	1 Tag with tag population estimate = 0 (Q=0)
		140		Tags/sec	20 Tags with tag population estimate = 16
		191		Tags/sec	100 Tags with tag population estimate = 128
Inventory Rate (RF Mode 3)		230		Tags/sec	1 Tag with tag population estimate = 0 (Q=0)
		207		Tags/sec	20 Tags with tag population estimate = 16
		214		Tags/sec	100 Tags with tag population estimate = 128

Note Data gathered with Mini-Guardrail antenna, Monza R6 tag inlays, with reader performing 10 seconds of inventory in Dual Target, Session 0.

8 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.

8.1 Package Mass

The mass of the RS1000 module is roughly 4.6 grams.

8.2 Package Dimensions

Package dimensions are shown in Figure 8-1 and Figure 8-2.

Dimension tolerances are in inches.

Dimension tolerances (unless otherwise specified):

X = ±0.04

X.X = ±0.02

X.XX = ±0.01

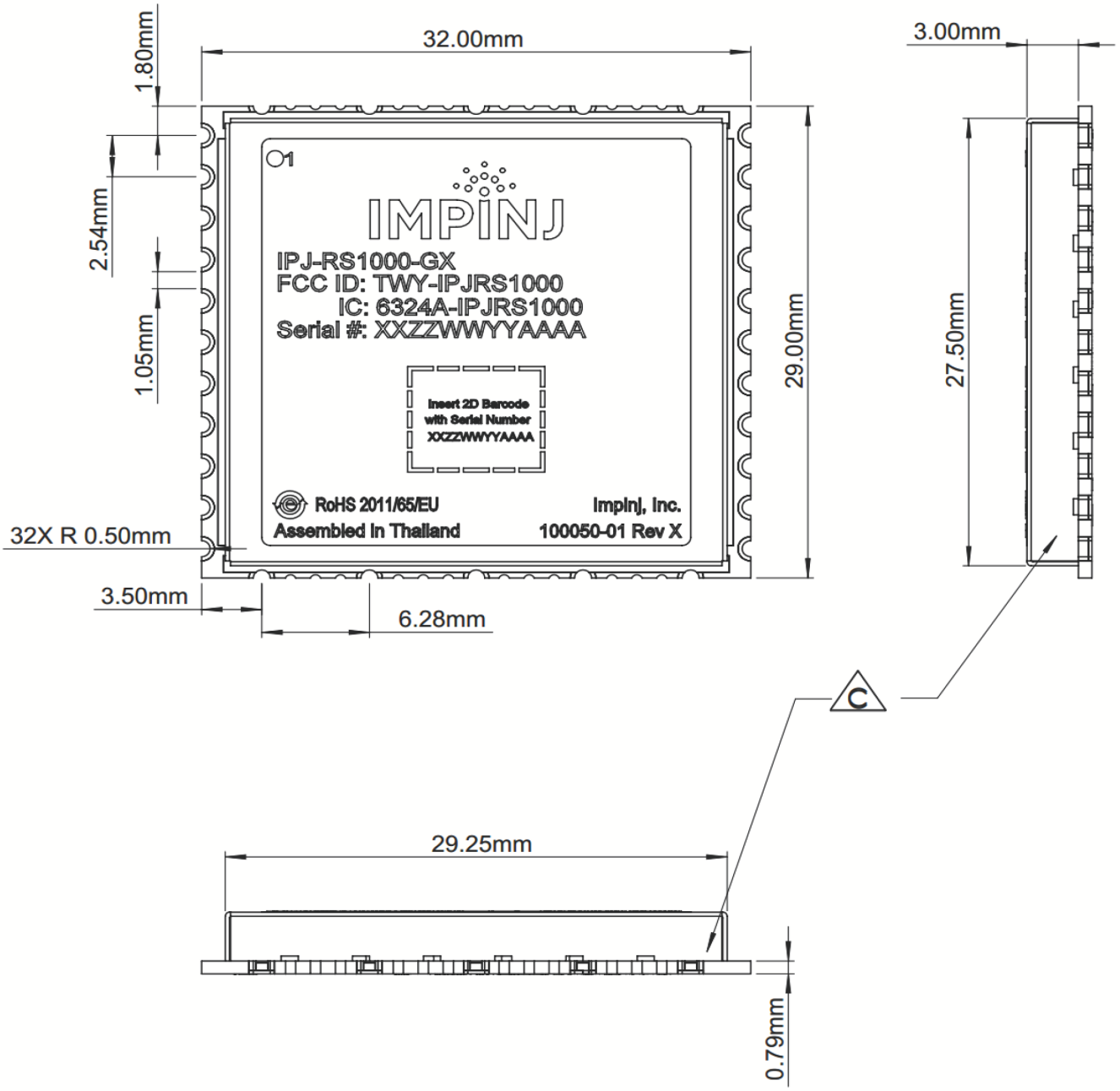
X.XXX = ±0.005

Hole = ±0.003

Angular: MACH ±0.5

Bend: ±1.0 Degree

Figure 8-1: RS1000 Package Dimensions, Top, Front, and Side Views



Note. Shield dimensions (Callout C above) are for informational purposes only, and do not meet the dimension tolerances listed above.

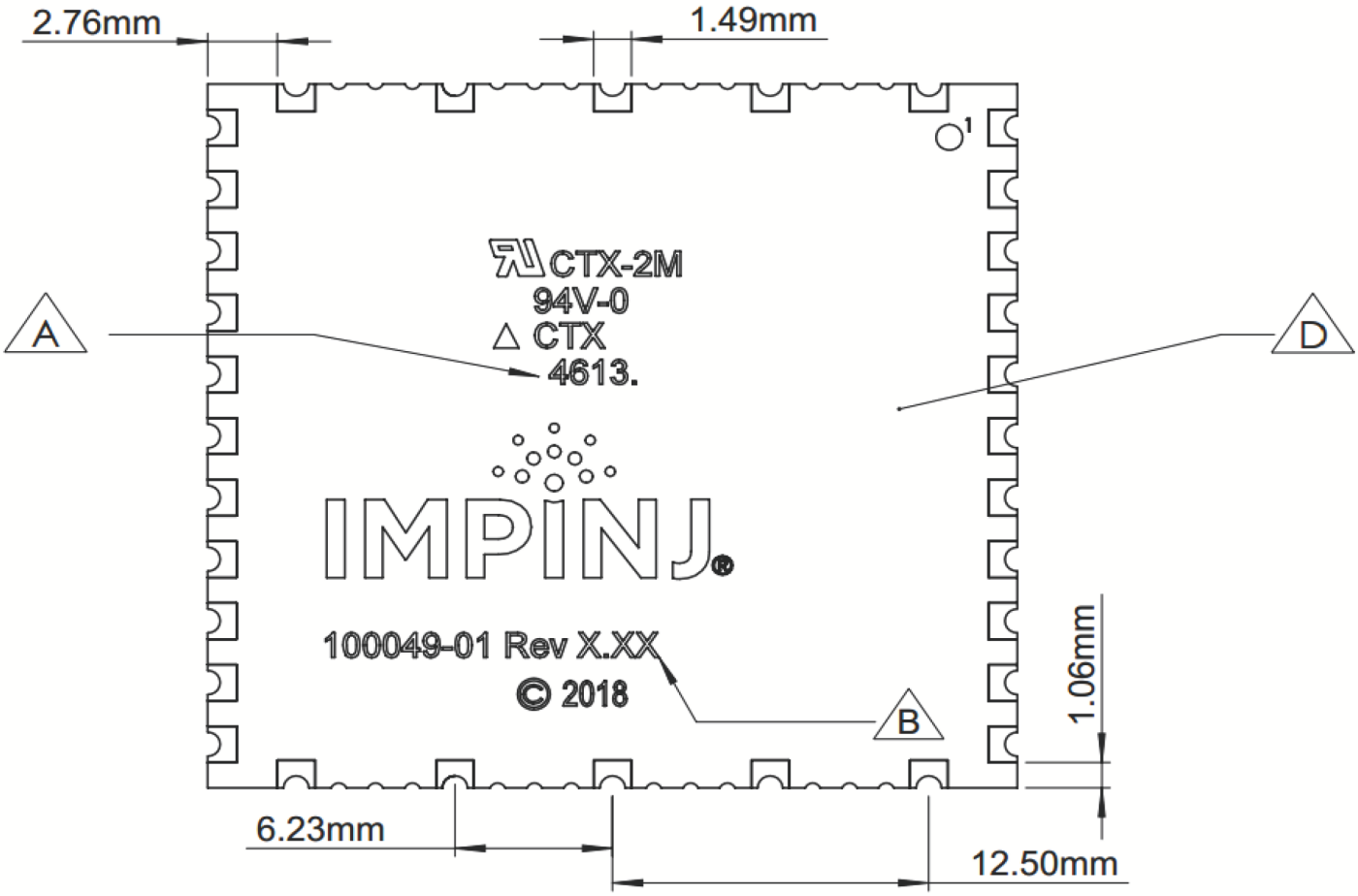
Note. GX markings are shown in Figure 8-1

Figure 8-1 shows the dimensions of the module, and the markings on the top of the module. The serial number is printed as text and also as a 2D barcode in the center of the module. 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 8-1.

Table 8-1: RS1000 Serial # Makeup

Digits	Meaning
XX	SKU code: 11 = GX
ZZ	Lot number
WW	Workweek produced
YY	Year produced
AAAA	Serial number within the lot

Figure 8-2: RS1000 Pin Dimensions (viewed from underneath package)

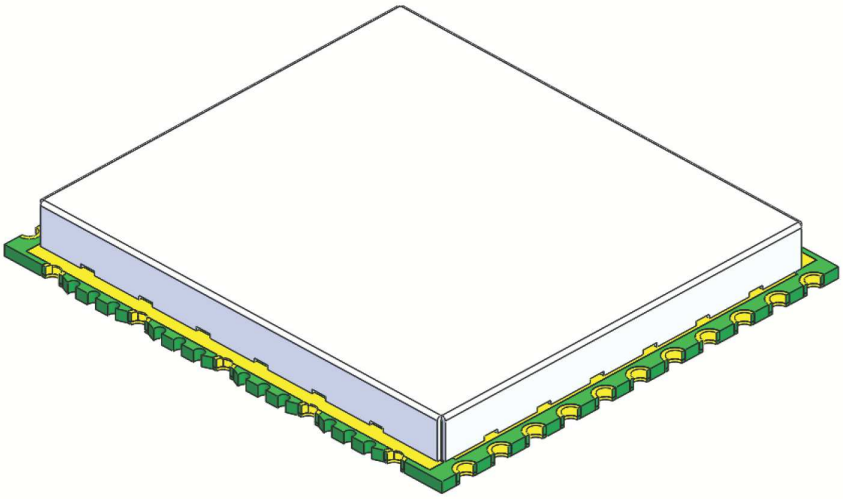


Note. Package backside silkscreen markings will vary depending on the manufacturing lot of the RS1000 unit.

8.3 RS1000 Module 3D Model

Impinj has created a 3D model of the RS1000 for visualization and dimensional planning purposes. A perspective render of the 3D model is shown in Figure 8-3. A STEP format version of this 3D model can be downloaded from support.impinj.com.

Figure 8-3: RS1000 Module 3D Model Perspective Render



8.4 PCB Footprint

Recommended footprint copper and pastemask dimensions are shown in Figure 8-4 and Figure 8-6. Dimensions for the individual pads are shown in Figure 8-5 and Figure 8-7.

Figure 8-4: RS1000 Recommended Etched Copper Footprint – All Pads

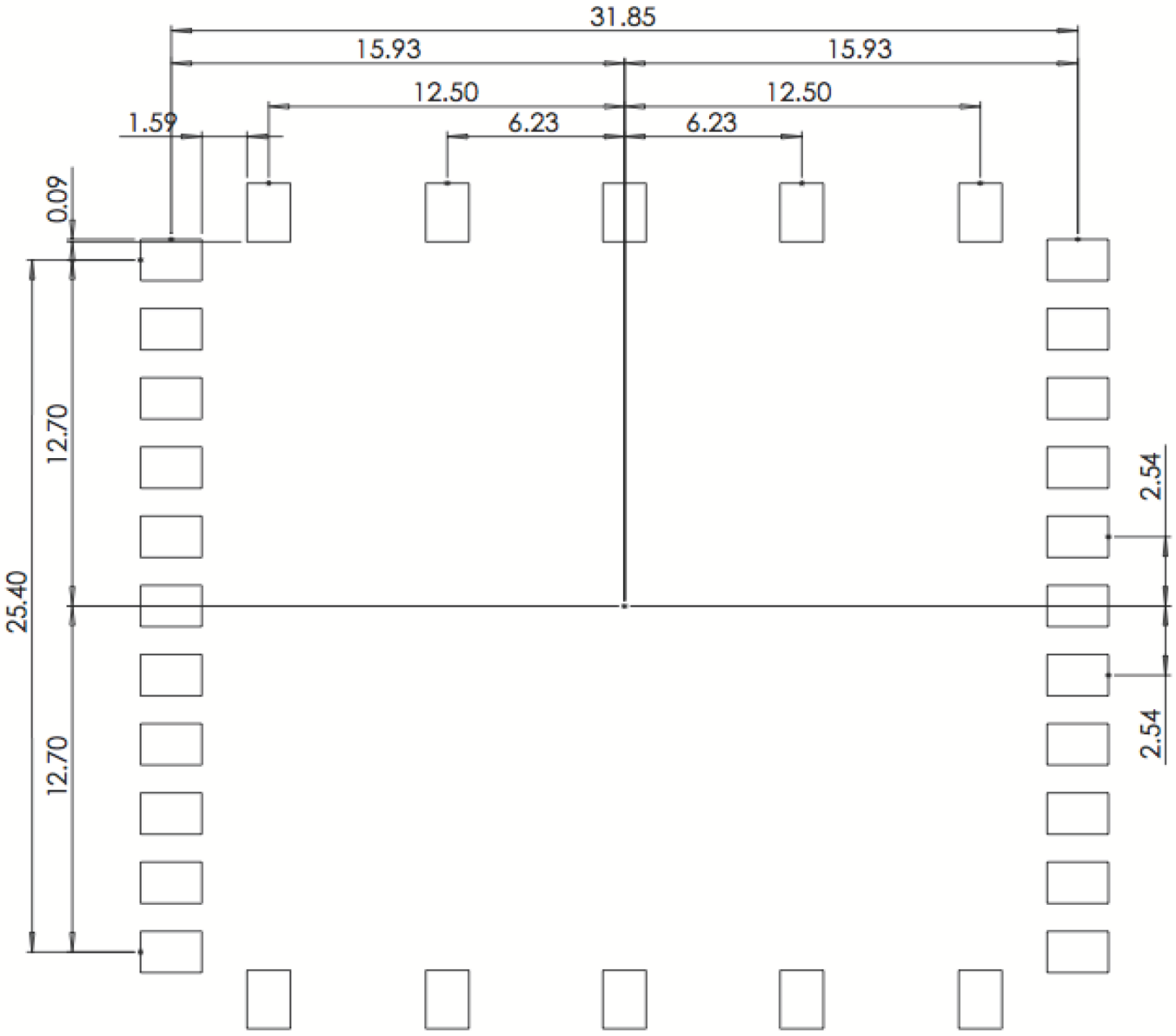


Figure 8-5: RS1000 Recommended Etched Copper Footprint – Single Pad

Figure 8-6: RS1000 Recommended Pastemask Footprint – All Pads

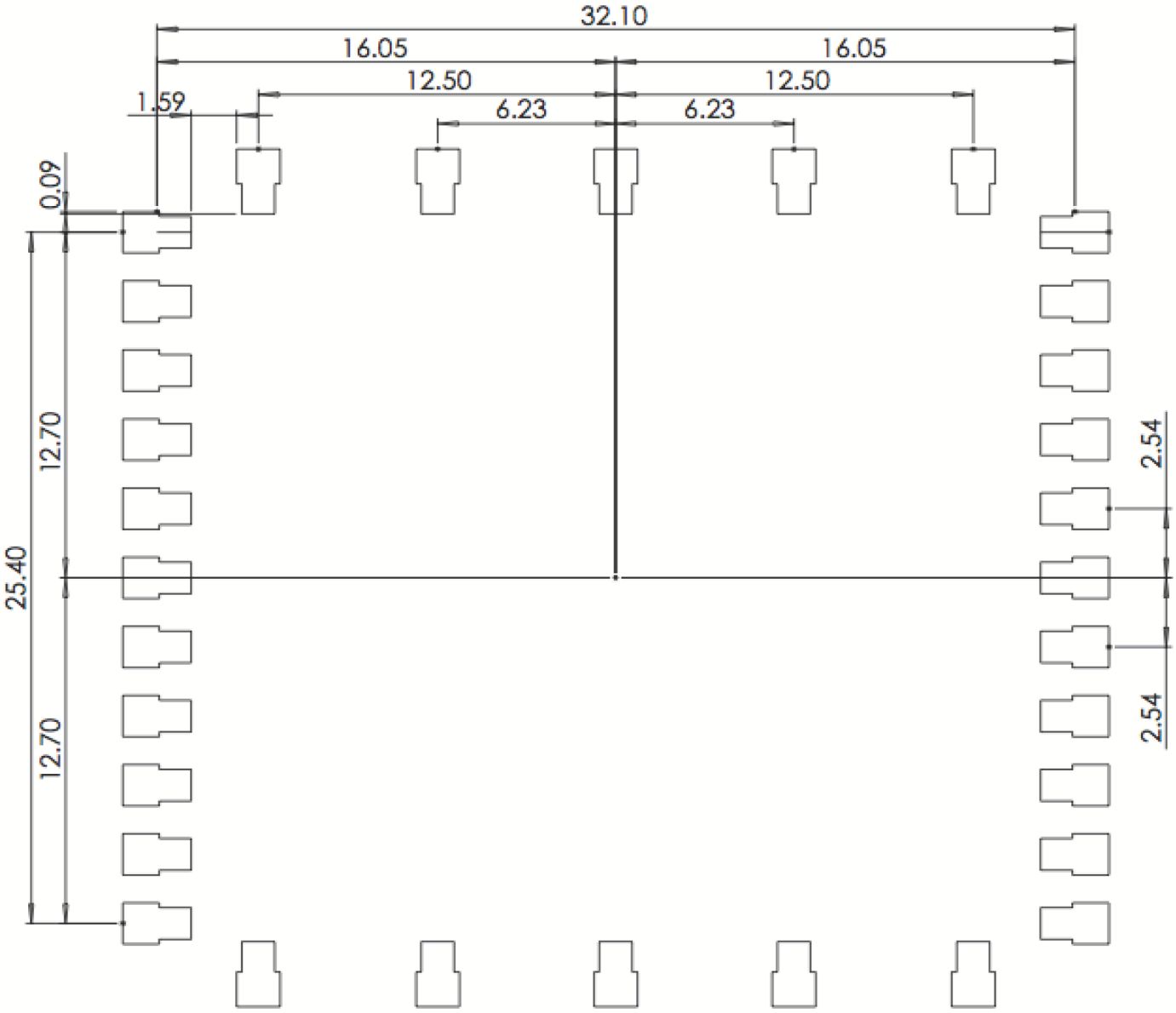
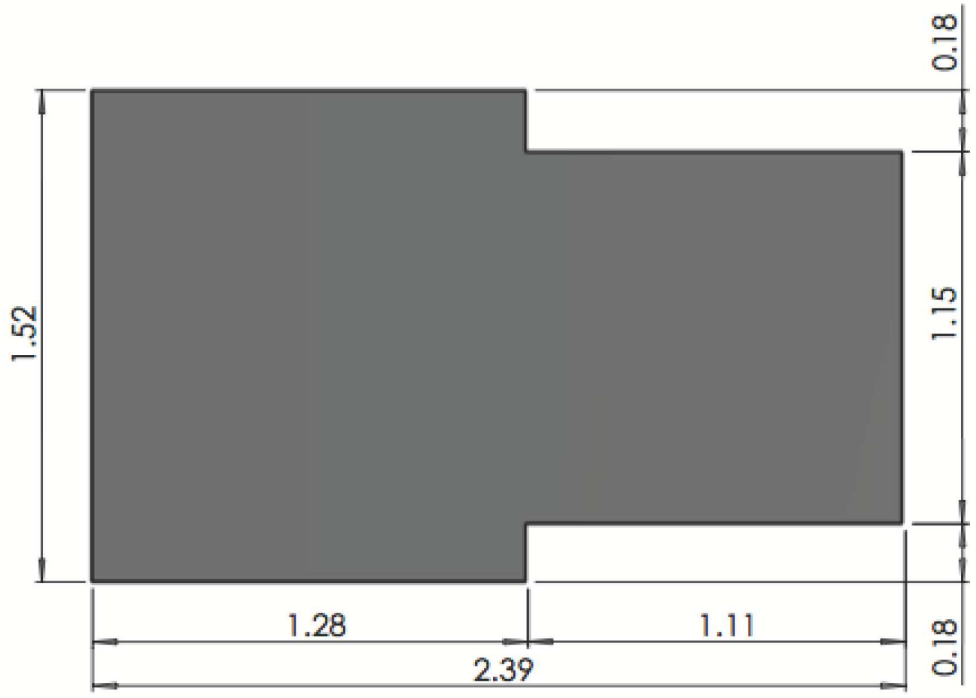
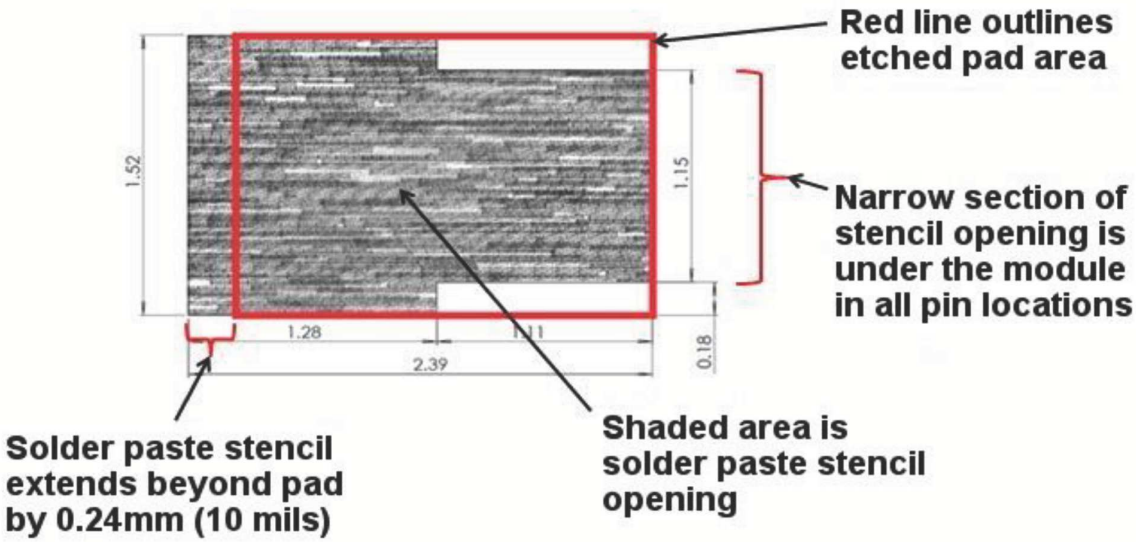


Figure 8-7: RS1000 Recommended Pastemask Footprint – Single Pad



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 module pad. Figure 8-8 depicts the pad/solder relationship.

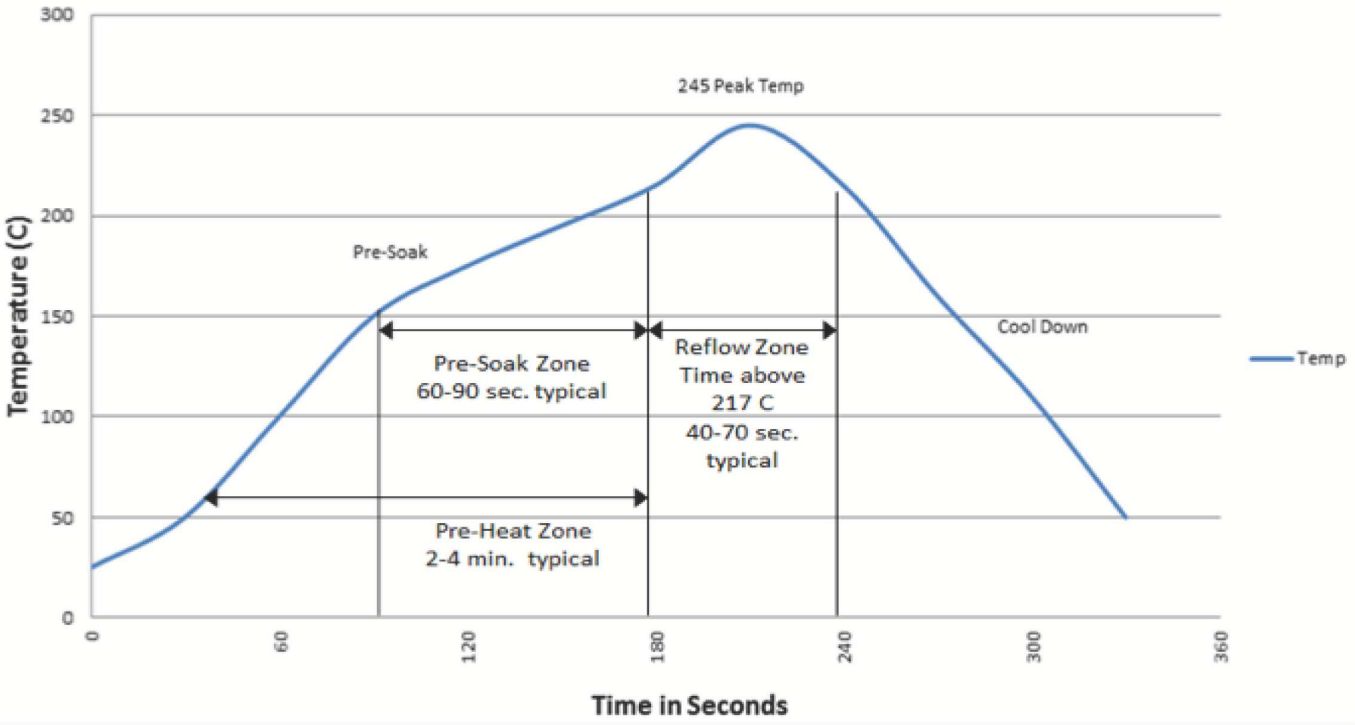
Figure 8-8: Recommended Solder Stencil Opening with Etched Pad for RS1000



8.5 SMT Reflow Information

No-clean Type 3 Sn3Ag0.5Cu Solder Paste (Koki S3X58- M650) was used during Impinj's testing of the Indy RS1000. The solder manufacturer's recommended reflow profile is shown in Figure 8-9.

Figure 8-9: Recommended Solder Reflow Profile for the Indy RS1000



9 Related Documentation

Table 9-1 contains a list of documentation related to this datasheet and the Indy reader products.

Table 9-1: Related Documentation

Indy Reader Surface Mount Module Brochure
RS1000 Hardware User's Guide
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

10 Document Change Log

Table 10-1: Document Change Log

Version	Date	Description
1.0	2/7/2018	Production datasheet

11 Notices

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