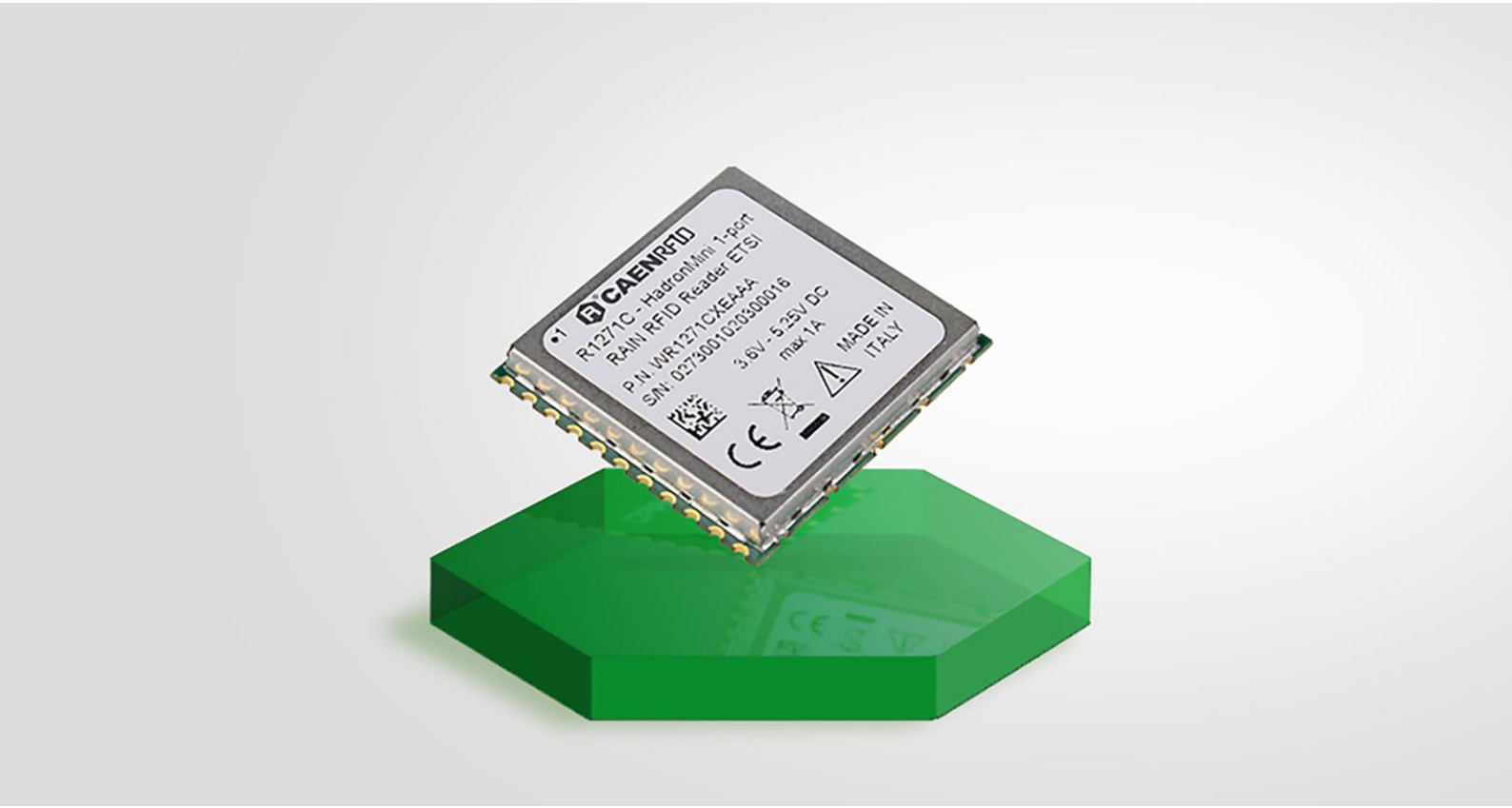
TECHNICAL INFORMATION MANUAL

Revision 2 – 12 July 2021

R1271C

Hadron$_{mini}$

High Performance 1-port Embedded Reader



Visit the Hadron$_{mini}$ R1271C web page, you will find the latest revision of data sheets, manuals, certifications, technical drawings, software and firmware. All you need to start using your reader in a few clicks!

Scope of Manual

The goal of this manual is to provide the basic information to work with the Hadron$_{mini}$ R1271C Reader.

This manual refers to:

- **Hadron$_{mini}$ R1271C firmware revision ≥ 1.9.0**

Change Document Record

Date	Revision	Changes	Pages
08 Jul 2020	01	First release	-
12 Jul 2021	02	Graphic Restyling	all pages
		Modified *RoHS EU Directive* paragraph	37
		Modified *Evaluation Board Layout* paragraph	34
		Modified *Development Kit* and *Ordering Options* paragraphs	8, 9
		Renamed *Development Kit* chapter in *Evaluation Board* chapter	29
		Renamed *development board* in *evaluation board*	all pages
		Added *Fig. 7.1: WRHML37XEVBX Evaluation Board for R1271C* and *Tab. 7.1: WRHML37XEVBX Evaluation Board* - Technical Specifications in *Evaluation Board* chapter	29
		Modified *CE Compliance*	35, 38

Reference Document

[RD1] EPCglobal: EPC Radio-Frequency Identity Protocols Class-1 Generation-2 UHF RFID Protocol for Communications at 860 MHz – 960 MHz, Version 2.0.1 (April 2015).

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Federal Communications Commission (FCC) Notice

This device was tested and found to comply with the limits set forth in Part 15 of the FCC Rules. Operation is subject to the following conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received including interference that may cause undesired operation. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment.

This device generates, uses, and can radiate radio frequency energy. If not installed and used in accordance with the instruction manual, the product may cause harmful interference to radio communications. Operation of this product in a residential area is likely to cause harmful interference, in which case, the user is required to correct the interference at their own expense. The authority to operate this product is conditioned by the requirements that no modifications be made to the equipment unless the changes or modifications are expressly approved by CAEN RFID.

Disposal of the product

Do not dispose the product in municipal or household waste. Please check your local regulations for disposal/recycle of electronic products.

CE

RoHS COMPLIANT

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1 INTRODUCTION

Description

Reader

The Hadron$_{mini}$ (Model R1271C), an embedded reader of the easy2read© product line, is an ultra compact reader for low power, high performance RAIN RFID applications. With programmable output power from 10dBm to 27dBm, the reader can detect tags at more than 3 mt of distance (depending on antenna and tag dimensions).

Due to its low power consumption, the module is specifically designed to be easily integrated in battery powered devices.

The radio frequency core of the module is based on the Impinj R2000 chipset that permits to achieve fast reading speed and to be used in dense reader and dense tag environments for top-class rated performances.

The compactness of the device and the surface mount technology allow to embed the Hadron$_{mini}$ inside the new small form factor industrial handhelds, smartphone accessories and other compact form factor devices.

The Hadron$_{mini}$ is available in versions for both European and US regulatory environments and so it's ideal for the integration in devices requiring compliance to different geographical regions.

The Hadron$_{mini}$ is pin-to-pin and SW compatible with the Impinj RS1000 and RS500 module making it a perfect replacement for these devices.

Fig. 1.1: Hadron$_{mini}$ Reader – top view

Fig. 1.2: Hadron$_{mini}$ Reader – back view

Evaluation Board

The Mod. RHML37XEVB allows managing the Hadron$_{mini}$ R1271C reader directly via USB and RS232 interfaces.
This board is particularly suited for Hadron$_{mini}$ R1271C reader evaluation and SW development purpose.

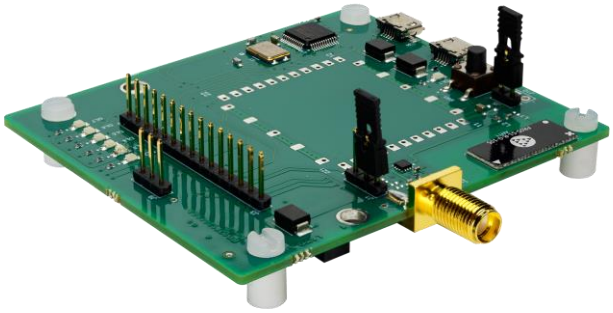


Fig. 1.3: WRHML37XEVBX Evaluation Board for R1271C

Development Kit

A development accessories kit (Mod. WRHML37XDKEU, WRHML37XDKUS) is available:

The kit includes:

- n. 1 WRHML37XEVBX R1271C - Hadron$_{mini}$ - Evaluation Board
- n.1 Circular Polarized Quadrifilar Antenna SMA (ETSI or FCC)
- n. 1 Set of Labels
- n. 1 RT0012 - Dual frequency NFC/UHF temperature logger
- n. 1 RT0005 Temperature Logger Tag
- n. 1 Support for kit assembling
- n. 2 USB cables
- n. 1 WALIM0000004 Wall mount AC-DC power supply

The R1271C Hadron$_{mini}$ reader and its development kit are a complete set up for a quick implementation of RFID solutions.

Fig. 1.4: Hadron$_{mini}$ reader and WRHML37XDKEU-WRHML37XDKUS Accessories kit

Ordering Options

The reader is available in **ETSI or FCC** version:

	Code	Description
Reader	WR1271CXEAAA	R1271C Hadron$_{mini}$ – High-Performance 1-port Embedded RAIN RFID Reader ETSI
	WR1271CXUAAA	R1271C Hadron$_{mini}$ – High-Performance 1-port Embedded RAIN RFID Reader FCC
Evaluation Board	WRHML37XEVBX	Evaluation Board for R1271C, R3100C and R7100C
Development Kit	WRHML37XDKEU	R1271C, R3100C and R7100C ETSI Dev Kit with antenna, interface, pws and tags (reader not included)
	WRHML37XDKUS	R1271C, R3100C and R7100C FCC Dev Kit with antenna, interface, pws and tags (reader not included)

2 TECHNICAL SPECIFICATIONS

Technical Specifications

Frequency Range	865.600÷867.600 MHz (ETSI EN 302 208 v3.1.1) 902÷928 MHz (FCC part 15.247)
RF Power	Configurable from 10 dBm to 27 dBm (from 10 mW to 500 mW) conducted power
RX Sensitivity	-75dBm – 1%PER, assuming 15 dB antenna RL @ 27 dBm output -80dBm – 1%PER, assuming 20 dB antenna RL @ 27 dBm output
Antenna VSWR Requirement	< 2:1 for optimum performances
Antenna Connectors	50 Ohm mono-static RF port on a single pin
Frequency Tolerance	±10ppm over the entire temperature range
Number of Channels	4 channels (compliant to ETSI EN 302 208 v3.1.1) 50 hopping channels (compliant to FCC part 15.247)
Standard Compliance	EPC C1G2 / ISO18000-63
I/O Interface	4 I/O lines 3.3V level I_{out} @ 8mA max
Connectivity	UART Serial Port – Baudrate: from 9.6 to 921.6 kbps, default 115.2 kbps – Databits: 8 – Stopbits:1 – Parity: none – Flow control: none – 3.3 V I/O voltage level
Power Supply	3.6 to 5.25 V DC
Power Consumption	- 700 mA @ 5 V - RF out = 27 dBm - 1000 mA @ 3.6 V - RF out = 27 dBm - 55 mA in idle mode - Ready to receive IRI packets - Lower latency to return to Active mode. - 10 mA in idle mode - Ready to receive IRI packets - 0.45 mA - GPIO activity or WKUP rising edge required to wakep part. – 0.08 mA - WKUP rising edge required to wakep part.
Dimensions	(L) 32 x (W) 29 x (H) 3.8 mm^3 1.26 x 1.14 x 0.15 $inches^3$
Package Type	32 pin surface mount module (SMT compatible)
Operating Temperature	-20°C to +70°C
Weight	4.6 g

Tab. 2.1: $Hadron_{mini}$ R1271C Technical Specifications

Warning: The RF settings must match the operating country/region to comply with local laws and regulations.

The usage of the reader in different countries/regions from the one in which the device has been sold is not allowed.

Key Features

- RAIN RFID (UHF EPC Class1 Gen2, ISO 18000-63) compliant
- ETSI and FCC versions available
- Ultra compact size
- Up to 27 dBm (500mW) output power
- -75 dBm Rx sensitivity, assuming 15 dB antenna return loss
- Impinj RS500 and RS1000 pin-to-pin compatibility
- 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
- UART serial interface using IRI (Impinj Radio Interface)
- Test features (CW, PRBS, custom regions, channel lists, and fixed frequency)

3 HARDWARE INTERFACE

Introduction

An example Hadron$_{mini}$ R1271C system-level block diagram for an embedded system is shown in *Fig. 3.1: Hadronmini R1271C - Example of Block* Diagram. This figure shows the electrical connections that may and must be made to control the Hadron$_{mini}$ R1271C. In the figure, the required connections are illustrated with solid lines. Recommended and optional connections are illustrated with different dotted and dashed line patterns. More details for each connection are listed in the following paragraphs.

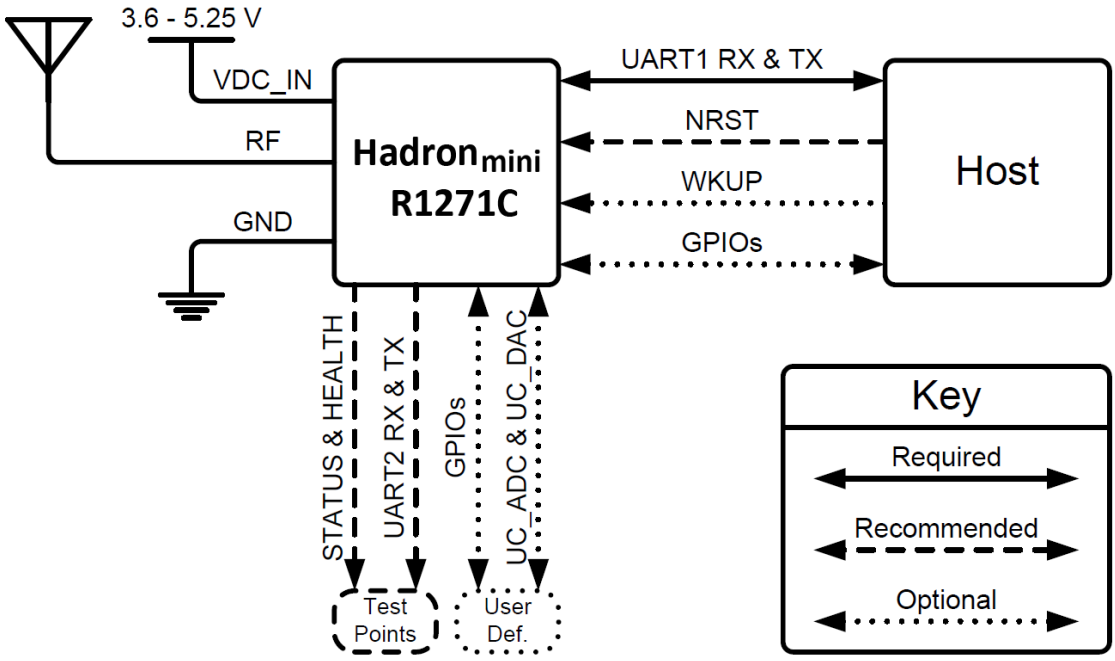


Fig. 3.1: Hadron$_{mini}$ R1271C - Example of Block Diagram

Required connections:

- VDC_IN and GND are required to power the Hadron$_{mini}$ R1271C.
- 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 Hadron$_{mini}$ R1271C if UART communication is not available. This connection is highly recommended. This pin is 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 IRI SDK user documentation.
- HEALTH indicates successful operation of the Hadron$_{mini}$ R1271C. Connection to a LED provides a visual indication of whether or not an error condition exists.
- STATUS provides an indication when the Hadron$_{mini}$ R1271C is in active mode (for example, inventorying tags). Connection to a LED provides a visual indicator of the device's activity.

Optional connections:

- GPIOs allow interaction with the Hadron$_{mini}$ R1271C 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 Hadron$_{mini}$ R1271C from the low power Sleep mode. WKUP is also used to force entry into the CAEN RFID 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 connections and must be left floating.

Power Supply

The Hadron$_{mini}$ R1271C 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 Hadron$_{mini}$ R1271C 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.

RF Connection

The Hadron$_{mini}$ R1271C 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 *PCB Layout for RF* page 22.

UART Communication

The Hadron$_{mini}$ R1271C has two full-duplex UART standard interfaces, 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 Hadron$_{mini}$ R1271C, and the Rx pins are inputs to the Hadron$_{mini}$ R1271C. 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 Input and Output Specifications* paragraph page 20. 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 § *Device Input and Output Specifications* paragraph page 20. Excessive current sunk or sourced on the GPIO pins can also cause electrical damage to the device.

Warning: 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.

Reset Pin

The Hadron$_{mini}$ R1271C 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 Hadron$_{mini}$ R1271C 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 10 kΩ nominal resistor. To reset the part, drive the pin strong low for at least the minimum reset pulse width as specified in § *Device Input and Output Specifications* paragraph page 20 (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 Hadron$_{mini}$ R1271C from resetting itself in case 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 *Fig. 3.2: NRST Pin Circuit Diagram* page 14, and the resistor size requirement is shown in Equation:

$$R1 < 10\ k\Omega * \left(\left(\frac{V_{DDIO}}{2.0\ V}\right) - 1\right)$$

Warning: 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.

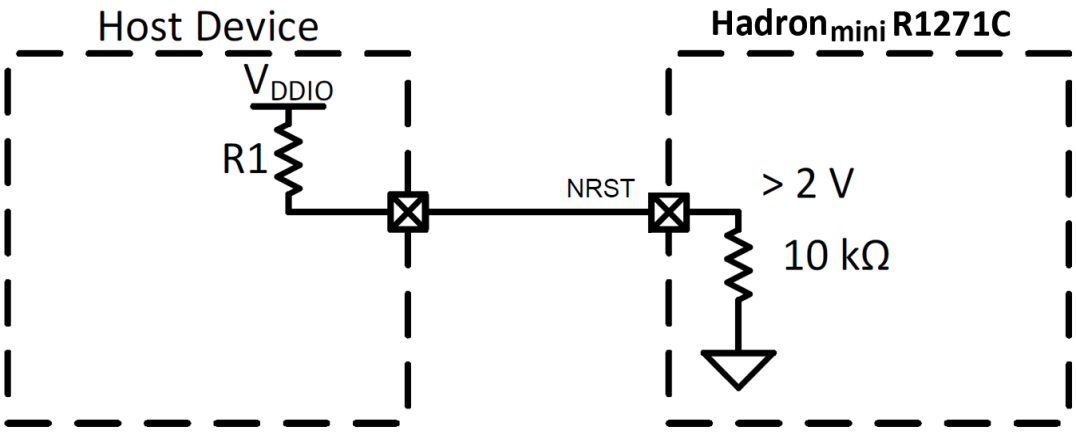


Fig. 3.2: NRST Pin Circuit Diagram

Health and Status Pins

The Hadron$_{mini}$ R1271C 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 IRI SDK 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 § *Device Input and Output Specifications* paragraph page 20.

Warning: Excessive current sunk or sourced on the pins can also cause electrical damage to the device.

Health Pin Behavior

The HEALTH pin indicates whether the Hadron$_{mini}$ R1271C 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 Hadron$_{mini}$ R1271C. Those patterns are as follows:

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

Tab. 3.1: Health Pin Behavior

Status Pin Behavior

The STATUS pin indicates whether the Hadron$_{mini}$ R1271C 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 Hadron$_{mini}$ R1271C. Those patterns are as follows:

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

Tab. 3.2: Status Pin Behavior

GPIO Pins

The Hadron$_{mini}$ R1271C'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 § *Device Input and Output Specifications* paragraph page 20.

Warning: 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 Input and Output Specifications* paragraph page 20 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 Input and Output Specifications* paragraph page 20.

Warning: 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.

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 CAEN RFID 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 Hadron$_{mini}$ R1271C. 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 CAEN RFID bootstrap.

Pin Listing and Signal Definitions

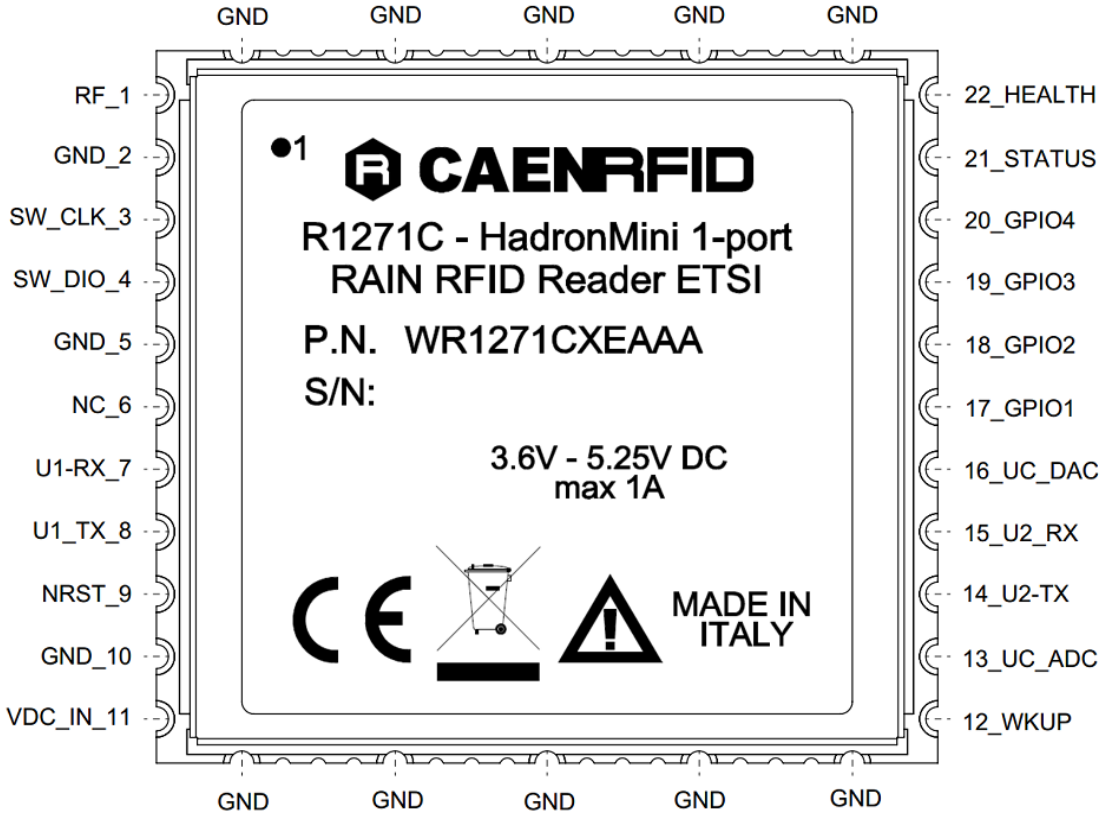


Fig. 3.3: Hadron$_{mini}$ R1271C Pin Listing

Note: GX markings are shown in *Fig. 3.3: Hadronmini R1271C Pin Listing.*

Pin#	Pin Name	Pin Type	Description
1	RF	RF	RF antenna port
2	GND	Power	Ground
3	SW_CLK	No Connect	Reserved
4	SW_DIO	No Connect	Reserved
5	GND	Power	Ground
6	NC	No Connect	Leave floating or drive to ground, resistively or strong
7	UART1-RX	Digital Input	R1271C UART Rx (Receive) from host
8	UART1-TX	Digital Output	R1271C UART Tx (Transmit) to host
9	NRST	Digital Input	Active low reset. Connect to open drain driver. Hadron$_{mini}$ R1271C 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	R1271C Debug UART Tx to host
15	UART2-RX	Digital Input	R1271C 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	R1271C status indication
22	HEALTH	Digital Output	R1271C health indication
23-32	GND	Power	Ground pins on the top and bottom edge of the package

Tab. 3.3: Pin Listing and Signal Definitions

Electrical Specifications

Absolute Maximum Ratings

The absolute maximum ratings (see *Tab. 3.4: Absolute Maximum Ratings*) define limitations for electrical and thermal stresses. These limits prevent permanent damage to the Hadron$_{mini}$ R1271C.

Operation outside maximum ratings may result in permanent damage to the device.

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	°C	
Humidity	-	95	% RH	Non-condensing
ESD immunity	-	2	kV	Human-body model, all I/O pads
Package moisture sensitivity level 3	-	-	-	Hadron$_{mini}$ R1271C from open trays must be baked before going through a standard solder reflow process (48 hours at 125 °C or 24hrs at 150 °C)

Tab. 3.4: Absolute Maximum Ratings

Operating Conditions

This section describes operating voltage, frequency, and temperature specifications for the Hadron$_{mini}$ R1271C during operation.

Parameter	Min.	Max.	Unit	Conditions
Supply	3.6	5.25	V	VDC_IN relative to GND
Temperature	-20	+70	°C	Ambient Temperature
Frequency	902	928	MHz	FCC part 15.247 (Mod. WR1271CXUAAA)
	865.6	867.6	MHz	ETSI EN 302 208 v3.1.1 (Mod. WR1271CXEAAA)

Tab. 3.5: Operating Conditions

Device Functional Specifications

This section describes operating voltage, frequency, and temperature specifications for the Hadron$_{mini}$ R1271C during operation.

Parameter	Typ.	Unit	Description
Supply Current			Current consumed by Hadronmini R1271C 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.
Sleep mode	80	µA	WKUP rising edge required to wakeup part.

Tab. 3.6: Supply Current Specifications

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.

Tab. 3.7: Startup and Wakeup Time

UHF Gen 2 RFID Radio Specifications

Parameter	Min.	Typ.	Max.	Unit	Conditions
Frequency	902		928	MHz	See § *Tab. 2.1: Hadronmini R1271C Technical Specifications* page 10
	865.6		867.6	MHz	
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

Tab. 3.8: RF Receiver Specifications

Parameter	Min.	Max.	Unit	Notes
Tx Power	10	27	dBm	Meets FCC and equivalent regulatory constraints
Tx Power Error				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
Room temp: 23 ≤ PTX < 27 dBm 10 ≤ PTX < 23 dBm	 -0.5 -1.0	 0.5 1.0	 dB dB	10 to 30°C
High temp: 23 ≤ PTX < 27 dBm 10 ≤ PTX < 23 dBm	 -0.75 -1.5	 0.75 1.5	 dB dB	30 to 60°C
Low temp: 23 ≤ PTX < 27 dBm 10 ≤ PTX < 23 dBm	 -1.0 -1.75	 1.0 1.75	 dB dB	-20 to 10°C
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	See § *Tab. 2.1: Hadronmini R1271C Technical Specifications* page 10
	865.6	867.6	MHz	See § *Tab. 2.1: Hadronmini R1271C Technical Specifications* page 10

Tab. 3.9: RF Transmitter Specifications

Device Input and Output Specifications

Parameter	Min.	Typ.	Max.	Unit	Conditions
nRST					
VIL	-0.3		0.8	V	
VIH	2		3.6	V	
Hysteresis voltage		200		mV	
Internal pull-up resistor	25	40	55	kΩ	
Reset pulse width	25			µs	
WKUP					
VIL	-0.3		1.0	V	
VIH	1.8		3.6	V	
Hysteresis voltage		200		mV	
Internal pull-down resistor	25	40	55	kΩ	
Digital inputs					
VIL	-0.3		1.0	V	
VIH	1.8		3.6	V	
Hysteresis voltage		200		mV	
Pull-up and pull-down resistor	25	40	55	kΩ	
Digital outputs					
VOL	0.0		0.4	V	
VOH	2.7		3.6	V	
Drive current (sink or source)	8			mA	
UART					
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	

Tab. 3.10: Digital 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 VSS 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
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	CLOAD < 50 pF & RLOAD > 5 kΩ

Tab. 3.11: Analog Interface Specification

EPC Class-1 Generation-2 Operation

Supported RF modes

The R1271C Hadron$_{mini}$ supports the following RF modes:

Key Value	Description
0	Auto (Defaults to mode 1)
1	Dense Reader Mode profile for FCC operation
2	Dense Reader Mode profile for ETSI operation
3	Very fast mode with reduced sensitivity and noise immunity
4	Very sensitive mode with reduced speed and reduced noise immunity

Tab. 3.12: Supported RF Modes

The link between each RF modes and the forward and reverse link profile are reported in the following table:

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

Tab. 3.13: RF Modes – Forward and Reverse Link Profiles

In the following table are reported the inventory performances that can be achieved with RF Mode 1 and RF Mode 3:

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

Tab. 3.14: Inventory Performance

Note: Data gathered with reader performing 10 seconds of inventory in Dual Target, Session 0.

EPC Class-1 Generation-2 Functionality

The following table shows the main EPC C1G2 functionalities of the R1271C Hadron$_{mini}$ reader:

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

Tab. 3.15: Gen 2 Functionality

[1] Only for FCC version (Mod. WR1271CXUAAA)

4 LAYOUT AND COMPONENTS

Introduction

This section describes hardware aspects of embedded RAIN RFID readers based on the Hadron$_{mini}$ R1271C.

PCB Layout for RF

50 Ohm Characteristic Impedance

As discussed in paragraph *RF Connection* page 13, a properly matched RF connection is critical to achieving high performance with Hadron$_{mini}$ R1271C. 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 Hadron$_{mini}$ R1271C'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 the following equation.

Reflection Coefficient of a Load:

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

In this equation, ZL represents the characteristic impedance of the transmission line, and Z0 represents the characteristic impedance of the Hadron$_{mini}$ R1271C, 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 the power will be reflected back into the Hadron$_{mini}$ R1271C, and only 88.9% of the power will be transmitted.

Hadron$_{mini}$ R1271C is designed to connect to a 50-Ohm characteristic impedance load. The connection between the Hadron$_{mini}$ R1271C 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 *Fig. 4.1: PCB Transmission Line Types* page 22. Material properties to note include the dielectric constant of the dielectrics in the PCB, and the conductivity of the conductor used.

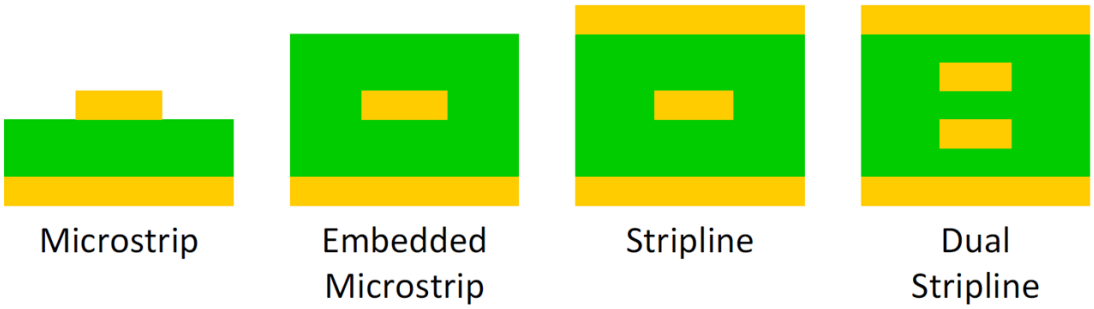


Fig. 4.1: PCB Transmission Line Types

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 on eeweb.com. These tools will require information about the PCB layout and also PCB characteristics, which should be obtained from the PCB manufacturer.

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.

Package Mass

The mass of the Hadron$_{mini}$ R1271C module is roughly 4.6 grams.

Package Dimensions

Package dimensions are shown in the following figure:

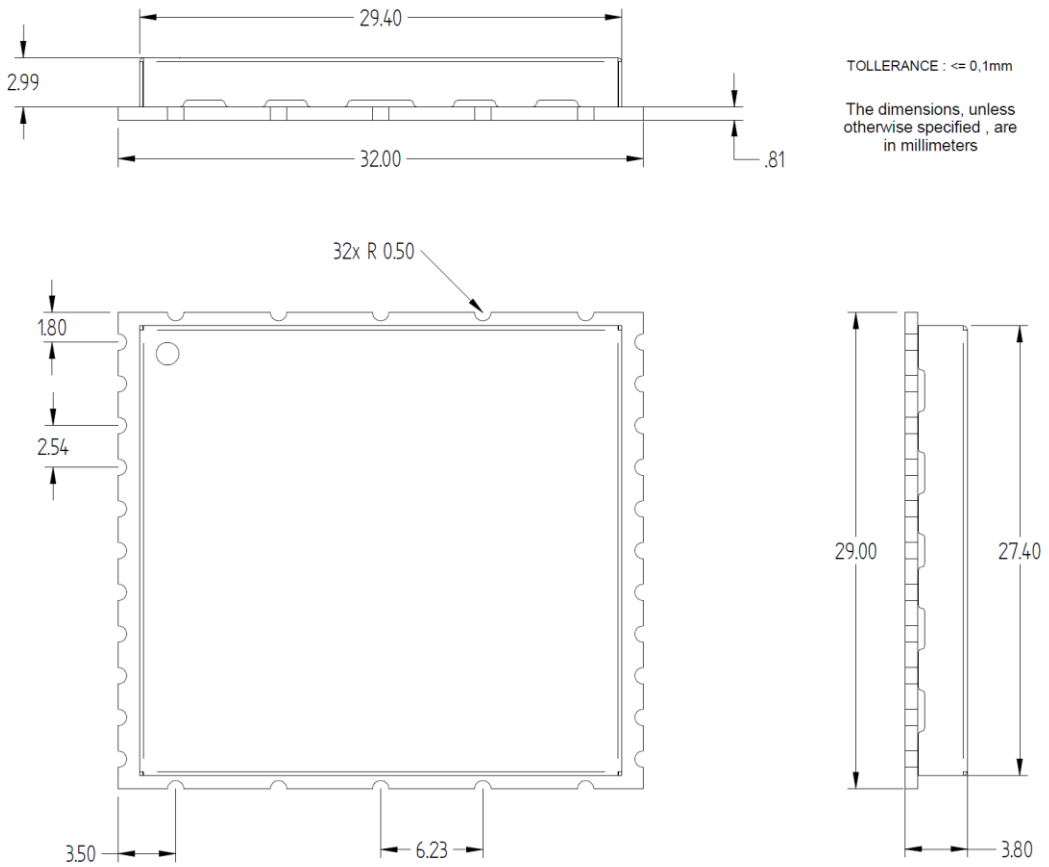


Fig. 4.2: Package Dimensions, Top, Front, and Side Views

Download the *Hadron$_{mini}$ R1271C Technical drawing* at Hadronmini R1271C web page (*Documents* section).

PCB Footprint

Recommended footprint copper and pastemask dimensions are shown in the following:

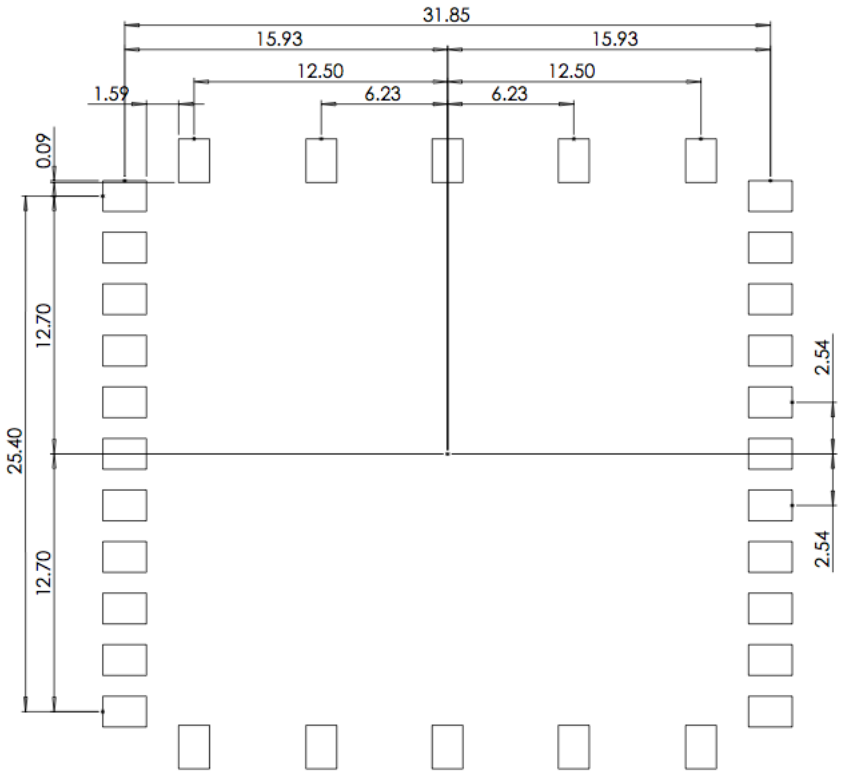


Fig. 4.3: Recommended Etched Copper Footprint – All Pads

SMT Reflow Information

The solder manufacturer's recommended reflow profile is shown in the following figure:

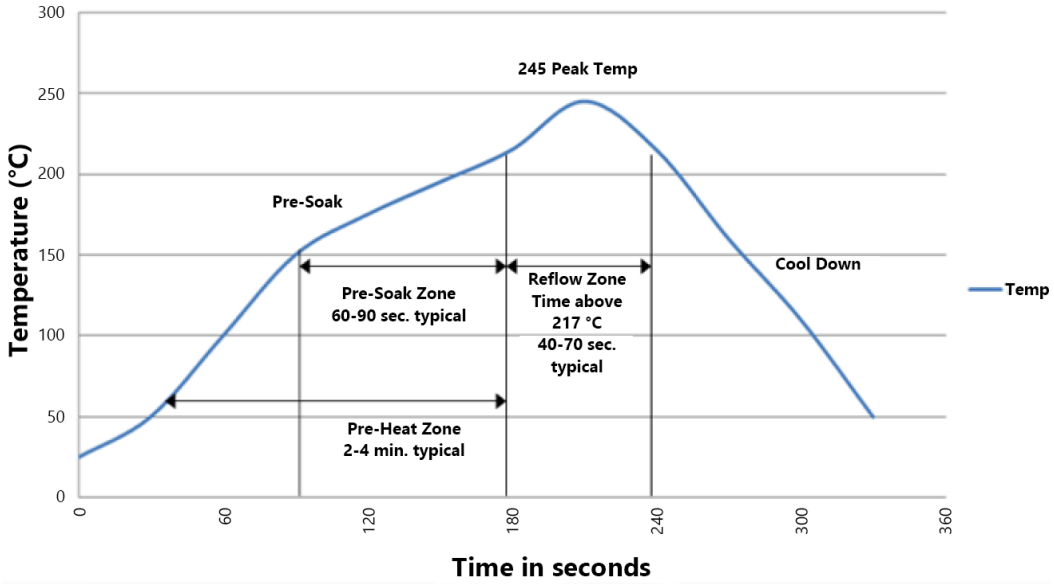


Fig. 4.4: Recommended Solder Reflow Profile for the Hadron$_{mini}$ R1271C

Moisture Sensitive Level 3 (MSL 3)

CAEN RFID srl follows JEDEC standards for moisture classifications. The Hadron$_{mini}$ R1271C RFID reader is classified as MSL 3.

Warning: The damaging effects of moisture absorbed in semiconductor packages during SMT assembly are known. Pay attention to the next paragraphs and follow the instructions to avoid problems.

MSL 3 Handling at PCB Assembly

The Hadron$_{mini}$ R1271C package is moisture sensitive and needs to be handled within proper MSL 3 guidelines to avoid damage from moisture absorption and exposure to solder reflow temperatures that can result in yield and reliability degradation.

A. During PCB Assembly

1. Devices are baked and dry-packed before shipment from CAEN RFID. The packing uses a Moisture Barrier Bag (MBB). A Humidity Indicator Card (HIC) and drying desiccant are included inside the MBB. A MSL 3 label is attached to caution that the bag contains moisture sensitive devices.
2. Shelf life of devices in a sealed bag is 12 months at <40°C and <90% room humidity (RH).
3. Upon opening of MBB, the HIC should be checked immediately; devices require baking before board mounting if the HIC is >10% when read at 23°C ± 5°C.
4. After MBB is opened, devices should go through reflow for board assembly within 168 hours at factory conditions of <30°C/60% RH, or stored at <10% RH. If both conditions are not met, baking is required before board mounting.
5. If baking is required, devices should be baked for a minimum of 48 hours at 125°C or 24 hours at 150°C.

B. Handling Unused Devices

1. Any unused devices after the MBB have been opened for more than 168 hours or not stored at <10% RH should be baked before any subsequent reflow and board assembly.
2. Re-baking should be done for a minimum of 48 hours at 125°C or 24 hours at 150°C.
3. Unused devices can either be baked and dry-packed first before storage, or they can be baked just before the next board assembly. It is recommended that the former be practiced as it helps to prevent operator error from re-using devices without baking. In both cases, the re-packed materials should follow the guidelines in section A.

C. Reworking a Device on a PCB

1. Before a device is removed from the module, the module must first be baked.
2. Baking should be done for a minimum of 48 hours at 125°C or 24 hours at 150°C.
3. It is recommended that during removal, localized heating be used, and the maximum body temperature of device should not exceed 200°C.
4. The replacement device should not exceed the specified floor life of 168 hours.

5 OPERATING MODES

Introduction

Hadron$_{mini}$ R1271C has five operating modes and a startup mode. The transitions between these modes are shown in *Fig. 5.1: Operating Mode State Diagram*. 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 behavior and low power modes are given in the following subsections.

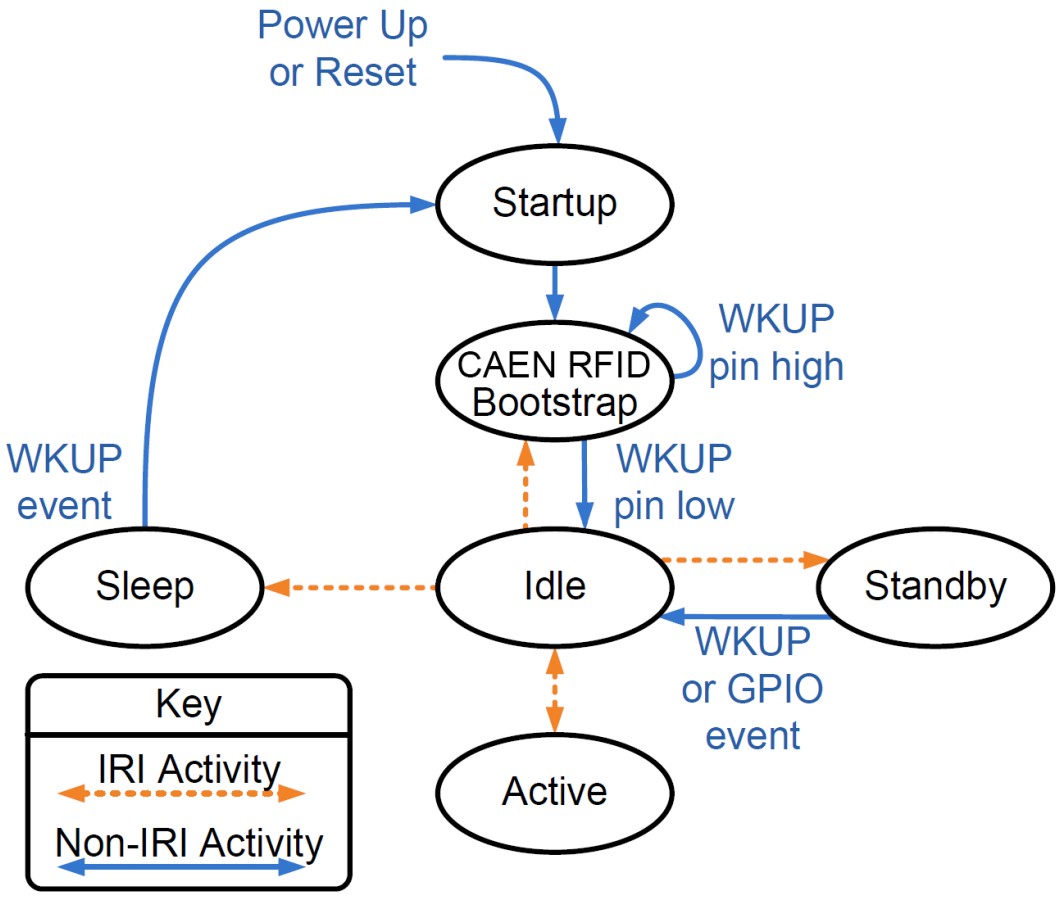


Fig. 5.1: Operating Mode State Diagram

Startup Behavior

Upon reset or power up, the Hadron$_{mini}$ R1271C configures itself in the Startup mode. It automatically begins code execution in the CAEN RFID bootstrap, which can be used to update the version of the Hadron$_{mini}$ R1271C 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 CAEN RFID Bootstrap via IRI. When the WKUP pin goes low, firmware execution transitions to the Idle operating mode.

Low Power Operation

The Hadron$_{mini}$ R1271C has multiple operating modes that enable reduced power consumption. The operating modes are Active, Idle, Standby, and Sleep. The Hadron$_{mini}$ R1271C 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 Hadron$_{mini}$ R1271C 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 § *Electrical Specifications* paragraph page 17.

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 § *Electrical Specifications* paragraph page 17 for more detailed specifications on wakeup time performance.

The NRST pin can be used in any mode to reset Hadron$_{mini}$ R1271C, eventually returning it to Idle mode via the normal startup behavior. For more detail see § *Wakeup Pin* paragraph page 16.

If the low power performance provided by these modes does not meet the requirement of a system, power may be gated to the Hadron$_{mini}$ R1271C'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 behavior.

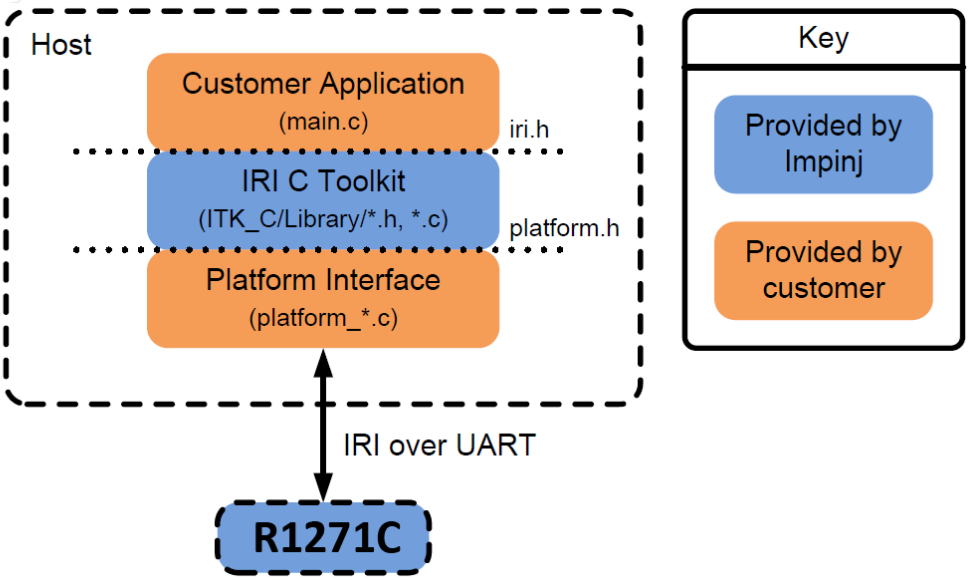
6 IRI INTERFACE

The Hadron$_{mini}$ R1271C 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 R1271C 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



7 EVALUATION BOARD

Introduction

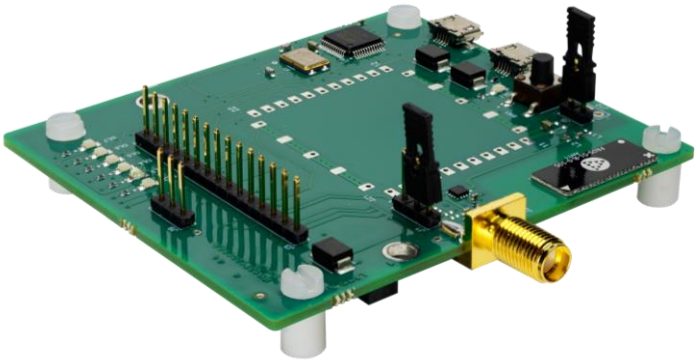


Fig. 7.1: WRHML37XEVBX Evaluation Board for R1271C

The WRHML37XEVBX Evaluation Board enables quick evaluation and development with Hadron$_{mini}$ R1271C. It provides an easy way to communicate with the Hadron$_{mini}$ R1271C via USB-UART or an arbitrary UART host and provides easy access to the inputs and outputs of the device.

The WRHML37XEVBX evaluation board is basically a "breakout board" that allows easy access to the connections of the Hadron$_{mini}$ R1271C module. The board is designed to roughly conform to the Raspberry Pi "HAT" form factor, meaning it can be plugged directly into the IO port of a Raspberry Pi single board computer, and be powered by and communicate with the Pi. It can also be used as a USB peripheral to a desktop computer, or connected to an arbitrary host device and power supply.

Technical Specifications

Digital I/O	Four I/O lines 5V out @ 3mA, 5V input
USB Port	USB micro female connector USB 2.0 device It appears as dual Virtual COM Port device; drivers for all Windows OS
DC power port via USB Port	USB micro female connector
External antenna connector	SMA jack
Embedded antenna	Fractus FR05-S1-R-0-105
Raspberry PI interface	HAT connector
LED display	GREEN: power from AC/DC adapter and/or USB port GREEN: reader module's HEALTH YELLOW: reader module's STATUS GREEN: GPIO[0..3]
Electrical Power	DC Voltage 5V +/-5%
Dimensions	(L) 78 x (W) 79 x (H) 23 mm^3 3.1x 3.1 x 0.9 inches^3
Operating Temperature	-20°C to +70°C

Tab. 7.1: WRHML37XEVBX Evaluation Board - Technical Specifications

Evaluation Board Overview

A block diagram of the WRHML37XEVBX Evaluation Board is shown in *Fig. 7.2: Evaluation Board Block Diagram*. It shows the most notable components and connections on the PCB. The block diagram shows the Hadron$_{mini}$ R1271C module's main connections: power, RF, and UART communication. The power for the Hadron$_{mini}$ R1271C can be provided by an USB micro power supply at J6, or via the Raspberry Pi HAT connector J7, or the breakout header J3. The RF signal is connected to an RF switch which can then connect to either the on-board surface mount antenna or the SMA connector. UART communication with Hadron$_{mini}$ R1271C can be connected via the USB- UART IC (using a USB micro cable), via the Raspberry Pi HAT connector, or via the breakout header.

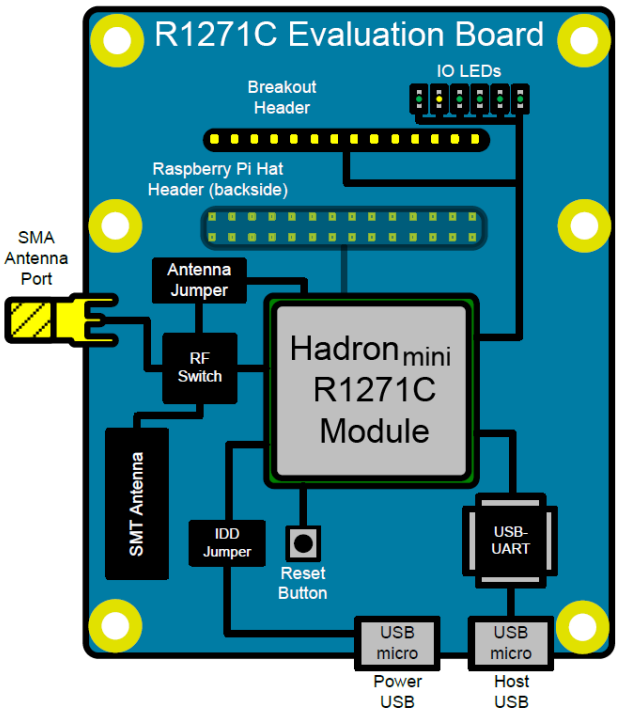


Fig. 7.2: Evaluation Board Block Diagram

Hadron$_{mini}$ R1271C Evaluation Board Key Components

The WRHML37XEVBX Evaluation Board is designed to allow easy development of Hadron$_{mini}$ R1271C applications using a PC or other hosts capable of generating IRI traffic over UART. It includes several integrated circuit components and connectors to allow connection to USB or UART hosts, or other development kits or customer hardware. These components are shown in *Fig. 7.3: WRHML37XEVBX Evaluation Board Key Components*. Components on the backside are shown with dotted lines. This section describes these components and connectors in detail.

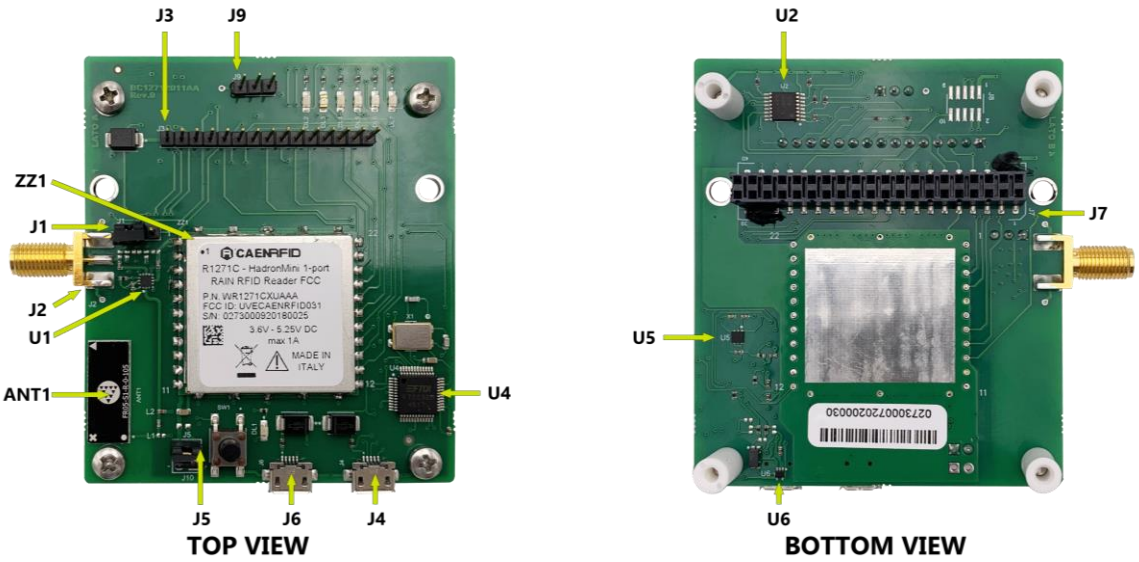


Fig. 7.3: WRHML37XEVBX Evaluation Board Key Components

Integrated Circuit Component Descriptions

ZZ1 is the Hadron$_{mini}$ R1271C RAIN RFID reader module. It is a completely integrated Gen2 UHF RFID reader, requiring only power, RF, and UART connections to read and write tags. It is in a 29 by 32 mm surface mountable package.

U1 is the RF switch IC that is used to switch between the two antenna options: the onboard surface mount (SMT) antenna ANT1, and the SMA antenna port J2.

ANT1 is a surface mounted far field fractal antenna for RAIN (UHF) RFID (Fractus FR05-S1-R-0-105 “EZConnectTM”). It uses the ground plane of the evaluation board to form a read zone near the board.

The RF switch IC is controlled by a single input which is connected to the center pin of the antenna selection jumper J1. Removing the jumper causes the switch to connect the Hadron$_{mini}$ R1271C’s RF port to the SMT antenna A1. Installing the jumper in the leftmost position selects the SMA connector J1. Installing the jumper in the rightmost position allows the Hadron$_{mini}$ R1271C to select the antenna using GPIO1. In the default low state, the SMA connector J1 will be selected. In the high state, the SMT antenna ANT1 will be selected. The antenna can be controlled dynamically, please refer to the IRI SDK documentation. The RF switch IC is a Peregrine PE42422.

U4 is the dual USB-UART IC. It allows an USB host to communicate with the Hadron$_{mini}$ R1271C module via 3.3 volt UART. It connects to both the host UART and debug UART. Both will be presented on a host as connection options. On a windows PC, they will be shown as adjacent COM ports, with the host UART being the lower numbered port. On a linux PC, they will appear as /dev/ttyUSB<X>. The USB-UART IC is an FTDI FT2232D.

U5 is the 3.3 volt linear regulator IC for the dual USB-UART IC. The USB-UART IC requires an external voltage source to specify the logic level of the UART interface. This IC supplies that voltage reference and supply. The voltage regulator IC is a Texas Instruments TPS73533DRVR.

U2 is the IO LED buffer IC. This buffer allows high current drive for the on-board GPIO LEDs DL2-DL7, which indicate the GPIO and Health and Status pin states. Without the buffer, the LEDs would load the IOs, and reduce the potential current supply available to custom hardware attached to the IOs. The buffer IC is a TI 74HC4050.

Connector Descriptions

J4 is the host USB micro connector. It allows a PC host to connect to the UART communication ports of the Hadron$_{mini}$ R1271C module via the USB-UART IC U4. It can also be used to provide power to the board, but note that most PC USB hosts cannot provide the ~1.5 amperes required to power the module during RFID operation.

J6 is the power USB micro connector. It allows connection of a USB power supply to the board, but is not connected to the USB-UART IC, and cannot be used to communicate with the module. The board requires roughly 1.5 amperes in the highest power configuration, which most USB chargers can supply.

J1 is the antenna select jumper and its function has been above described.

J2 is the SMA antenna connector. This port can be connected to any 50 ohm characteristic impedance UHF RFID antenna, and with the proper selection of the antenna selection jumper J1, the antenna will be connected to the Hadron$_{mini}$ R1271C's RF port.

J3 is a breakout header for the IOs of the Hadron$_{mini}$ R1271C as well as a few other signals on the board, including the power supplies. It can be used to both monitor and control the signals on the board. If an arbitrary host is to be used to control the Hadron$_{mini}$ R1271C, it can be connected to the UART Tx and Rx signals using this header as well as which Raspberry Pi GPIOs will be connected to each signal, when using the Raspberry Pi "HAT" header J7.

J7 is the Raspberry Pi "HAT" header which allows the WRHML37XEVBX evaluation board to be stacked on top of a Raspberry Pi single board computer (SBC). It connects power and ground, UART Tx and Rx, as well as the other IOs of the Hadron$_{mini}$ R1271C.

J5 is the series current "IDD" jumper. It allows a series current measurement to be performed while the Hadron$_{mini}$ R1271C is operating. If no series current measurement is desired, the jumper should be populated with a short, so that the Hadron$_{mini}$ R1271C receives power.

J9 is the BOOT recovery connector, it has no customer-facing functionality, and can be safely ignored.

Evaluation Board Default Configuration

In the default configuration of the WRHML37XEVBX evaluation board, the jumpers J1 and J5 should be as follows:

1. J1 – Antenna Selection Jumper – should be in the leftmost position so that the external antenna on connector J2 is selected.
2. J5 – series current jumper – should be populated (shorted) with a 0 ohm jumper.

Evaluation Board Alternate Power Options

The most common configuration for powering the WRHML37XEVBX evaluation board is to use a USB micro power supply. This can be a USB charger style device, or a USB DC adapter, like those used for Raspberry Pi single board computers.

Power can also be supplied by an attached Raspberry Pi device, via the "HAT" connector J7.

Power can also be supplied by applying a voltage supply to the "5V-VDC_IN" pin of breakout header J3.

Note: No matter the method used to supply power, the board requires roughly 1.5 amperes in the highest power configuration.

Evaluation Board USB-UART Details

U4 is a dual USB-UART made by FTDI. Its part number is FT2232D. This part allows a PC without a UART or RS232 interface to communicate with the RS500 over USB. The FTDI part achieves this by enumerating as a USB device, and adding a pair of COM ports. When it enumerates, the lower numbered COM port will correspond to the host UART interface, and the higher numbered COM port will correspond to the debug UART interface. In Windows, these COM ports can be viewed in the Device Manager under the "Ports (COM & LPT)" category.

The FTDI driver has a configurable latency for communication. Reducing this latency provides more responsiveness. The latency should be reduced to 1 ms for ideal performance. In Windows, this latency can be changed by the following process:

- Open the Windows Device Manager

- Navigate to the “Ports (COM & LPT)” section
- Right click on the “USB Serial Port (COMx)” representing the FTDI interface
- Select “Properties”
- In the Properties dialog, navigate to the “Port Settings” tab and click “Advanced”
- Under the “BM Options” group, lower the “Latency Timer” using the dropdown

Evaluation Board Schematic

The schematic for the WRHML37XEVBX evaluation board is shown in *Fig. 7.4: Evaluation Board Schematic*. A high resolution PDF of the schematic can be downloaded from the Hadronmini R1271C web page (*Hadron$_{mini}$ R1271C Technical drawing*).

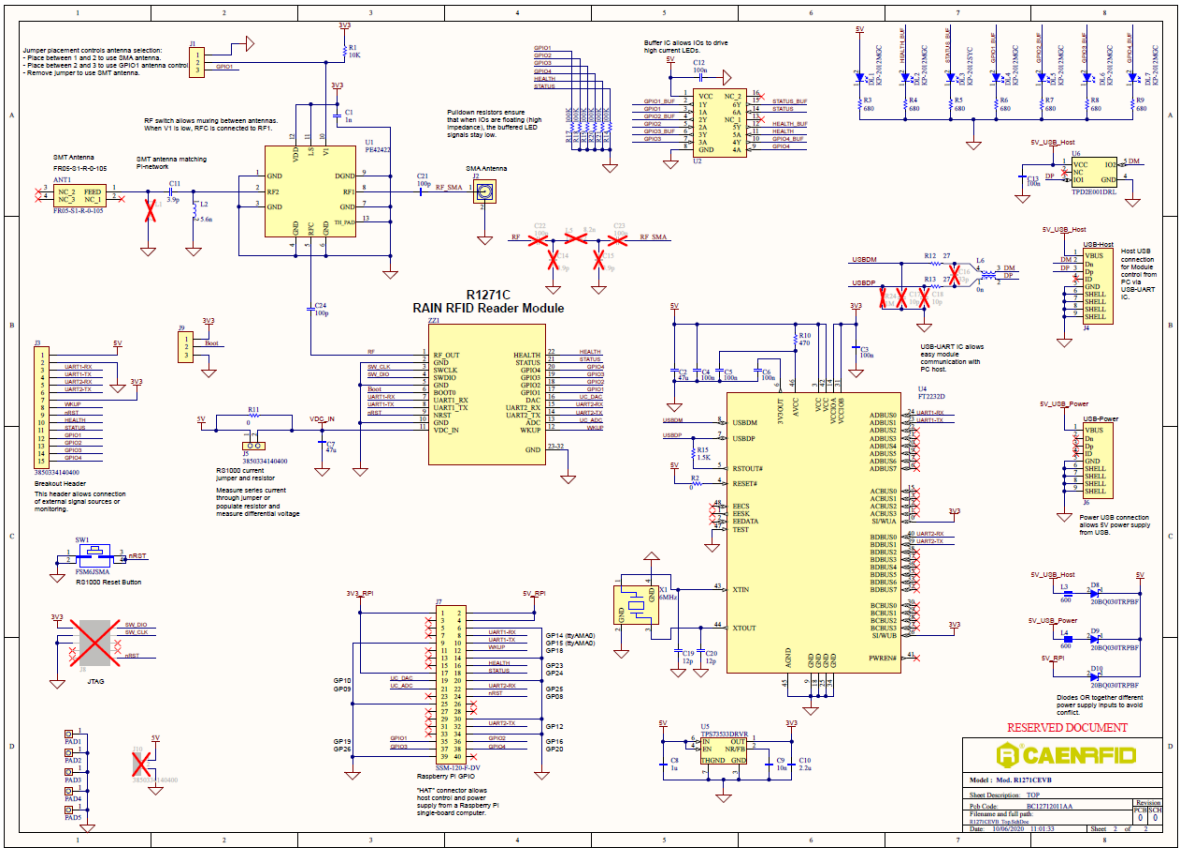


Fig. 7.4: Evaluation Board Schematic

Evaluation Board Layout

The layout shows the physical construction of the WRHML37XEVBX evaluation board. The top and bottom layers are shown in *Fig. 7.5: Evaluation Board Front and Backside(flipped) Layout*. The layout can be downloaded from the Hadronmini R1271C web page (*Hadron$_{mini}$ R1271C Technical drawing*).

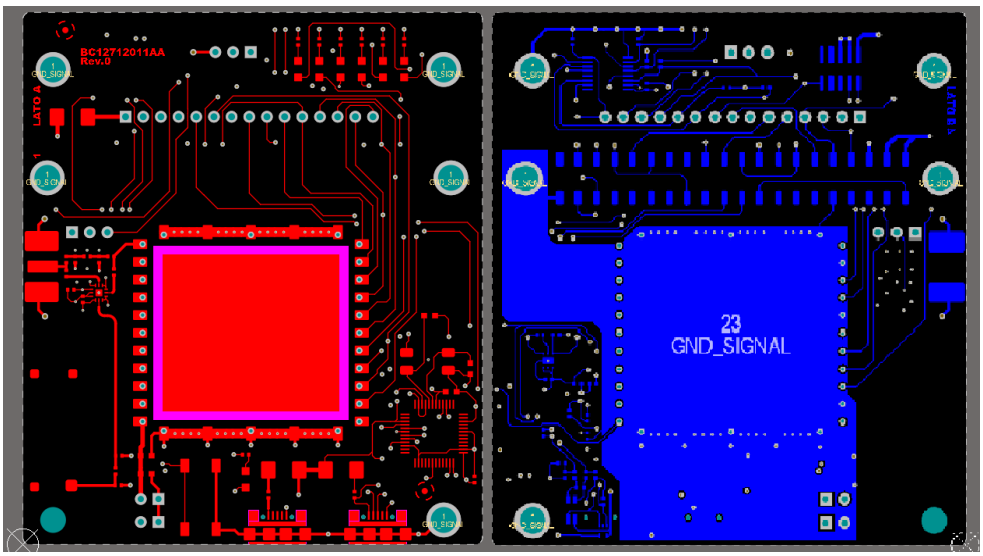


Fig. 7.5: Evaluation Board Front and Backside(flipped) Layout

The ground plane free of component on the bottom side of the board under Hadron$_{mini}$ module (as shown in detail in the following figure) is recommended in order to increase the power dissipation and should be implemented in user's own board design.

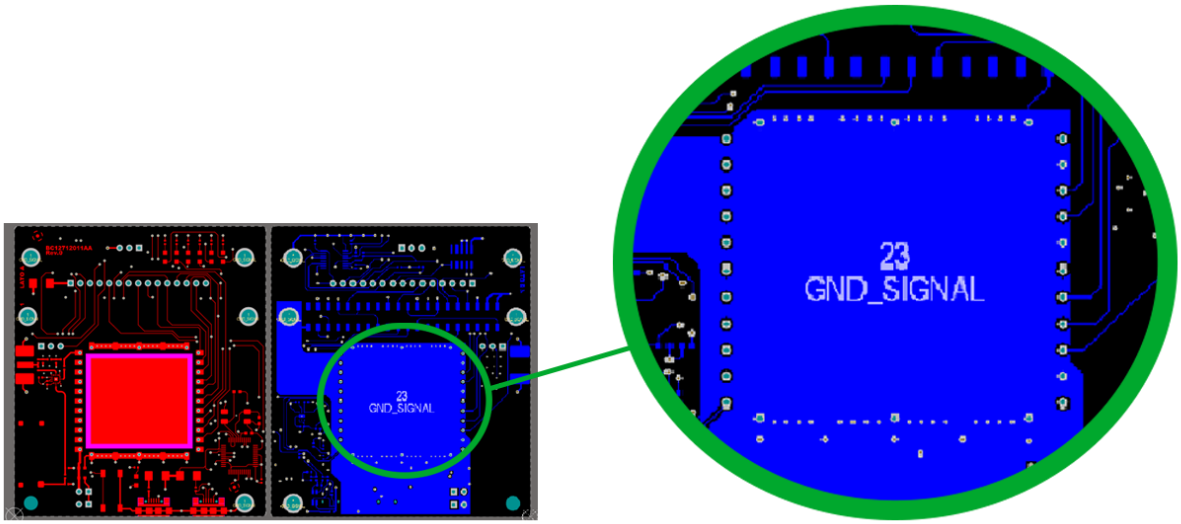


Fig. 7.6: Evaluation Board Front and Backside(flipped) Layout - detail

Evaluation Board Bill of Materials (BOM)

The bill of materials lists the components used to construct the WRHML37XEVBX evaluation board. It can be downloaded from the Hadronmini R1271C web page (*Hadron$_{mini}$ R1271C Technical drawing*).

8 REGULATORY COMPLIANCE

CE Compliance

Reference standard:

ETSI EN 301 489-1 V2.2.3:2019

ETSI EN 301 489-3 V2.1.1:2017

ETSI EN 302 208 V3.1.1:2017

IEC 62368-1:2018

See § *HADRONmini R1271C CE DECLARATION OF CONFORMITY* page 38 for the Hadron$_{mini}$ R1271C CE Compliance Certificate.

Warning: The CE compliance is guaranteed only if the reader is used as described in this manual

FCC Compliance

Regulatory Guidelines

The Hadron$_{mini}$ R1271C (Model Number WR1271CXUAAA) is approved for modular certification by FCC under the following ID number:

- FCC ID: UVECAENRFID031

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 Hadron$_{mini}$ R1271C. 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 Technical Information Manual and in the FCC filing for the Hadron$_{mini}$ R1271C. 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 Hadron$_{mini}$ R1271C. 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 Hadron$_{mini}$ R1271C 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.

Product Labeling

A statement must be included on the exterior of the final OEM product which communicates that the device identified by the above FCC number is contained within the product. For example:

> This product contains a radio module certified as FCC ID: UVECAENRFID031

OR

> Contains FCC ID: UVECAENRFID031

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.

Product Manuals

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

> 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

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 CAEN RFID, 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.

Antenna Requirements

The Hadron$_{mini}$ R1271C is compatible with many varieties of antennas, but for purposes of CAEN RFID's modular certification with FCC, only one antenna was tested. Hadron$_{mini}$ R1271C users can have their own antenna and Hadron$_{mini}$ R1271C systems certified with FCC.

In order to operate the Hadron$_{mini}$ R1271C under FCC ID: UVECAENRFID031, 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 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 Hadron$_{mini}$ R1271C into its final environment to ensure that the conditions are met.

Maximum Power Exposure (MPE) and Usage Limitations

The minimum safe distance for people from the Hadron$_{mini}$ R1271C 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.

See § *HADRONmini R1271C FCC Grant* page 39 for the Hadron$_{mini}$ R1271C FCC Compliance Certificate.

RoHS EU Directive

The Hadron$_{mini}$ R1271C RFID Reader is compliant with the EU Directive 2015/863/EU on the Restriction of the Use of certain Hazardous Substances in Electrical and Electronic Equipment (RoHS3).

HADRON$_{mini}$ R1271C
CE DECLARATION OF CONFORMITY

We

CAEN RFID Srl
Via Vetraia, 11
55049 Viareggio (LU)
Italy
Tel.: +39.0584.388.398 Fax: +39.0584.388.959
Mail: info@caenrfid.com
Web site: www.caenrfid.com

herewith declare under our own responsibility that the product:

Code: **WR1271CXEAAA**

Description: **R1271C Hadron$_{mini}$ – High-Performance 1-port Embedded RAIN RFID Reader ETSI**

corresponds in the submitted version to the following standards:

ETSI EN 301 489-1 V2.2.3:2019

ETSI EN 301 489-3 V2.1.1:2017

ETSI EN 302 208 V3.1.1:2017

IEC 62368-1:2018

and declare under our sole responsibility that the specified product meets the principle requirements and other applicable regulations of directives 2014/53/EU (RED) and 2015/863/EU (RoHS3)

Date: 12/07/2021

Adriano Bigongiari (Chief Executive Officer)

On the basis of this declaration, this product will bear the following mark: CE

The compliance is guaranteed only if the reader is used as described in the Hadron$_{mini}$ R1271C Technical Information Manual.

HADRON$_{mini}$ R1271C
FCC GRANT

TCB

GRANT OF EQUIPMENT AUTHORIZATION

Certification

Issued Under the Authority of the

Federal Communications Commission

By:

TCB

EMCCons DR RASEK GmbH & Co. KG
Stoernhofer Berg 15
Unterleinleiter, 91364
Germany

Date of Grant: 06/26/2020

Application Dated: 06/26/2020

CAEN RFID srl
via Vetraia, 11 - 55049 Viareggio (LU) - ITALY
Viareggio, 55049
Italy

Attention: Adriano Bigongiari , CEO

NOT TRANSFERABLE

EQUIPMENT AUTHORIZATION is hereby issued to the named GRANTEE, and is VALID ONLY for the equipment identified hereon for use under the Commission's Rules and Regulations listed below.

FCC IDENTIFIER: UVECAENRFID031
Name of Grantee: CAEN RFID srl
Equipment Class: Part 15 Spread Spectrum Transmitter
Notes: R1271C HadronMini 1-port Embedded RAIN RFID Reader
Modular Type: Limited Single Modular

Grant Notes	FCC Rule Parts	Frequency Range (MHZ)	Output Watts	Frequency Tolerance	Emission Designator
	15C	902.75 - 927.25	0.516		

Output power is conducted. The antenna(s) used for this transmitter must be installed to provide a separation distance of at least 20 cm from all persons and must not be collocated or operating in conjunction with any other antenna or transmitter within a host device, except in accordance with FCC multi-transmitter product procedures. This module can only be used with a host antenna circuit trace layout design in strict compliance with the OEM instructions provided. Installers and end-users must be provided with antenna installation instructions and transmitter operating conditions for satisfying RF exposure compliance.