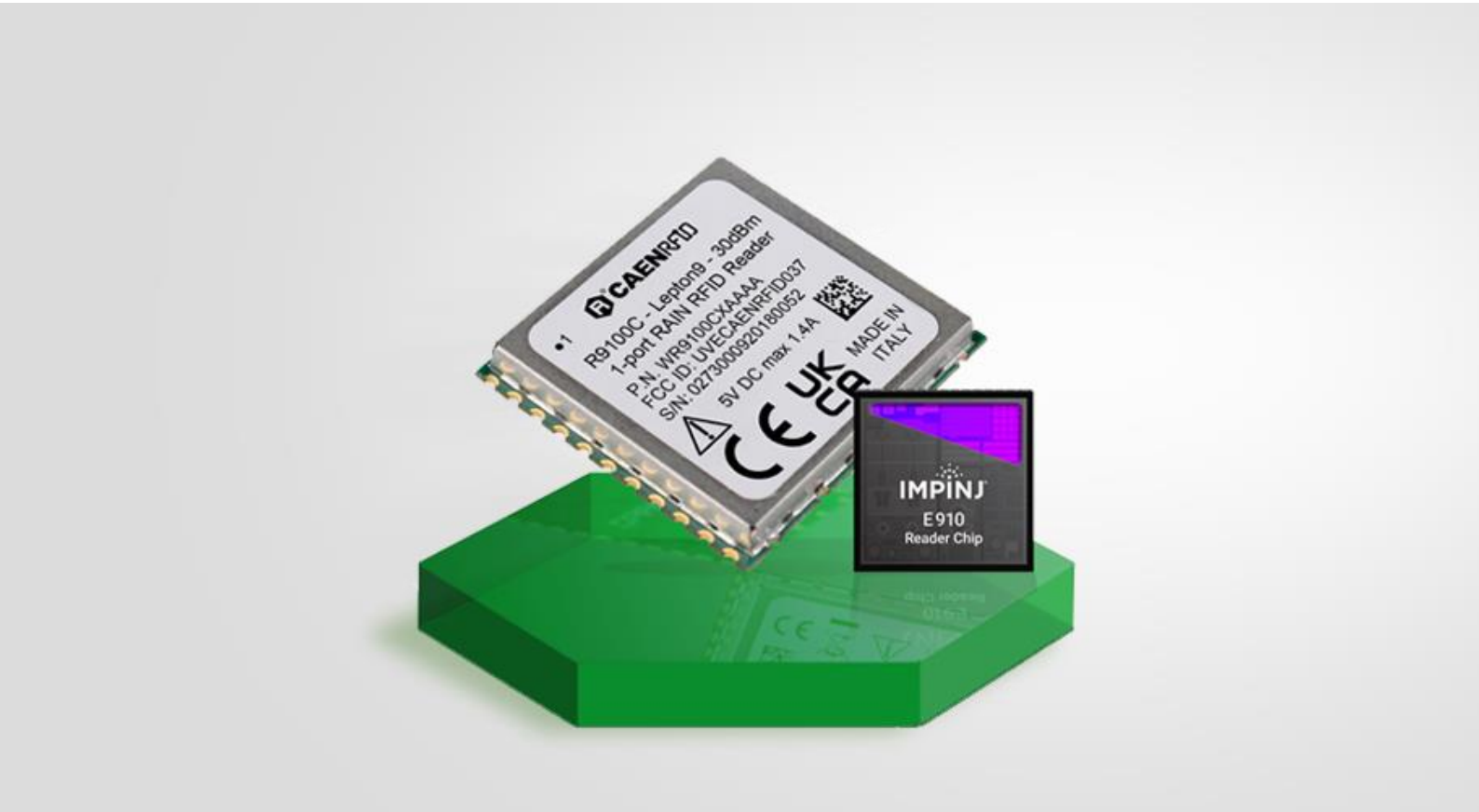
TECHNICAL INFORMATION MANUAL

Revision 1 - 16/06/2023

R9100C

Lepton⁹

30dBm 1-Port RAIN RFID Reader Module



Visit the Lepton[9] R9100C 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 Lepton[9] R9100C Reader and the RHML37XEVB evaluation board.

This manual refers to:

- **Lepton[9] R9100C firmware revision ≥ 1.0.0**

Change Document Record

Date	Revision	Changes	Pages
22/12/2022	00	Preliminary revision	-
16/06/2023	01	Added CE Declaration of Conformity and UKCA Declaration of Conformity in the *Regulatory Compliance* chapter	35÷37
		Removed *WKUP pin* information in the *Hardware Interface* chapter	11÷18
		Modified *Tab. 3.4: Supply Current Specifications*	16
		Modified *Fig. 3.1: Lepton9 R9100C - Example of Block Diagram*	11
		Modified images in the *Firmware Upgrade* chapter	24, 25

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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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.

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1 INTRODUCTION

Description

Reader

The Lepton[9] (Model R9100C), 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 30dBm, the reader can detect tags at more than 5 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 E910 IC 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 Lepton[9] inside the new small form factor industrial handhelds, smartphone accessories and other compact form factor devices.

The Lepton[9] complies with and can operate in both European and US regulatory environments and, thanks to its multiregional capabilities, it's ideal for integration in devices requiring compliance to different geographical regions.

The Lepton[9] is pin-to-pin compatible with the Impinj RS1000 and RS500 modules making it a perfect replacement for these devices.

Fig. 1.1: Lepton[9] Reader – top view

Fig. 1.2: Lepton[9] Reader – back view

Evaluation Board

The Mod. RHML37XEVB allows managing the Lepton[9] R9100C reader directly via USB interface.
This board is particularly suited for Lepton[9] R9100C reader evaluation and SW development purpose.

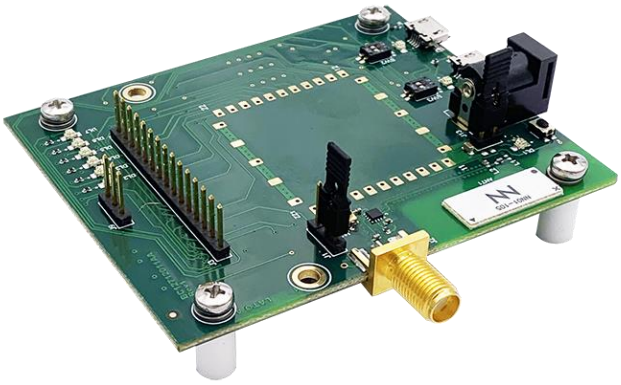


Fig. 1.3: WRHML37XEVBX Evaluation Board for Lepton[9] R9100C

Development Kit

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

The kit includes:

- n. 1 WRHML37XEVBX - Lepton[9] R9100C - 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 WALIM0000005 Wall mount AC-DC power supply

The Lepton[9] R9100C reader and its development kit are a complete set up for a quick implementation of RFID solutions.

Fig. 1.4: Lepton[9] R9100C reader and WRHML37XDKEU-WRHML37XDKUS Accessories kit

Ordering Options

	Code	Description
Reader	WR9100CXAAAA	R9100C - Lepton[9] - 30dBm 1-Port RAIN RFID Reader Module
Evaluation Board	WRHML37XEVBX	Evaluation Board for R1271C, R3100C, R7100C and R9100C
Development Kit	WRHML37XDKEU	R1271C, R3100C, R7100C and R9100C ETSI Dev Kit with antenna, interface, pws and tags (reader not included)
	WRHML37XDKUS	R1271C, R3100C, R7100C and R9100C 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 v3.3.1) 902÷928 MHz (FCC part 15.247)
RF Power	Configurable from 10 dBm to 30 dBm (from 10 mW to 1W) conducted power
RX Sensitivity	-90dBm – 10%PER, assuming 20 dB antenna RL @ 30 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 v3.3.1) 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 921.6 kbps • Databits: 8 • Stopbits:1 • Parity: none • Flow control: none – 3.3 V I/O voltage level
Power Supply	4.75 ÷ 5.25 V DC
Power Consumption	- 1.4 A @ 5 V - RF out = 30 dBm - 5 mA in idle mode - Ready to receive commands
Dimensions	(L) 32 x (W) 29 x (H) 4.1 mm^3 1.26 x 1.14 x 0.16 $inches^3$
Package Type	32 pin surface mount module (SMT compatible)
Operating Temperature	-20°C to +70°C
Weight	5.4 g

Tab. 2.1: Lepton[9] R9100C 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
- Both ETSI and FCC support in the same module
- Ultra compact size
- Up to 30 dBm (1W) output power
- -90 dBm Rx sensitivity, assuming 20 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 4.1 mm surface mount package with SMT compatibility
- Single mono-static RF port
- Field upgradability via firmware updates
- UART serial interface using CAEN RFID easy2read© protocol

3 HARDWARE INTERFACE

Introduction

An example Lepton[9] R9100C system-level block diagram for an embedded system is shown in *Fig. 3.1: Lepton9 R9100C - Example of Block* Diagram. This figure shows the electrical connections that may and must be made to control the Lepton[9] R9100C. 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.

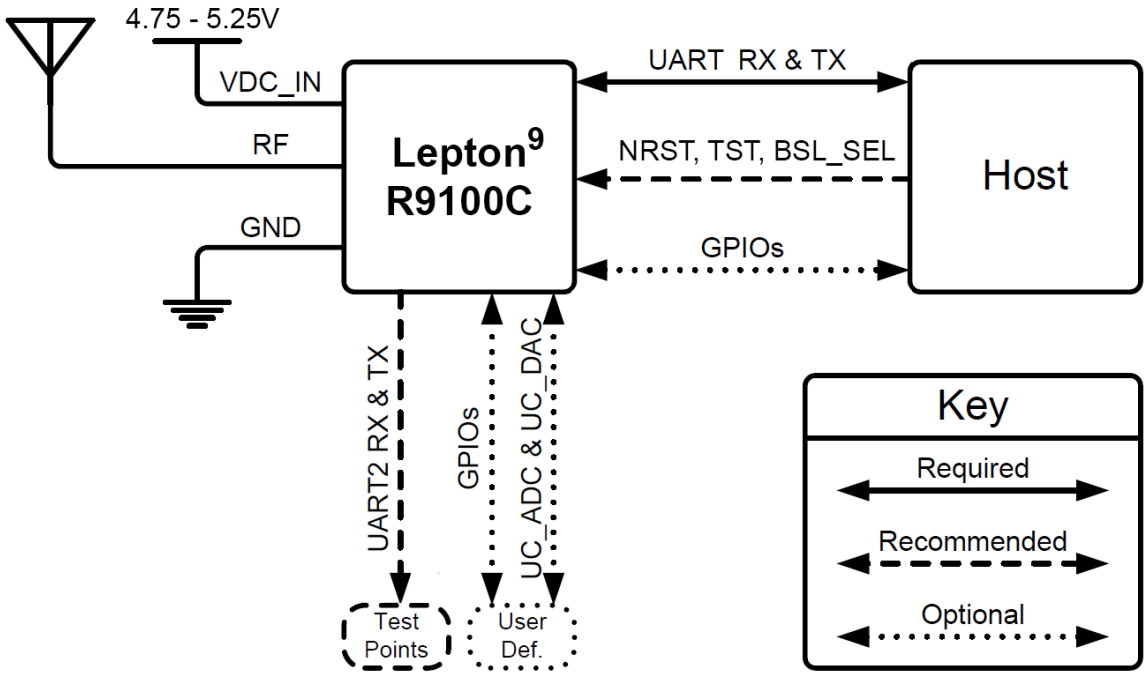


Fig. 3.1: Lepton[9] R9100C - Example of Block Diagram

Required connections:

- VDC_IN and GND are required to power the Lepton[9] R9100C.
- 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 Lepton[9] R9100C 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.
- TST and BSL_SEL shall be used for the FW recovery/upgrade procedure.

  To start the Boot Strap Loader of Lepton[9] internal microcontroller NRST, TST and BSL_SEL signals shall be driven as in the picture below:

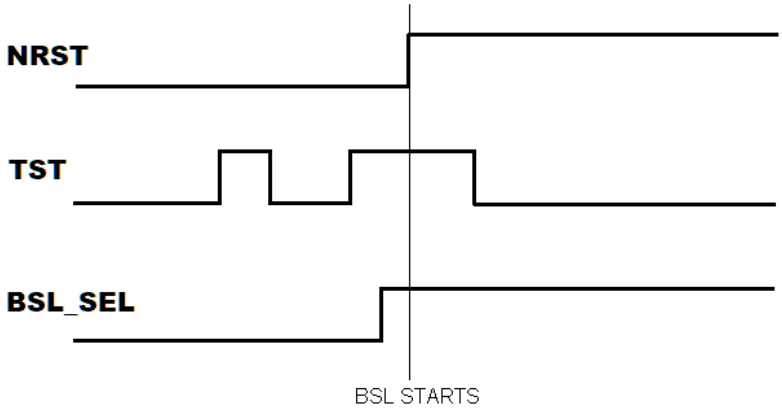


Fig. 3.2: BSL sequence

The BSL program execution starts when TST pin has received a minimum of two positive transitions and if TST is high while /RST rises from low to high. BSL_SEL shall be at high level before BSL starts. Pulses length and distance between edges of all signals shall be 10ms at least.

- UART2 Tx and Rx may be used to examine debug information.

Optional connections:

- GPIOs allow interaction with the Lepton[9] R9100C 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.
- 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.
- RFU is a GPIO reserved for future use.

Power Supply

The Lepton[9] R9100C is powered by a voltage applied to the VDC_IN pin (pin 11) relative to the GND pins. The supply voltage operating range is 4.75 V to 5.25 V. Current consumption varies from about 1400 mA to about 5mA 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 Lepton[9] R9100C 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 Lepton[9] R9100C 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 19.

UART Communication

The Lepton[9] R9100C 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 easy2read©, and UART2 implements the debug interface (RFU). The Tx pins are outputs from the Lepton[9] R9100C, and the Rx pins are inputs to the Lepton[9] R9100C. Both UART interfaces are 921,600 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 17. The TX pins are driven strong high and low with a sink/source current of about 8 mA. If the load on a pin draws more than the 8 mA sink and source current, the pin is not guaranteed to meet the VOH and VOL specs listed in

the § *Device Input and Output Specifications* paragraph page 17. 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 Lepton[9] R9100C 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 Lepton[9] R9100C 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 51,1 kΩ nominal resistor. To reset the part, drive the pin strong low for at least the minimum reset pulse width as specified in the § *Device Input and Output Specifications* paragraph page 17 (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 Lepton[9] R9100C 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.

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.

GPIO Pins

The Lepton[9] R9100C's GPIOs can be controlled using the easy2read© interface. Their drive mode, direction, and state are all controllable via easy2read©. 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 easy2read© to control the GPIOs, see the easy2read© protocol 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 17.

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 35 kΩ nominal. See the in the § *Device Input and Output Specifications* paragraph page 17 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 17.

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.

Pin Listing and Signal Definitions

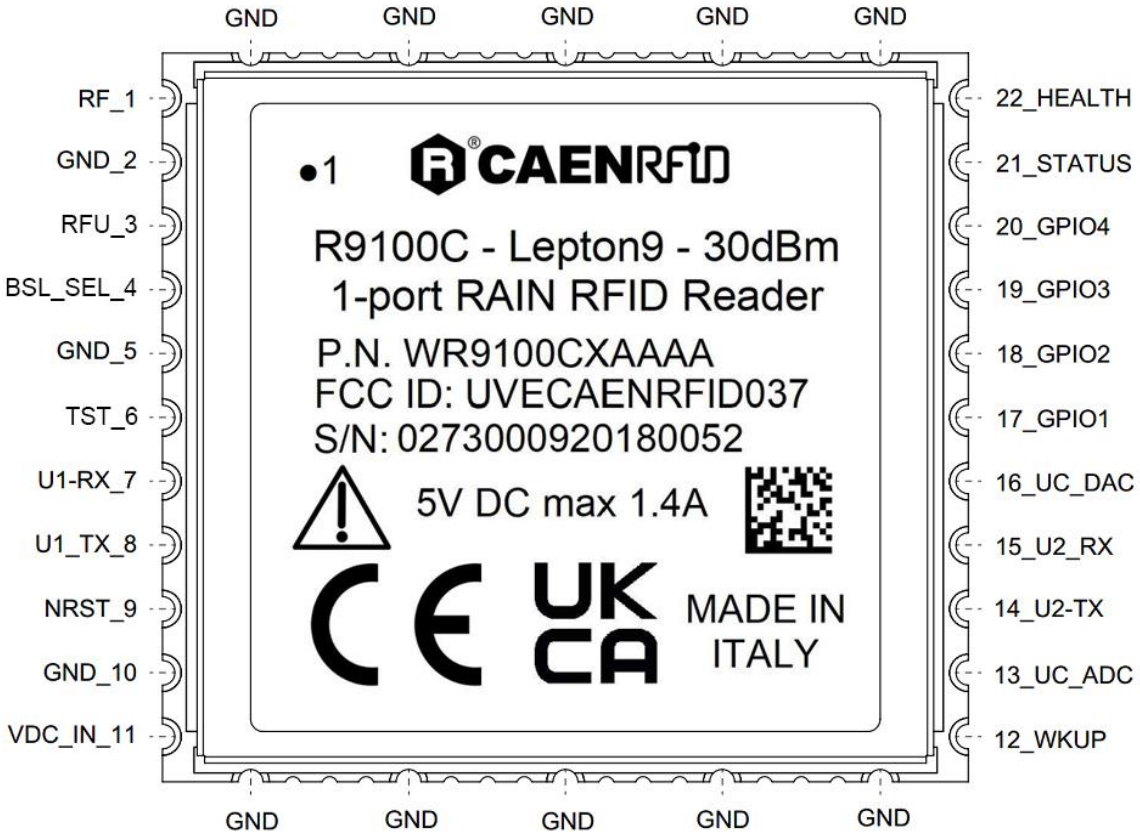


Fig. 3.3: Lepton[9] R9100C Pin Listing

Pin#	Pin Name	Pin Type	Description
1	RF	RF	RF antenna port
2	GND	Power	Ground
3	RFU	Digital I/O	Reserved for Future Use
4	BSL_SEL	Digital Input	Boot Strap Loader interface enable signal
5	GND	Power	Ground
6	TST	Digital Input	TST pin to be used for FW recovery/upgrade
7	UART1-RX	Digital Input	R9100C UART Rx (Receive) from host
8	UART1-TX	Digital Output	R9100C UART Tx (Transmit) to host
9	NRST	Digital Input	Active low reset. Connect to open drain driver. R9100C must be able to internally pull down this signal to reset.
10	GND	Power	Ground
11	VDC_IN	Power	DC voltage supply (4.75 – 5.25 V)
12	WKUP - RFU	Digital Input	Reserved for future use
13	UC_ADC	Analog Input	Analog to digital converter input
14	UART2-TX	Digital Output	R9100C Debug UART Tx to host
15	UART2-RX	Digital Input	R9100C 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- RFU	Digital Output	Reserved for future use
22	HEALTH- RFU	Digital Output	Reserved for future use
23-32	GND	Power	Ground pins on the top and bottom edge of the package

Tab. 3.1: Pin Listing and Signal Definitions

Electrical Specifications

Absolute Maximum Ratings

The absolute maximum ratings (see *Tab. 3.2: Absolute Maximum Ratings*) define limitations for electrical and thermal stresses. These limits prevent permanent damage to the Lepton[9] R9100C.

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	-	+30	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	-	-	-	Lepton[9] R9100C 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. 3.2: Absolute Maximum Ratings

Operating Conditions

This section describes operating voltage, frequency, and temperature specifications for the Lepton[9] R9100C during operation.

Parameter	Min.	Max.	Unit	Conditions
Supply	4.75	5.25	V	VDC_IN relative to GND
Temperature	-20	+70	°C	Ambient Temperature
Frequency	902	928	MHz	FCC part 15.247
	865.6	867.6	MHz	ETSI EN 302 208 v3.3.1

Tab. 3.3: Operating Conditions

Device Functional Specifications

This section describes operating voltage, frequency, and temperature specifications for the Lepton[9] R9100C during operation.

Parameter	Typ.	Unit	Description
Supply Current			Current consumed by Lepton[9] R9100C via VDC_IN pin
Active mode - 5V supply	1400	mA	+30 dBm transmit power Inventorying tags
Idle mode – low latency	45	mA	Ready to receive easy2read© protocol packets. Lower latency to return to Active mode.
Idle mode – standard latency	5	mA	Ready to receive easy2read© packets

Tab. 3.4: Supply Current Specifications

UHF Gen 2 RFID Radio Specifications

Parameter	Min.	Typ.	Max.	Unit	Conditions
Frequency	902		928	MHz	See § *Tab. 2.1: Lepton9 R9100C Technical Specifications* page 9
	865.6		867.6	MHz	
Input impedance		50		Ω	
Input match		-10		dB	S11
Rx sensitivity		-90		dBm	10%PER, assuming 20 dB antenna RL @ 30 dBm output

Tab. 3.5: RF Receiver Specifications

Parameter	Min.	Max.	Unit	Notes
Tx Power	10	30	dBm	Meets FCC and equivalent regulatory constraints
Tx Power Error		1	dB	Difference between desired Tx power and actual Tx power
Return Loss	0		dB	No damage into open RF port at 30 dBm at any phase angle
Frequency	865.6	867.6	MHz	ETSI EN 302 208 v3.3.1
	902	928	MHz	FCC part 15.247

Tab. 3.6: 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		400		mV	
Internal pull-up resistor	14	21	25	kΩ	
Reset pulse width	25			µs	
WKUP					
VIL	-0.3		0.8	V	
VIH	2		3.6	V	
Hysteresis voltage		400		mV	
Internal pull-down resistor	20	35	50	kΩ	
Digital inputs					
VIL	-0.3		0.8	V	
VIH	2		3.6	V	
Hysteresis voltage		400		mV	
Internal pull-down resistor	20	35	50	kΩ	
Digital outputs					
VOL	0.0		0.6	V	
VOH	2.7		3.6	V	
Drive current (sink or source)	8			mA	
UART					
Default baud rate			921.6	kbaud	
Configurable baud rate	9.6		921.6	kbaud	
Data bits		8		bits	
Parity bit		None			
Stop bits		1		bits	

Tab. 3.7: Digital Interface Specification

Parameter	Min.	Typ.	Max.	Unit	Conditions
ADC (Pin 13)					
Resolution		12		Bits	
Conversion voltage range	0		3.3	V	
Sampling rate	0.47		2.7	MSPs	
Total conversion time			3.1	µsec	
Power-up time			3.1	µsec	
Sampling switch resistance			200	Ω	
Internal sample and hold capacitance			25	pF	
Total unadjusted error		±3.5	±7.1	LSB	
Offset error		±3.0	±5.6	LSB	
Gain error		±1	±2.5	LSB	
DNL error			±1	LSB	
INL error			±2	LSB	
DAC (Pin 16)					
Resolution		12		Bits	
Resistive load	3			kΩ	
Capacitive load			100	pF	Maximum capacitive load at the DAC_OUT pin
Output voltage range	0.1		3.15	V	
DNL			±1	LSB	
INL			±4	LSB	
Offset			±21	mV	
Gain error			±2.5	%FSR	
Settling time		15	30	µsec	CLOAD < 50 pF & RLOAD > 5 kΩ

Tab. 3.8: Analog Interface Specification

EPC Class-1 Generation-2 Operation

Supported RF modes

The Lepton[9] R9100C supports the following link profiles, whose characteristics are reported in the following table:

Link Profile	Regulation	Forward Link Profile			Reverse Link Profile	
		R2T Modulation	Tari	PIE	T2R Modulation	Link Frequency
1	ETSI	PR-ASK	20 µs	2	Miller M=2	320 kHz
2	ETSI	PR-ASK	20 µs	2	Miller M=4	320 kHz
3	FCC	PR-ASK	20 µs	2	Miller M=4	250 kHz
4	ETSI	PR-ASK	15 µs	2	Miller M=2	320 kHz
5	ETSI/FCC	PR-ASK	20 µs	2	Miller M=8	160 kHz
6	FCC	PR-ASK	7.5 µs	2	FM0	640 kHz
7	FCC	PR-ASK	7.5 µs	2	Miller M=2	640 kHz
8	FCC	PR-ASK	7.5 µs	2	Miller M=4	640 kHz
9	FCC	DSB-ASK	6.25 µs	2	FM0	640 kHz
10	FCC	DSB-ASK	6.25 µs	2	Miller M=2	640 kHz

Tab. 3.9: RF Modes – Forward and Reverse Link Profiles

4 LAYOUT AND COMPONENTS

Introduction

This section describes hardware aspects of embedded RAIN RFID readers based on the Lepton[9] R9100C.

PCB Layout for RF

50 Ohm Characteristic Impedance

As discussed in paragraph *RF Connection* page 12, a properly matched RF connection is critical to achieving high performance with Lepton[9] R9100C. 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 Lepton[9] R9100C'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 Lepton[9] R9100C, 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 Lepton[9] R9100C, and only 88.9% of the power will be transmitted.

Lepton[9] R9100C is designed to connect to a 50-Ohm characteristic impedance load. The connection between the Lepton[9] R9100C 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 19. Material properties to note include the dielectric constant of the dielectrics in the PCB, and the conductivity of the conductor used.

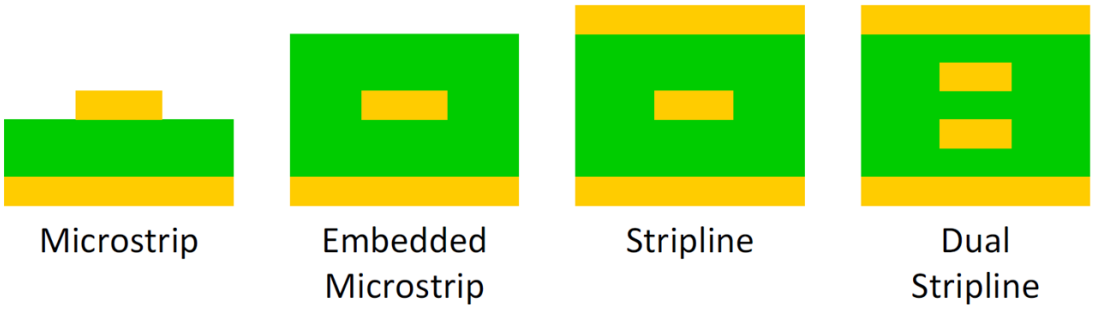


Fig. 4.1: PCB Transmission Line Types

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 Lepton[9] R9100C module is roughly 5.4 grams.

Package Dimensions

Package dimensions are shown in the following figure:

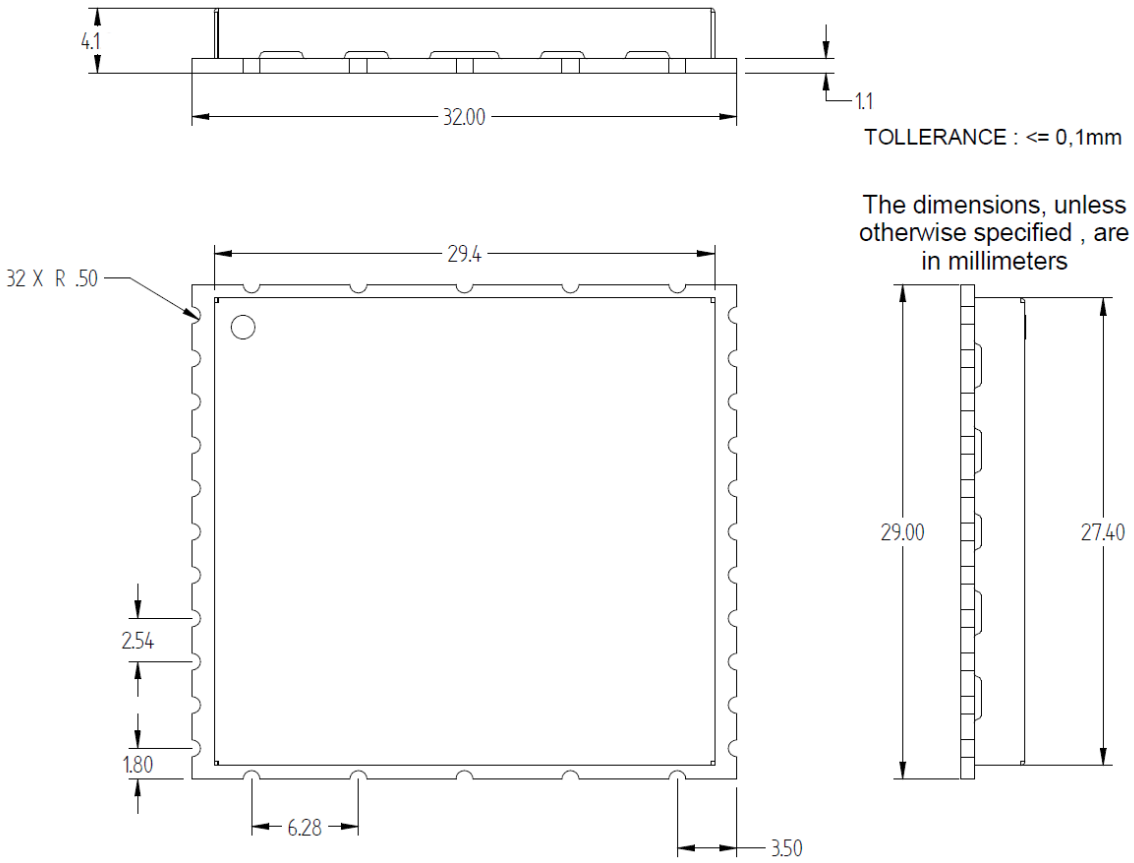


Fig. 4.2: Package Dimensions, Top, Front, and Side Views

Download the *Lepton[9] R9100C Technical drawing* at Lepton[9] R9100C web page (*Documents* section).

PCB Footprint

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

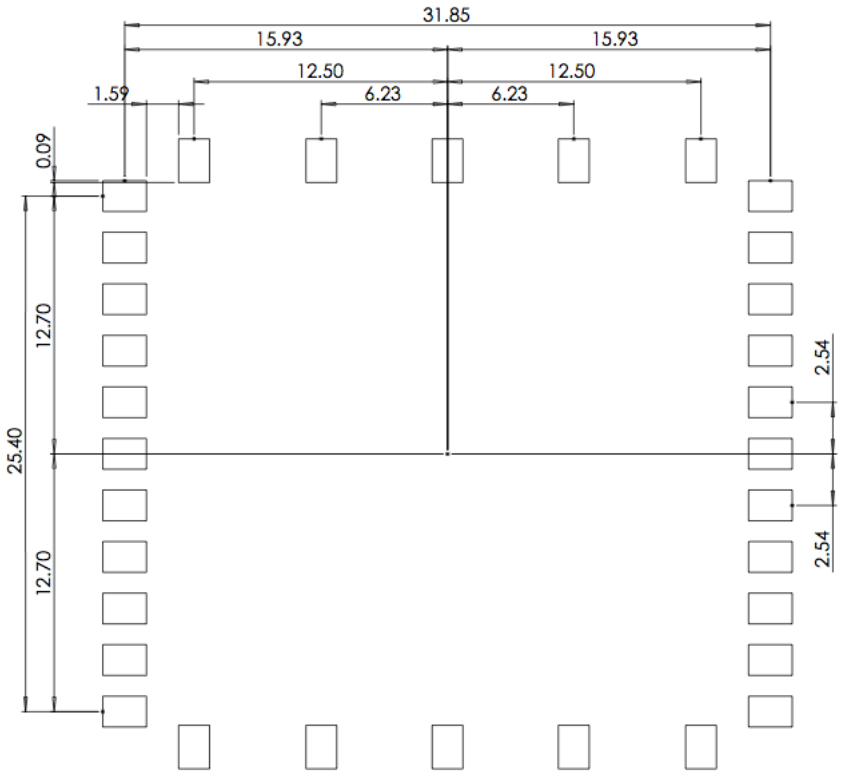
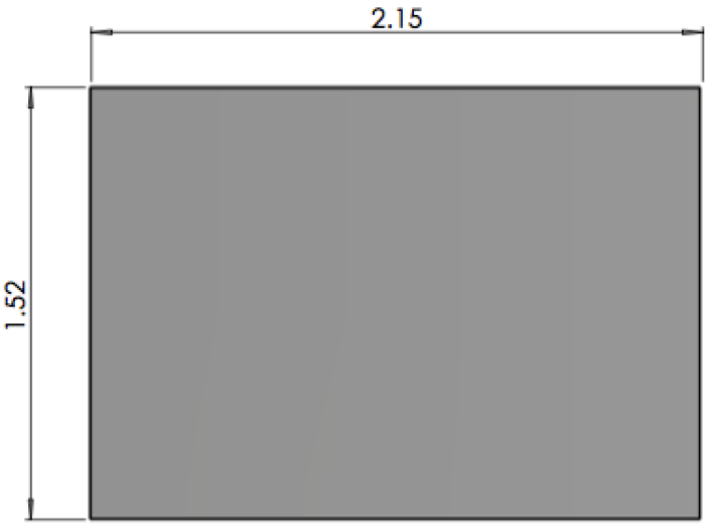


Fig. 4.3: Recommended Etched Copper Footprint – All Pads



units: mm

Fig. 4.4: Pad size

SMT Reflow Information

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

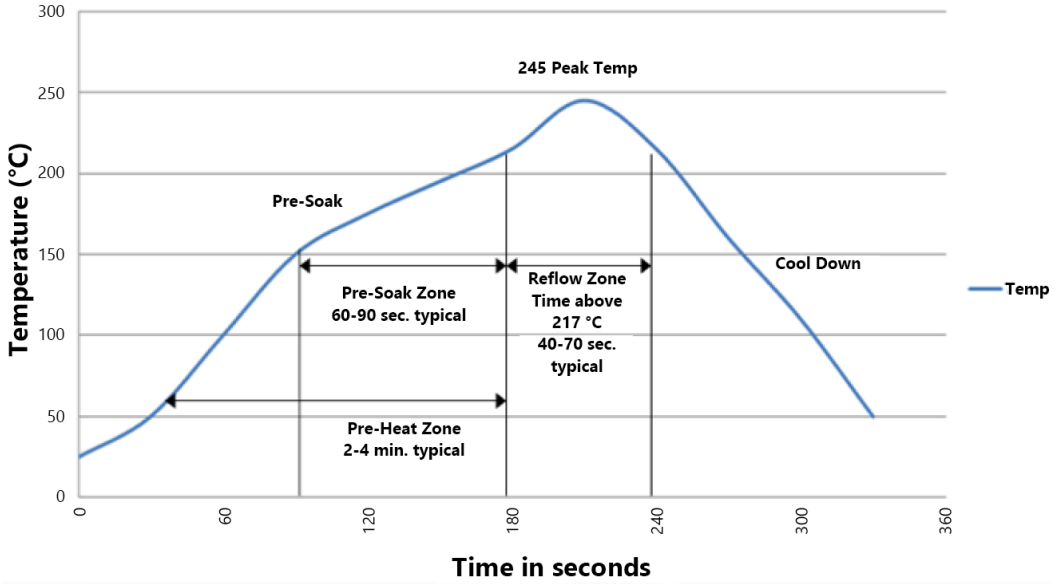


Fig. 4.5: Recommended Solder Reflow Profile for the Lepton[9] R9100C

Moisture Sensitive Level 3 (MSL 3)

CAEN RFID srl follows JEDEC standards for moisture classifications. The Lepton[9] R9100C 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 Lepton[9] R9100C 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

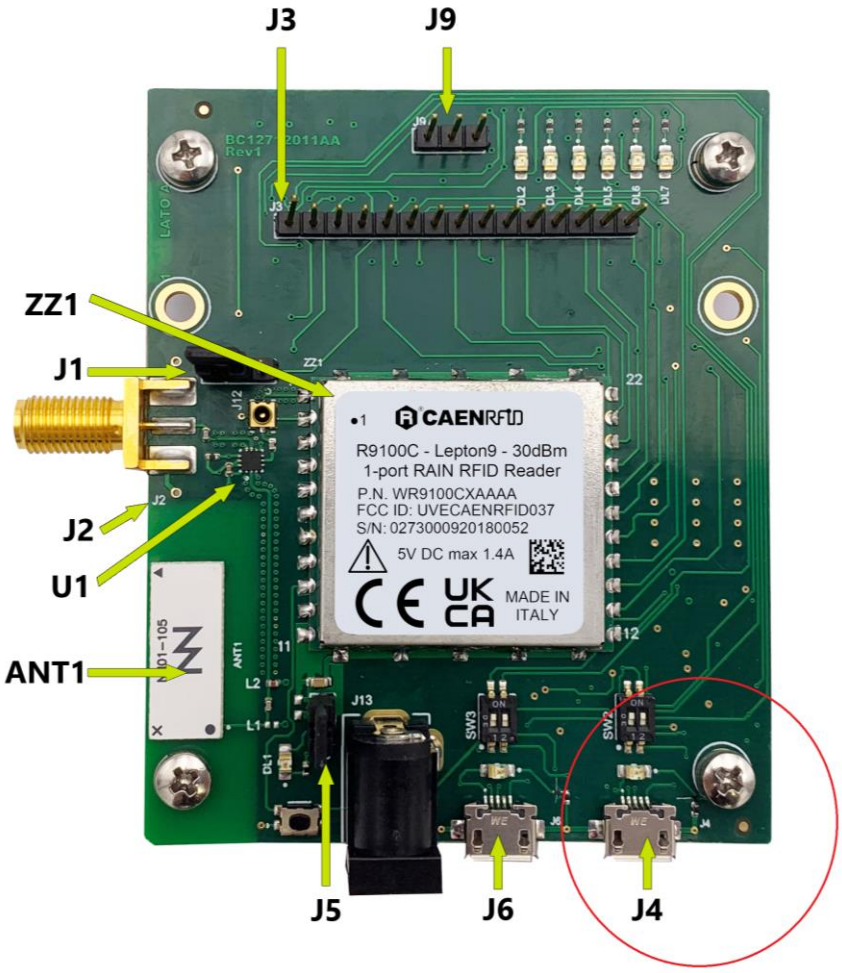
1. Before a device is removed from the module, the module must first be baked.
2. Baking should be done for a minimum of 48 hours at 125°C or 24 hours at 150°C.
3. It is recommended that during removal, localized heating be used, and the maximum body temperature of device should not exceed 200°C.
4.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

5 FIRMWARE UPGRADE

The Lepton[9] R9100C reader firmware upgrade shall be performed via UART1 interface.

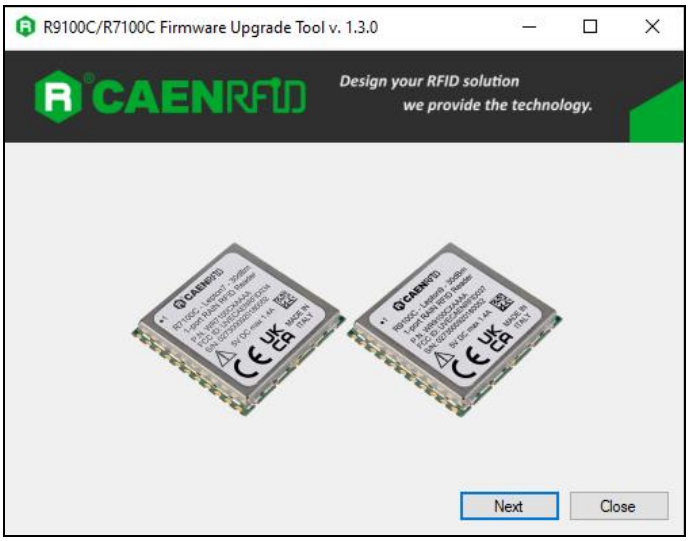
In the following procedure it is assumed to use the WRHML37XEVBX adapter board, a PC as host and the USB interface of the board connected via an USB-UART converter to the module.

1) Power on the board via the DC power jack (J13) and connect the USB cable to J4 connector and to the PC.

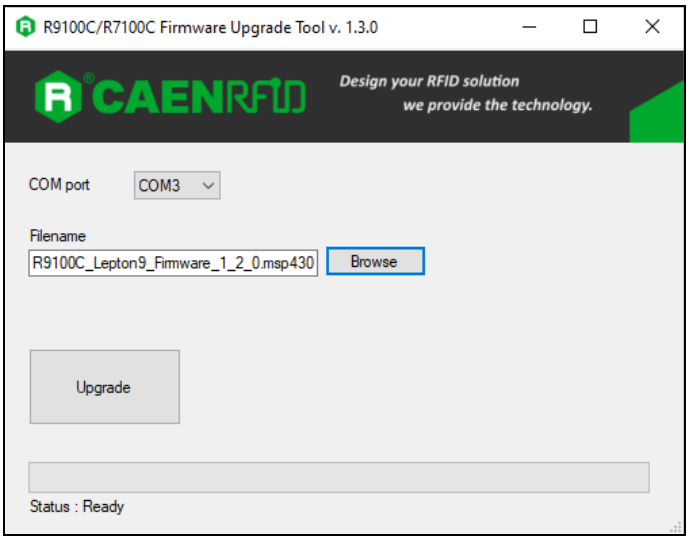


2) Download the *R9100C Lepton[9]/R7100C Lepton[7] Upgrade Tool* and the *R9100C Lepton[9] Firmware* at the *R9100C Lepton9 web page*.

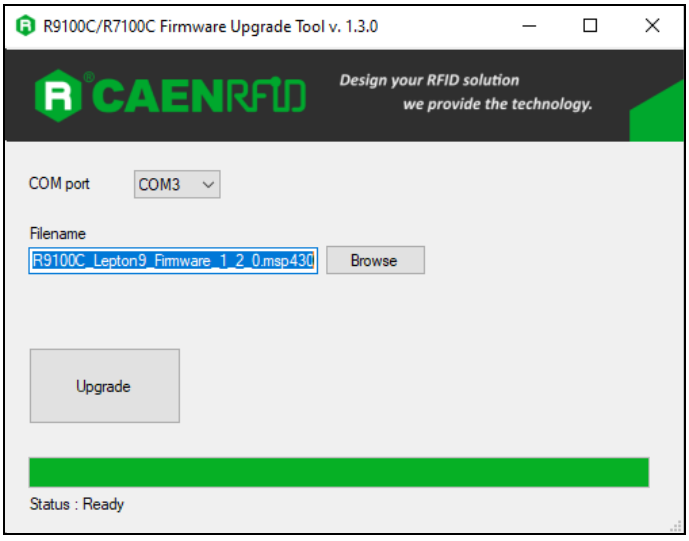
3) Launch the *R9100C Lepton[9]/R7100C Lepton[7] Upgrade Tool* and click on *Next* button.



4) Select the COM port related to the device (Bossa Program Port assigned by OS).
5) Select the R9100C Lepton[9] firmware image file.
6) Click on the *Upgrade Firmware* button:



7) Wait for the progress bar to be full:



8) Switch off the module; at the next power on the device will be operating with the new FW image.

6 EVALUATION BOARD

Introduction

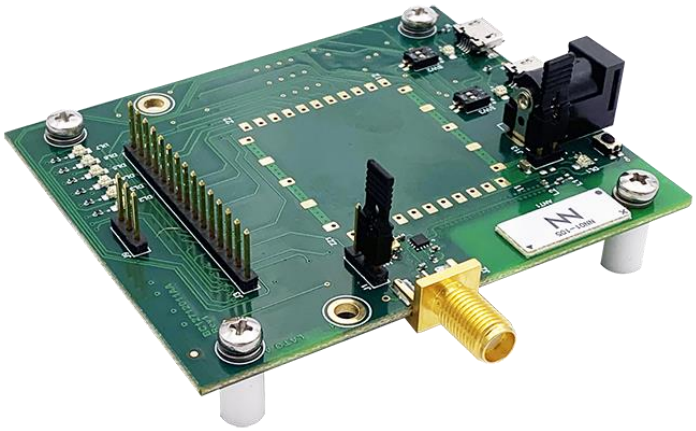


Fig. 6.1: WRHML37XEVBX Evaluation Board for R9100C

The WRHML37XEVBX Evaluation Board enables quick evaluation and development with Lepton[9] R9100C. It provides an easy way to communicate with the Lepton[9] R9100C 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 Lepton[9] R9100C 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	Ignion NN01-105
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%
Current consumption	1.5A max
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. 6.1: WRHML37XEVBX Evaluation Board - Technical Specifications

Evaluation Board Overview

A block diagram of the WRHML37XEVBX Evaluation Board is shown in *Fig.* 6.2: Evaluation Board Block Diagram. It shows the most notable components and connections on the PCB. The block diagram shows the Lepton[9] R9100C module's main connections: power, RF, and UART communication. The power for the Lepton[9] R9100C is provided by a +5V AC/DC adapter at DC power jack J13 (inner pin is the GND, outer is the +5V). 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 Lepton[9] R9100C can be connected via the USB- UART IC (using a USB micro cable), via the Raspberry Pi HAT connector, or via the breakout header.

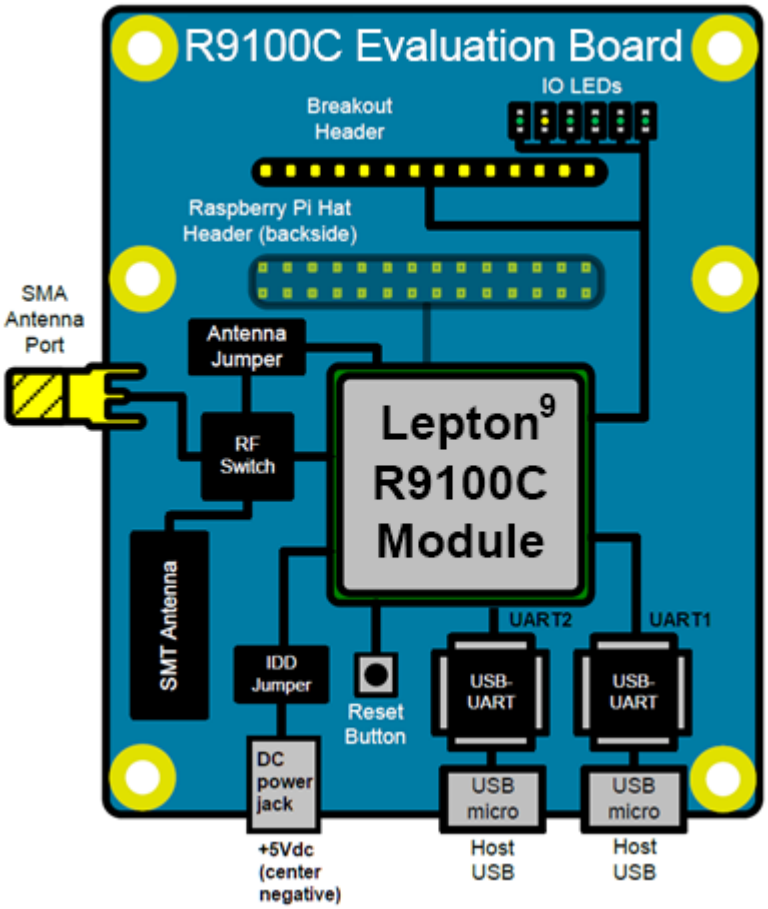


Fig. 6.2: Evaluation Board Block Diagram

Lepton[9] R9100C Evaluation Board Key Components

The WRHML37XEVBX Evaluation Board is designed to allow easy development of Lepton[9] R9100C applications using a PC or other hosts capable of generating easy2read© 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.* 6.3: WRHML37XEVBX Evaluation Board Key Components. Components on the backside are shown with dotted lines. This section describes these components and connectors in detail.

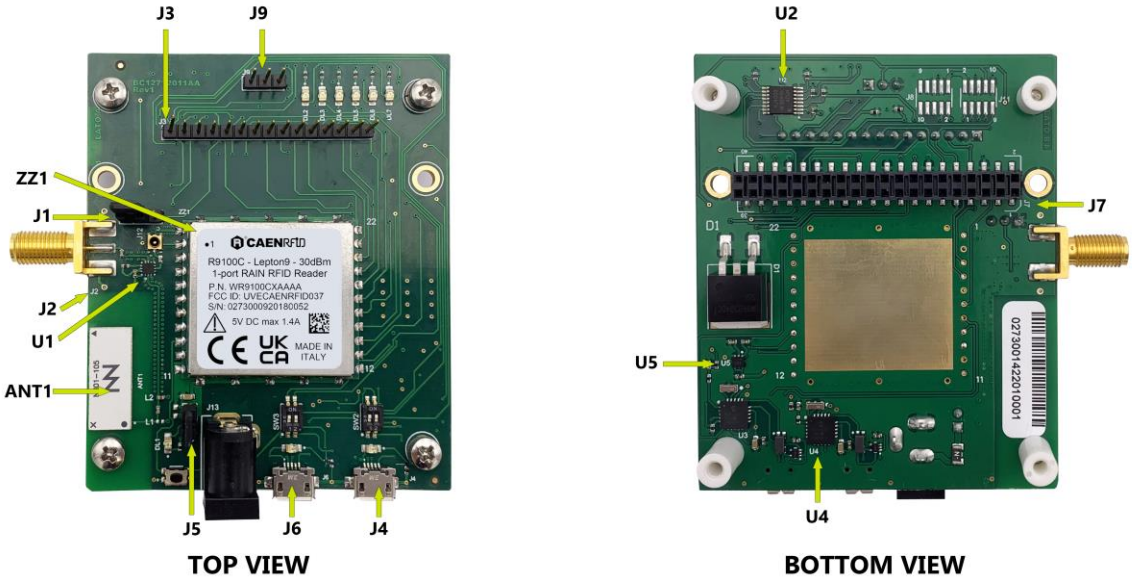


Fig. 6.3: WRHML37XEVBX Evaluation Board Key Components

Integrated Circuit Component Descriptions

ZZ1 is the Lepton[9] R9100C 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 (Ignion NN01-105). 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 Lepton[9] R9100C'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 Lepton[9] R9100C 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 easy2read© SDK documentation. The RF switch IC is a Peregrine PE42422.

U3 and U4 are the USB-UART ICs. They allow an USB host to communicate with the Lepton[9] R9100C module via 3.3 volt UART. U3 connects to the host serial interface (UART1) via the micro USB connector J4.

U4 connects to the debug serial interface (UART2) via the micro USB connector J6. Both will be presented on a host as connection options. On a windows PC, they will be shown COM ports. On a linux PC, they will appear as /dev/ttyUSB<X>. The USB-UART IC is the Microchip MCP2200-I/MQ.

U5 is the 3.3 volt linear regulator IC for the USB-UART ICs. The USB-UART ICs require 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 and J6 are the host USB micro connectors. They allow a PC host to connect to the UART1 and UART2 communication ports of the Lepton[9] R9100C module via the USB-UART ICs U3 and U4 respectively. Please note that such connectors do not provide power to the board.

J13 is the power supply connector, the central pin (2.1mm diam.) is the negative terminal. The use of the WALIM0000005 Wall mount AC-DC power supply is recommended (see § Development Kit). Maximum power consumption is 1.5A.

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 Lepton[9] R9100C's RF port.

J12 is a coaxial switch connector (Hirose MS-156HF) that can be used to perform measurements directly at RF output pin of Lepton[9] R9100C. Verification of the circuit performance is accomplished by simply inserting the external plug (i.e. Hirose MS-156-HRMJ-H1) in the board mounted receptacle. This action re-directs the circuit from normal condition to the plug side. Removing the plug restores circuit to its normal condition.

J3 is a breakout header for the IOs of the Lepton[9] R9100C 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 Lepton[9] R9100C, 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 Lepton[9] R9100C.

J5 is the series current "IDD" jumper. It allows a series current measurement to be performed while the Lepton[9] R9100C is operating. If no series current measurement is desired, the jumper should be populated with a short, so that the Lepton[9] R9100C receives power.

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

Switch Descriptions

SW1 is a pushbutton that can be used to reset the Lepton[9] R9100C.

SW2 and SW3 connect or disconnect from the USB-UART ICs module's UART1 and UART2 respectively according to the following configuration:

- SW2 closed to be used when UART1 via USB interface is used (connection to PC via J4 connector)
- SW2 open to be used when UART1 interface is used directly connected to external device (i.e. when the board is plugged in a Raspberry PI via HAT connector J7 or it is connected to external controller via the breakout header J3)
- SW3 closed to be used when UART2 via USB interface is used (connection to PC via J6 connector)
- SW3 open to be used when UART2 interface is used directly connected to external device (i.e. when the board is plugged in a Raspberry PI via HAT connector J7 or it is connected to external controller via the breakout header J3)

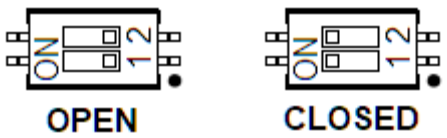


Fig. 6.4: SW2 and SW3 configuration

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.
3. SW2 closed so that UART1 interface is accessible via PC USB host via J4.
4. SW3 closed so that UART2 interface is accessible via PC USB host via J6.

Evaluation Board USB-UART Details

U3 and U4 are USB-UART converters made by Microchip. Their part number is MCP2200-I/MQ. This part allows a PC to communicate with the Lepton[9] R9100C over USB. The MCP2200 part achieves this by enumerating as an USB device and adding a COM port. In Windows, this COM ports can be viewed in the Device Manager under the "Ports (COM & LPT)" category. To identify the COM port associated to UART1 host interface connect USB cable to J4 connector only. To identify the COM port associated to UART2 host interface connect USB cable to J6 connector only.

Evaluation Board Schematic

The schematic for the WRHML37XEVBX evaluation board is shown in *Fig.* 6.5: Evaluation Board Schematic. A high resolution PDF of the schematic can be downloaded from the Lepton[9] R9100C web page (*Lepton[9] R9100C Technical drawing*).

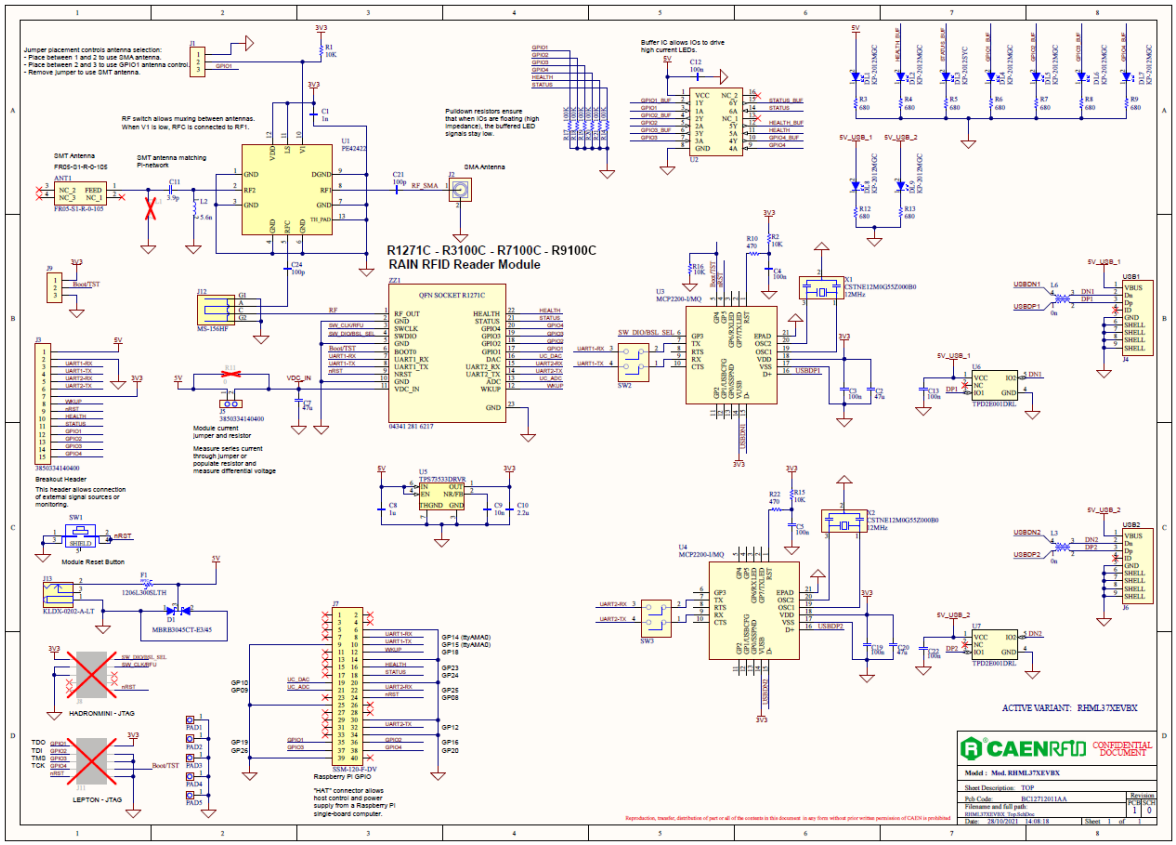


Fig. 6.5: Evaluation Board Schematic

Evaluation Board Layout

The layout shows the physical construction of the WRHML37XEVBX evaluation board. The top and bottom layers are shown in *Fig. 6.6: Evaluation Board Front and Backside(flipped) Layout*. The layout can be downloaded from the Lepton[9] R9100C web page (*Lepton[9] R9100C Technical drawing*).

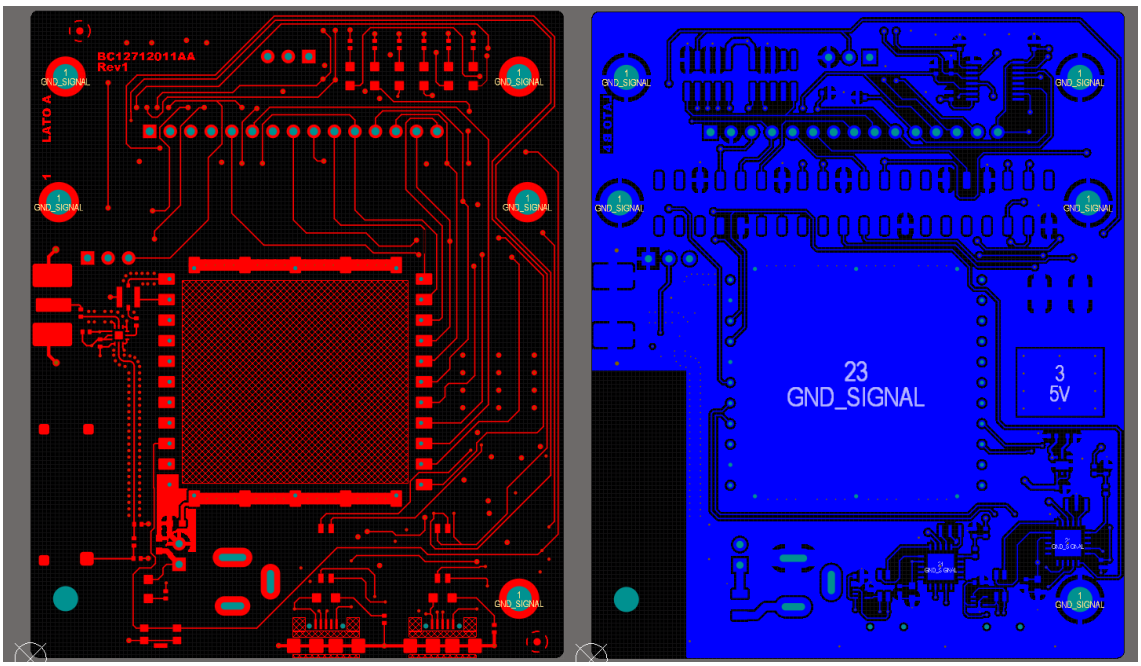


Fig. 6.6: Evaluation Board Front and Backside(flipped) Layout

The ground plane free of component on the bottom side of the board under Lepton[9] 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.

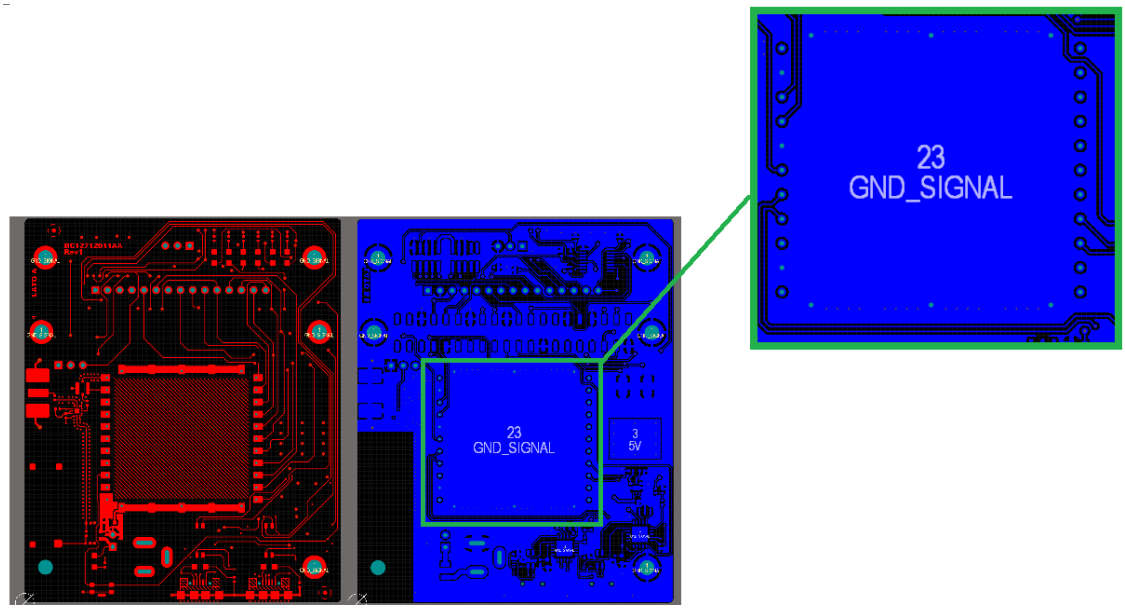


Fig. 6.7: Evaluation Board Front and Backside(flipped) Layout - detail

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 Lepton[9] R9100C web page (*Lepton[9] R9100C Technical drawing*).

Connecting to the Lepton[9] R9100C reader

USB Communication Setup

Warning: If your PC is running a Windows version older than Windows 10, to correctly operate with the reader, you need to install the *Gadget Serial USB driver*. You can find it easily via a WEB research.

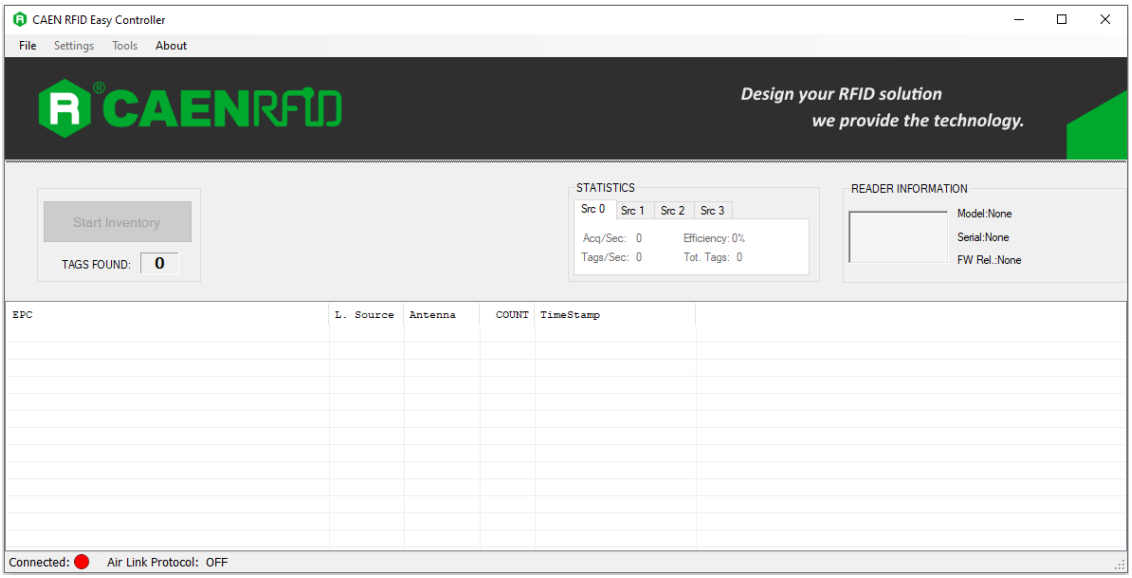
Evaluation Board USB-UART Details

U3 and U4 are USB-UART converters made by Microchip. Their part number is MCP2200-I/MQ. This part allows a PC to communicate with the Lepton[9] R9100C over USB. The MCP2200 part achieves this by enumerating as an USB device and adding a COM port. In Windows, this COM ports can be viewed in the Device Manager under the "Ports (COM & LPT)" category. To identify the COM port associated to UART1 host interface connect USB cable to J4 connector only. To identify the COM port associated to UART2 host interface connect USB cable to J6 connector only.

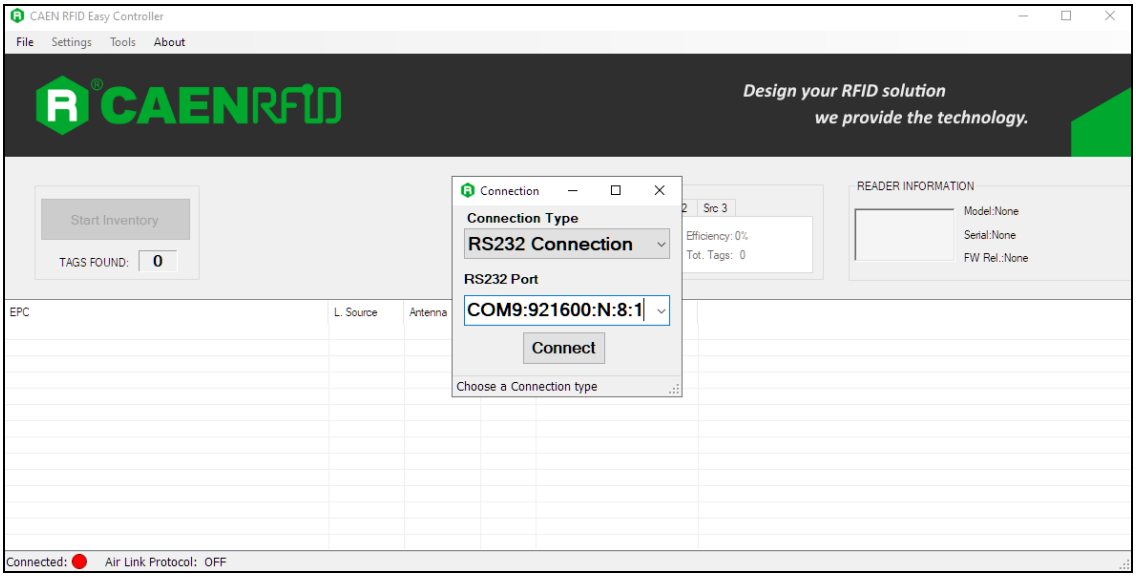
Easy Controller

Follow these steps to connect the Lepton[9] R9100C using the *Easy Controller* application for Windows:

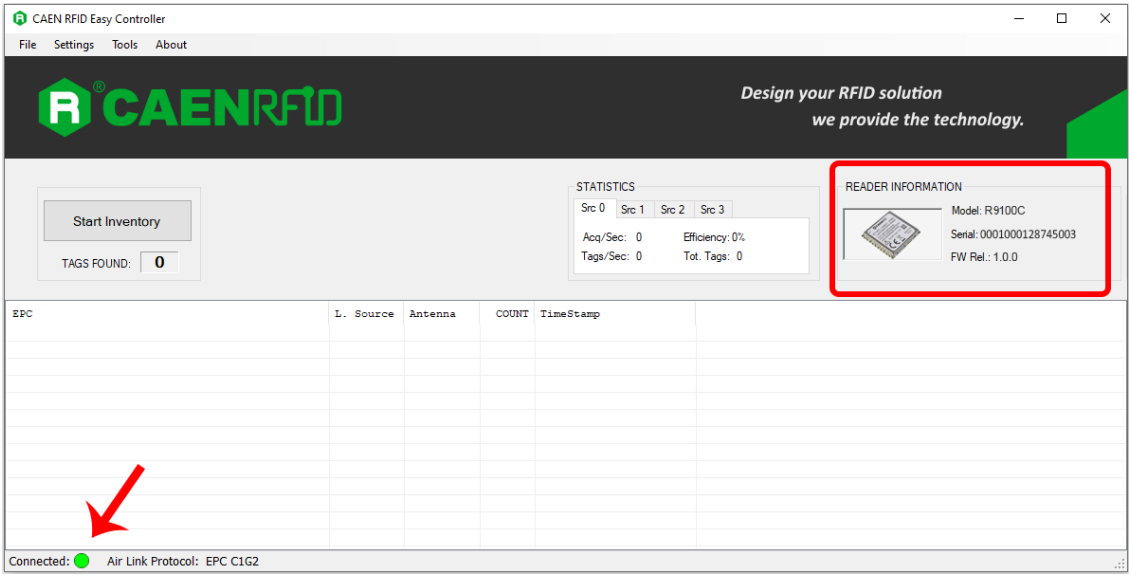
1. Download the latest version of the *Easy Controller software* from the Lepton[9] R9100C web page, *Downloads* section and install it.
2. Launch the *Easy Controller* application:



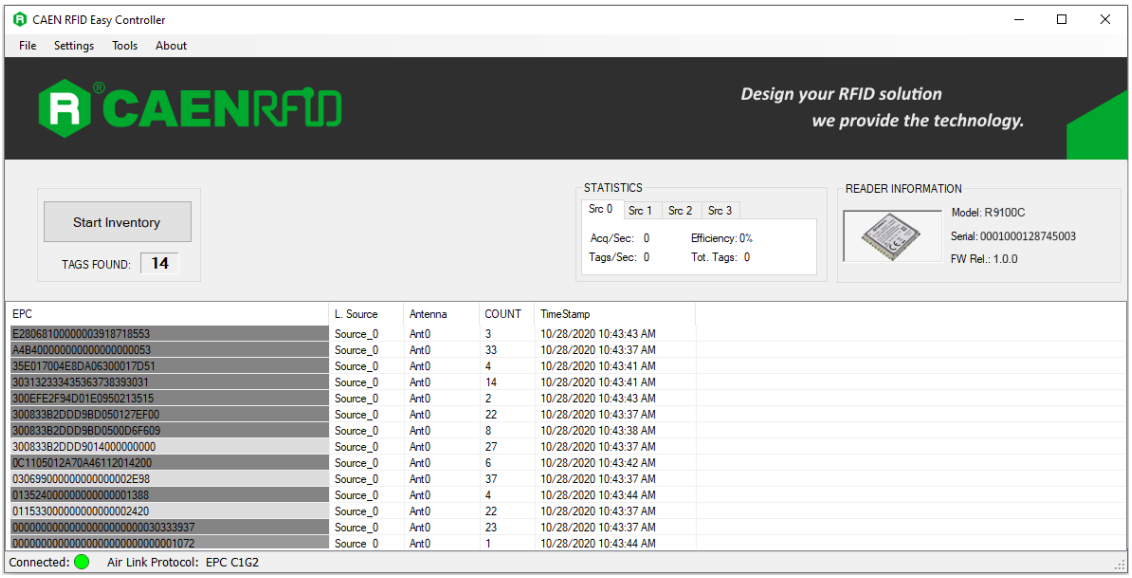
3. On the main screen click on *File → Connect*. A Connection window will open. Select the C*onnection Type* (RS232) and specify the RS232 port (COM 9 in this example). In order to connect to the module via Easy Controller software the serial settings shall be added to the COM port address since Lepton[9] R9100C module has a different baudrate (921600bps) from default value used by the SW:



4. To verify if the connection with the reader has been established, check the green dot on the bottom left side of the sidebar and on the *READER INFORMATION* box you can find information on reader model, serial number and firmware release:



5. Place one or more tags near the antenna connected to the reader, click on *Start Inventory* and see tags information displayed on the main window:



For more information on the CAEN RFID *Easy Controller for Windows* application usage, please refer to the relevant user manual: you can download it from the Lepton[9] R9100C web page, *Downloads* section or in the Manual and Documents web area.

Firmware Upgrade

Please refer to § *Firmware Upgrade* page 24.

7 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 V3.3.1:2020

EN 62368-1:2018

See § *Lepton[9] R9100C CE DECLARATION OF CONFORMITY* page 36 for the Lepton[9] R9100C CE Compliance Certificate.

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

UKCA 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 V3.3.1:2020

BS EN 62368-1:2014+A11:2017

See § *Lepton[9] R9100C UKCA DECLARATION OF CONFORMITY* page 37 for the Lepton[9] R9100C UKCA Compliance Certificate.

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

RoHS Directive

The Lepton[9] R9100C RFID Reader is compliant with the EU Directive 2015/863/EU (RoHS3) and the UK Regulation 2012 SI 2012/3032 (RoHS) on the Restriction of the Use of certain Hazardous Substances in Electrical and Electronic Equipment.

LEPTON^9 R9100C
CE DECLARATION OF CONFORMITY

We

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Mail: info@caenrfid.com
Web site: www.caenrfid.com

herewith declare under our own responsibility that the product:

WR9100CXAAAA - R9100C - Lepton9 - 30dBm 1-Port RAIN RFID Reader Module

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 V3.3.1:2020

EN 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: 16/06/2023

CAEN RFID srl
Via Vetraia, 11
55049 VIAREGGIO - ITALY
VAT IT 02032050466

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 R9100C Lepton^9 Technical Information Manual.

LEPTON^9 R9100C
UKCA DECLARATION OF CONFORMITY

We

CAEN RFID Srl
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Mail: info@caenrfid.com
Web site: www.caenrfid.com

herewith declare under our own responsibility that the product:

WR9100CXAAAA - R9100C - Lepton9 - 30dBm 1-Port RAIN RFID Reader Module

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 V3.3.1:2020

BS EN 62368-1:2014+A11:2017

and declare under our sole responsibility that the specified product meets the principle requirements and other applicable regulations of directives UK Regulation 2016 No. 1206 and UK Regulation 2012 SI 2012/3032 (RoHS).

Date: 16/06/2023

CAEN RFID srl
Via Vetraia, 11
55049 VIAREGGIO - ITALY
VAT IT 02032050466

Adriano Bigongiari (Chief Executive Officer)

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

The compliance is guaranteed only if the reader is used as described in the R9100C Lepton^9 Technical Information Manual.