SiRad Easy® r4, SiRad Easy® & SiRad Simple®

User Guide

Status: Release
Date: 19-Nov-2021
Author: Silicon Radar GmbH
Filename: UserGuide_SiRad_Easy_Simple

Version: 2.5
Product number: -
Package: -
Marking: -

Page: 1 of 14

Document: Annex to VA_U03_01
Anlage 8_Template_Datenblatt_RevE
Date: 19-May-2020
Rev D
Version Control

<table>
<thead>
<tr>
<th>Version</th>
<th>Changed section</th>
<th>Description of change</th>
<th>Reason for change</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>all</td>
<td>Content and appearance</td>
<td>Initial document</td>
</tr>
<tr>
<td>2.0</td>
<td>all</td>
<td>Firmware info for flashing</td>
<td>Hardware &amp; firmware update</td>
</tr>
<tr>
<td>2.1</td>
<td>all</td>
<td>Added section</td>
<td>Added info for older Easy Kits</td>
</tr>
<tr>
<td>2.2</td>
<td>all</td>
<td>Software updates</td>
<td>Added mechanical drawing</td>
</tr>
<tr>
<td>2.3</td>
<td>all</td>
<td>Combined Easy and Simple User Guide</td>
<td>Software updates</td>
</tr>
<tr>
<td>2.5</td>
<td>all</td>
<td>Added Section 2 and minor changes in other sections</td>
<td>Added content for Easy r4</td>
</tr>
</tbody>
</table>

Table of Contents

1 Overview ........................................................................................................................................... 4
1.1 Features ........................................................................................................................................ 4
1.2 Application .................................................................................................................................. 5
2 Hardware Setup SiRad Easy® r4 ...................................................................................................... 5
  2.1 Changing the Radar Front End .................................................................................................. 5
  2.2 UART Data Connection & External Power (External UART Header) ........................................... 5
  2.3 PLL Control Connection (External PLL Header) ....................................................................... 6
  2.4 Data Connection & External Power (Breakout Board) .............................................................. 6
  2.5 Firmware Update ....................................................................................................................... 6
3 Hardware Setup SiRad Easy® .......................................................................................................... 7
  3.1 Changing the Radar Front End .................................................................................................. 7
  3.2 Data Connection Mode - External Header (J1) ......................................................................... 7
  3.2.1 Serial/USB Data Connection .................................................................................................. 8
  3.2.2 Wireless Data Connection .................................................................................................... 8
  3.3 Firmware Update ....................................................................................................................... 8
  3.3.1 Microcontroller Board .......................................................................................................... 9
  3.3.2 WiFi Module .......................................................................................................................... 9
  3.3.3 USB Controller Firmware ..................................................................................................... 9
4 Hardware Setup SiRad Simple® ...................................................................................................... 10
  4.1 Data Connection Mode - External Header (J1) ......................................................................... 10
  4.1.1 Serial/USB Data Connection .................................................................................................. 10
  4.1.2 Wireless Data Connection .................................................................................................... 11
  4.2 Firmware Update ....................................................................................................................... 11
  4.2.1 Microcontroller ..................................................................................................................... 11
  4.2.2 WiFi Module .......................................................................................................................... 11
5 Mounting a Lens (Optional) ......................................................................................................... 12
6 Communication Interfaces (SER1/SER2) ....................................................................................... 13
Disclaimer ........................................................................................................................................... 14
List of Figures

Figure 1  *SiRad Easy® r4* (left), *SiRad Easy®* (middle) and *SiRad Simple®* (right) .............................................. 4
Figure 2  122 GHz configuration with lens assembled .................................................................................................. 5
Figure 3  UART header pinout ....................................................................................................................................... 6
Figure 4  PLL control header pinout .......................................................................................................................... 6
Figure 5  *SiRad Easy® r4* with Breakout Board for data connection & external power ............................................... 6
Figure 6  24 GHz configuration .................................................................................................................................... 7
Figure 7  122 GHz configuration with lens assembled .................................................................................................. 7
Figure 8  External header (J1) pinout .......................................................................................................................... 7
Figure 9  Hardware configuration for Serial/USB connection ....................................................................................... 8
Figure 10 Hardware configuration for WiFi connection .............................................................................................. 8
Figure 11 WiFi module update configuration ............................................................................................................ 9
Figure 12 WiFi module select switch SW1 ................................................................................................................ 9
Figure 13 External header (J1) pinout .......................................................................................................................... 10
Figure 14 UART pinout on J1 (left) and Serial/USB (FTDI) cable connection at J1 (right) ........................................... 10
Figure 15 WiFi pinout on J1 (left) and WiFi mode configuration (right) .................................................................. 11
Figure 16 Firmware update configuration .................................................................................................................. 12
Figure 17 WiFi module update configuration ............................................................................................................ 12
Figure 18 Standard black lens ..................................................................................................................................... 12
Figure 19 Acrylic lens ................................................................................................................................................... 12
Figure 20 Terminal output of the evaluation kit (left) and Octave (right) ................................................................ 13
1 Overview

**SiRad Easy® r4, SiRad Easy®** and **SiRad Simple®** evaluation kits are experimental showcase systems for Silicon Radar’s integrated IQ transceivers, with antennas in chip / package and on board. The systems measures distance and velocity using FMCW or CW radar principles (frequency modulated continuous wave or continuous wave principles).

**SiRad Easy® r4** consists of an evaluation baseband board that can hold exchangeable radar front ends (24 GHz to 300 GHz), all stackable as shown in Figure 1 (left).

**SiRad Easy®** consists of an evaluation baseband board and a microcontroller board. The baseband can hold exchangeable radar front ends (24 GHz to 300 GHz), all stackable as shown in Figure 1 (middle).

**SiRad Simple®** consists of one 122 GHz evaluation board and a lens assembly as shown in Figure 1 (right).

The evaluation kits come with a free graphical user interface (WebGUI) - for user-friendly parametrization of the baseband board and multiple visualization modes for radar data. Due to the flexibility of the system, it can be used to change radar parameters on-the-fly, to learn the basics of radar signal processing, or to find specific parameter settings for a certain application.

![Figure 1 SiRad Easy® r4 (left), SiRad Easy® (middle) and SiRad Simple® (right)](image)

### 1.1 Features

- Serial/USB or WiFi communication to PC,
- microcontroller for triggering, signal processing and target recognition for up to 16 targets simultaneously, transfer to the host system,
- web-based graphical user interface to change relevant parameters, plot the FFT of the baseband channels, display the distance and velocity measurements and the target list,
- phase locked loop (PLL) to adjust the start and stop frequencies,
- programmable FMCW / CW parameters,
- analog signal conditioning to amplify and filter the I and Q output signals of the transceiver,
- Analog-to-Digital-converter to digitize the I and Q receiver signals,
- DC-DC conversion to provide single supply from USB or an external DC supply.
1.2 Application

SiRad Easy® r4, SiRad Easy® and SiRad Simple® are supposed to be used for short-term evaluation purposes in laboratory environments. Please see our disclaimer at the end of this document.

IMPORTANT:
The radar front ends are able to use a larger bandwidth than what is allowed in the ISM bands. In most countries, the bandwidth is limited to 1 GHz between 122 GHz and 123 GHz for production purposes by law. Please check your local regulations. It remains the customer’s responsibility to assure the operation of the front end according to local regulations, especially when applying to frequency band allocations outside of the laboratory environment. Silicon Radar and its distributors will not accept any responsibility for consequences resulting from the disregard of these instructions and warnings.

2 Hardware Setup SiRad Easy® r4

2.1 Changing the Radar Front End

Figure 2 shows SiRad Easy® r4 with a 122 GHz radar front end board mounted. Follow the instructions below for changing the front end board.

Disassembly
- Disconnect the power from the Evaluation Kit.
- Remove the radar front end from the top of the baseband board. Press thumbs and index fingers under the edges of the radar front end board and pull and press it simultaneously straight out of its connections. Do not tilt or bend the front end board.

Assembly
- The radar front end board can only be connected one way. Place the radar front end board centered onto the connectors, then press it down until no space is left.

2.2 UART Data Connection & External Power (External UART Header)

The UART header in Figure 3 provides an alternative way to power and connect to the board using a second UART port. The Base Board can be powered from the 5V and GND lines of the port. The UART header can also be used to trigger measurements manually via the trigger line (TI), or receive triggers on each ramp start (TO). Also see the section about trigger options in the Protocol Description.
### UART Header Pinout

<table>
<thead>
<tr>
<th>Pin</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5V</td>
<td>+5V</td>
</tr>
<tr>
<td>GD</td>
<td>GND</td>
</tr>
<tr>
<td>TX</td>
<td>microcontroller TX*</td>
</tr>
<tr>
<td>RX</td>
<td>microcontroller RX*</td>
</tr>
<tr>
<td>TI</td>
<td>external trigger line*</td>
</tr>
<tr>
<td>TO</td>
<td>trigger output line*</td>
</tr>
</tbody>
</table>

(*3.3V tolerant only!

![UART header pinout](image-url)

#### 2.3 PLL Control Connection (External PLL Header)

The external header in Figure 4 is used to debug the PLL configuration on the board.

<table>
<thead>
<tr>
<th>Pin</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ce</td>
<td>CE* line of the PLL</td>
</tr>
<tr>
<td>Clk</td>
<td>CLK* line of the PLL</td>
</tr>
<tr>
<td>Mx</td>
<td>MUXOUT output line of uC (reserved)</td>
</tr>
<tr>
<td>Da</td>
<td>DATA* line of the PLL</td>
</tr>
<tr>
<td>Le</td>
<td>LE* line of the PLL</td>
</tr>
<tr>
<td>Fs</td>
<td>PLL_FSK line of uC (reserved)</td>
</tr>
</tbody>
</table>

(*) 1.8V

![PLL control header pinout](image-url)

#### 2.4 Data Connection & External Power (Breakout Board)

The optional Breakout Board can be used to connect to different lines from standard pin headers, otherwise only available on the small connectors of the Base Board. The Base Board can be also powered from the Breakout Board’s BV5 and GND lines.

![SiRad Easy® r4 with Breakout Board](image-url)

#### 2.5 Firmware Update

Please also see the Firmware Update Wiki page for detailed information about firmware updates.
3 Hardware Setup SiRad Easy®

3.1 Changing the Radar Front End

Figure 6 and Figure 7 show the SiRad Easy® with 24 GHz and 122 GHz radar front end boards mounted. Follow the instructions below for changing the front end board.

Disassembly
- Disconnect the power from the Evaluation Kit.
- Remove the radar front end from the top of the baseband board. Grab the short edges and pull it straight out of its connections. Do not tilt or bend the front end. You don’t need to remove the baseband board from the microcontroller board to exchange the front end board.

Assembly
- The radar front end can only be connected one way since the connector pins are different. Slightly press it down and make sure no pins are bent during the process.

3.2 Data Connection Mode - External Header (J1)

The external header in Figure 8 is used to connect to the sensor board in different operating modes (data transfer over Serial/USB or WiFi). In programming mode, the external header is used to program either the WiFi module or the microcontroller, please see Section 3.3. The external header can also be used to trigger measurements manually via the trigger line (TR), also see the section about trigger options in the Protocol Description.

<table>
<thead>
<tr>
<th>Pin</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5V</td>
<td>+5V</td>
</tr>
<tr>
<td>GD</td>
<td>GND</td>
</tr>
<tr>
<td>MT</td>
<td>microcontroller TX*</td>
</tr>
<tr>
<td>MR</td>
<td>microcontroller RX*</td>
</tr>
<tr>
<td>TR</td>
<td>external trigger line*</td>
</tr>
<tr>
<td>WT</td>
<td>WiFi TX*</td>
</tr>
<tr>
<td>WR</td>
<td>WiFi RX*</td>
</tr>
</tbody>
</table>

(*) 3.3V tolerant only!
3.2.1 **Serial/USB Data Connection**

Put jumper JP5 on the microcontroller board in the USV setting as shown in Figure 9 (left). Remove all jumpers from the external header (J1) on the baseband board shown in Figure 9 (middle). Bring the WiFi switch SW1 on the baseband board in the OFF position as shown in Figure 9 (right).

![Hardware configuration for Serial/USB connection](image)

*SiRad Easy®* can now be connected to a PC using a USB cable.

**We recommend using an active USB Hub between the PC and *SiRad Easy®*.**

Alternatively, the board can be powered by a 5V DC power supply via the external header (pins 5V and any of the four GD pins).

3.2.2 **Wireless Data Connection**

In WiFi mode, the external header (J1) is used to connect the WiFi module to the microcontroller on the board. Put jumper JP5 on the microcontroller board in the ESV setting as shown in Figure 10 (left). Use jumpers to connect the MT/WR and MR/WT lines of the external header (J1) on the baseband board as shown in Figure 10 (middle). Apply power from a DC source: +5V to the 5V pin and GND to the any GD pin of the external header (J1). Bring the WiFi switch SW1 on the baseband board in the ON position as shown in Figure 10 (right).

![Hardware configuration for WiFi connection](image)

3.3 **Firmware Update**

Please also see the [Firmware Update Wiki page](#) for detailed information about firmware updates and the [Download Area](#) to download *esptool* for updating the WiFi firmware.
3.3.1 Microcontroller Board

To update or change the microcontroller firmware, the board has to be connected to the PC via the USB port. It opens a new mass storage device called NODE_F303RE in the Windows Explorer. Drag and drop the .bin file that you want to flash on that device. LD1 on the board starts flashing red and green. As soon as the flashing stops, the board is programmed and after a reset the new firmware should be running. Alternatively, you can use ST-LINK Utility to flash the firmware on the microcontroller board.

3.3.2 WiFi Module

Connect the SiRad Easy® using a Serial/USB (FTDI) cable or Serial/USB adapter as shown in Figure 11 using the external header (J1). Please read Section 3.2 about the external header connection. Then connect cable TX to WR (WiFi RX) and cable RX to WT (WiFi TX).

Make sure to use a cable with 3.3V TTL levels!

Switch SW1 to the PROG position.

Download esptool. Copy the desired firmware into a folder together with esptool. Edit the batch file esptool.bat and replace the COM port with the COM port of your Serial/USB (FTDI) cable or Serial/USB adapter and the firmware name with the desired firmware, for example:

```
esptool -bz 1M -cp COMx -cf websocket_mini.ino.generic.bin
```

The baud rate for flashing the firmware needs to be 1 Mbaud. Run the batch file and the WiFi module gets programmed, indicated by a flashing blue LED. The programming is finished after about 40 seconds. Switch the DIP switch WP back to the OFF position and connect a jumper between MT and WR and MR and WT on the external header (J1).

3.3.3 USB Controller Firmware

Download and extract the ST-LINK firmware update tool. Go into the AllPlatforms folder and start the .jar file. Connect the SiRad Easy®, click Refresh device list and then Open in update mode to see the current USB controller firmware. Click Upgrade to flash it to the latest version.
4 Hardware Setup SiRad Simple®

4.1 Data Connection Mode - External Header (J1)

The external header in Figure 13 is used to connect to the sensor board in different operating modes. In UART mode, the external header is used to connect a UART cable with RX/TX lines and power supply to the sensor board. The data connection setup via UART is explained in Section 3.2.1. In WiFi mode, the external header is used to connect the WiFi module to the microcontroller on the board. The wireless data connection setup via WiFi is explained in Section 3.2.2. In programming mode, the external header is used to program either the WiFi module or the microcontroller, please see Section 3.3. The external header can also be used to trigger measurements manually via the external trigger line (TR), also see the section about trigger options in the Protocol Description.

<table>
<thead>
<tr>
<th>Pin</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5V</td>
<td>+5V</td>
</tr>
<tr>
<td>GD</td>
<td>GND</td>
</tr>
<tr>
<td>MT</td>
<td>microcontroller TX*</td>
</tr>
<tr>
<td>MR</td>
<td>microcontroller RX*</td>
</tr>
<tr>
<td>TR</td>
<td>external trigger line*</td>
</tr>
<tr>
<td>WT</td>
<td>WiFi TX*</td>
</tr>
<tr>
<td>WR</td>
<td>WiFi RX*</td>
</tr>
</tbody>
</table>

* 3.3V tolerant only!

Figure 13  External header (J1) pinout

4.1.1 Serial/USB Data Connection

The UART interface pins of the sensor board are shown in Figure 14 (left). You can use the UART interface to connect the sensor board to a PC or in a target application with a serial interface. Figure 14 (right) shows the sensor board with a Serial/USB (FTDI) cable or Serial/USB adapter attached to the external header (J1), which provides a virtual serial port via USB to a PC.

Make sure to use a cable with 3.3V TTL (TX/RX) levels!

Figure 14  UART pinout on J1 (left) and Serial/USB (FTDI) cable connection at J1 (right)

The Serial/USB (FTDI) cable’s VCC is connected to +5V, the cable’s GND to any GD pin (there are four), the cable’s RX to the TX line of the microcontroller (MT) and the cable’s TX to the RX line of the microcontroller (MR).

Make sure that both DIP switches are in their OFF positions and the power jumper (J2) for the WiFi module is open (switched off).
4.1.2 Wireless Data Connection

The WiFi interface pins of the sensor board are shown in Figure 15 (left). To run the sensor in WiFi mode, use the three jumpers delivered with the sensor and close the power jumper (J2) for the WiFi module (switched on) and connect two jumpers between MT/WR and MR/WT on the external header (J1). Apply +5V to the 5V pin and GND to the any GD pin (there are four).

![Figure 15 WiFi pinout on J1 (left) and WiFi mode configuration (right)]

4.2 Firmware Update

Please also see the Firmware Update Wiki page for detailed information about firmware updates and the Download Area to download the stm32flash tool for flashing the firmware or esptool for updating the WiFi firmware.

4.2.1 Microcontroller

To update or change the microcontroller firmware, the board has to be set in bootloader mode, as shown in Figure 16. This is done by switching the DIP switch MP to the ON position. Then connect the module to the PC via a Serial/USB (FTDI) cable or Serial/USB adapter using the external header (J1). Please read Section 4.1 about the external header connection. Connect line TX to MR (microcontroller RX) and line RX to MT (microcontroller TX).

Make sure to use a cable with 3.3V TTL levels!

Download the stm32flash tool. Copy the desired firmware into a folder together with the stm32flash tool. Edit the batch file stm32flash.bat and replace the COM port with the COM port of your Serial/USB (FTDI) cable or Serial/USB adapter and the firmware name with the desired firmware, for example:

```
stm32flash.exe -b 115200 -w <date>_SiRad_Simple_L8_<version>.bin -v -g 0x0 COMx
```

The baud rate for flashing the firmware needs to be 115200 baud. Run the batch file and the microcontroller gets programmed. After about 30 seconds the programming is finished. Switch the DIP switch MP back to the OFF position and do a power cycle to reset the module.

4.2.2 WiFi Module

Connect the sensor using a Serial/USB (FTDI) cable or Serial/USB adapter as shown in Figure 17 using the external header (J1). Please read Section 4.1 about the external header connection. Switch the DIP switch WP to the ON position. Then connect cable TX to WR (WiFi RX) and cable RX to WT (WiFi TX).

Make sure to use a cable with 3.3V TTL levels!
Now connect the power Jumper J2 to enable the supply voltage for the WiFi module.

Download esptool. Copy the desired firmware into a folder together with esptool. Edit the batch file esptool.bat and replace the COM port with the COM port of your Serial/USB (FTDI) cable or Serial/USB adapter and the firmware name with the desired firmware, for example:

```
esptool -bz 1M -cp COMx -cf websocket_mini.ino.generic.bin
```

The baud rate for flashing the firmware needs to be 1 Mbaud. Run the batch file and the WiFi module gets programmed, indicated by a flashing blue LED. The programming is finished after about 40 seconds. Switch the DIP switch WP back to the OFF position and connect a jumper between MT and WR and MR and WT on the external header (J1).

5  Mounting a Lens (Optional)

Please see the Collimator Lens data sheet for mounting our standard black lens for the 122 GHz transceivers and further information. The Collimator Lens is hardware compatible with SiRad Easy® r4, SiRad Easy® and SiRad Simple® evaluation kits.

Please see the Acrylic Lens data sheet for mounting the small lens for the 122 GHz transceiver TRA.120.002 and wideband 120 GHz transceivers TRA.120.031 / TRA.120.045 and further information. The Acrylic Lens is hardware compatible with our 5mm x 5 mm packaged transceivers, independently of the evaluation kit.
6 Communication Interfaces (SER1/SER2)

Please visit the Download Area for the drivers, software download links and software requirements.

The connection parameters for the Serial/USB ports SER1 and SER2 are: 8 bit, 1 stop bit, 1 start bit, now flow control, 230400 or 1000000 baud (depending on the flashed firmware).

SER1 – Serial/UART is available on the external header (J1), lines MR and MT.
SER2 – Serial/USB is available on the USB port (only on SiRad Easy®).

You can connect to both SER1 and/or SER2 using a terminal program such as Realterm, PuTTY or third-party software instead of the COM2WebSocket Tool / WebGUI. You should see plenty of protocol output from the evaluation kit as shown in Figure 20 (left) after connection. Now you can send commands to the evaluation kit. The communication protocol is described in the Easy r4, Easy and Simple Protocol Descriptions.

![Figure 20](image-url)  Terminal output of the evaluation kit (left) and Octave (right)
Disclaimer

Silicon Radar GmbH 2021. The information contained herein is subject to change at any time without notice.

Silicon Radar GmbH assumes no responsibility or liability for any loss, damage or defect of a product which is caused in whole or in part by

(i) use of any circuitry other than circuitry embodied in a Silicon Radar GmbH product,
(ii) misuse or abuse including static discharge, neglect, or accident,
(iii) unauthorized modifications or repairs which have been soldered or altered during assembly and are not capable of being tested by Silicon Radar GmbH under its normal test conditions, or
(iv) improper installation, storage, handling, warehousing, or transportation, or
(v) being subjected to unusual physical, thermal, or electrical stress.

Disclaimer: Silicon Radar GmbH makes no warranty of any kind, express or implied, with regard to this material, and specifically disclaims any and all express or implied warranties, either in fact or by operation of law, statutory or otherwise, including the implied warranties of merchantability and fitness for use or a particular purpose, and any implied warranty arising from course of dealing or usage of trade, as well as any common-law duties relating to accuracy or lack of negligence, with respect to this material, any Silicon Radar product and any product documentation. Products sold by Silicon Radar are not suitable or intended to be used in a life support applications or components, to operate nuclear facilities, or in other mission critical applications where human life may be involved or at stake. All sales are made conditioned upon compliance with the critical uses policy set forth below.

CRITICAL USE EXCLUSION POLICY: BUYER AGREES NOT TO USE SILICON RADAR GMBH’S PRODUCTS FOR ANY APPLICATIONS OR IN ANY COMPONENTS USED IN LIFE SUPPORT DEVICES OR TO OPERATE NUCLEAR FACILITIES OR FOR USE IN OTHER MISSION-CRITICAL APPLICATIONS OR COMPONENTS WHERE HUMAN LIFE OR PROPERTY MAY BE AT STAKE.

Silicon Radar GmbH owns all rights, titles and interests to the intellectual property related to Silicon Radar GmbH’s products, including any software, firmware, copyright, patent, or trademark. The sale of Silicon Radar GmbH’s products does not convey or imply any license under patent or other rights. Silicon Radar GmbH retains the copyright and trademark rights in all documents, catalogs and plans supplied pursuant to or ancillary to the sale of products or services by Silicon Radar GmbH. Unless otherwise agreed to in writing by Silicon Radar GmbH, any reproduction, modification, translation, compilation, or representation of this material shall be strictly prohibited.