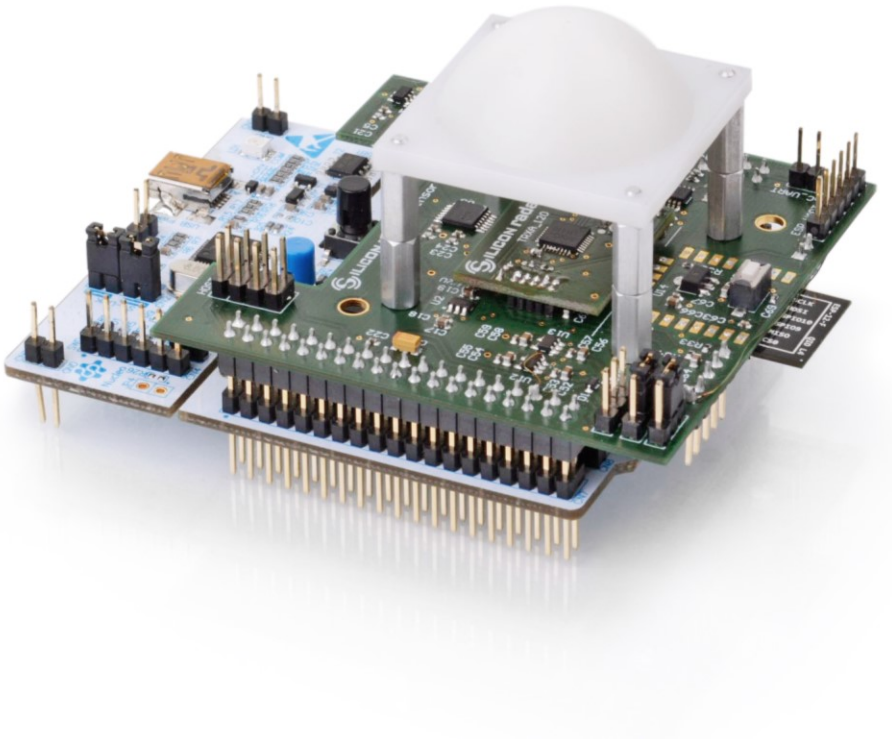
Silicon Radar GmbH
Im Technologiepark 1
15236 Frankfurt (Oder)
Germany

fon +49.335.557 17 60
fax +49.335.557 10 50
http://www.siliconradar.com
support@siliconradar.com

User Guide
SiRad Easy®
Evaluation Kit



Status:	Date:	Author:	
Release	24 Apr. 17	Silicon Radar GmbH	
Version:	Document number:	Filename:	Page:
2.2		UserGuide_SiRad_Easy®	1 of 35

Version Control

Version	Changed section	Description of change	Reason of change
1.0	all		Initial document
2.0	all	Content and appearance	Hardware & firmware update
2.1	5.1	Firmware info for flashing	Added info for older Easy Kits
2.2	6	Added section	Added mechanical drawing

Table of Contents

1 Overview and Package Contents 5
1.1 Overview 6
1.2 Features 6
1.3 Application 6
2 Installation 7
2.1 Hardware Setup 7
2.1.1 Changing the Radar Frontend 7
2.1.2 Understanding the External Header (J1) 8
2.1.3 Data Connection via USB Cable (USB Mode) 8
2.1.4 Wireless Data Connection via WiFi (WiFi Mode) 9
2.1.5 Mounting the Lens (Optional) 9
2.2 Software Installation 10
2.2.1 Software requirements 10
2.2.2 Connecting to the Board via USB 11
2.2.3 Connecting to the Board via WiFi 12
2.2.4 Starting the Graphical User Interface (Silicon Radar WebGUI) 12
3 Getting Started with the Silicon Radar WebGUI 13
3.1 Understanding the User Interface 13
3.2 Using the Control Panel (Sensor Settings) 14
3.2.1 Communication Options (COM Tab) 14
3.2.2 Load and Save Settings (Presets Tab) 14
3.2.3 System Settings (System Configuration Tab) 15
3.2.4 Radar Frontend Settings (RF Parameters Tab) 17
3.2.5 Baseband Processing Settings (BB Processing Tab) 18
3.2.6 Target Recognition Settings (Target Recognition Tab) 19
3.2.7 Scene Control Options (Scene Controls Tab) 20
3.2.8 Radar Hardware Information (System Info Tab) 21
3.2.9 Recently Sent Control Frames (Log Tab) 21
3.3 Using the Main Menu 21
3.3.1 FFT View 21
3.3.2 Status Field and Target List 22
3.3.3 Target-Timeline 23
3.3.4 Spectrogram 23
3.3.5 Options 23

3.4 Understanding the Configuration Info Field 24
3.5 Camera Controls 24
3.6 Understanding the Error Info Field 25
3.7 Understanding the Data View 25
4 Troubleshooting 27
4.1 Drivers 27
4.1.1 Where can I get the driver to connect the SiRad Easy® ? 27
4.1.2 I installed the USB driver for the SiRad Easy® but it does not show up. 27
4.1.3 The USB driver for the SiRad Easy® does not work properly. 27
4.2 WebGUI 27
4.2.1 I cannot store presets in the Preset tab. 27
4.2.2 I cannot see any output in the WebGUI window. 27
4.2.3 The spectrum output jumps (partly). 28
4.2.4 How does the Auto Gain Control (AGC)-Mode work? 28
4.2.5 Can I trigger the SiRad Easy® manually? 28
4.2.6 Can I use multiple SiRad Easy® Evaluation Kits in parallel? 28
4.2.7 The LED goes off when I connect to the WebGUI. 28
4.2.8 The RF Parameters tab does not show the min / max frequencies properly. 28
4.2.9 How do I choose a base-frequency? 28
4.2.10 How do I set the maximum bandwidth in the RF Parameters tab? 28
4.2.11 How do I choose a bandwidth? 28
4.2.12 How can I choose the ramp time? 28
4.2.13 What is the MTI-Mode? 29
4.2.14 There are too many targets. The CFAR operator does not work. 29
4.2.15 How is the distance information calculated? 29
4.2.16 The update rate of the SiRad Easy® is very low. How can I improve it? 29
4.3 Sensor Behavior, Range & Lens 29
4.3.1 How is the resolution defined? 29
4.3.2 How is the accuracy defined? 29
4.3.3 Is there a minimum range / blind spot when using the SiRad Easy®? 29
4.3.4 Can something be detected within the minimum range / blind spot? 29
4.3.5 What is the maximum range of the SiRad Easy®? 30
4.3.6 Can the range of the SiRad Easy® be increased? 30
4.3.7 How is the field of view of the SiRad Easy®? 30
4.3.8 How can I get directional information from the SiRad Easy®? 30
4.4 Protocol & RAW data 30
4.4.1 Can I use the the SiRad Easy® with own or third-party software? 30
4.4.2 Can I activate raw data only or FFT data only output? 30
4.4.3 Can I use the sensor protocol with <any> device? 30
4.5 Schematics & Firmware 30
4.5.1 Where can I find the schematics for the SiRad Easy®? 30
4.5.2 Where can I get the source code for the SiRad Easy®? 30
5 Firmware Update 31
5.1 Microcontroller Board 31
5.2 WiFi Module 31
5.3 USB Controller Firmware 32
6 Mechanical Drawing 33
7 Disclaimer / License 34

List of Figures

Figure 1: SiRad Easy® Evaluation Kit (left) and graphical user interface (right)....5
Figure 2: 24 GHz configuration....7
Figure 3: 122 GHz configuration with lens assembled....7
Figure 4: External header (J1) pinout....8
Figure 5: Hardware configuration for USB connection....8
Figure 6: Hardware configuration for USB connection....9
Figure 7: Mounting the lens....9
Figure 8: Schematic comparison of range with and without the lens....10
Figure 9: Terminal output of the Evaluation Kit (left) and COM2WebSocket tool (right)....11
Figure 10: Silicon Radar WebGUI after start (left) and connected to the SiRad Easy® (right)....12
Figure 11: Main panels of the Silicon Radar WebGUI....13
Figure 12: Control panel with its different tabs....14
Figure 13: COM tab of the Control Panel for USB (left) and WiFi (right) communication....14
Figure 14: Presets tab (left) and predefined settings (right)....14
Figure 15: Save settings in the Presets tab of the Control Panel....15
Figure 16: System Configuration tab of the Control Panel....15
Figure 17: RF Parameters tab of the Control Panel....17
Figure 18: BB Processing tab of the Control Panel....18
Figure 19: Target Recognition tab of the Control Panel....20
Figure 20: Schematic description of the CACFAR-operator....20
Figure 21: Scene Controls tab of the Control Panel....20
Figure 22: System Info tab (left) and Log tab (right) of the Control Panel....21
Figure 23: Main menu of the WebGUI....21
Figure 24: 2D view of the FFT data....22
Figure 25: 3D view of the FFT data....22
Figure 26: Target list with the status field at the top....22
Figure 27: Target-Timeline....23
Figure 28: Spectrogram....23
Figure 29: Magnitude coloring with phase markers....23
Figure 30: Range / target number coloring....23
Figure 31: Phase coloring....24
Figure 32: No color....24
Figure 33: Configuration words....24
Figure 34: Camera controls....24
Figure 35: Error info field....25
Figure 36: Data view with different elements in the display scene....25
Figure 37: WiFi module update configuration....31
Figure 38: WiFi module select switch SW1....31
Figure 37: Mechanical drawing of the SiRad Easy® Baseband Board....33

1 Overview and Package Contents

Thank you for purchasing Silicon Radar's SiRad Easy® Evaluation Kit. SiRad Easy® is an easy to use, state-of-the-art radar sensor evaluation system including a high performance target recognition algorithm and WiFi connectivity.

What's in the box?

The SiRad Easy® Evaluation Kit consists of two radar frontends (24 GHz and 122 GHz), an evaluation baseband board, and an ST Microelectronics Nucleo64 microcontroller board – all stackable as shown in Figure 1 (left). The SiRad Easy® Evaluation Kit comes with a free graphical user interface for user-friendly parametrization of the baseband board and multiple visualization modes for radar data, shown in Figure 1 (right).

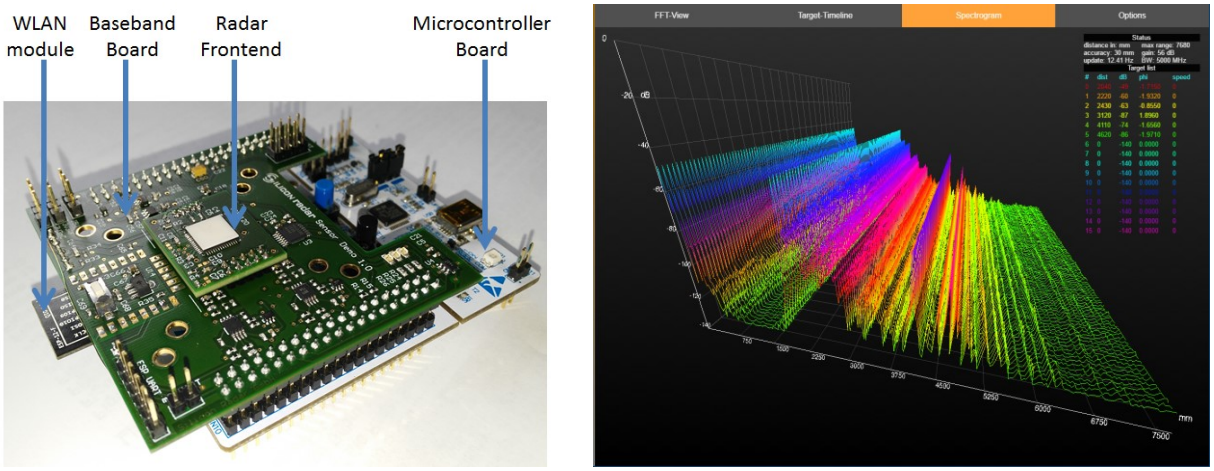


Figure 1: SiRad Easy® Evaluation Kit (left) and graphical user interface (right)

The SiRad Easy® Evaluation Kit demonstrates the performance and parameters of the 122 GHz radar transceiver chip of Silicon Radar. The aim of the evaluation kit is to showcase the FMCW / CW radar mode using a beginner-friendly system. Due to the flexibility of the system, it can be used to change important radar parameters on-the-fly to learn to know the basics of radar signal processing or to find specific parameter settings for a certain radar sensor application.

Silicon Radar puts the focus of the SiRad Easy® Evaluation Kit on an easy-to-use approach and supports the customer with a set of default key parameters guaranteeing a proper operation of the radar hardware (including automatically set parameters of optimized operation mode).

1.1 Overview

The SiRad Easy® Evaluation Kit is an experimental showcase system for Silicon Radar's different integrated IQ transceivers with antennas in package and on board. For more information about the features of Silicon Radar's transceiver chips, all data sheets are available on the Silicon Radar webpage[1].

We developed the evaluation kit to demonstrate our millimeter-wave sensors to measure the distance and velocity using RADAR principles. Both - frequency modulated continuous wave (FMCW) or continuous wave (CW) - principles are applied.

1.2 Features

The SiRad Easy® Evaluation Kit feature set includes:

- phase locked loop (PLL) running the integrated low phase noise Push-Push VCO in the transceiver chip,
- frequency lock control to automatically adjust the start and stop frequencies of the generated FMCW radar frequency ramp,
- programmable FMCW parameters,
- 122 GHz ISM band or 7 GHz high bandwidth FMCW operations for TRX_120 chips,
- 24 GHz ISM band or 3 GHz high bandwidth operations for TRX_24 chips,
- 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,
- microcontroller to do
  - PLL setup, ramp configuration, A-D conversion,
  - signal processing and target recognition for up to 16 targets simultaneously,
  - transfer to the host system, trigger configurable GP output pins,
- 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,
- standard USB or WiFi communication to PC,
- DC-DC conversion to provide single supply from USB or an external DC supply.

1.3 Application

The SiRad Easy® Evaluation Kit is supposed to be used for short-term evaluation purposes in laboratory environments only. All regulations of the according Silicon Radar Evaluation Agreement may apply.

IMPORTANT:

The radar frontends are able to use a larger bandwidth than what is allowed in the ISM bands. In most countries, the bandwidth is limited to 250 MHz between 24 GHz and 24.25 GHz and to 1 GHz between 122 GHz and 123 GHz for production purposes by law. Please check your local regulations. It is up to the customer to make sure that the frontend is not used in these conditions.

[1] http://www.siliconradar.de/transceiver_d.html

2 Installation

2.1 Hardware Setup

2.1.1 Changing the Radar Frontend

The SiRad Easy® Evaluation Kit consists of two radar frontends (24 GHz and 122 GHz), an evaluation baseband board, and an ST Microelectronics Nucleo64 microcontroller board that are stackable. Figure 2 and Figure 3 show the 24 GHz and the 122 GHz configurations.

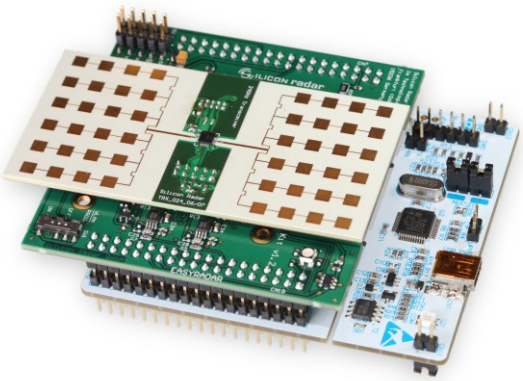


Figure 2: 24 GHz configuration

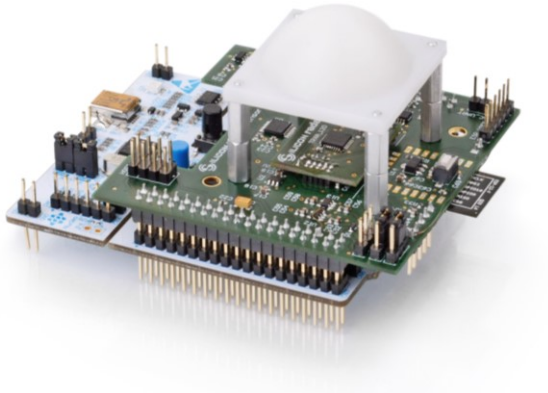


Figure 3: 122 GHz configuration with lens assembled

Silicon Radar delivers the Evaluation Kit in the 122 GHz configuration without the lens assembled. Follow the instructions below for changing the Evaluation Kit configuration. **Please note that you have to flash another firmware to the microcontroller board when you change the frontend.**

Disassembly

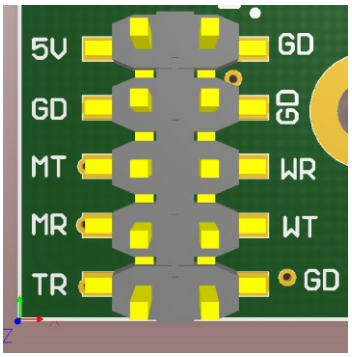
- Disconnect the USB cable from the Evaluation Kit.
- Remove the radar frontend from the baseband board. Grab the short edges and pull it straight out of its connections. Do not tilt or bend the frontend.
- **Not recommended unless the baseband board or the microcontroller board must be replaced:** Remove the baseband board from the microcontroller board by grabbing the short edges and pulling it straight out of its connections. Do not tilt or bend the baseband board.

Assembly

- If you need to connect the baseband board to the microcontroller board, first look for any bend connectors. Pull them straight before trying to connect the boards. Connect the baseband board to the microcontroller board by placing them on top of each other and matching the connectors. The WiFi module should point away from the USB connector of the microcontroller board. Now slightly press them together alternately on both sides until both boards are fully connected. **Improper connection may cause shortcuts and destroy the boards**.
- The radar frontend has to be attached to the baseband board from the top side (where the LEDs are located). It can only be connected in one way since the headers are different. **Improper connection may cause shortcuts and destroy the boards**.
- **Proceed to Section 5.1 to flash the corresponding firmware for the assembled frontend to the microcontroller board.**

2.1.2 Understanding the External Header (J1)

The external header in Figure 2 is used to connect to the sensor board in different operating modes. 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 2.1.4. In programming mode, the external header is used to program either the WiFi module or the microcontroller, please see Section 5. The external header can also be used to trigger measurements manually via the external trigger line (TR), also see Section 3.2.3.1.



Pin	Description
5V	+5V
GD	GND
MT	microcontroller TX*
MR	microcontroller RX*
TR	external trigger line*
WT	WiFi TX*
WR	WiFi RX*
	*** 3.3V tolerant only!**

Figure 4: External header (J1) pinout

2.1.3 Data Connection via USB Cable (USB Mode)

If you want to connect to the sensor via WiFi instead of USB, please directly continue with Section 2.1.4. Put the jumper JP5 on the microcontroller board in the U5V setting like shown in Figure 5 (left). Remove all jumpers from the external header on the baseband board shown in Figure 5 (middle). Bring the WiFi switch SW1 on the baseband board in the OFF position as shown in Figure 5 (right).

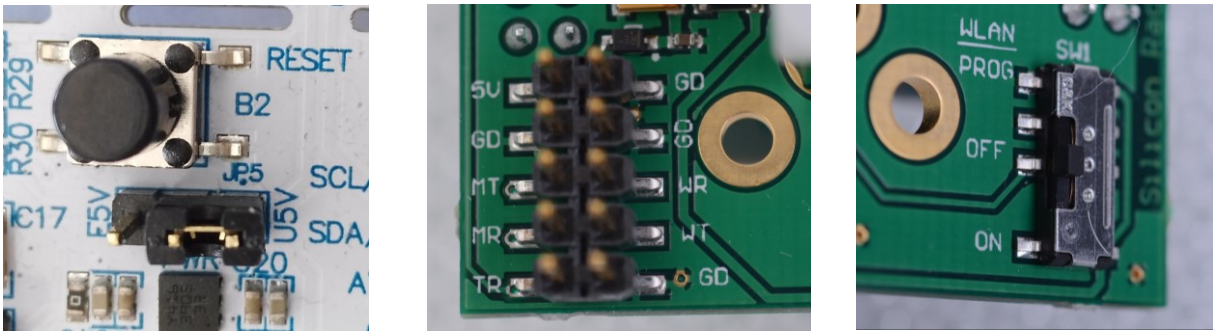


Figure 5: Hardware configuration for USB connection

The Evaluation Kit can now be connected to a PC using a USB cable. We recommend using an active USB Hub between the PC and the Evaluation Kit, especially when connected to a Laptop. Alternatively, the board can be powered by a standard 5V supply via the external header (pins 5V and any of the four GD pins).

Please proceed to Section 2.1.5 to install the lens (optional) or to Section 2.2 for running the Evaluation Kit software.

2.1.4 Wireless Data Connection via WiFi (WiFi Mode)

If you want to connect to the sensor via USB instead of WiFi, please skip this section and go back to Section 2.1.3. **Please be aware that the WiFi module has a limited transfer rate. The maximal possible frame update rate is about 10 Hz when using the WiFi connection.** Put the jumper JP5 on the microcontroller board in the E5V setting like shown in Figure 6 (left). Use the jumpers delivered with the Evaluation Kit and connect MT/WR and MR/WT on the baseband board as shown in Figure 6 (middle). Apply power from a standard source: +5V to the 5V pin and GND to the any GD pin (there are four) of the external header (J1). Bring the WiFi switch SW1 on the baseband board in the ON position as shown in Figure 6 (right).

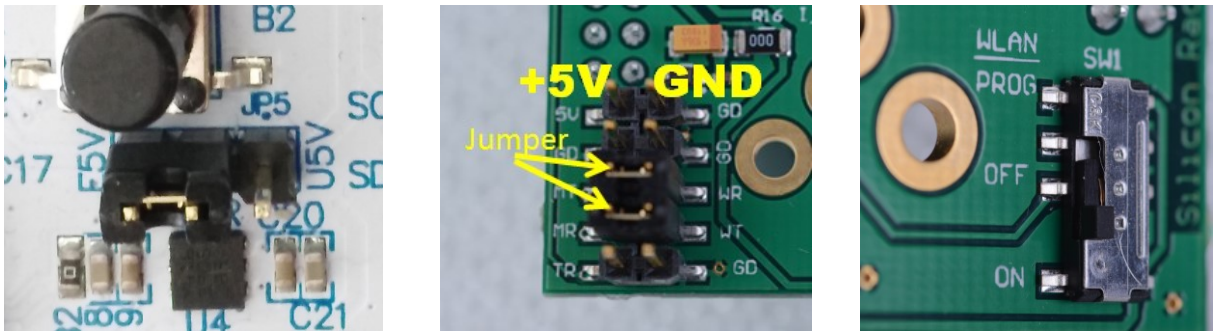


Figure 6: Hardware configuration for USB connection

Please proceed to Section 2.1.5 to install the lens (optional) or to Section 2.2 for running the Evaluation Kit software.

2.1.5 Mounting the Lens (Optional)

The maximum range of the 122 GHz frontend is approximately 40 meters with an opening angle of around +/- 30 degrees (-6dB) - for strong targets like a building or car - or +/- 4 degrees with the lens mounted. If you want to use the lens to increase the maximum range of the system and to decrease the opening angle, please install the lens at a distance about 10 to 15 mm away from the radar frontend's surface, see Figure 7. You can use the provided 10 mm spacers to mount the lens. With the lens installed, the opening angle of the system decreases like compared in Figure 8.

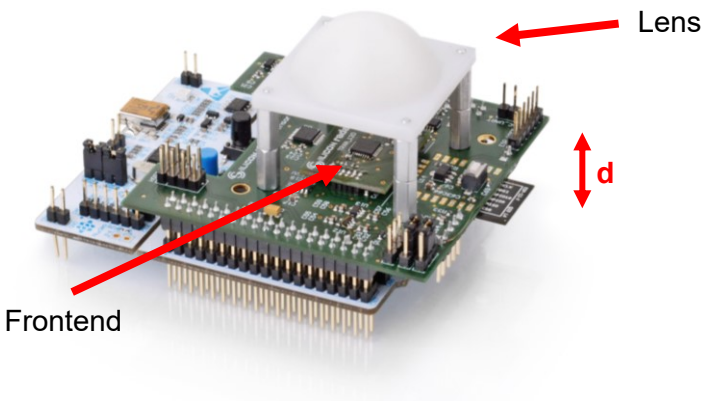


Figure 7: Mounting the lens

The lens has a focal length of 15 mm with an opening angle of +/- 4 degrees. If it is installed closer to the radar frontend, the beam will be wider. Figure 8 shows a schematic diagram of the two range configurations modes - with and without the lens.

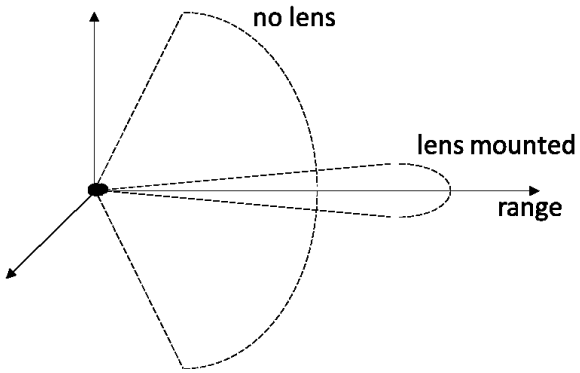


Figure 8: Schematic comparison of range with and without the lens

2.2 Software Installation

2.2.1 Software requirements

The SiRad Easy® Evaluation Kit software for PC is available from the Silicon Radar webpage[2] upon request. There are two possibilities to connect the SiRad Easy® to the Evaluation Kit software, either using the USB connection provided by a virtual COM port – explained in Section 2.2.2 – or via WiFi – explained in Section 2.2.3. The hardware setup for the USB and WiFi connection modes have been explained in Section 2.1.3 (USB) and 2.1.4 (WiFi).

Please configure the SiRad Easy® for either the USB mode or the WiFi mode before proceeding to one of the next sections.

The Evaluation Kit software requires a web browser (not included in the software package) that supports WebGL, for example, Google Chrome Browser or Mozilla Firefox. WebGL requires a graphics card that supports OpenGL. Further, the software requires a 32 bit Java JRE or JDK version 1.8.0-111 or later to be installed on the system running the software. Please also have a look at Table 1 for the software requirements.

Please note that 64 bit Java is not supported by the software package.

Table 1: Software requirements

Requirement	Software / Version
Operating system	Microsoft Windows 7/10
Java	32 bit Java JRE/JDK 1.8.0-111[3]
Browser	Chrome Browser or Mozilla Firefox[4]

[2] http://www.siliconradar.de/evalkits_d.html

[3] http://www.oracle.com/technetwork/java/javase/downloads/index.html

[4] https://www.google.com/chrome/browser/desktop/index.html

2.2.2 Connecting to the Board via USB

The SiRad Easy® can be connected to a PC via USB that provides a virtual COM port. If you want to connect to the SiRad Easy® via WiFi instead of USB, please follow this section anyway to install the flash tool and then go ahead to Section 2.2.3. **You need the flash tool to change the firmware in case you want to exchange the radar frontend on the SiRad Easy®.**

Installing the USB driver and Flash Tool

To install the USB driver, go to the ST Microelectronics website[5] and download and install ST-LINK USB driver (STSW-LINK009). Optionally, you may also install the ST-LINK Utility[6] to flash the microcontroller firmware in case you want to exchange the radar frontend. Please read the Installation Guide and Release Note linked on the vendor's website. Once the USB driver is installed, the Evaluation Kit should provide a virtual COM port. On Microsoft Windows, the COM port number can be checked in the device manager by connecting and disconnecting the USB port of the Evaluation Kit. Before you proceed with the installation of the software, you can now optionally connect to this serial port using a terminal program such as PuTTY[7] or Realterm[8] with the following UART settings: 230400 baud, 8 bits, 1 stop bit, no flow control. You should see plenty of protocol output from the SiRad Easy® like in Figure 9 (left).

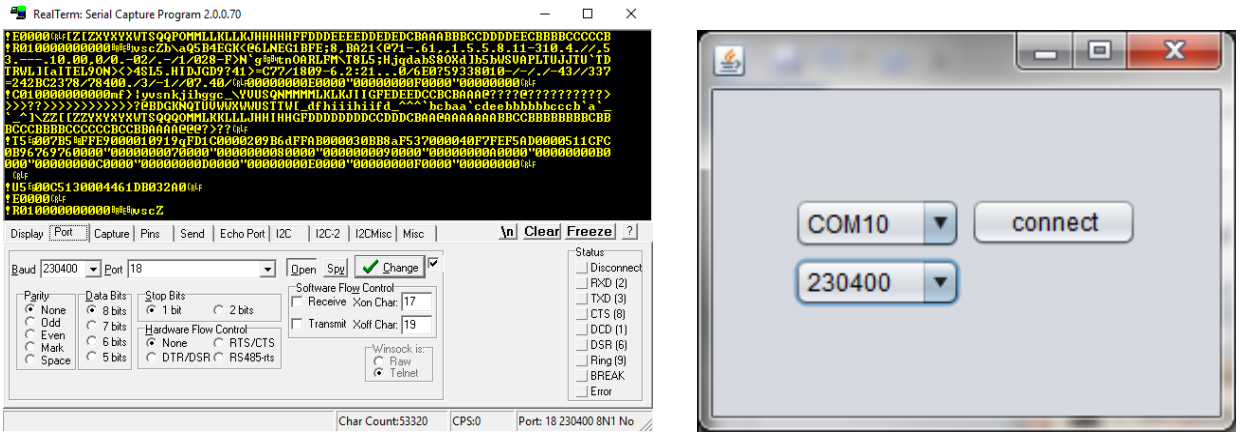


Figure 9: Terminal output of the Evaluation Kit (left) and COM2WebSocket tool (right)

Installing the Evaluation Kit's COM2WebSocket tool

The Evaluation Kit software contains a COM2WebSocket tool that creates a WebSocket from the virtual COM port to provide it to the graphical user interface. You can find the tool in the Install Package in the 'Software' folder. The COM2WebSocket tool is portable and can be copied to a path of your choice on your PC. Make sure that the java.exe of your Java JRE or SDK installation is available in the PATH variable of Windows, then start it by double clicking the Com2Websocket.jar file. Alternatively, or if you do not have Admin rights, you can also change the path to the 'java.exe' file of your Java installation in the file 'runme.bat' of the COM2WebSocket tool and then run it by a double click on the 'runme.bat' file. In the COM2WebSocket application window, select the virtual COM port number that belongs to your SiRad Easy® and select 230400 baud as the baudrate like shown in Figure 9. A click on the 'connect' button opens a WebSocket server, which is fed with the data coming from the SiRad Easy®. Proceed to Section 2.2.4 for running the graphical user interface.

---

5 http://www.st.com/content/st_com/en/products/embedded-software/development-tool-software/stsw-link009.html

6 http://www.st.com/en/embedded-software/stsw-link004.html

7 http://www.putty.org

8 https://realterm.sourceforge.io

2.2.3 Connecting to the Board via WiFi

Even if you want to connect to the SiRad Easy® via WiFi instead of USB, please go back to Section 2.2.2 to install the USB driver and flash tool and then come back to this section. **You need the flash tool to change the firmware in case you want to exchange the radar frontend on the SiRad Easy®.**

Please be aware that the WiFi module has a limited transfer rate. The maximum possible frame update rate is about 10 Hz when using the WiFi connection. Once you power-up the SiRad Easy® in WiFi configuration, the WiFi module's LED is flashing in blue. The WiFi module opens an own access point. This may last approximately 40 seconds. Please set the WiFi module of your PC to use automatic IP address selection via DHCP to get an IP address from the SiRad Easy®. If your PC's WiFi module uses a static IP, it might not be possible to connect to the WiFi module of the SiRad Easy®. Connect to the SiRad Easy®'s WiFi access point using the following login credentials:

SSID: **EasyRadar** Password: **Greetings**

Once the SiRad Easy®'s WiFi module has opened an access point, it waits for approximately 40 seconds until it starts the sensor operation and the blue LED is switched off. On Windows, the IP address that was assigned by the SiRad Easy®'s WiFi module to your PC can be checked in the network manager. Proceed to Section 2.2.4 for running the graphical user interface.

2.2.4 Starting the Graphical User Interface (Silicon Radar WebGUI)

You can find the Silicon Radar WebGUI in the Install Package in the 'Software' folder. It is portable and can be copied to a path of your choice on your PC. The user interface is started by opening the 'startEasy.html' file or the 'index.html' file in a Chrome or Firefox Webbrowser. Once the WebGUI is launched, the main window is displayed, also see Figure 10 (left).

WiFi only: If you are using a WiFi connection to connect to the Evaluation Kit, unfold the 'COM' section in the control panel on the left side of the WebGUI. Provide the IP address and the port of the WiFi module of the SiRad Easy® you want to connect to before you proceed, like so: '192.168.4.1:9090'. The standard port is 9090.

Click the 'Connect' button on the top left to connect to the WebSocket provided by the COM2WebSocket tool or to the WiFi module of the Evaluation Kit. The WebGUI should display the sensor data as shown in Figure 10 (right).

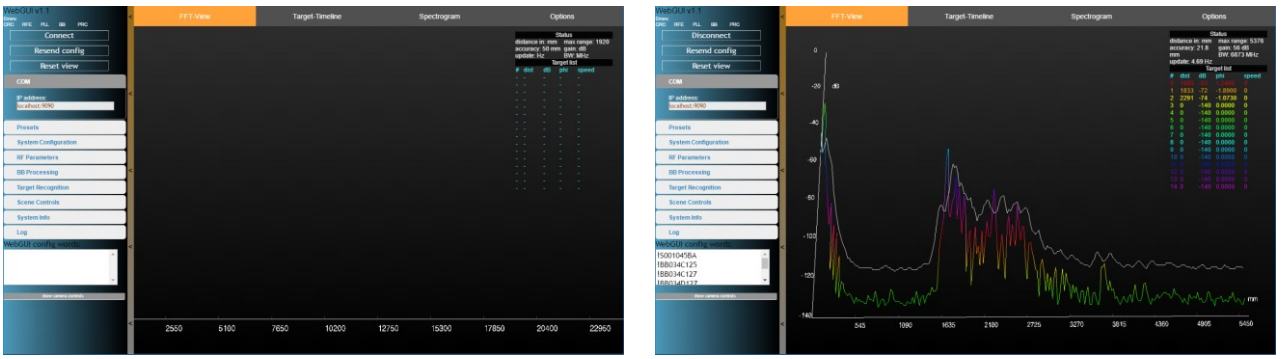


Figure 10: Silicon Radar WebGUI after start (left) and connected to the SiRad Easy® (right)

The WebGUI can now be used as described in Section 3.

3 Getting Started with the Silicon Radar WebGUI

3.1 Understanding the User Interface

The SiRad Easy® Evaluation Kit is developed to demonstrate the functionality of Silicon Radar's transceiver chips as millimeter-wave distance and velocity sensor frontends. Once the WebGUI is launched, the main window is displayed like shown in Figure 11.

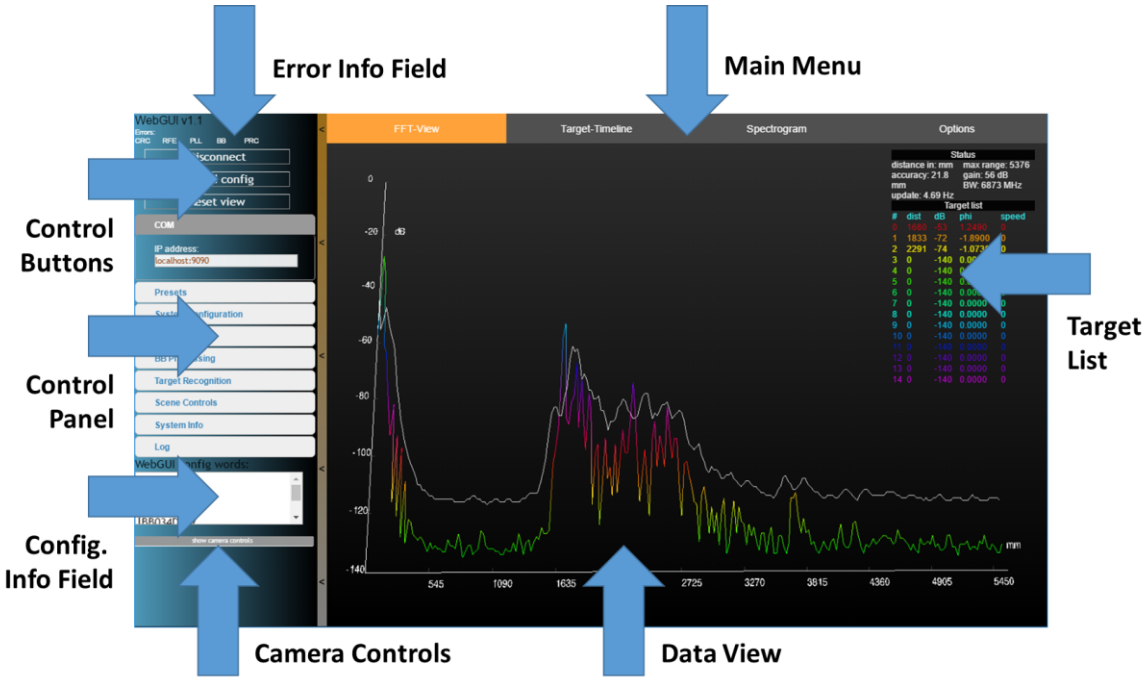


Figure 11: Main panels of the Silicon Radar WebGUI

The Silicon Radar WebGUI consists of four main panels:

- control panel on the left side,
- main menu on the top of the screen - with the active view in orange,
- scene/canvas itself - where the sensor data is displayed,
- target list with the status fields on the right side of the screen (draggable).

The control buttons on the top left corner are used to connect the WebGUI to the SiRad Easy®:

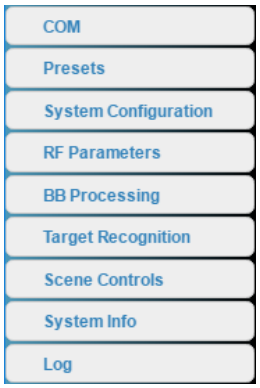
Connect: is used to connect the WebGUI to the WebSocket provided by the Com2WebSocket tool, which should be started before connecting the WebGUI.

Resend config: used to send the current settings to the SiRad Easy®. Usually, the settings made in the WebGUI will immediately take effect on the SiRad Easy®, however, this feature is useful when a SiRad Easy® was reset or reconnected.

Reset view: resets the view area to use the maximal available window space for displaying the data and centers the view in the view area.

3.2 Using the Control Panel (Sensor Settings)

The control panel on the left side of the WebGUI provides the controls for the user interface. It is used to connect to the Evaluation Kit, to send commands and to change the data view. The control panel contains the sections shown in Figure 12.



Tab	Description
COM	communication options
Presets	load and save settings
System Configuration	system settings
RF Parameters	radio and frequency settings
BB Processing	baseband processing settings
Target Recognition	target recognition settings
Scene Controls	scene control options
System Info	hardware information
Log	recently sent control frames

Figure 12: Control panel with its different tabs

3.2.1 Communication Options (COM Tab)

The standard setting 'localhost:9090' is for communication via the USB port, see Figure 13 (left). If you are using WiFi, type in the IP address and the port 9090 of the SiRad Easy®'s WiFi module like in Figure 13 (right), for example, '192.168.4.1:9090'.

Figure 13: COM tab of the Control Panel for USB (left) and WiFi (right) communication

3.2.2 Load and Save Settings (Presets Tab)

Load predefined settings: You can load predefined settings via the dropdown box in the 'Presets' tab, see Figure 14 (left). Choose a setting and press 'Load'. Afterwards go to the 'System Configuration' tab and choose 'SER2' if you use the USB connection instead of WiFi. The factory presets are explained Figure 14 (right).

Setting	Description
landing mode	high accuracy: 25 mm, distance: 6.4 m, update rate: 17.67 Hz
max accuracy	***very high accuracy: 6.2 mm***, short distance: 3 m, update rate: 11.29 Hz
max distance	low accuracy: 75.1 mm, ***long distance 38.4 m,*** update rate 7.96 Hz
max update rate	high accuracy: 30 mm, distance: 7.6 m, ***high update rate: 31.65 Hz,*** no spectrum output
standard	high accuracy: 30 mm, distance: 7.6 m, max update rate: 12.56 Hz

Figure 14: Presets tab (left) and predefined settings (right)

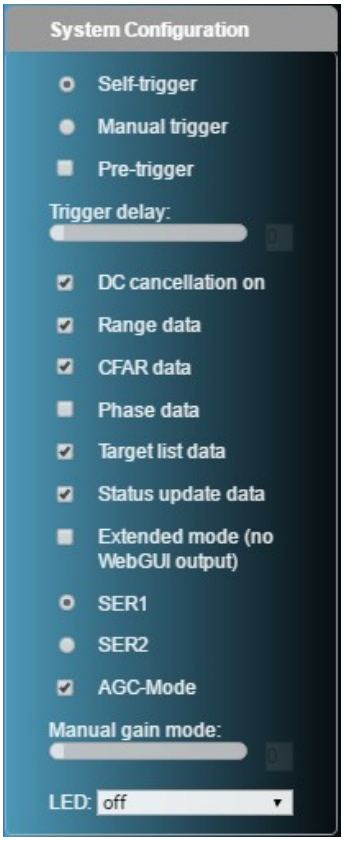
Save own settings: To save your settings, click the 'New' button. The dialog in Figure 15 appears. Enter a preset name and description for your settings and click 'Save'. All settings are stored as cookies in your browser so that they are available next time when you open the browser. **Please make sure that your browser saves and keeps cookies (Mozilla Firefox) or local storage is enabled (Chrome Browser) to enable this feature. Do not use a 'private' mode and do not set up your browser to delete all saved content each time you close the window.**

Figure 15: Save settings in the Presets tab of the Control Panel

Delete settings: To delete settings, choose a preset name and click 'Delete'. In case you accidentally deleted one of the factory presets that are explained in Figure 14 (right), those will be automatically restored next time you open the browser.

3.2.3 System Settings (System Configuration Tab)

The 'System Configuration' tab shown in Figure 16 is used to control the kind and amount of transmissions from the SiRad Easy®.



Setting	Description
Self-trigger	SiRad Easy® triggers itself continuously
Manual trigger	manual or external triggering mode
Pre-trigger	used to synchronize measurements
Trigger delay	set a delay between trigger and measurement
DC cancellation	switch DC offset compensation on
Range data	transmit distance data frames
CFAR data	transmit CFAR data frames
Phase data	transmit phase data frames
Target list data	transmit target list data frames
Status update data	transmit status data update frames
Extended mode	switch to raw data output
SER1	connect to the SiRad Easy® via WiFi
SER2	connect to the SiRad Easy® via USB
AGC-Mode	switch automatic gain control on
Manual gain	set a gain (when AGC-Mode is switched off)
LED	choose an LED operating mode

Figure 16: System Configuration tab of the Control Panel

3.2.3.1 Triggering measurements

You can choose between the two triggering modes 'Self-triggering' and 'Manual triggering'. You can find the steps to set them in Table 2.

Table 2: Triggering modes

Self-triggering (internal)	Manual (external) triggering
1. choose 'Self-trigger'	1. choose 'Manual trigger'
2. disable 'Pre-trigger'	2. optionally enable 'Pre-trigger'
3. optionally set a 'Trigger delay'	3. manually send triggers on the external trigger line (TR) - also see Section 3.2.3.1 - or by sending command frames (see the Protocol Description)

Self-trigger: activates the continuous measurement mode (default). The SiRad Easy® triggers itself repeatedly for continuous measurements.

Manual trigger: deactivates the continuous measurement mode for manual external triggering. Use this setting for asynchronous triggering or synchronized measurements between multiple radar sensors. The SiRad Easy® enters a low power mode after the transmission of measurement results and wakes up upon the next trigger. Also see the Protocol Description for manual trigger commands.

Pre-trigger: can be used to synchronize measurements between multiple radar sensors. If selected, and the SiRad Easy® is not in self-trigger mode, the SiRad Easy® expects two external trigger commands to execute one measurement. The two triggers have to be sent with a maximum delay of about 40ms or the second trigger is ignored. Also see the Protocol Description for the trigger commands.

Trigger delay: sets a delay time between two measurements when in self-trigger mode.

3.2.3.2 Frame options

DC cancellation: activates the DC offset compensation of the ADC data.

Range data: activates the transmission of the distance data frames, which contain the distance spectrum data in dB for each distance bin (magnitude of the complex FFT output).

CFAR data: activates the transmission of the CFAR data frames, which contain the threshold of the constant false alarm rate (CFAR) operator in dB for each distance bin. The CFAR operator is an adaptive algorithm to derive detection threshold for targets against noise.

Phase data: activates the transmission of the phase data frames, which contain the values of the phase angles for each distance bin (argument of the complex FFT output).

Target list data: activates the transmission of the target list data frames, which contain a list of targets including a target number, distance to the target, and their magnitude in dB and their phase. The speed field is reserved.

Status update data: activates the transmission of the status data update frames after every measurement. If deactivated, the status frame is only transmitted after the Evaluation Kit settings changed. The status frame contains the distance unit (default: mm), the current maximum range of the Evaluation Kit, the measurement accuracy of the current setting, the gain setting of the baseband amplifier for the last measurement, the update rate of the Evaluation Kit and the bandwidth of the frequency ramps used in the current setup.

Extended mode: activates the transmission of the extended data frames (raw data) instead of the standard data frames. Please be aware that the extended data frames are not supported by the WebGUI. No data will be shown in the WebGUI as long as the extended data mode is enabled. Please see the Protocol Description for more information about the 'Extended mode'.

3.2.3.3 Connection control

SER1: connect to the SiRad Easy® using the WiFi module.

SER2: connect to the SiRad Easy® using the USB port.

Please note that, if the wrong connection option is selected, the WebGUI will appear to be frozen because no data will be displayed. However, the SiRad Easy® always listens on both serial ports, so reconfiguring is possible at any time.

3.2.3.4 Gain settings

AGC-Mode: activates the automatic gain control. If activated, the SiRad Easy® uses two extra frequency ramps to detect and set the optimal gain setting. When AGC-Mode is turned on, the settings of the gain slider are overridden by the automatic gain control.

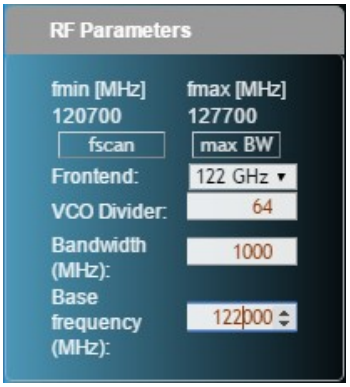
Gain: used to manually set one of 4 gain levels. The gain control is only used when the AGC-Mode is switched off. There are 4 gain modes, which depend on the hardware version of the baseband board due to adaptations in the attenuation network and ADC lines of the baseband amplifier. The gain settings for the latest SiRad Easy® baseband board (v1.3) are 8, 21, 43, 56 dB (left to right).

3.2.3.5 LED control

LED: switches the LED on or off. If switched on, the LED indicates the distance to the first detected target in rainbow colors.

3.2.4 Radar Frontend Settings (RF Parameters Tab)

The 'RF Parameters' tab in Figure 17 is used to control the radar frontend of the Evaluation Kit. For each radar measurement, the frontend is driven with one or more frequency ramps starting from a defined start frequency f_1 (base-frequency) to a higher frequency f_2 with the bandwidth BW = $f_2 - f_1$. The higher the bandwidth, the smaller is the detection range of the SiRad Easy® due to Nyquist limitations. The start frequency is technically limited by the minimum frequency f_{min} supported by the frontend. The bandwidth is limited by the maximum frequency f_{max} supported by the frontend. **Please note, that in most countries, the permitted bandwidth is regulated by law to 250 MHz between 24 GHz and 24.25 GHz and to 1 GHz between 122 GHz and 123 GHz for field applications. Please check your local regulations.**



Setting	Description
fmin	shows the minimum supported frequency of the radar frontend in MHz
fmax	shows the maximum supported frequency of the radar frontend in MHz
fscan	re-scan the minimum and maximum supported frequencies
max BW	auto set the maximum available bandwidth for the frequency ramps depending on the supported min and max frequencies
Frontend	switch the presets for the used radar frontend
VCO Divider	shows the VCO divider, fixed per frontend type
Bandwidth	set the bandwidth used for the frequency ramps in MHz
Base-frequency	set the start frequency of the frequency ramps in MHz

Figure 17: RF Parameters tab of the Control Panel

fmin / fmax: displays the result of the frequency scan (done once automatically during startup) to find the minimum and maximum supported frequencies of the installed radar frontend (f_{min} and f_{max}). The scan can be performed manually by using the 'fscan' feature (click it 3 times in a row).

fscan: performs a manual min / max frequency scan for the installed frontend when clicked 3 times in a row. The frequencies supported by your frontend should be approximately in the range of 23300 to 26200 MHz for the 24 GHz frontend and 119100 to 125900 MHz for the 122 GHz frontend.

max BW: sets the frequency ramp bandwidth to the maximum possible value for the installed frontend when clicked 3 times in a row. The maximum bandwidth is hardware dependent and may vary. The maximum useful bandwidth BW is (including a margin of 200 MHz):

$$BW_{max} = (f_{max} - 100\ MHz) - (f_{min} + 100\ MHz).$$

Frontend: switches the presets for the used radar frontend.

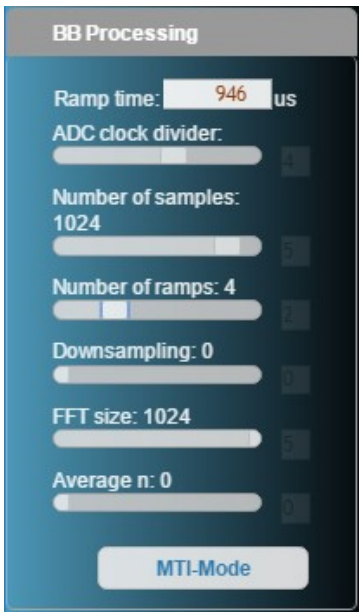
VCO Divider: is hardware dependent per frontend type. **The VCO divider for the SiRad Easy® frontends are 8 for the 24 GHz frontend and 64 for the 122 GHz frontend, fixed.**

Bandwidth: set the bandwidth (in MHz) used for the frequency ramps. The bandwidth should not exceed the maximum frequency f_{max} of the frontend minus the minimum frequency f_{min} of the frontend minus 200 MHz.

Base-frequency: set the start frequency of the frequency ramps (in MHz). The start frequency f_B should be at least 100 MHz larger than the minimum supported frequency f_{min} of the frontend, and at least 100 MHz smaller than the maximum supported frequency of the frontend f_{max} minus the desired bandwidth. **If the base-frequency and bandwidth are chosen in a way that the bandwidth exceeds the minimum and maximum supported frequencies of the frontend, the voltage applied to the VCO for the voltage ramp may drive into saturation, which decreases the signal quality.**

3.2.5 Baseband Processing Settings (BB Processing Tab)

The 'BB Processing' tab shown in Figure 18 is used to control the baseband processing of the SiRad Easy® to tune the SNR, accuracy, or processing speed.



Setting	Description
Ramp time	shows the calculated ramp time per ramp
ADC clock divider	adjust the sampling frequency indirectly
Number of samples	adjust the number of samples per ramp
Number of ramps	adjust the number of ramps used for SNR reduction
Downsampling	adjust the number of samples that are averaged after sampling
FFT size	adjust the number of FFT bins
Average n	adjust the number of FFTs to average
MTI-Mode	activate / deactivate the Moving Target Indicator mode

Figure 18: BB Processing tab of the Control Panel

Ramp time: is reported back by the SiRad Easy®. The ramp time t is calculated using the selected sampling time t_{Smp}, the number of samples n_{Smp} and the clock frequency of the ADCs, like

$$t\ [us] = t_{Smp}\ [clock\ cycles] * 1.04 * n_{Smp} / (36\ MHz)$$

The sampling time t_{Smp} is an internal value that is controlled by the ADC Clock Divider setting according to Table 3. The sample frequency f_{Smp} is determined by the clock frequency of the ADCs (36 MHz) divided by the ADC sampling time t_{Smp}. The constant 1.04 is an overhead correction factor for the ramp handling.

Table 3: Sampling time and sample frequency

ADC Clock Divider	ADC sampling time t_{Smp} [clock cycles]	Sample frequency [MS/s]
0	14	2.5
1	15	2.4
2	17	2.1
3	20	1.8
4	32	1.1
5	74	0.4
6	194	0.1
7	614	0.05

ADC clock divider: sets the sampling time of the ADCs indirectly. A higher ADC clock divider means slower sampling, according to Table 3.

Number of samples: sets the number of samples taken per ramp.

Number of ramps: sets the number of ramps that are driven per measurement. All ramps are integrated to improve the SNR. Hence, higher values give slower measurements but better SNR. However, too many ramps may smear out the signal due to the phase noise of the system.

Downsampling: determines how many samples are averaged after sampling. Higher downsampling values improve the accuracy but reduce the maximum range of the SiRad Easy®. Voids are filled with zeroes when downsampling. A downsampling of 0 means no downsampling, 1 means an average of 2 values, 2 an average of 4 values, etc.

FFT size: sets the number of FFT bins. Higher values mean better accuracy but slower calculation.

Average: determines the number of FFTs to average. An average of 0 means 1 FFT without averaging, 1 means an average of 2 FFTs, etc.

MTI-Mode: activates the Moving Target Indicator mode. When activated, the SiRad Easy® displays the difference between the current measurement and the average of the previous measurements (set by the 'Average n' slider).

3.2.6 Target Recognition Settings (Target Recognition Tab)

The 'Target Recognition' tab shown in Figure 19 is used to control the CFAR-operator for the target recognition and the reported distance format / unit. Please also see Table 4 below for the valid format options. The CFAR-operator is explained in Figure 20. We use a simple CACFAR-operator that calculates the average from the reference cells for the CFAR.

Setting	Description
CFAR guard	adjust the number of guard cells before and after the cell under test
CFAR size	adjust the number of FFT bins used on either side of the guard cells
CFAR threshold	adjust the detection threshold in dB above the noise floor
Format	adjust the format in which the distance data is sent / displayed

Figure 19: Target Recognition tab of the Control Panel

Table 4: Format options

Format	Option	Description
0 - 3	Reserved	
4	bins	number of the distance bin which receives the data
5	mm	data is displayed in 'mm' depending on the accuracy
6	cm	data is displayed in 'cm' depending on the accuracy

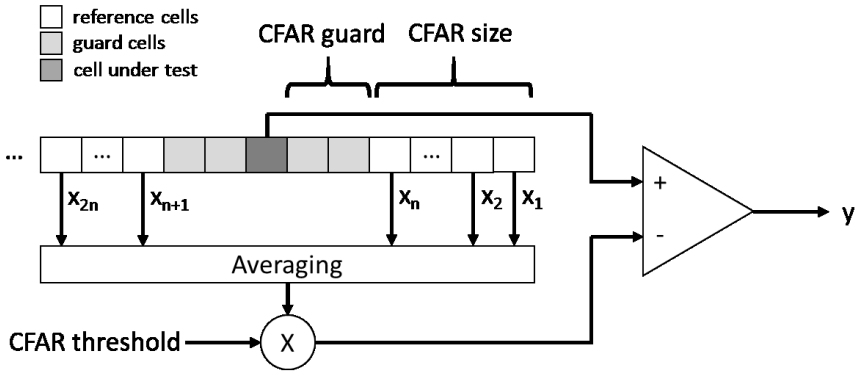
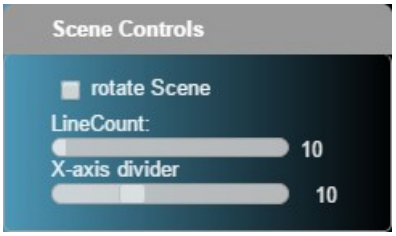


Figure 20: Schematic description of the CACFAR-operator

3.2.7 Scene Control Options (Scene Controls Tab)

You can control the scene with the settings shown on the 'Scene Control' tab shown in Figure 21.



Setting	Description
rotate Scene	rotates the view around the center of the drawing area
LineCount	adjust the number of datasets shown in the waterfall view (3D)
X-axis divider	adjust the number of data labels shown on the x-axis

Figure 21: Scene Controls tab of the Control Panel

3.2.8 Radar Hardware Information (System Info Tab)

The 'System Info' tab in Figure 22 (left) shows the unique hardware identification number of the SiRad Easy®. You can press the 'Update system info' button to refresh this information.

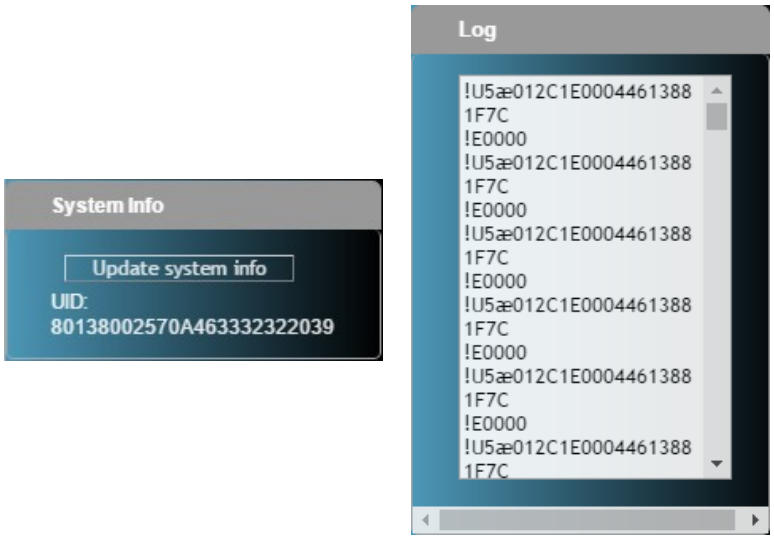


Figure 22: System Info tab (left) and Log tab (right) of the Control Panel

3.2.9 Recently Sent Control Frames (Log Tab)

Figure 22 (right) shows the Log tab which lists the latest control frames sent to the SiRad Easy®. Also see the Protocol Description for further information about the SiRad Easy®'s communication protocol.

3.3 Using the Main Menu

The main menu is shown in Figure 23. Here you can select how the data should be displayed. You have the following main options, which are explained in the following subsections:

- FFT-View: FFT (2D) and Waterfall (3D)
- Target-Timeline
- Spectrogram
- Options

Figure 23: Main menu of the WebGUI

3.3.1 FFT View

FFT (2D) chart (Figure 24):

The x-axis shows the distance and the y-axis shows the magnitude in dB at this distance.

Waterfall (3D) chart (Figure 25):

In the 3D view you can see the history of data, with the z-axis being the timeline. Older values move to the back (higher z-values). The x and y-axes behave like in the 2D view.

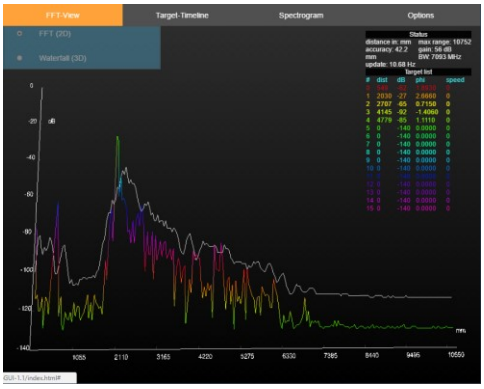


Figure 24: 2D view of the FFT data

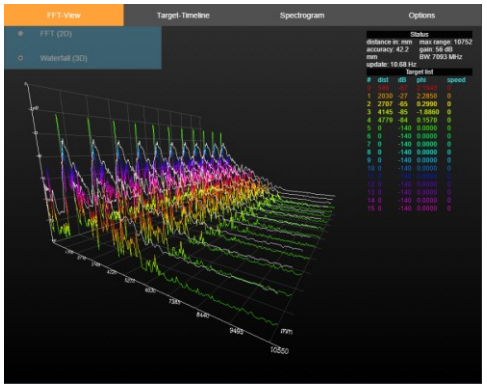


Figure 25: 3D view of the FFT data

3.3.2 Status Field and Target List

The 'Status' field shown in Figure 26, top, displays a couple of useful information about the current measurements.

distance: shows the used distance format of the SiRad Easy®, for example, [mm, cm, bins].

max range: current max. measurement range of the SiRad Easy® in the chosen distance format.

accuracy: the width of one distance bin of the SiRad Easy® after the formula

$$acc = \frac{c \cdot n_{Smp}}{2 \cdot BW \cdot n_{FFT} \cdot n_{down}}$$

where c is the speed of light, BW is the bandwidth, n_{Smp} is the number of samples, n_{FFT} is the FFT size, and n_{down} is the downsampling factor.

gain: current gain setting of the baseband amplifier in dB.

BW: the chirp's bandwidth.

update: calculated update rate from the TSLM-value („time since last measurement").

The 'Target list' shown in Figure 26, bottom part, is ordered by distance. With every new measurement having the CFAR operator enabled, the 'Target list' is updated. Where the distance bin crosses the CFAR threshold from below, the local maximum is searched and a target is generated. If two or more target peaks cross the CFAR threshold from below before the distance bin goes back underneath the CFAR threshold, only the first target is marked.

Target list column	Description
num	indicates the number of the target
dist	the distance of the target in the selected format
db	magnitude of the target peak
phi	phase angle of the target, meaning the phase shift between the outgoing wave and the incoming wave; the value should change rapidly, if the target is moving
speed	radial velocity of the target [m/s] calculated as a distance difference since the last measurement

Figure 26: Target list with the status field at the top

3.3.3 Target-Timeline

The ‘Target-Timeline’ in Figure 27 shows the magnitudes of past targets. The x-axis shows the distances of the targets and the y-axis shows the magnitudes of the targets in dB. The z-axis shows the timeline of the data. Older values move to the back (higher z-values).

3.3.4 Spectrogram

The ‘Spectrogram’ shown in Figure 28 is another time dependent display of distance data.

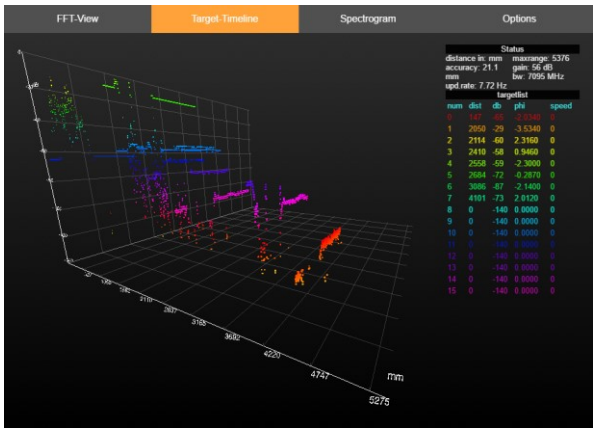


Figure 27: Target-Timeline

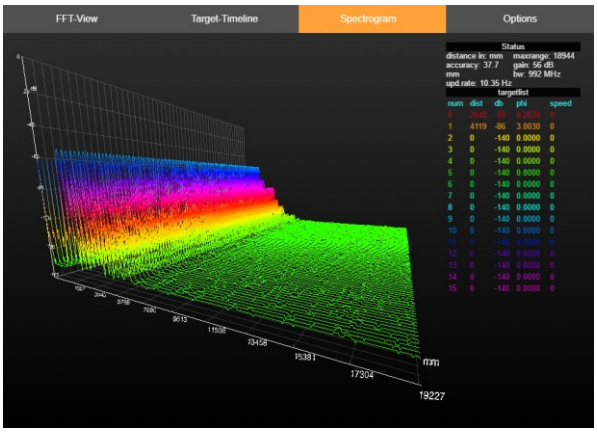


Figure 28: Spectrogram

3.3.5 Options

In the ‘Options’ menu, you can choose the coloring of the data between:

- Magnitude
- Range / target number
- Phase angles (the phase angles are only colorized if the magnitude is larger than -120 dB and when the Phase-frame transmission is enabled in the ‘System Configuration’ Tab)
- No coloring

Coloring examples are shown in Figure 29 to Figure 32. There is also an additional option to display phase markers above the detected targets. These markers show the phase angle of the detected target. The phase angle is very sensitive to slight changes of the target distance within one distance bin. It can be used to display relative motion in the µm range.

Figure 29: Magnitude coloring with phase markers

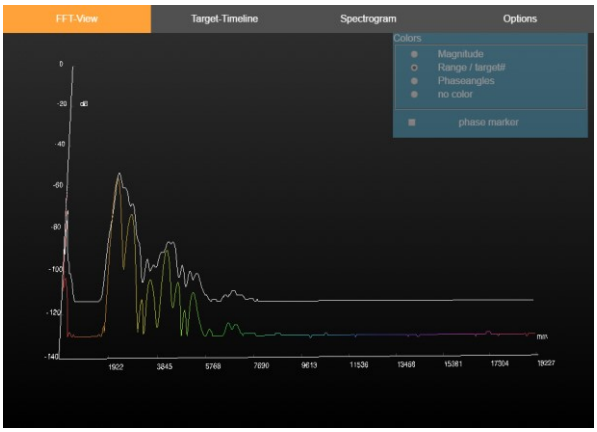


Figure 30: Range / target number coloring

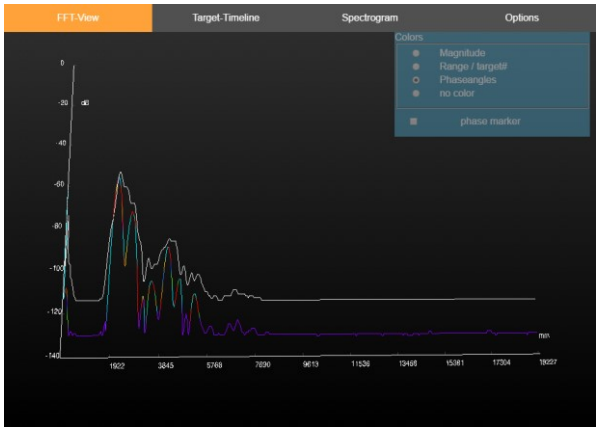


Figure 31: Phase coloring

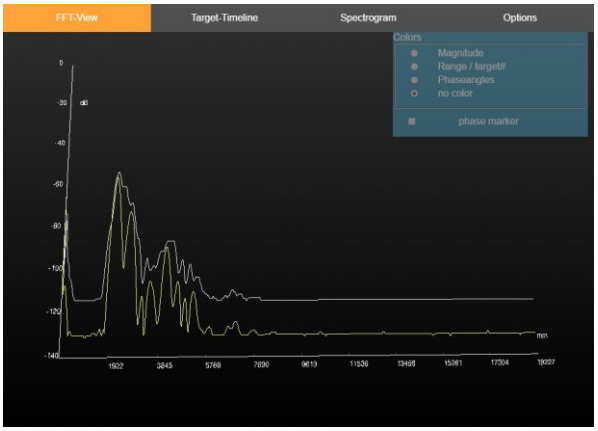


Figure 32: No color

3.4 Understanding the Configuration Info Field

The 'config' field shows the configuration that was send by the WebGUI to the SiRad Easy® on connect. Those config words are further explained in the protocol description.

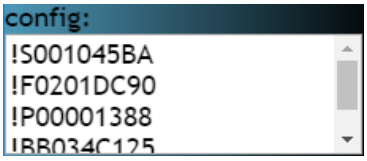
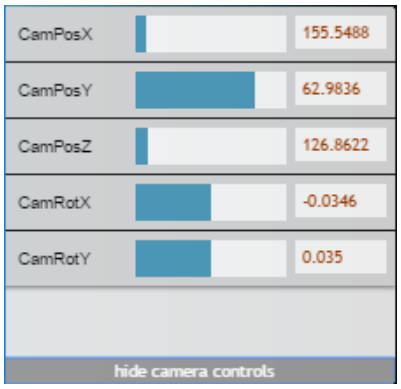


Figure 33: Configuration words

3.5 Camera Controls

Click on the

bar in the bottom left to show the camera controls. Here you can see and change the camera position and rotation of the view relative to the specified axis. The camera view can be changed using the mouse within the scene area. A left-click-drag pans the camera position. A right-click-drag changes the camera view angle. A middle-click-drag or moving the mouse wheel changes the zoom setting (z-coordinate) of the camera, also see Figure 34.



Camera control	Description
CamPosX	camera position on x-axis, move left (-) or right (+)
CamPosY	camera position on z-axis, move up (+) or down (-)
CamPosZ	camera position on z-axis, move to front(-) or back(+)
CamRotX	camera rotation on x-axis, rotate up(+) or down(-) relative to the x-axis
CamRotY	camera rotation on y-axis, rotate to left(+) or right(-) relative to the y-axis

Figure 34: Camera controls

3.6 Understanding the Error Info Field

The 'Error' info field is located in the top left of the WebGUI, see Figure 35.

Error flag	Description
CRC	UART transmission CRC checksum errors
RFE	radar frontend configuration errors
PLL	PLL configuration errors
BB	baseband processing errors
PRC	errors in the signal processing

Figure 35: Error info field

Temporary errors are indicated in yellow and persistent errors in red. Temporary errors are errors that are raised during processing but do not last longer than 3 times checking them. The temporary error flags are removed automatically. Persistent errors are errors that last longer than 3 times checking them and can be removed manually by resetting the SiRad Easy® or by using the command frames explained in the Protocol Description.

3.7 Understanding the Data View

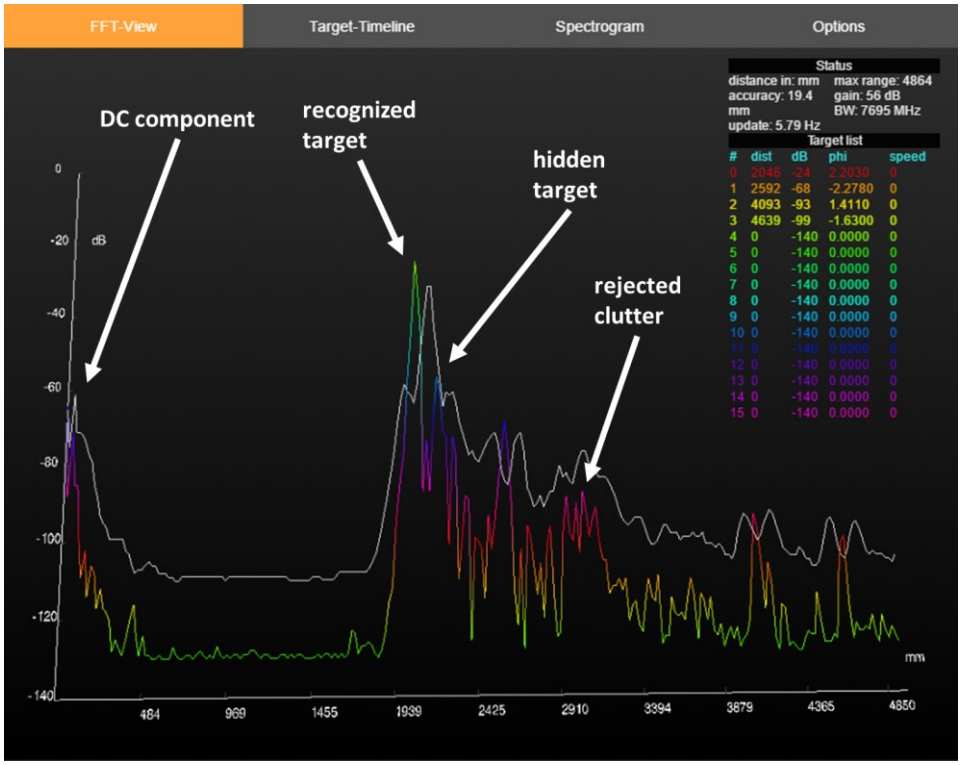


Figure 36: Data view with different elements in the display scene

Figure 36 shows a typical spectrum output of the SiRad Easy® when placed on a tabletop and looking to the ceiling. Viewing a radar target spectrum for the first time might be confusing for the beginner. However, with some practice, it is easy to find targets and understand why some things work while others might not.

Targets:

The first ceiling echo is around 200 cm, which should be quite high versus the neighboring noise floor. Using a lens will make this target peak thinner and higher and more easily detectable by the CFAR operator. The next targets are around 260 cm, 410 cm, and 460 cm.

Due to the adaptive nature of the CFAR operator it might happen that if two targets are too near to each other or are very different in magnitude, one of them is rejected (hidden) by the CFAR operator, such a target may be hidden around 220 cm. Changing the target recognition settings might help in this situation.

DC component:

There is some DC component on the left side. If this DC offset is high, it might trigger a false target detection of the CFAR operator.

Clutter:

Around 290 cm to 330 cm there might be some clutter which is rejected by the CFAR operator.

4 Troubleshooting

Below you can find a number of questions often asked by our customers. If you still cannot find the answer to your specific question about SiRad Easy®, please write to support@siliconradar.com.

4.1 Drivers

4.1.1 Where can I get the driver to connect the SiRad Easy® ?

To install the USB driver, go to the ST Microelectronics website[9] and download and install ST-LINK USB driver (STSW-LINK009). Optionally, you may also install the ST-LINK Utility[10] to flash the microcontroller firmware in case you want to exchange the radar frontend. Please read the Installation Guide and Release Note linked on the vendor's website, also see Section 2.2.2.

4.1.2 I installed the USB driver for the SiRad Easy® but it does not show up.

Please open the Device Manager in Windows and unfold the 'Ports (COM & LPT)' section. You should see a couple of ports there. Now unplug and plug your SiRad Easy®. The SiRad Easy® is installed properly if you can see another port show up, usually named 'USB Serial Port (COMx)' or similar. If this is not the case, please check your connection and if the device has power. Remove the USB driver and start over with the USB driver installation (see Section 2.2.2).

4.1.3 The USB driver for the SiRad Easy® does not work properly.

We recommend using another USB cable since some cables may operate unstable. If that does not help, please update the USB controller firmware of the Nucleo64 board as described in Section 5.

4.2 WebGUI

4.2.1 I cannot store presets in the Preset tab.

Please make sure you are not working in the private mode of your browser and you have enabled cookies, since the presets are stored as cookies, also see Section 3.2.2.

4.2.2 I cannot see any output in the WebGUI window.

Please first set the SiRad Easy® up for the USB connection. For that, check if the jumper J5 on the microcontroller board is set to the U5V setting, if all jumpers are removed from the external header of the baseband board, and if the dip switch SW1 on the SiRad Easy® baseband board is set to the OFF position according to Section 2.1. If not, please unplug the SiRad Easy®, adjust the settings, and plug it in again. Also check the USB cable connection and if your device is powered properly. Then go to the 'System Configuration' tab and chose SER2 for the USB connection. You can also toggle the 'Close' and 'Open' button of the Com2WebSocket tool without closing the WebGUI and see if that helps. Lastly, you can start over, close all WebGUI / Webbrowser and Com2WebSocket windows, disconnect the SiRad Easy® and start over with connecting the SiRad Easy®, connecting the Com2WebSocket tool and connecting the WebGUI.

[9] http://www.st.com/content/st_com/en/products/embedded-software/development-tool-software/stsw-link009.html

[10] http://www.st.com/en/embedded-software/stsw-link004.html

4.2.3 The spectrum output jumps (partly).

First, if you are not using the WiFi connection, disable the WiFi module by switching the dip switch SW1 to the OFF position. Sometimes it is necessary to turn the AGC-Mode off in the 'System Configuration' tab and manually choose one of the 4 gains using the gain slider. Further, you can try to manually set and increase the base-frequency in 100 MHz steps to see if that stabilizes the output.

4.2.4 How does the Auto Gain Control (AGC)-Mode work?

The AGC algorithm uses the first two ramps of each measurement to elaborate the highest gain setting without saturating the ADC or the baseband amplifier. In each of the two ramps the controller samples two gain stages while switching on an attenuation network during the first ramp. After that, the controller has 4 gain settings to choose from for the subsequent measurement.

4.2.5 Can I trigger the SiRad Easy® manually?

Yes. Please read Section 3.2.3.1 about the triggering options.

4.2.6 Can I use multiple SiRad Easy® Evaluation Kits in parallel?

Yes. You can synchronize the Evaluation Kits using the pre-trigger feature. We suggest either driving them in different frequency ranges so they do not interfere, or you trigger them manually to measure alternately. Please read Section 3.2.3.1 about the triggering options.

4.2.7 The LED goes off when I connect to the WebGUI.

This is because the WebGUI sends a different configuration to the SiRad Easy® when it is connected. The LED will light again when the proper serial port (SER1 for WiFi connection, SER2 for USB connection) is set in the 'System Configuration' tab and the LED mode is changed from off to 1st target rainbow.

4.2.8 The RF Parameters tab does not show the min / max frequencies properly.

You can try a manual min / max frequency scan by clicking the 'fscan' button three times.

4.2.9 How do I choose a base-frequency?

The base frequency should be at least 100 MHz above the minimum frequency and far away from the maximum frequency. For small bandwidths, you may choose the base frequency 500 MHz or more above the minimum frequency for an improved signal quality. **Please be aware, that in most countries the base frequency has to bet set between 24 GHz and 24.25 GHz or 122 GHz and 123 GHz for production purposes by law. Please check your local regulations.**

4.2.10 How do I set the maximum bandwidth in the RF Parameters tab?

Click the 'max BW' button three times to set the maximum possible bandwidth for the frontend.

4.2.11 How do I choose a bandwidth?

The smaller the bandwidth, the greater will the range of the SiRad Easy® become. However, with larger bandwidths the accuracy will decrease. **Please be aware, that in most countries the bandwidth is limited to 250 MHz between 24 GHz and 24.25 GHz and 1 GHz between 122 GHz and 123 GHz for production purposes by law. Please check your local regulations.**

4.2.12 How can I choose the ramp time?

The ramp time can only be set indirectly by adjusting the ADC clock divider and the number of samples, please read Section 3.2.5.

4.2.13 What is the MTI-Mode?

The Moving Target Indicator mode. When activated, the SiRad Easy® displays the difference between the current measurement and the average of the previous measurements (set by 'Average n' slider).

4.2.14 There are too many targets. The CFAR operator does not work.

You may experience that there are no targets detected by the CFAR operator although there are plenty of targets visible in the FFT output. If there are too many targets adjacent to each other in the field of view, the CFAR operator may treat those targets like noise floor and calculates an envelope around those targets. Increasing the number of guard cells may help in such a scenario.

4.2.15 How is the distance information calculated?

All calculations are done on the microcontroller on the SiRad Easy®, so that the reported target distance is already in millimeters. The distance formula used is

$$d = n_{Bin} * acc,$$

where d is the distance to the target, n_{Bin} is the FFT bin of the target, and acc is the accuracy (see Section 3.3.2 for the formula).

4.2.16 The update rate of the SiRad Easy® is very low. How can I improve it?

The update rate is dependent on the chosen parameters in the 'BB Processing' tab, in particular, on the ramp time, number of samples, number of ramps, and FFT size. Further, the amount of data that has to be transferred is important. You can select the transmitted frames in the 'System Configuration' tab. Using only the target list output, the SiRad Easy® can reach about 50 Hz update rate.

4.3 Sensor Behavior, Range & Lens

4.3.1 How is the resolution defined?

We define the resolution as the ability to separate two targets in range. The resolution is only dependent on the selected bandwidth. With 1 GHz bandwidth the resolution is 15 cm, 6 GHz bandwidth equals 2.5 cm resolution. In practice, target recognition works from twice the resolution.

4.3.2 How is the accuracy defined?

We define accuracy as the maximum error of the measured distance to a single target. It is dependent on the number of samples, the bandwidth, the downsampling and the FFT size. If the FFT size is twice the number of samples, the accuracy is two times less than the resolution. We can reach about 1 mm accuracy, also see Section 3.3.2 for the formula.

4.3.3 Is there a minimum range / blind spot when using the SiRad Easy®?

The minimum range depends on the selected bandwidth. 1 GHz bandwidth works from about 30cm, 6 GHz bandwidth works from about 7cm. The blind spot is approximately as wide as once or twice the resolution.

4.3.4 Can something be detected within the minimum range / blind spot?

Going below the bandwidth-dictated minimum range leads to an increased DC-offset in the FFT output. It could be used to detect 'something is nearby' but this is very application-specific.

4.3.5 What is the maximum range of the SiRad Easy®?

The maximum range is dependent on the target. The 24 GHz frontend reaches about 200 m and the 122 GHz frontend reaches about 40 m with strong targets like buildings.

4.3.6 Can the range of the SiRad Easy® be increased?

You can increase the range of the 122 GHz frontend by assembling the lens delivered with the SiRad Easy® Evaluation Kit, however, the opening angle will decrease. Larger detection distances are possible using bigger lenses or well-designed patch array antennas.

4.3.7 How is the field of view of the SiRad Easy®?

The area covered by the radar over distance is dependent on the field of view of the SiRad Easy®. Without a lens, the SiRad Easy® has an opening angle of +/- 30 degrees (-6dB). With the lens delivered with the SiRad Easy®, this can be narrowed to about +/- 4 degrees.

4.3.8 How can I get directional information from the SiRad Easy®?

SiRad Easy® has a single radar transceiver chip, which is not capable of giving directional information directly. It is possible, however, to use more than one SiRad Easy® to get rudimentary directional information.

4.4 Protocol & RAW data

4.4.1 Can I use the the SiRad Easy® with own or third-party software?

Yes. Please read the Protocol Description to get an idea how to control the SiRad Easy® with your own software or third-party software like MATLAB.

4.4.2 Can I activate raw data only or FFT data only output?

Yes. Please read the Protocol Description about how to set up the SiRad Easy® for raw data only or FFT data only output. You may choose between unwindowed raw data and windowed raw data as well as complex FFT data and magnitude / phase data output.

4.4.3 Can I use the sensor protocol with <any> device?

Yes. The protocol can be used to talk to the SiRad Easy® from any device, it does not need to be a PC.

4.5 Schematics & Firmware

4.5.1 Where can I find the schematics for the SiRad Easy®?

You may apply for a non-disclosure agreement (NDA) with Silicon Radar to get the schematics.

4.5.2 Where can I get the source code for the SiRad Easy®?

The firmware on the SiRad Easy® is not freely available but we are working on the SiRad library with a user friendly C programming API that we may provide to our customers. We do, however, provide the source code for the WebGUI and the Com2WebSocket tool.

5 Firmware Update

Please be careful when following this section. Silicon Radar is not responsible for any damages to your hardware or software that occurred during the flashing process.

5.1 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.

Just drag and drop the .bin file 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 the ST-LINK Utility[11] to flash the firmware on the microcontroller board. Please read the User Manual of the ST-LINK Utility linked on the vendor's website.

You can find the firmware for the 24 GHz frontend and the 122 GHz frontend in the folder 'Firmware\SiRad_Easy' of the provided Install Package:

- 'SiRad_Easy_L7_TRX_24_<version>.bin' for the 24 GHz frontend, bought after 10/2016,
- 'SiRad_Easy_L7_TRX_120_<version>.bin' for the 122 GHz frontend, bought after 10/2016,
- 'SiRad_Easy_L8_TRX_24_<version>.bin' for the 24 GHz frontend, bought before 11/2016,
- 'SiRad_Easy_L8_TRX_120_<version>.bin' for the 122 GHz frontend, bought before 11/2016.

If you are unsure, which firmware version is appropriate for your hardware, please contact support@siliconradar.com.

5.2 WiFi Module

Connect the SiRad Easy® using a USB to UART cable like shown in Figure 38 using the external header. Please read Section 2.1.2 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.

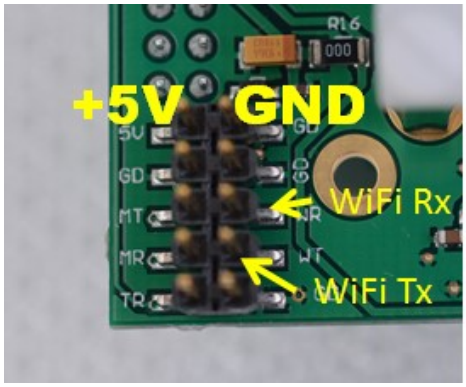


Figure 37: WiFi module update configuration

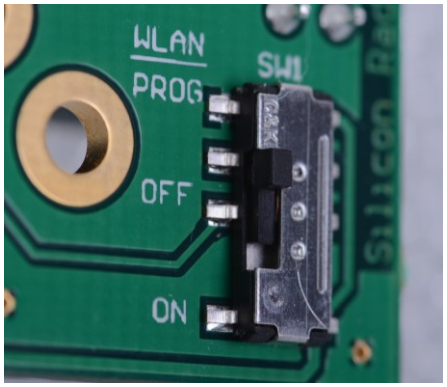


Figure 38: WiFi module select switch SW1

[11] http://www.st.com/en/embedded-software/stsw-link004.html

Find and install the esptool in the Firmware folder of the provided Install Package. Copy the firmware from the 'Firmware\WiFi_Module\websocket_mini' folder of the Install Package into the esptool folder. Edit the batch file esptool.bat and replace the COM port with the COM port of your USB to UART cable and the firmware name with the desired firmware, marked here:

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

Run the batch file and the WiFi module gets programmed, indicated by a flashing blue LED. After about 40 seconds programming is finished. Switch SW1 back to the ON position and connect a jumper between MT and WR and MR and WT.

5.3 USB Controller Firmware

Download and extract the ST-LINK firmware update tool[12] from the ST Microelectronics website. 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.

[12] http://www.st.com/content/st_com/en/products/embedded-software/development-tool-software/stsw-link007.html

6 Mechanical Drawing

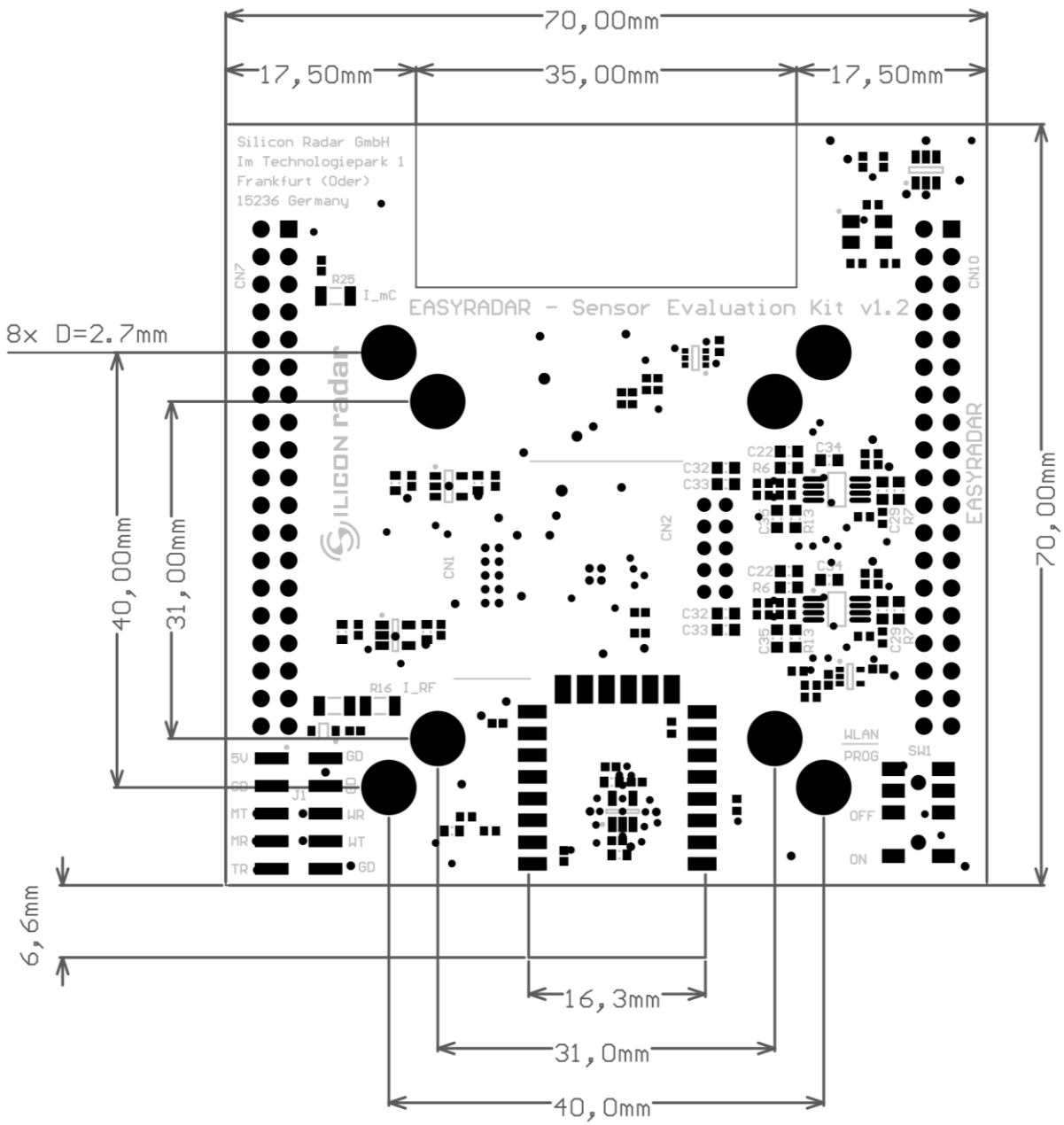


Figure 39: Mechanical drawing of the SiRad Easy® Baseband Board

7 Disclaimer / License

By using the information in this document, our products and the provided software, you agree to our disclaimer and license conditions.

| Disclaimer |
==========

The information contained in this document 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 that 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 modification 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.

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 APPLICATION 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, title and interest 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 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.

Silicon Radar GmbH, 2017

| License |
========

The radar software delivered with the Install Package is provided by Silicon Radar GmbH.

The software is provided ‘as is’ for testing purposes only. While hoping it will be useful, there is NO WARRANTY of any kind, including, but not limited to, the implied warranties of merchantability and fitness for a particular purpose. In no event shall the distributor, the authors, any of the contributors, or any third party be liable for any direct, indirect, incidental, or consequential damages (including, but not limited to, procurement of substitute goods and services, loss of use, damage to hardware, loss of data, loss of profits, or business interruption).

All software in the Install Package marked as third-party is copyrighted by their respective owners and covered by their respective licenses. Please see the corresponding websites or the package information for details. Please also see the README.txt files of the Install Package for details.

Silicon Radar GmbH, 2017