



PCR sensor A121 EVK hardware user guide

- XE121, XC120, XS121

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Author: Acconeer

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Acconeer AB

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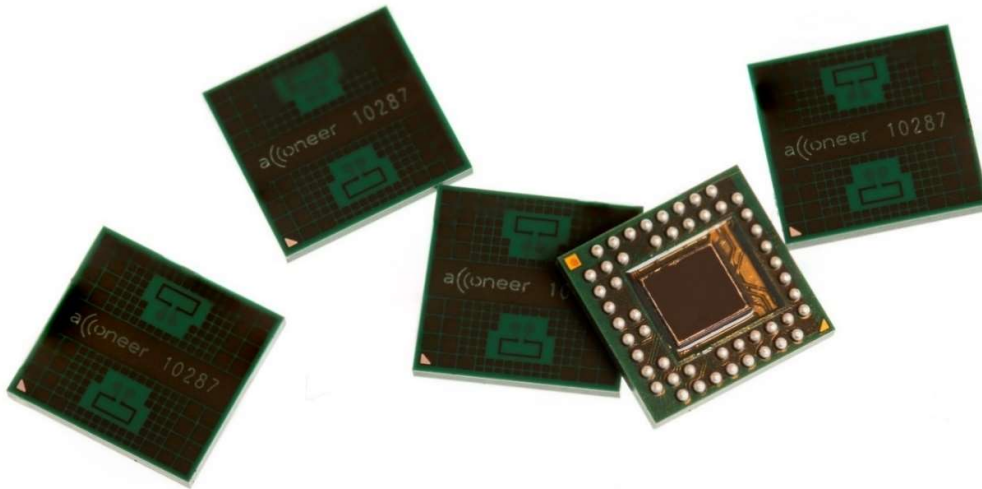
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1. Overview of the A121 Evaluation Kit

1.1 Introduction

The A121 Evaluation Kit (The EVK) is a development platform featuring Acconeer’s latest radar sensor, the A121. This is a low-power, high-precision 60 GHz radar in one package solution with integrated baseband, RF front-end and antenna. It is pin compatible with its predecessor, A111, but comes with improved power consumption and signal to noise ratio.

The A121 is based on pulsed coherent radar technology (PCR). It has leading-edge patented sensor technology with pico-second time resolution. It is possible to realize use cases requiring ranges up to 20m and it supports mm accuracy on absolute distances and sub-mm accuracy on relative distances.



The A121 EVK consists of three boards that can be connected in different combinations:

- XC120 (“Connector Board”)
- XE121 (“Evaluation Board”)
- XS121 (“Satellite Board”)

The XC120 board carries a cortex M7 MCU which is to be flashed with a software dedicated to stream data from the A121 radar sensor to Acconeer’s “Exploration Tool” via USB HS 2.0. The XC120 is intended to be used with the exploration server for streaming radar sensor data only and after flashing, no further configuration by the user is expected.

The XE121 features an on board A121 pulsed coherent radar sensor and the possibility to add up to four additional A121 radar sensors via FFC (Flat Flexible Cable) to the XS121 radar satellite boards. The XE121 can’t be used stand-alone since it isn’t equipped with an MCU. It is designed to be compatible with the XC120, Raspberry Pi and STM Nucleo-64 or Nucleo-144 development boards.

The most straight-forward and optimized way to evaluate the A121 radar sensor is to connect the XE121 to the XC120 Connector board which enables evaluation of the radar sensor using the Acconeer “Exploration Tool”¹. Connecting the XE121 to the XC120 gives you the highest data

¹ Available for download on github: <https://github.com/acconeer/acconeer-python-exploration>

streaming rate thanks to the USB HS 2.0 connection on the XC120 and the high SPI speed that is possible to achieve when using the XC120 in combination with XE121. This document will focus mainly on using XC120+XE121+XS121.

If you prefer, you can connect the XE121 to a Raspberry Pi, using the “Software Development Kit for Raspberry Pi”. The rate at which you can retrieve data from the A121 is in this case limited by the Raspberry Pi SPI interface speed.

Another option is to connect XE121 directly to an STM Nucleo-64 or Nucleo-144 development board featuring the MCU of your choice. The main reason for making XE121 compatible with the STM Nucleo development boards is to facilitate SW development, there is no support for this configuration in Acconeer “Exploration Tool”. Acconeer provides a SW integration guideline “STM32CubeIDE User Guide” to help you get started. Refer to the Acconeer Developer page for the different SW guides and downloads: <https://developer.acconeer.com/>

1.2 Getting Started

A Quick Installation Guide is available at [\[youtube link\]](#) and a pdf variant can be downloaded from <https://developer.acconeer.com>

This short instruction video will ensure a smooth setup and installation. For more information on retrieving the Acconeer SW, please refer to the next chapter.

2. Software for the EVK

2.1 SW download

The SW is available for downloading at <https://developer.acconeer.com/>

2.2 SW API Description

The Acconeer SW comes with an API (Application Programming Interface). Acconeer provides several service oriented example applications, as well as customer guidelines for application development when utilizing the API. All APIs provided by Acconeer are documented.

Open the SW zip file downloaded from Acconeer’s developer page. In the file structure, please locate /doc.

doc/ contains API documentation in HTML format – simply open doc/html/index.html.

3. The EVK Hardware

Figure 1 shows the block diagram for the EVK

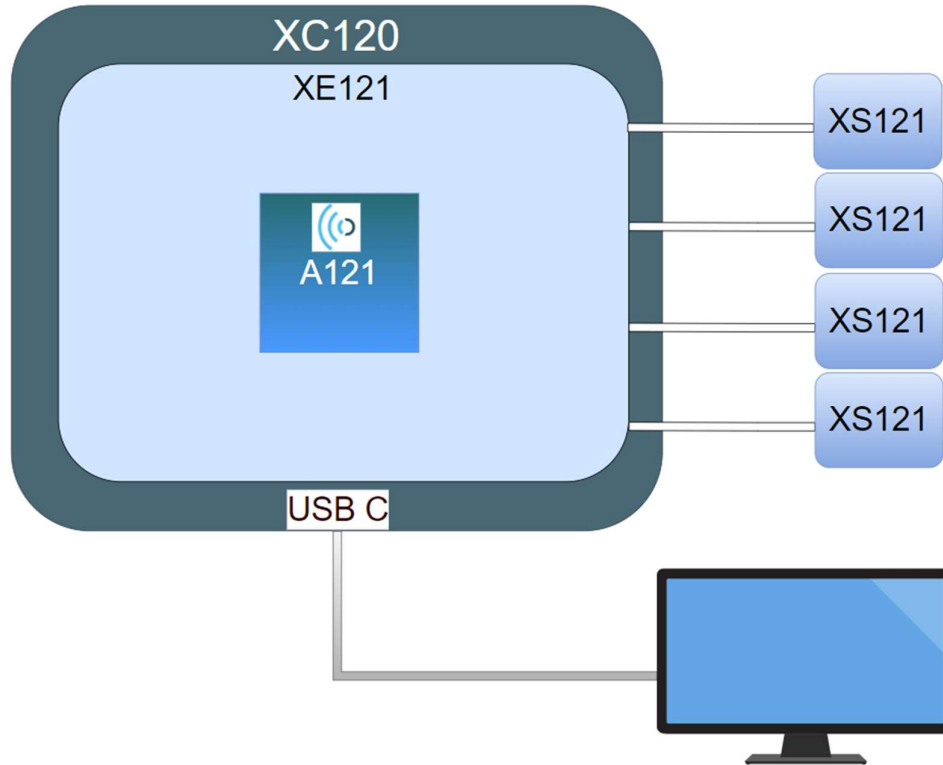


Figure 1 The EVK block diagram.

3.1 XC120 Connector Board

3.1.1 Overview

The purpose of the XC120 board is to act as a high-speed USB bridge to the A121 Pulsed Coherent Radar Sensor Evaluation Board XE121. The XC120 does NOT contain an A121 radar sensor and is intended to be used together with XE121. Without the XE121, XC120 serves no purpose.

The XC120 board carries a cortex M7 MCU to stream radar sensor data from XE121 to Acconeer’s “Exploration Tool” via USB HS 2.0.² This board is intended to be used for streaming sensor data only and after flashing, no further configuration by the user is expected. The XC120 is delivered with a bootloader so that it can be flashed via the USB interface. For details on how to flash the XC120, refer to the “A121 EVK Getting Started Guide”. The XC120 is connected to XE121 via pin headers. The XE121 is designed to be compatible with STM Nucleo-64 and STM Nucleo-144 Development boards and thus the pin headers on XC120 are placed in the same way. The XC120 is however NOT a Nucleo development board and is not intended to be flashed with any SW not provided by Acconeer.

Figure 2 shows the block diagram of the XC120 Connector Board.

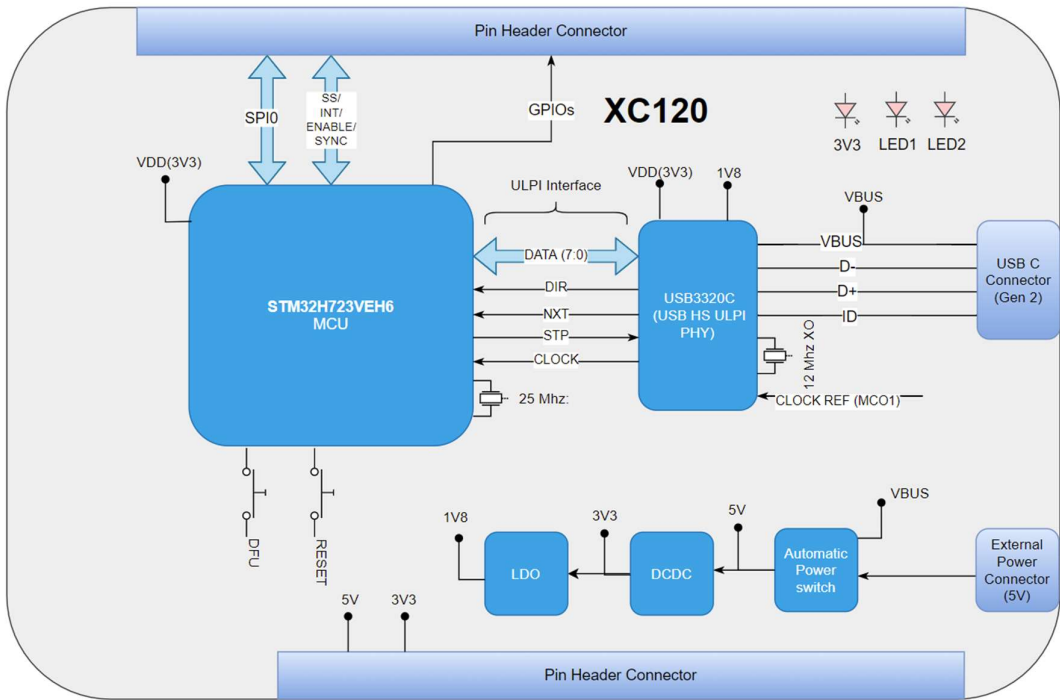
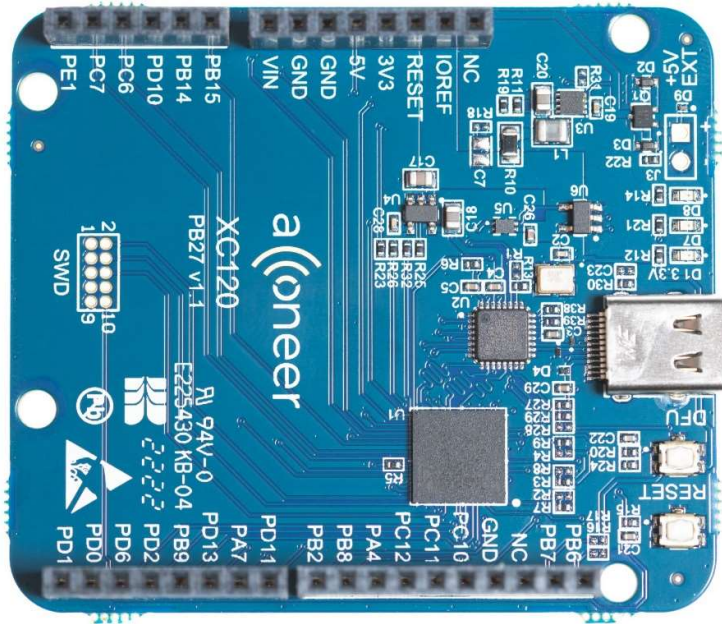


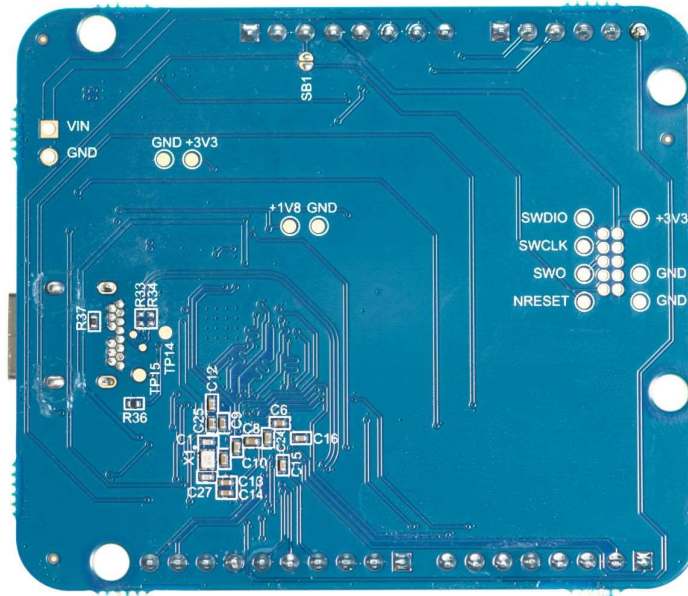
Figure 2. The block diagram of XC120.

Picture 1 and Picture 2 show the XC120 front and reverse sides.

² Acconeer’s “Exploration Tool” is supported by Linux and Windows OS.

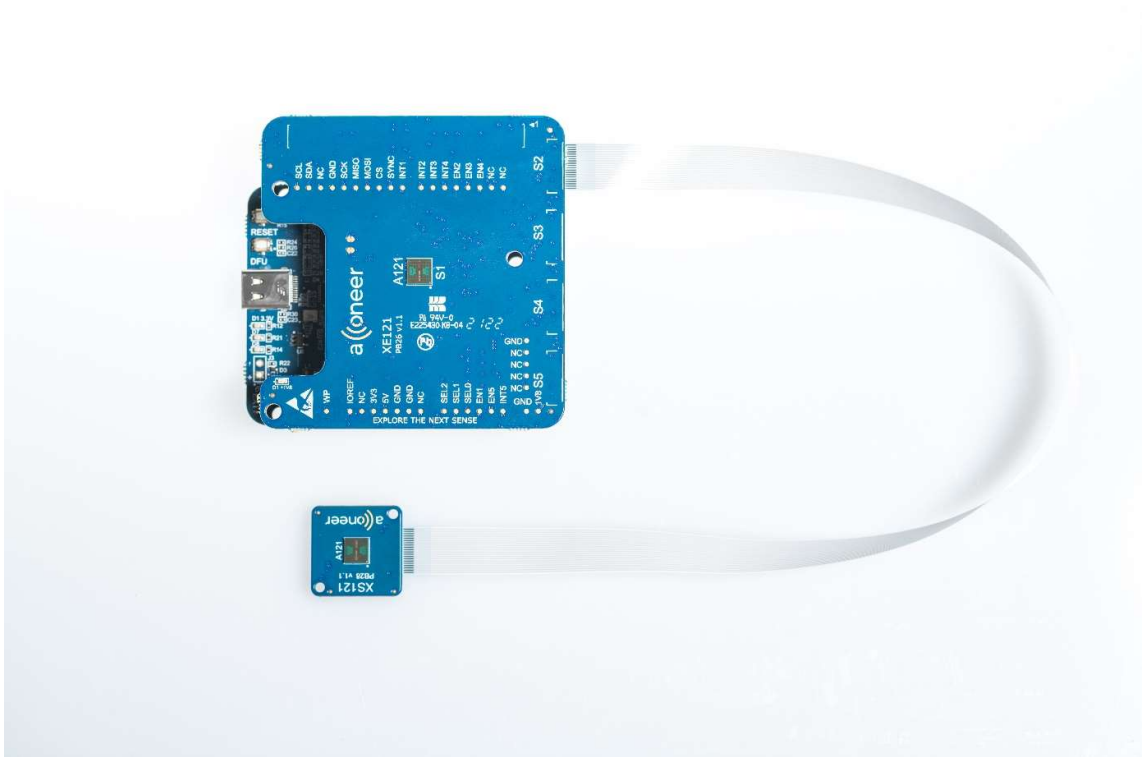


Picture 1. XC120 front side.

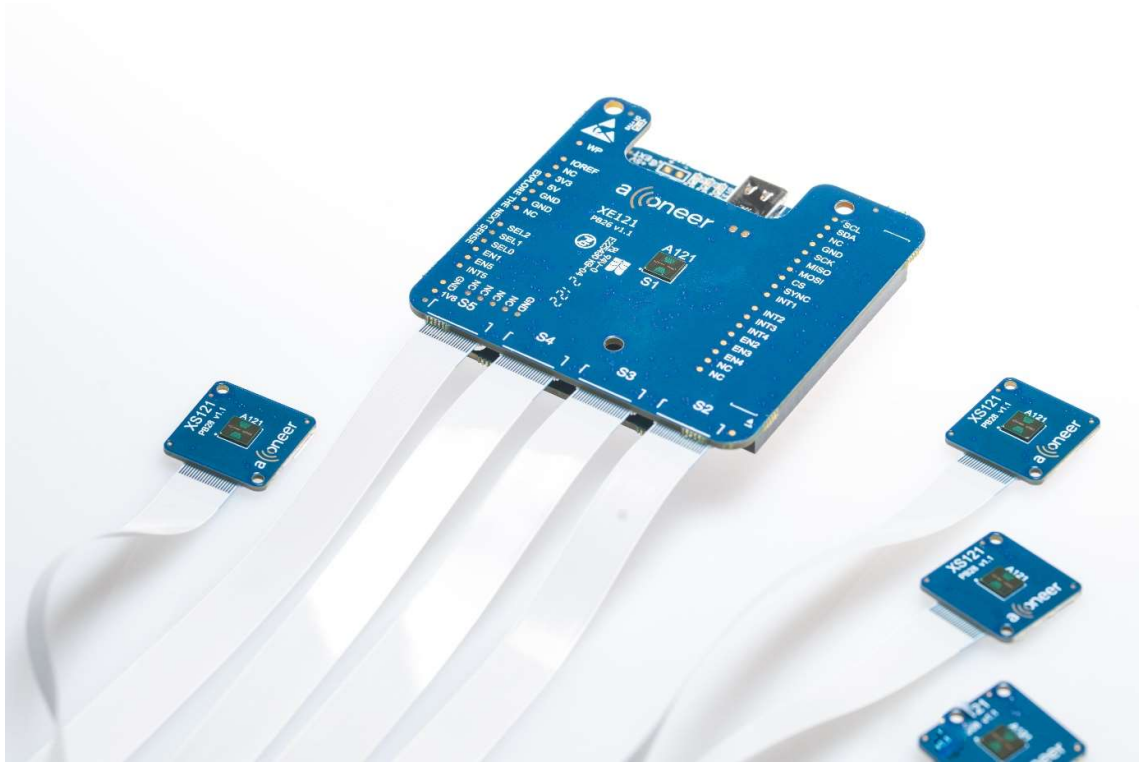


Picture 2. XC120 reverse side.

Picture 3 shows XC120 connected to XE121 and one XS121. Picture 4 shows XC120 connected to XE121 and four XS121 (fully loaded configuration).



Picture 3. XC120 connected to XE121 and one XS121.



Picture 4. XC120 connected to XE121 and four XS121.

3.1.2 Power

The XC120 connector board is powered via USB (5V, 500mA). This 5V power domain powers the complete A121 EVK (XC120+XE121+XS121). For some use cases (when attaching more than one XS121 board to XE121 and running simultaneous radar measurements on them), more power may be needed. An external power supply can then be connected via J3 (not mounted pin header on XC120). As soon as 5V is available on J3, the current is automatically drawn from the external power supply. When the power LED D1 is lit on XC120, the board is powered on and ready for use. Refer to Picture 1 for details on J3 and D1 placement.



3.2 XE121 Evaluation Board

3.2.1 Overview

The XE121 Evaluation Board is part of the Acconeer A121 Evaluation Kit and is intended to be used together with the XC120, a Raspberry Pi or STM Nucleo-64 or STM Nucleo-144 development boards. XE121 is equipped with 1 fixed A121 pulsed coherent radar sensor as well as 4 FFC (Flat Flexible Cable) connectors to which XS121 satellite boards can be connected (optional). The flex cable solution enables a wide variety of use cases involving multiple radar sensors. It also facilitates proof of concepts since the radar sensor board placement is not limited by the size of the evaluation board. It is not possible to run the XE121 without one of these “MCU boards” since the XE121 is not equipped with an MCU for control and communication of the A121 pulsed coherent radar sensor. Figure 3 shows the block diagram of XE121:

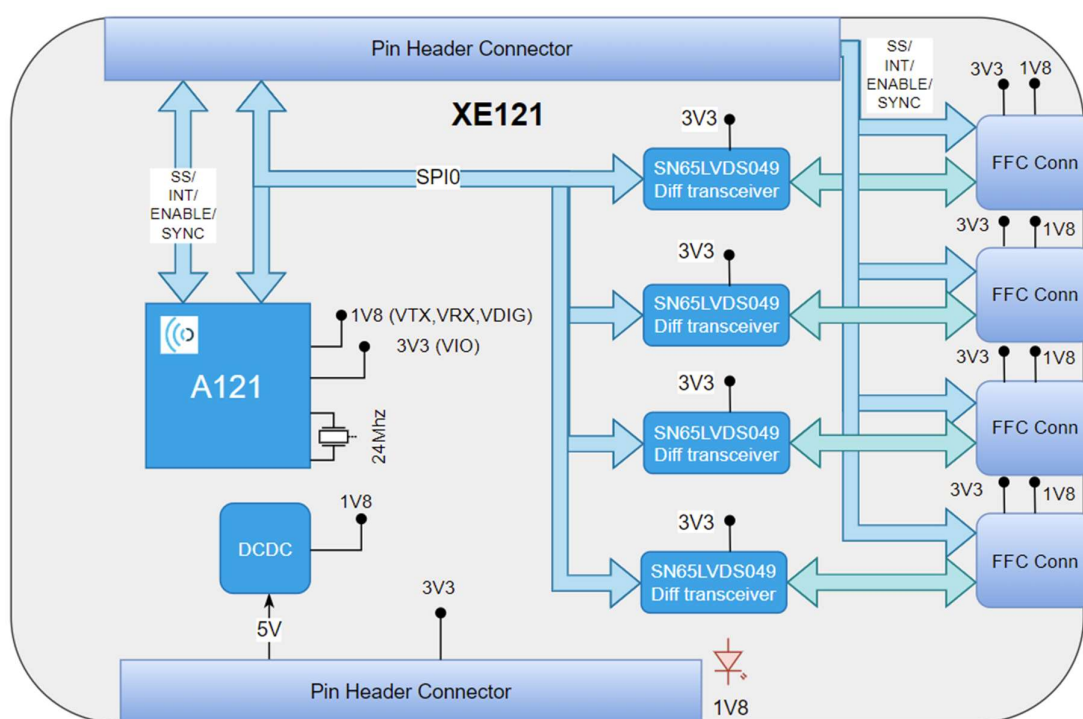
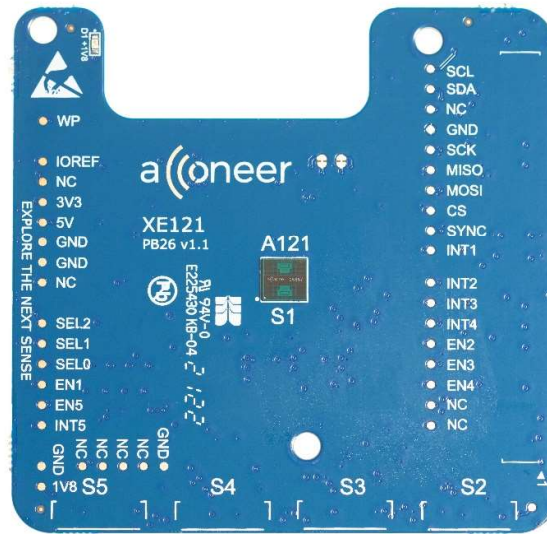
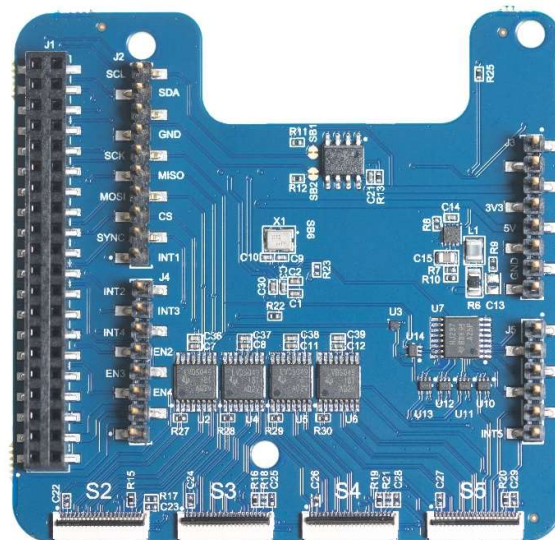


Figure 3. The XE121 block diagram.

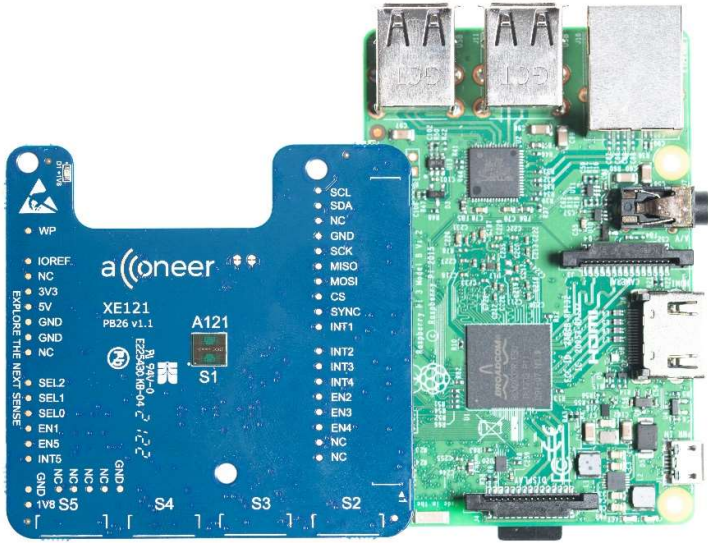
In the pictures below, the XE121 front and reverse sides are shown as well as how to connect it to Raspberry Pi and STM Nucleo development boards.



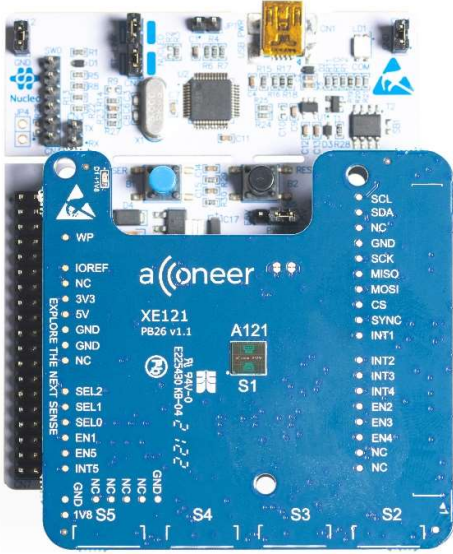
Picture 5. XE121 front side.



Picture 6. XE121 reverse side.



Picture 7. XE121 connected to Raspberry Pi.

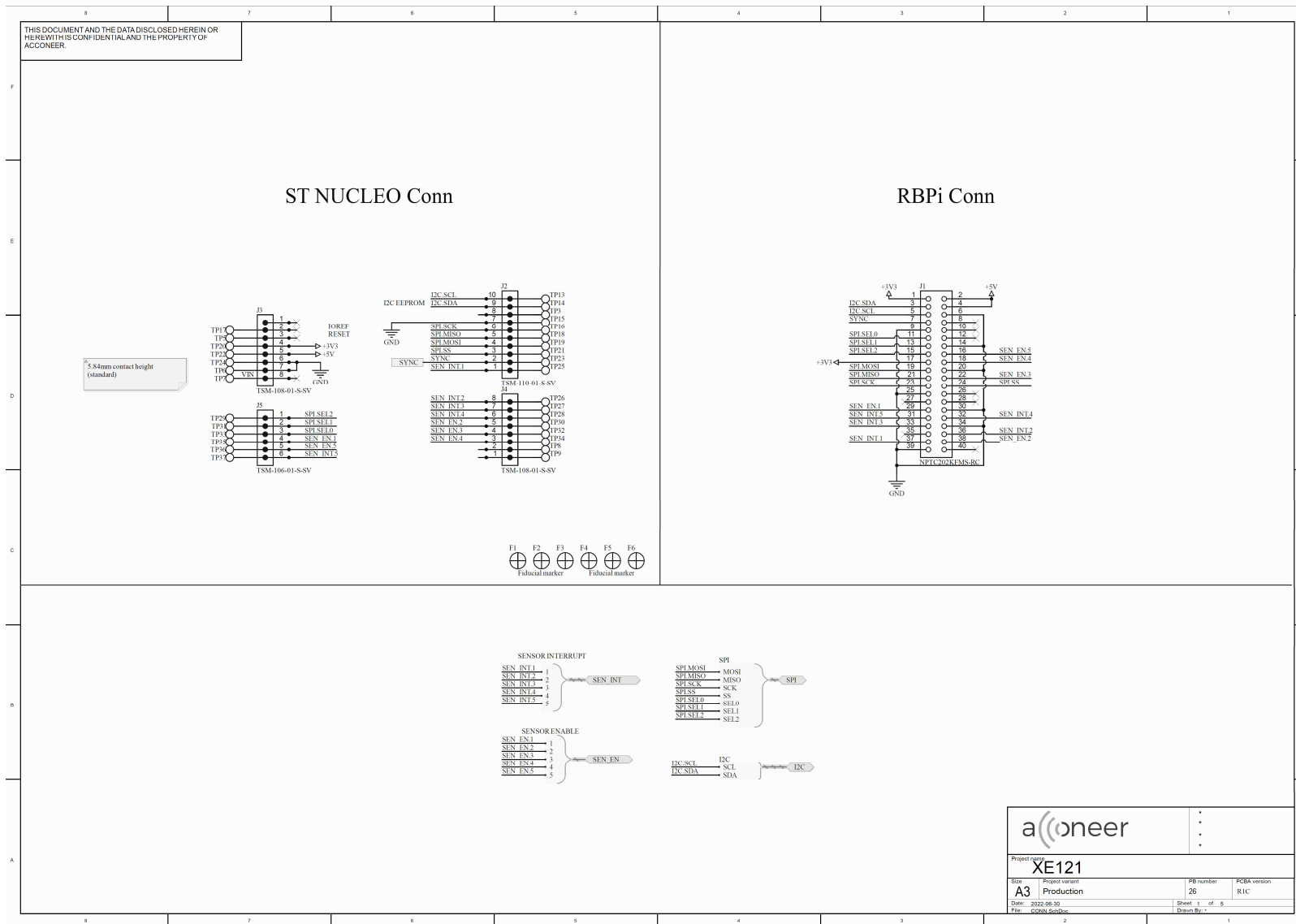


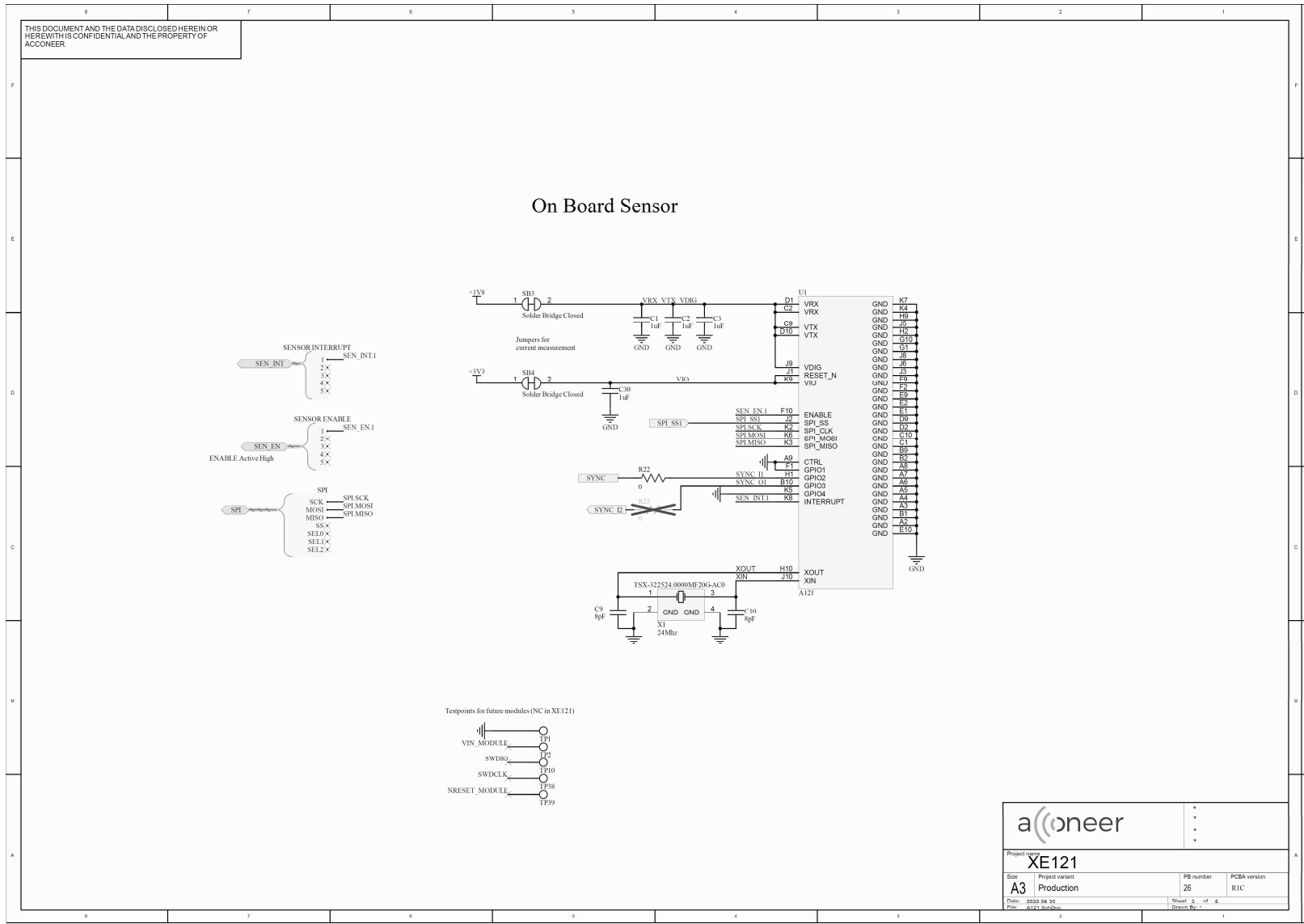
Picture 8. XE121 connected to an STM Nucleo Development Board.

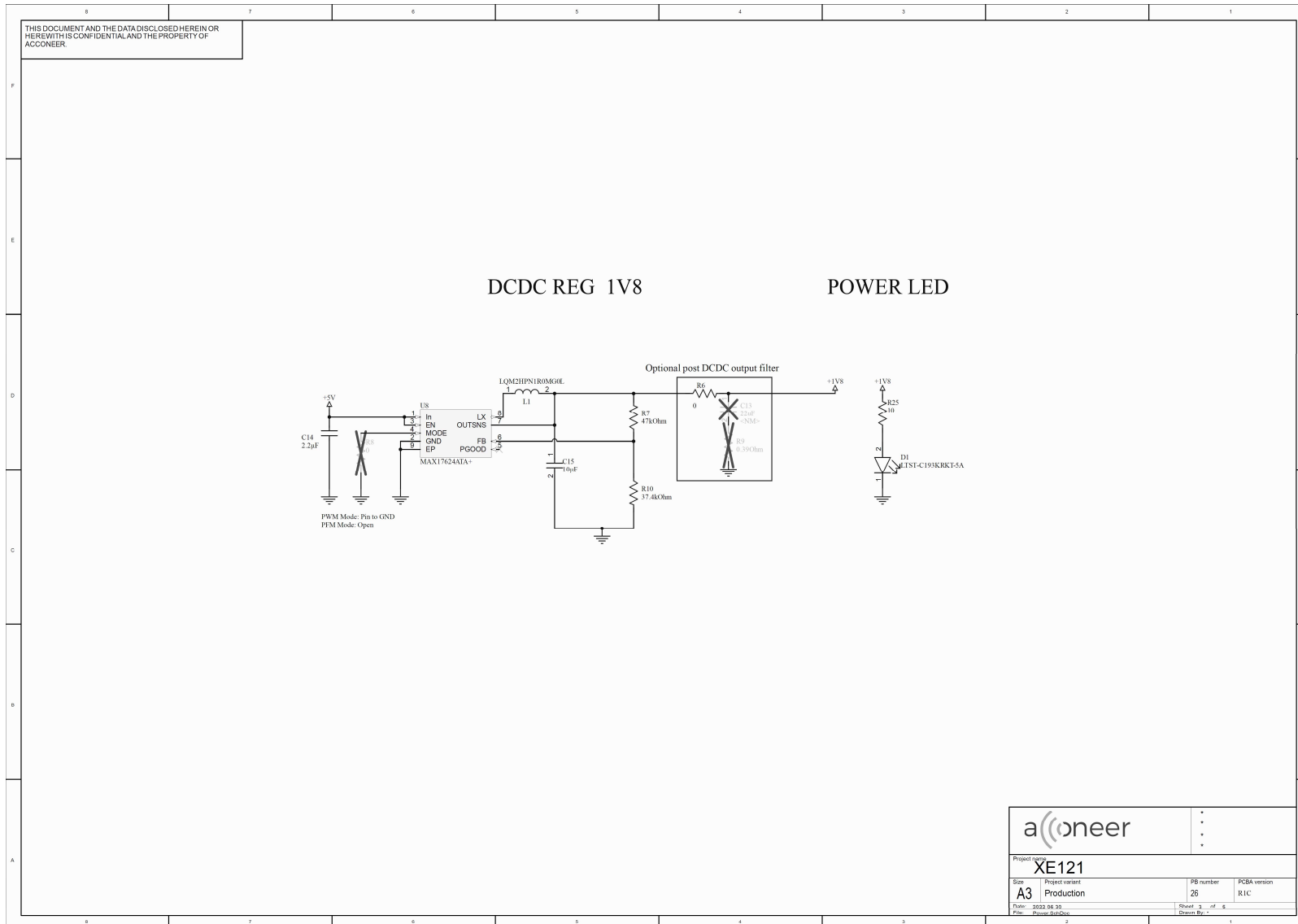


3.2.2 Electrical Schematics

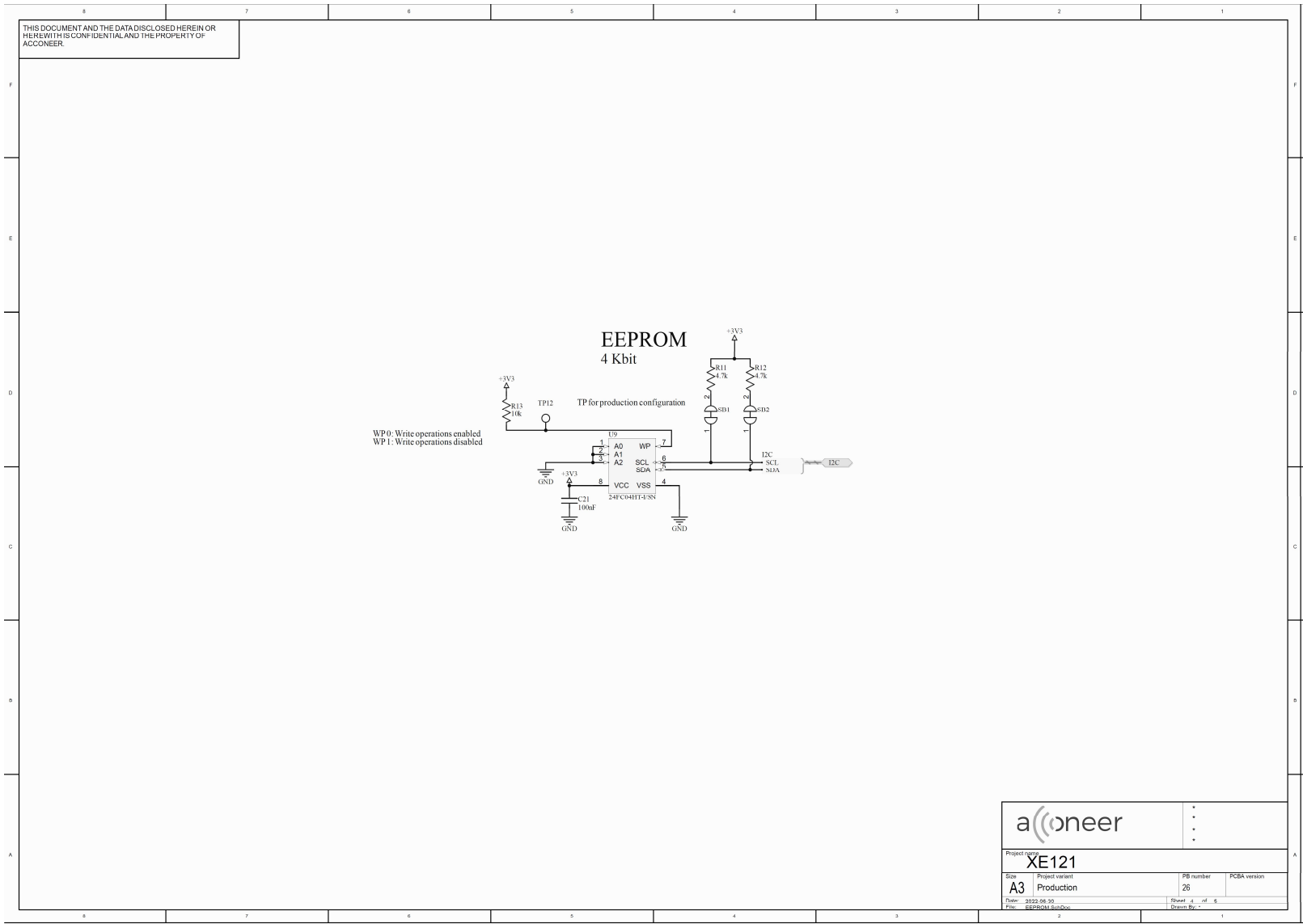
On the following pages, please find the schematics for the XE121:

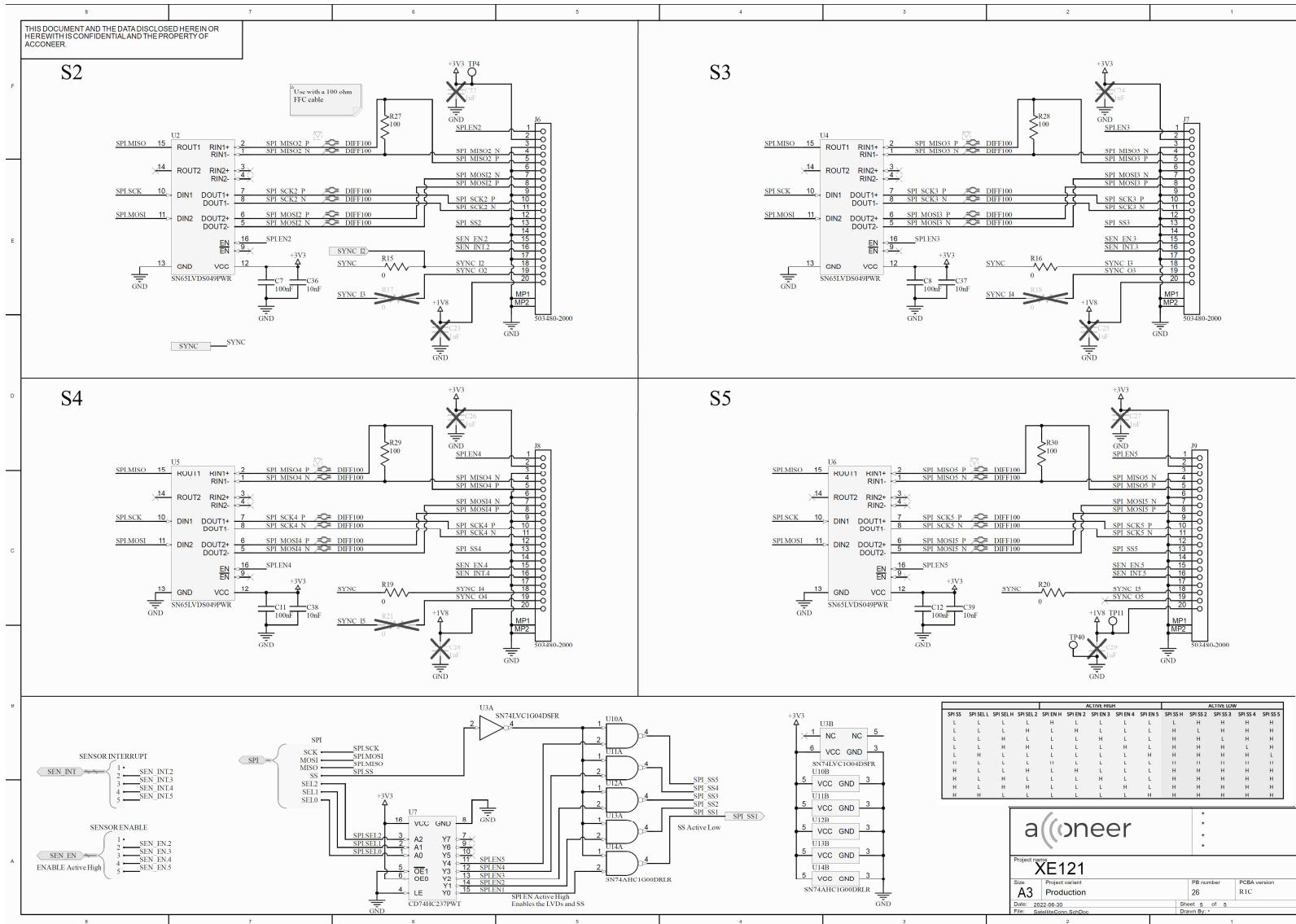






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3.2.3 Bill of Material

Table 1 shows the BOM for the XE121

Table 1. The BOM for XE121.

Designator	Name	Qty	Value	Voltage rating	Tolerance	Manufacturer
C1, C2, C3, C30	Capacitor 1uF, metric 1005	4	1uF	10V	10%	
C7, C8, C11, C12, C21	Capacitor 100nF, metric 1005	5	100nF	10V	10%	
C9, C10	Capacitor 8 pF, metric 1005	2	8pF	10V	1%	
C14	Capacitor 2.2uF, metric 1005	1	2.2uF	10V	10%	
C15	Capacitor 10uF, metric 2012	1	10uF	10V	10%	
C36, C37, C38, C39	Capacitor 10nF, metric 1005	4	10nF	10V	10%	
D1	LTST-C193KRKT-5A	1				Vishay Lite-on
J1	NPTC202KFMS-RC	1				Sullins
J2	TSM-110-01-S-SV	1				Samtec
J3, J4	TSM-108-01-S-SV	2				Samtec
J5	TSM-106-01-S-SV	1				Samtec
J6, J7, J8, J9	503480-2000	4				Molex
L1	LQM2HPN1R0MG0L	1				Murata
R6	Resistor 0 Ohm, metric 2012	1	0 Ohm		1%	
R7	Resistor 47 kOhm, metric 1005	1	47kOhm		1%	
R15, R16, R19, R20, R22	Resistor 0 Ohm, metric 1005	5	0		1%	
R10	Resistor 37.4 kOhm, metric 1005	1	37.4kOhm		1%	
R11, R12	Resistor 4.7 kOhm, metric 1005	2	4.7k		1%	
R13	Resistor 10 kOhm, metric 1005	1	10k		1%	
R25	Resistor 10 Ohm, metric 1005	1	10		1%	
R27, R28, R29, R30	Resistor 100 Ohm, metric 1005	4	100		1%	
U1	A121	1				Acconeer
U2, U4, U5, U6	SN65LVDS049PWR	4				TI
U3	SN74LVC1G04DSFR	1				TI
U7	CD74HC237PWT	1				TI
U8	MAX17624ATA+	1				Maxim
U9	24FC04HT-I/SN	1				Microchip
U10, U11, U12, U13, U14	SN74AHC1G00DRLR	5				TI
X1	TSX-322524.0000MF20G-AC0	1				Epson

3.2.4 Pinning

Table 2 shows the pinout of XE121 connectors to XC120 and ST Nucleo development boards:

Table 2. Pinout of XE121 connectors to XC120 and ST Nucleo development boards.

Pin	XC120 (J6)	XE121 (J2)	ST Nucleo	Description
10	I2C1.SCL	I2C.SCL	D15	Used for EEPROM on the XE121
9	I2C1.SDA	I2C.SDA	D14	Used for EEPROM on the XE121
8	NC	NC	AVDD	
7	GND	GND	GND	
6	SPI3.SCK	SPI.SCK.CON	D13	SPI interface for communication with sensor on XE121 and XS121
5	SPI3.MISO	SPI.MISO.CON	D12	SPI interface for communication with sensor on XE121 and XS121
4	SPI3.MOSI	SPI.MOSI.CON	D11	SPI interface for communication with sensor on XE121 and XS121
3	SPI3.SS	SPI.SS	D10	SPI interface for communication with sensor on XE121 and XS121
2	SYNC	SYNC	D9	Signal for sensor synchronization
1	SEN_INT.1	SEN_INT.1	D8	XE121 sensor Interrupt signal
Pin	XC120 (J7)	XE121(J4)	ST Nucleo	Description
8	SEN_INT.2	SEN_INT.2	D7	XS121 sensor interrupt signal
7	SEN_INT.3	SEN_INT.3	D6	XS121 sensor interrupt signal
6	SEN_INT.4	SEN_INT.4	D5	XS121 sensor interrupt signal
5	SEN_EN.2	SEN_EN.2	D4	XS121 sensor enable signal
4	SEN_EN.3	SEN_EN.3	D3	XS121 sensor enable signal
3	SEN_EN.4	SEN_EN.4	D2	XS121 sensor enable signal
2	UART4_TX	NC	D1	Not used on XE121
1	UART4_RX	NC	D0	Not used on XE121
Pin	XC120 (J8)	XE121(J3)	ST Nucleo	Description
1	NC	NC	NC	Not used on XE121
2	+3V3	NC	IOREF	Not used on XE121
3	PE3	NC	RESET	Not used on XE121
4	+3V3	+3V3	+3V3	
5	+5V	+5V	+5V	
6	GND	GND	GND	
7	GND	GND	GND	
8	VIN	NC	VIN	Not used on XE121
Pin	XC120 (J9)	XE121(J5)	ST Nucleo	Description
1	SPI3.SEL2/UART4 CTS	SPI.SEL2	A0	SPI selection for LVDS enable and SPI SS
2	SPI3.SEL1/UART4 RTS	SPI.SEL1	A1	SPI selection for LVDS enable and SPI SS
3	SPI3.SEL0	SPI.SEL0	A2	SPI selection for LVDS enable and SPI SS
4	SEN_EN.1/DUART6 TX	SEN_EN.1	A3	XE121 sensor enable signal
5	SEN_EN.5/DUART6 RX	SEN_EN.5	A4	XS121 sensor enable signal
6	SEN_INT.5	SEN_INT.5	A5	XS121 sensor interrupt signal

Table 3 shows the pinout of XE121 connector to Raspberry Pi:

Table 3. The pinout of XE121 connector to Raspberry Pi.

Pin	XE121	Raspberry Pi	Description
1	+3V3	3V3	
2	+5V	5V Power	
3	I2C.SDA	GPIO 2 (I2C1 SDA)	Used for EEPROM on the XE121
4	+5V	5V Power	
5	I2C.SCL	GPIO 3 (I2C1 SCL)	Used for EEPROM on the XE121
6	GND	GND	
7	SYNC	GPIO 4 (GCLK0)	Signal for sensor synchronization
8	NC	GPIO 14 (UART TX)	Not used on XE121
9	GND	GND	
10	NC	GPIO 15 (UART RX)	Not used on XE121
11	SPI.SEL0	GPIO 17	SPI selection for LVDS enable and SPI SS
12	NC	GPIO 18 (PCM CLK)	Not used on XE121
13	SPI.SEL1	GPIO 27	SPI selection for LVDS enable and SPI SS
14	GND	GND	
15	SPI.SEL2	GPIO 22	SPI selection for LVDS enable and SPI SS
16	SEN_EN.5	GPIO23	XS121 sensor enable signal
17	+3V3	+3V3	
18	SEN_EN.4	GPIO 24	XS121 sensor enable signal
19	SPI.MOSI.CON	GPIO 10 (SPI0 MOSI)	SPI interface for communication with sensor on XE121 and XS121
20	GND	GND	
21	SPI.MISO.CON	GPIO 9 (SPI0 MISO)	SPI interface for communication with sensor on XE121 and XS121
22	SEN_EN.3	GPIO 25	XS121 sensor enable signal
23	SPI.SCK.CON	GPIO 11 (SPI0 SCK)	SPI interface for communication with sensor on XE121 and XS121
24	SPI.SS	GPIO 8 (SPI0 CE0)	SPI interface for communication with sensor on XE121 and XS121
25	GND	GND	
26	NC	GPIO 7 (SPI00 CE1)	Not used on XE121
27	NC	GPIO 0 (EEPROM SDA)	Not used on XE121
28	NC	GPIO1 (EEPROM SCL)	Not used on XE121
29	SEN_EN.1	GPIO 5	XE121 sensor enable signal
30	GND	GND	
31	SEN_INT.5	GPIO 6	XS121 sensor interrupt signal
32	SEN_INT.4	GPIO 12 (PWM0)	XS121 sensor interrupt signal
33	SEN_INT.3	GPIO 13 (PWM1)	XS121 sensor interrupt signal
34	GND	GND	
35	NC	GPIO 19 (PCM FS)	Not used on XE121
36	SEN_INT.2	GPIO 16	XS121 sensor interrupt signal
37	SEN_INT.1	GPIO 26	XE121 sensor Interrupt signal
38	SEN_EN.2	GPIO 20 (PCM DIN)	XS121 sensor enable signal
39	GND	GND	
40	NC	GPIO 21 (PCM DOUT)	Not used on XE121

3.3 XS121 Satellite Board

3.3.1 Overview

The XS121 is a 20x20mm satellite board equipped with an A121 pulsed coherent radar sensor that via FFC (Flat Flexible Cable) can be connected to the Acconeer Evaluation Board XE121. It is not a mandatory component in the Acconeer A121 Evaluation Kit but can come in handy when you want to evaluate multi sensor use cases or a use case where space for sensor placement is limited. It is not possible to operate the XS121 without an XE121 Evaluation board. The XS121 is delivered with an FFC cable from Molex: 0151660225. The FFC has 20 channels, 0.5mm pitch. The XS121 is compatible with the Acconeer LH112 lens kit.

Figure 4 shows the block diagram of XS121:

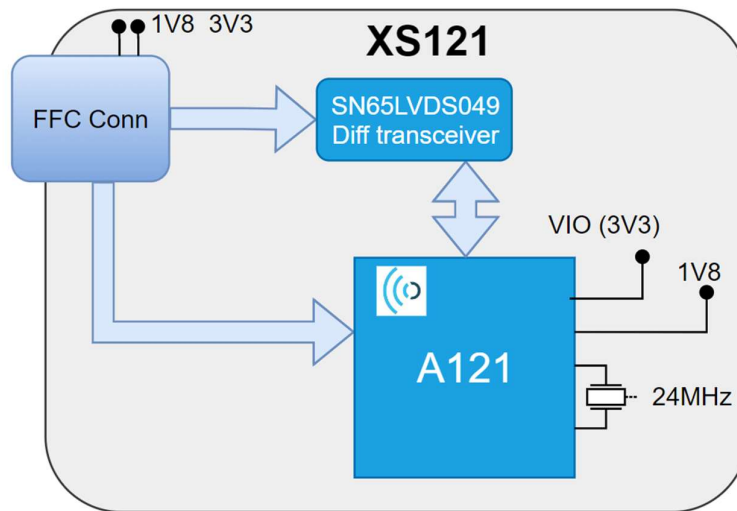
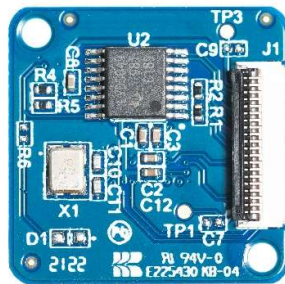


Figure 4. The block diagram of XS121.

Picture 9 and Picture 10 shows the front and reverse sides of XS121. Refer to Picture 3 and Picture 4 for pictures of XS121 connected to XC120 and XE121.



Picture 9. XS121 front side.



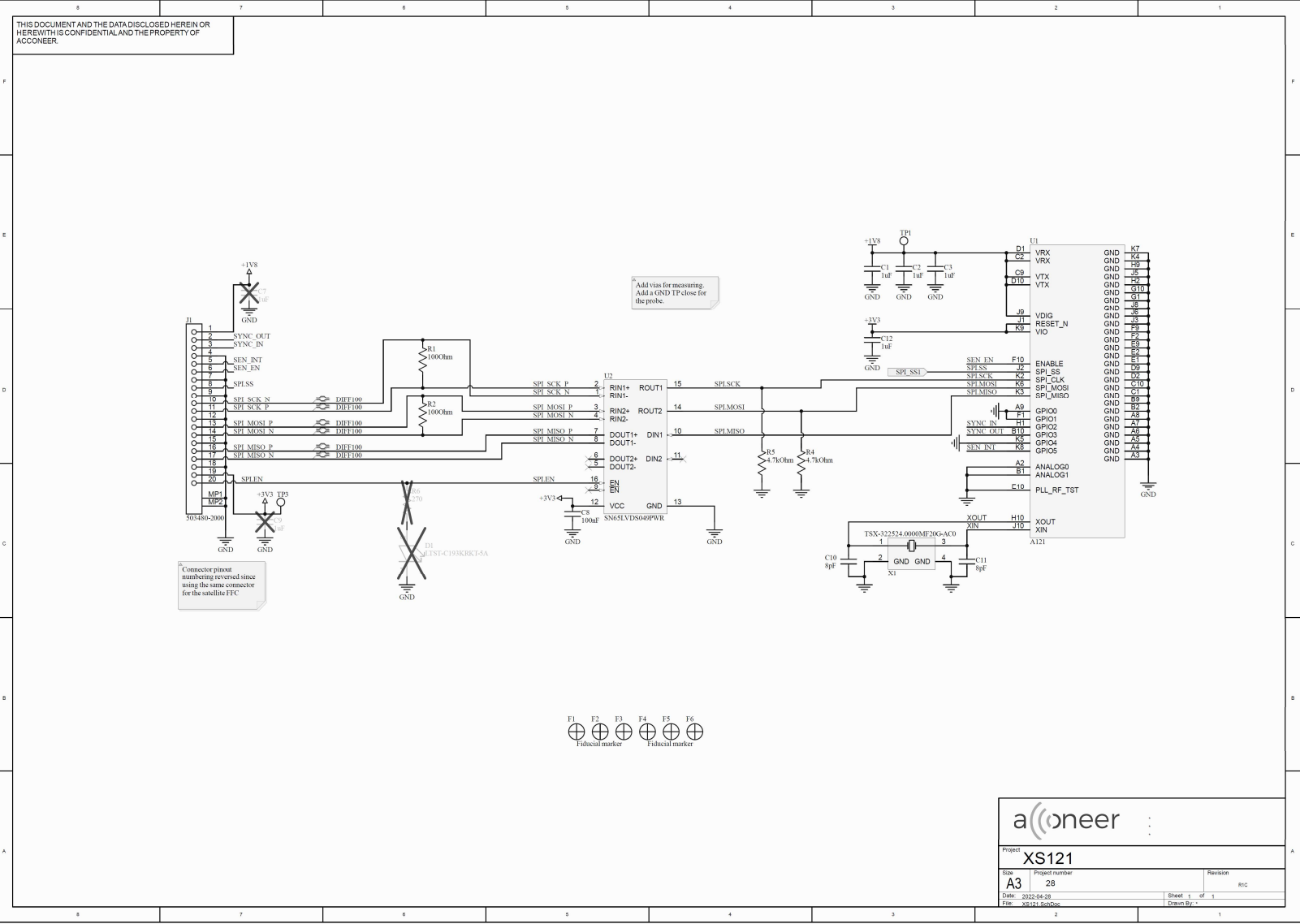
Picture 10. XS121 reverse side.



3.3.2 Electrical Schematics

On the following pages, please find the electrical schematics for the XS121:

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3.3.3 Bill of Material

Table 1 shows the BOM for the XS121

Component ref.	Part Number	QTY	Value	Comment
C1, C2, C3, C12	1uF, M1005, 10V, X5R, +-10%	4	1uF	
C8	100nF, M1005, 10V, X5R, +-10%	1	100nF	
C10, C11	8pF, M1005, 50V, C0G, NP0, +-1%	2	8pF	
J1	503480-2000	1		FFC/FPC Connector, 20 Contact(s), 1 Row(s), Right Angle, 0.02 inch Pitch, Surface Mount Terminal, Locking. MOLEX
R1, R2	100 Ohm, M1005, +-1%	2	100 Ohm	
R4, R5	4.7kOhm, M1005, +-1%	2	4.7kOhm	
U1	Acconeer A121 pulsed coherent 60 GHz radar sensor	1		
U2	SN65LVDS049PWR	1		
X1	TSX-322524.0000MF20G-AC0	1	24MHz	
N/A	0151660225	1		20 Position FFC, FPC Cable 0.020" (0.50mm) 12.0" (304.8mm)

3.4 Lens kits – LH120 and LH112

3.4.1 Overview

The LH120 lens evaluation kit is an accessory to the XE121 Evaluation board. The LH112 lens evaluation kit is an accessory to the XS121 Satellite board (the same lens kit is also used for XR112 and XM112). The lenses can be used to increase sensor performance. The lenses increase signal strength by focusing the beam width of the radiated EM-waves and thereby concentrating the emitted power. The lens kits are sold separately from XE121 and XS121.

3.4.2 LH120 - Contents and assembly

The LH120 lens kit is delivered including 4 parts. The included items are:

1. Lens and PCB holder (Shown in Picture)
2. HBL Lens (Hyperbolic Lens) (Shown in picture)
3. FZP Lens (Fresnel Zone Plate)
4. Flat cover

Picture 11 shows the LH120 lens holder. Picture 12 shows LH120 with HBL lens inserted.

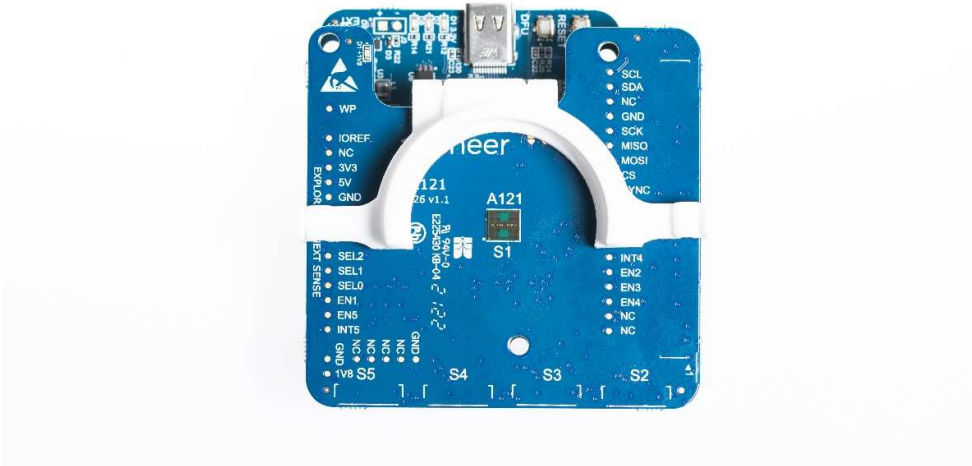


Picture 11. LH120 lens and PCB holder.



Picture 12. LH120 with HBL lens inserted.

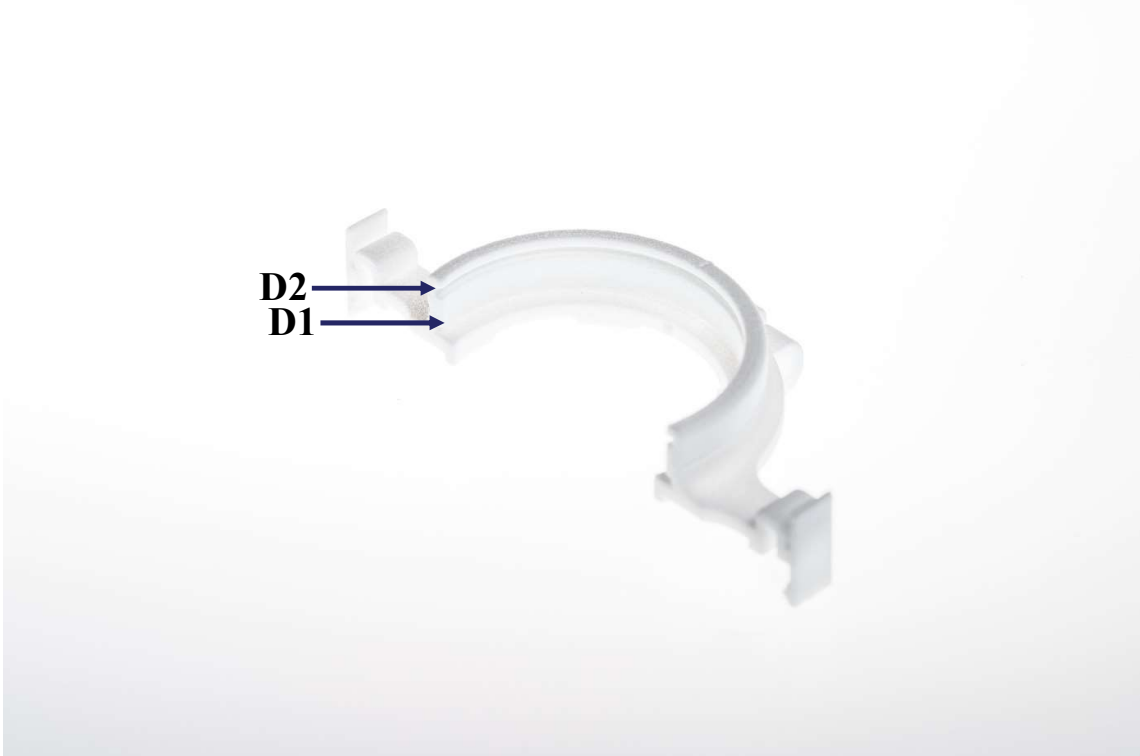
Picture 13 shows LH120 lens holder mounted on XE121.



Picture 13. LH120 mounted on XE121 which in turn is mounted on XC120.

The XE121 can be mounted directly to the lens and PCB holder. Make sure that the sensor is mounted correctly as the exact sensor position in relation to the lens is important for optimal performance.

Both lenses can be fitted in the holder in two different positions, D1 or D2. The cover is only used in the D1 position. The two positions will give you slightly different performance. Performance results can be found in the next section. Picture 14 shows the difference between positions D1 and D2.



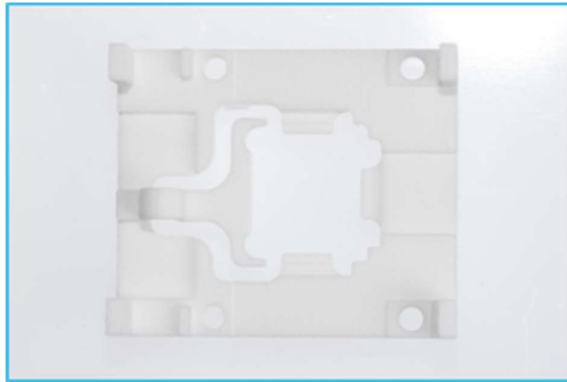
Picture 14. D1 and D2 marked on LH120.

3.4.3 LH112 - Contents and assembly

The LH112 lens kit is delivered including four parts. The included items are:

1. Lens and PCB holder
2. HBL Lens (Hyperbolic Lens)
3. FZP Lens (Fresnel Zone Plate)
4. Flat cover

Picture 15 shows the LH112 lens holder.



Picture 15. The LH112 lens and PCB holder.

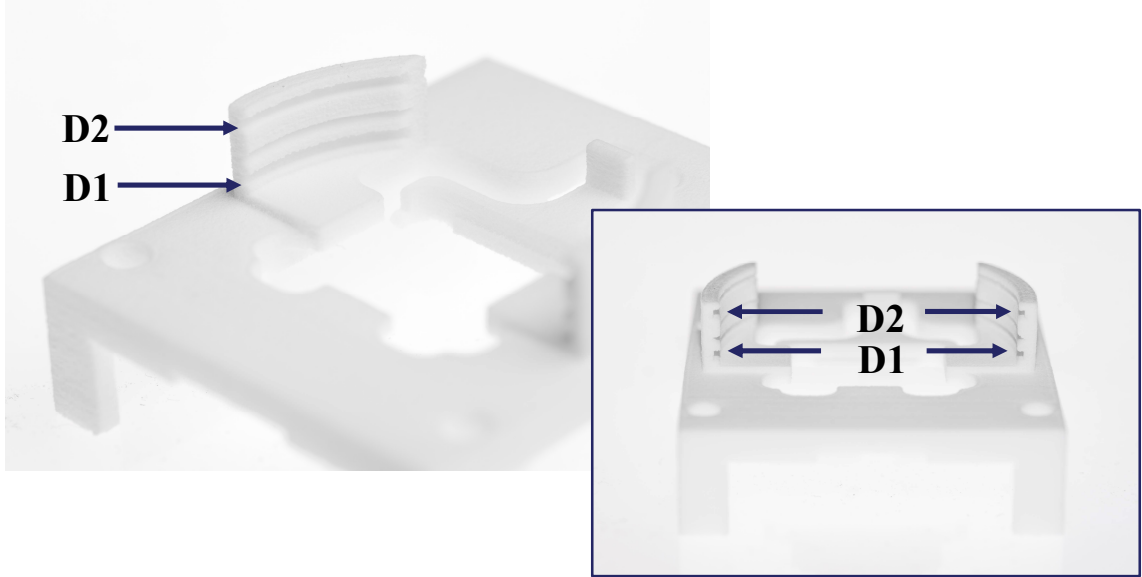
The XS121 can be mounted directly to the lens and PCB holder. Make sure that the sensor is mounted correctly as the exact sensor position in relation to the lens is important for optimal performance.

Picture 16 shows XS121 mounted in the lens and PCB holder.



Picture 16. XS121 mounted in LH112.

Both lenses can be fitted in the holder in two different positions, D1 or D2. The cover is only used in the D1 position. The two positions will give you slightly different performance. Picture 17 below show the difference between positions D1 and D2:



Picture 17. D1 and D2 marked on LH112.

3.5 Design considerations

The EVK was designed for sensor evaluation purposes only. Should you want to design a product, it is strongly recommended to carefully read and follow the A121 data sheet. The Evaluation Kit is not optimized for product development.

4 Safety

4.1 Electrostatic precautions



Please take electrostatic precautions, including using ground straps, when using the EVK or any of its components. An electrostatic discharge could damage the device.

5 Regulatory Information

Acconeer have no plans to certificate the A121 EVK, it is only for evaluation purposes. For A121 Certification status, refer to A121 datasheet:

<https://developer.acconeer.com/>

6 Revision History

Date	Revision	Changes
2022-07-06	1.0	Original Version
2023-07-11	1.1	Updated XS121 schematic and BOM.

7 Disclaimer

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Acconeer AB
Västra Varvsgatan 19
211 77 Malmö
Sweden

www.acconeer.com
info@acconeer.com
+46 10 218 92 00