SERES-5.X

User Guide

Optical frontend for 3D-vision

Published by ams-OSRAM AG
Tobelbader Strasse 30, 8141 Premstaetten, Austria
Phone +43 3136 500-0
ams-osram.com

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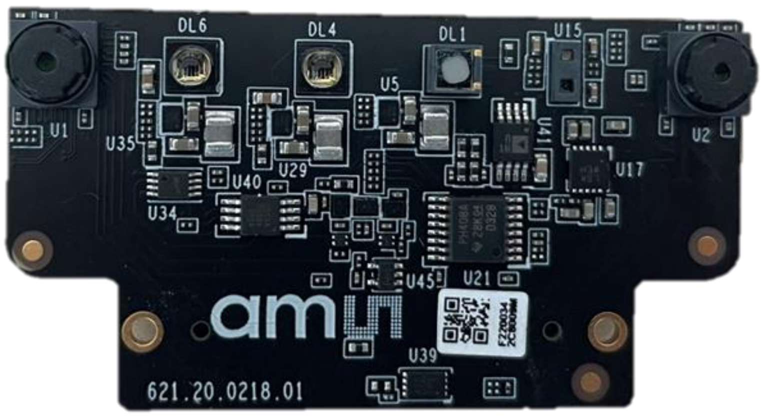
1 Introduction

The SERES optical frontend is a generic evaluation board which allows users to quickly evaluate 3D vision solutions by ams OSRAM. SERES provides the complete hardware infrastructure of an 3D optical frontend for experimenting with structured light as well as stereo-vision setups. The hardware is built around a common interface adapter which enables customers to experiment with different imager resolutions and spectral configurations as well as dot-pattern projector resolutions.

ams OSRAM shares with interested users the complete design database consisting of bill-of-material, schematics and board layout files, as well as the sources for the basic software device drivers to quickly operate mounted imager, projection and optional direct time-of-flight (dToF) proximity sensing components.

Figure 1: SERES optical frontend hardware



Having direct access to all required sources, ams OSRAM enables users to quickly adapt the design to own application and integrations constraints to modify, baselines for 3D vision but also replace individual components to modify the field-of-views, illuminators and others. The combination with embedded dToF proximity sensing even allows for experimenting with different 3D-sensing and system wake-up concepts to quickly narrow down on a best fitting 3D-vision solution within the desired target application.

On request, ams OSRAM and selected partners also provide ready-made SERES boards samples which can be directly integrated into user hardware. Eventually a simple user-made mezzanine board needs to be added, which re-routes the specific interfaces signals from the generic SERES board connector to the user selected image processing hardware. The provided sources make it possible to put in place the required interface adapter as quickly as possible.

This user guide explains the technical capabilities of the existing SERES hardware, the available variations and how users can potentially modify the design to adapt to own integration constraints.

1.1 Note on eye-safety

CAUTION:

The SERES optical frontend is not prepared or tested for eye-safety and shall therefore only be operated in protected lab environments by qualified personnel.

If eye-safety is required, the user must provide additional measures to achieve the required standards. Support on additional eye-safety compliant measures can be provided by ams OSRAM experts or via qualified partners within ams OSRAM's partner network[1].

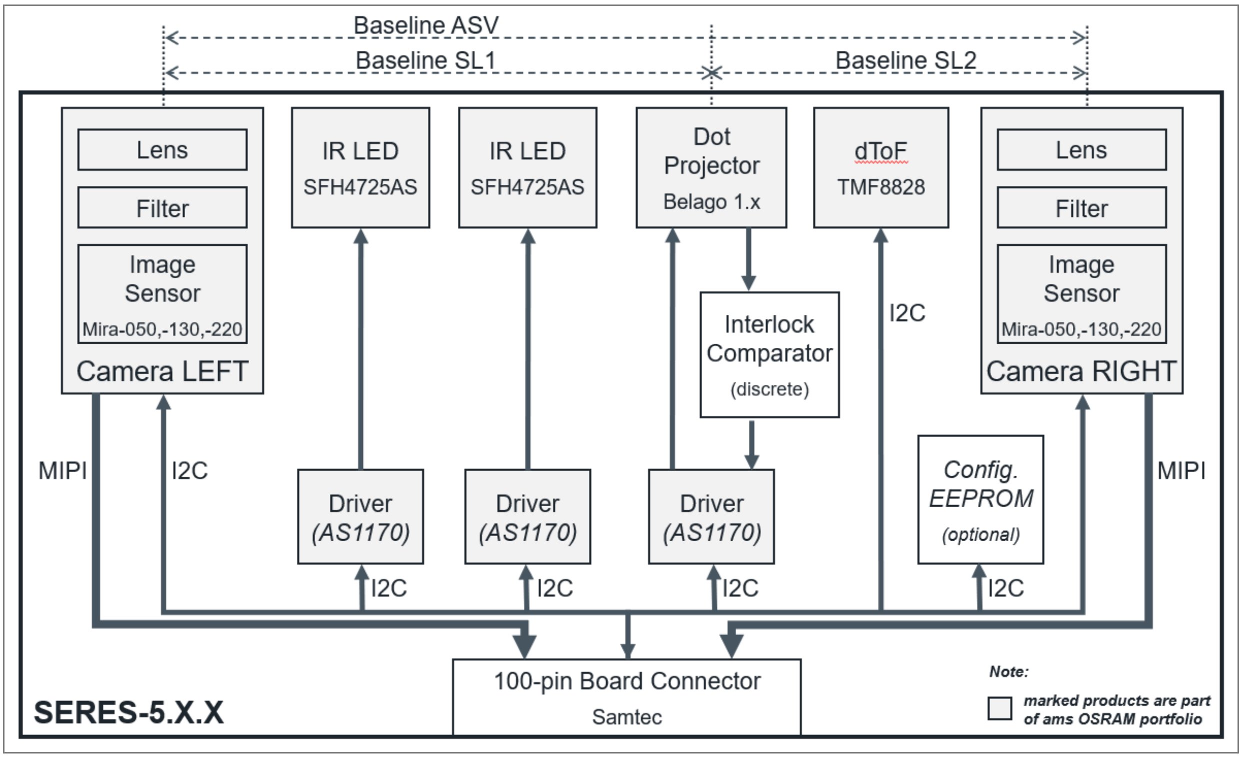
2 Overview of SERES hardware architecture

The SERES hardware is composed out of the following components:

- 2x MIRA highest quantum efficiency image sensors @ 0.5, 1.3 or 2.2 MPx with filter options for MONO, RGB or RGB-IR spectrum.
- BELAGO dot-pattern projector for structured light, operated with driver (recommended AS1170).
- 2x separately controllable OSLON BLACK infrared LEDs, operated with driver (recommended AS1170).
- Configurable, up to 8x8 multizone direct time-of-flight sensor (dToF) for complementary proximity / presence detection[2].
- Optional: On-board non-volatile memory for configuration / calibration data storage.

[1] Check: ams-osram.com/support/partner-network/partner-search
[2] Not required for MIRA-050 based designs due to inbuilt low-power wake-up functionality; complementary for MIRA-130/-220 designs

Figure 2: Structural overview of SERES optical frontend



All components are controllable via I²C bus, which is accessible through selected pins on the "100-Pin Board Connector (Samtec)". Image data from both cameras is sent separately over the same connector on dedicated interface pins in MIPI CSI2 format.

Information:

The SERES optical frontend provides 2 parallel I²C bus instances which connect the various components according to mapping scheme listed in below table. Both I²C instances have been routed to the SERES board connector. It is possible to connect SERES hardware to 2 separate I²C entities on the processor board or collapse on an interface adapter board into a single I²C instance, which then connects via two pairs of pins to the existing I²C interfaces on the SERES board connector. If this I²C collapsing option is chosen, the user must make sure to configure the hardwired I²C component addresses to unique addresses on the collapsed I²C bus. This is done by changing the corresponding pull-up/-down resistors for address selection at the individual components.

The following I^2C addresses have been assigned for the SERES hardware:

Table 1: I^2C bus configuration

Component	Comp. ID	I^2C bus	I^2C slave address	Comment
SERES-5.0.X & SERES-5.1.X				
MIRA imager (LEFT)	U1	1	Configurable (→ comment)	Configurable via board pull-up/-down resistors R169,170, R171, R172 according to following coding: **SID1 SID0 I^2C-Addr**[1] **0 0 0x54 *(default)*** 0 1 0x55 0 0 0x56 1 1 0x57 **Note** that this image sensor acts as “master” in case synchronization between the image sensors is required, e.g. for stereovision operation
MIRA imager (RIGHT)	U2	2	Configurable (→ comment)	Configurable via board pull-up/-down resistors R4, R6, R57, 58 according to following coding: **SID1 SID0 I^2C-Addr** **0 0 0x54 (default)** 0 1 0x55 1 0 0x56 1 1 0x57
IR LEDs	DL4, DL6	N/A	N/A	Controlled via driver (see below)
BELAGO	DL1	N/A	N/A	Controlled via driver (see below)
dToF Prox. Sensor	U15	1	0x41	TMF8828, 8x8 segment multi-zone
LED Driver	U29, U35	2 (ext’d)	0x63	Drives IR LED DL4 & DL6, using extended I^2C bus (see below)
VCSEL Driver	U5	1	0x63	Drives Dot Projector DL1
EEPROM	U39	1	Configurable (→ datasheet)	100kB 2-wire serial EEPROM (FM24C128D), config data storage
I^2C Bus Extender	U40	2	0x70	2-Ch. I^2C-Bus Switch, extended addressing for LED drivers
I^2C GPIO Extender	U21	1	0x20	I^2C mapped GPIO controls for RESET, ToF Enable, Alternate Illumination, DOT Projector Enable, 2x IR LED Enable (Flood)
SERES-5.2.X (MIRA-050)				
MIRA imager (LEFT)	MIRA050 LEFT	1	Configurable (→ comment)	Configurable via board pull-up/-down resistor pairs R2, R3 according to following coding: **SID I^2C-Addr** 0 0x68 **1 0x69 (default)**
MIRA imager (RIGHT)	MIRA050 RIGHT	2	Configurable (→ comment)	Configurable via board pull-up/-down resistor pairs R10, R11 according to following coding: **SID I^2C-Addr** **0 0x68 (default)** 1 0x69

Component	Comp. ID	I²C bus	I²C slave address	Comment
IR LED	D1 & D2	N/A	N/A	Controlled via driver (see below)
BELAGO	DL1	N/A	N/A	Controlled via driver (see below)
dToF Prox. Sensor	U11	1	0x41	TMF8828, 8x8 segment multi-zone
LED Driver	U8, U9	2 (ext'd)	0x63	Drives IR LED DL1 & DL2, using extended I²C bus (see below)
VCSEL Driver	U5	2	0x63	Drives Dot Projector DL1
I²C Bus Extender	U7		0x70	2-Ch. I²C-Bus Switch, extending addressing for LED drivers
I²C GPIO Extender	U3	1	0x20	I²C mapped GPIO controls for RESET, ToF Enable, Alternate, DOT Projector Enable, 2x IR LED Enable (Flood)

(1) Configurable via resistors R1/R2 & R55/56

3 Hardware configuration options

All SERES optical frontend boards share the same design concept. This shall make it easier for users to switch between different hardware configurations in terms of imager resolution, dot projection pattern etc. Although there are different component setups, all SERES optical front ends share the same connector layout. Electrical adaptations which are associated to the different imager options in terms of clock generation, reference voltages etc. are already covered by the implementation of the different SERES variants and are therefore transparent to the user. The user can seamlessly switch the SERES optical frontend hardware between different hardware configurations. Below table gives an overview of the different SERES hardware variants which are available to the user.

The naming convention for the SERES optical frontend follows this convention:

SERES-X.Y.ZZ-FILTER

Where,

- SERES: Stands for the board type
- X: Generation of SERES hardware, here Gen-5
- Y: Imager option ("0" →MIRA-130, "1" →MIRA-220, "2" →MIRA-050)
- ZZ: Resolution of Belago dot-pattern ("11" →5k Belago-1.1, "12" →15k Belago-1.2)
- FILTER: Monochrome, RGB or RGB-IR filter option of image sensor module

Table 2: Available hardware configurations

SERES board type	Image sensor	Optical filter	Field-of-view (FoV)[1]	Dot projector	Flood illuminator	Proximity sensor
5.0.11-MONO	MIRA-130 (1.3 MPx)	Bandpass	45° x 55° (Portrait)	Belago 1.1 (5k dots)	IRED SFH 4725	dToF TMF8828 (up to 8x8 multizone, configurable)
5.1.12-MONO	MIRA-220 (2.2 MPx)	Bandpass	60° x 50° (Landscape)	Belago 1.2 (15k dots)		
5.1.12-RGB		RGB Dual Bandpass				
5.1.12-RGBIR		RGB-IR Dual bandpass				
5.2.11-MONO	MIRA-050 (0.5 MPx)	Bandpass	45° x 60° (Portrait)	Belago 1.1 (5k dots)		
5.2.11-RGBIR		RGB-IR Dual bandpass				

(1) Rounded values; the exact FoV values are SERES-5.0: 47° x 55°, SERES-5.1: 61° x 53°, SERES-5.2: 45° x 64°

As Belago dot-pattern projectors are pin compatible between their 5k and 15k dot versions, further variations are possible without need for redesign of the SERES optical frontend boards. The missing component of interest can be provided by ams OSRAM upon request to provide an additional soldering option.

Regarding user intended target application, the SERES board concept anticipates the following typical use-cases:

- Robotics & Machine Vision
  - SERES-5.1.12 with image sensor placement for landscape orientation and sufficient resolution for the imager as well as the dot projector. Typically operated in active stereovision mode with both image sensor active plus structured light dot-pattern projection.
- Access / Face Authentication
  - SERES-5.2.11 with portrait mode image sensor orientation, MIRA-050 inbuilt system wake-up functionality to unlock ultimate low-power vision solutions with matching 5k dot projection. Typically operated in structured light projection mode with single camera.

All SERES optical frontends come with the following baseline options:

- Active Stereovision
  - Fixed 50mm baseline with recommended depth-of-field 40cm to 150cm
- Structured Light
  - 30mm optional baseline with recommended depth-of-field 20cm to 100cm
  - 20mm optional baseline with recommended depth-of-field 10cm to 60cm

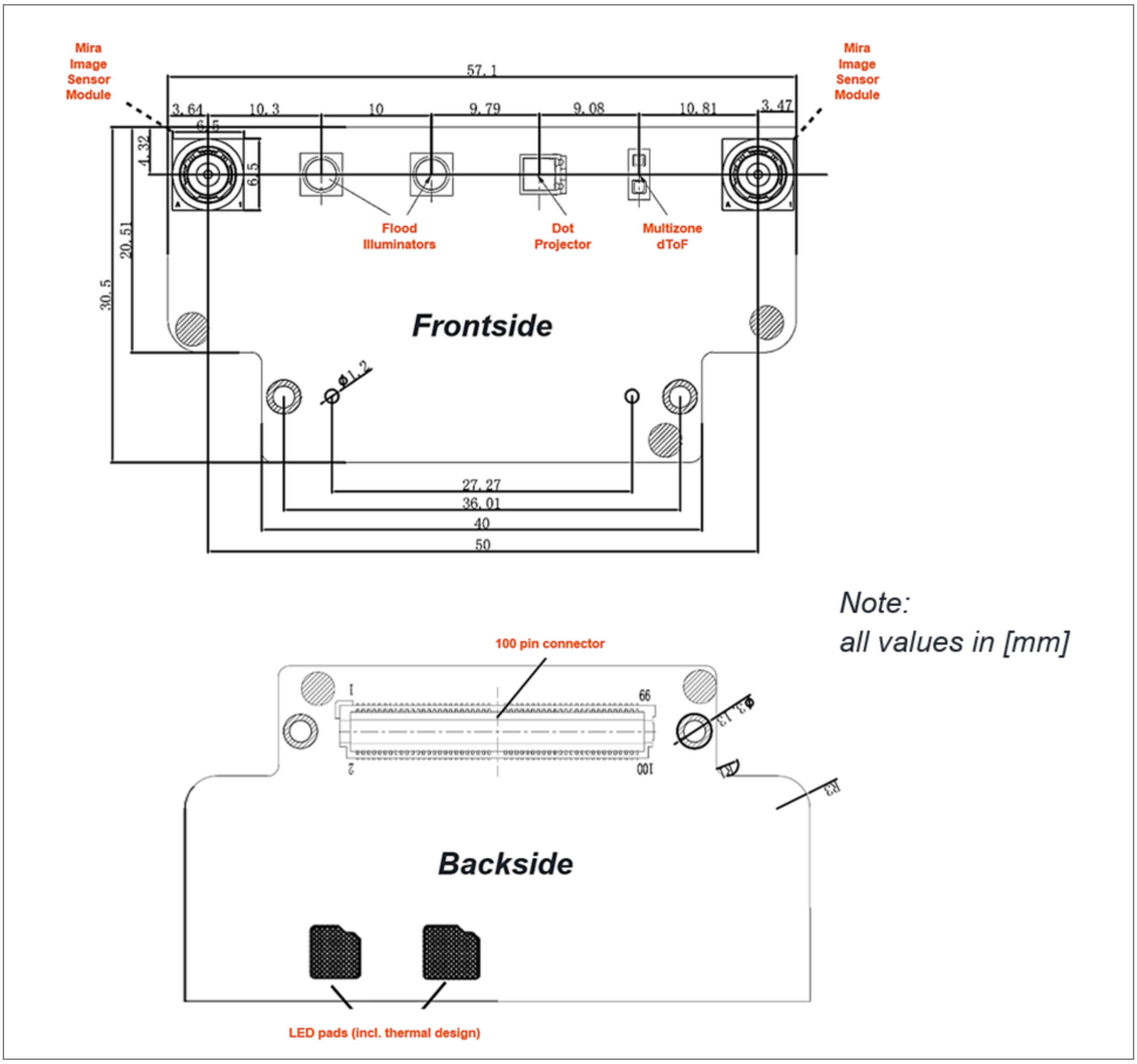
For given depth-of-field values, the measured RMS error is <1% @ 0 - 50klux. Wider depth-of-field deployment is possible but might require additional or more powerful scene illumination. Any other baseline setting is possible but would require modification of the board layout with bigger distance between both image sensor modules or the image sensor module(s) and the dot projector.

See also section on the different modes of operation for more in-depth information.

4 Mechanical data

All variants of the SERES share the same form factors for the PCB as well as the same connector (including pin assignments).

Figure 3: Board outlines



In case SERES shall be operated as an optical frontend to an existing image processing hardware solution (aka “ISP board”) which does not natively support the SERES connector, an additional mezzanine adapter board needs to be put in between. This mezzanine board is very low effort and cost as it only needs to provide the translation between different connectors and pin assignments. The design files provided by ams OSRAM accelerate the creation of such a use-case specific mezzanine board.

Due to the common design concept among all SERES optical frontend options, this mezzanine board would have to be developed only once.

5 Electrical data

SERES optical frontend is equipped with a 100-pin connector which provides full access to all component resources:

Table 3: Structural overview connector layout

MIPI CSI2 Image Sensor #1	MIPI CSI2 Image Sensor #2	I²C Slave Image Sensors #1 & #2	I²C Slave dToF Prox. Sensor	Strobe & Sync. Triggers	Ext.Supply & Ref.Voltages SERES-5.0.X (MIRA-130) 2.5V[1] 1.8V[2], 1,2V[3] SERES-5.1.X (MIRA-220) 2.5V[4], 1.8V[1], *(on-board: 1.35V[5])* SERES-5.2.X (MIRA-050) 2.8V[6], 1.2V[7]

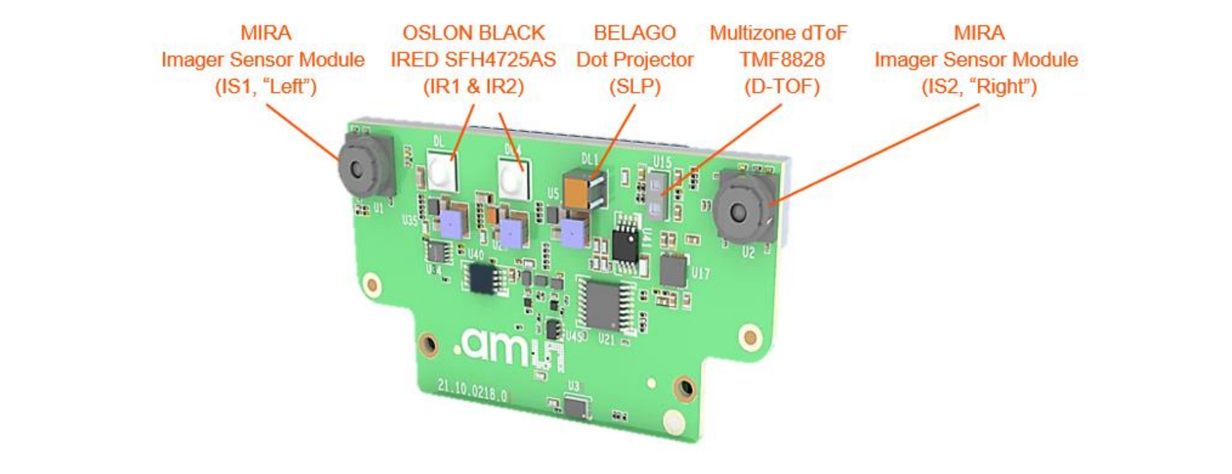
(1) AVDD2.5V / AVDD
(2) DVDD_1V8 / DOVDD_1V8 / DOVDD
(3) DVDD_1V2 / DVDD
(4) Rounded values: The exact FoV values are SERES-5.0: 47° x 55°, SERES-5.1: 61° x 53°, SERES-5.2: 45° x 64°
(5) Not on connector: VDD13A / VDD13D / VDD13P generated on board from 2.5V reference.
(6) 2V8 / VDD28
(7) 1V2 / VDD12

Refer to section 9 Circuit description, for greater detail on the connector's exact pin assignments.

6 Modes of operation

On top of default 2D vision, SERES optical frontend supports 5 different depth modalities to evaluate best fitting 3D vision concept according to ambient conditions and user-specific application constraints. Switching between different depth modalities can be done by software as all components are controllable via I²C bus. For reference all relevant components have been marked on below board example below.

Figure 4: Active component localization



Within the depth modalities table, you find the corresponding identifiers from figure for pointing to the components which need to be activated when a specific depth modality is chosen:

Table 4: Overview of available modes of operation (depth modalities)

Depth modality	Imager sensor (IS1)	Flood illuminator (IR1)	Flood illuminator (IR2)	Dot projector (SLP)	dToF prox sensor (D-TOF)	Imager sensor (IS2)	Comment
2D	X	(x)	(x)			(x)	Or IS2 instead of IS1, IREDs accord. filter
SL1	X			X			30mm baseline
SL2				X		X	20mm baseline
SV	X	(x)	(x)			X	Opt. IREDs activation according to filter
ASV	X	(x)	(x)	X		X	IREDs accord. to filter but pwr << dot-pattern
dToF	(x)				X	(x)	

(1) "X" denotes mandatory settings, "(x)" optional extensions. If structured light dot-pattern projection is activated flood illuminators IR1 & IR2 must be operated at very low power to not overrun dot-pattern.

The depth modalities have been abbreviated as follows:

- 2D: Single image sensor operation with 2-dimensional vision (no depth info)
- SL1: Single image sensor operation with structured light @ 30mm baseline
- SL2: Single image sensor operation with structured light @ 20mm baseline
- SV: Dual imager sensor stereovision without structured light support
- ASV: Dual imager sensor active stereovision with structured light support
- dToF: Pulsed direct time-of-flight operation with up to 8x8 multizone support

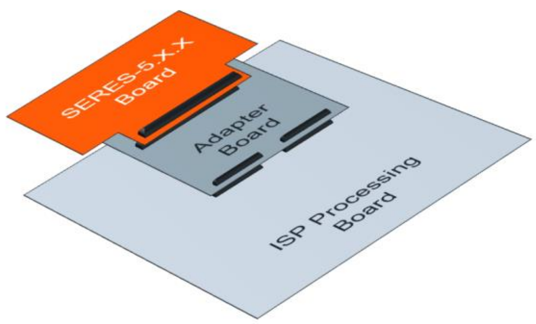
7 Interfacing to image processing hardware

The SERES optical frontend has been intentionally designed in a very generic way: All relevant data and control signals as well as reference and supply voltages have been routed to the SERES board connector. This enables interested users to quickly design their own processing hardware specific interface adapter board which,

- Reroutes pins from the SERES physical connector to any desired processor board specific connector and its required pin assignments.
- Adds the missing clocks, supply and reference voltages - if not natively supported by the processor board itself - via local on-board oscillators and voltage regulators.

Such a processing hardware specific adapter board enables stacking of the SERES optical frontend to the targeted processing hardware of choice.

Figure 5: Interfacing SERES to processing hardware



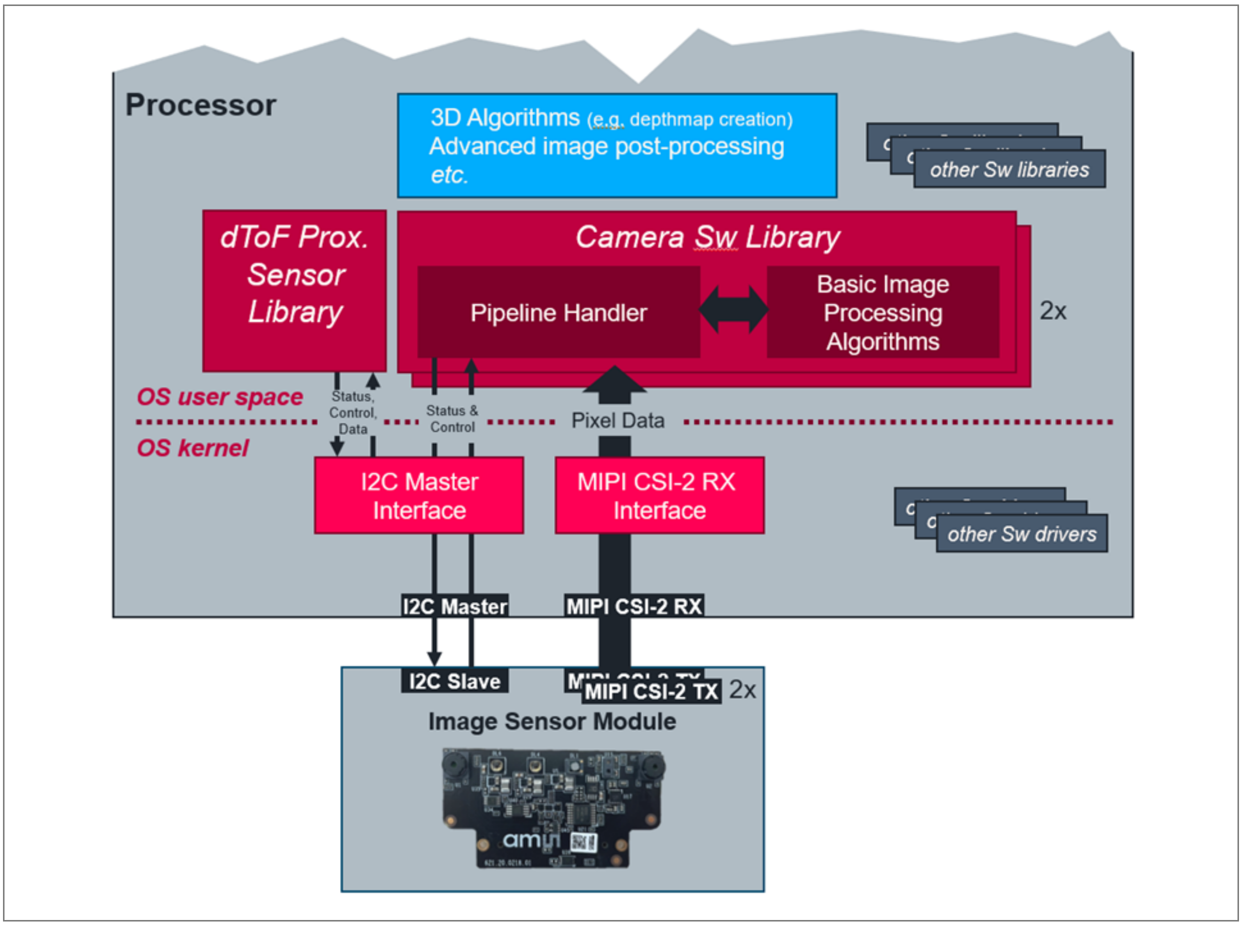
ams OSRAM has implemented such an adapter board for the Khadas EDGE-V with Rockchip RK3399 ISP, which could serve as a blueprint for other customized adapters. The complete design can be found in section 9.3 but is also provided by ams OSRAM as complete design package to enable interested users to jump-start on their own board design.

8 Software support

Different levels of software support for operating the SERES optical frontends are provided by either ams OSRAM directly or via official partners listed in ams OSRAM's partner network.

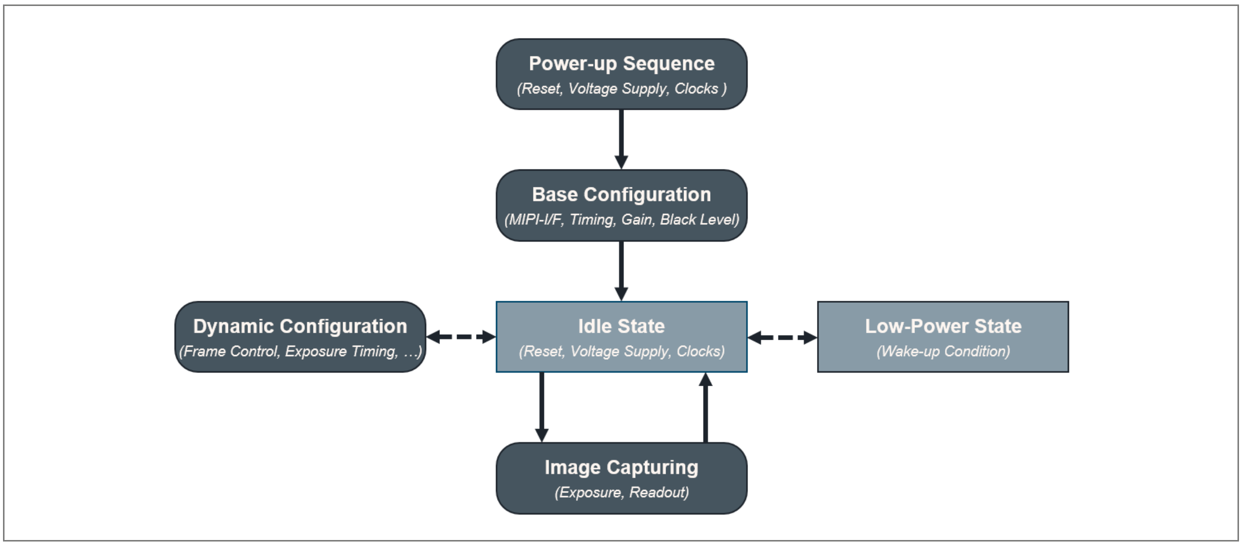
ams OSRAM primarily focuses on generic device driver software supporting the raw image datapath from SERES optical frontend into the processing platform of choice. Complete vertical 3D-vision integrations for dedicated processing platforms are available via official ams OSRAM partners. In additional there is an opportunity to deploy open source libraries for basic 3D optical frontend calibration and image processing (e.g. OpenCV, opencv.org) as well as higher level application support, such as face recognition for authentication solutions or SLAM libraries for robotic navigation. ams OSRAM partner network is constantly extended to provide additional vertical integration support beyond the individual imaging components on SERES optical frontend.

Figure 6: Generic device driver overview



Standard C-source Linux device drivers to operate the image sensor modules and the optional proximity sensor can be downloaded after registration from ams OSRAM download-center. These device drivers need to be ported to the desired target processing hardware, but they already provide programming structures for powering-up the image sensor modules, a default base configuration and the required steps for image capturing as well as the dynamic image sensor configuration for adjusting e.g. exposure timings to changing ambient light conditions.

Figure 7: MIRA image sensor operation



The standard C-source Linux device drivers provide in the header files (.h) all required symbolic address assignments to operate the individual I²C connected bus instances, basic image sensor configuration sets as well as configurations sets for adjusting the image sensors' analog gain for 1x, 2x or 4x, all for 12-bit operation. Additional configuration options can be easily composed using ams OSRAM configuration tool for the MIRA image sensors. This tool allows composition of valid configuration sets for the image sensor, which are checked for consistency and can be stored / exported for usage in own register programming sequences.

In the source files (.c) users can find the required routines for configuring and activating the MIPI interfaces, as well as programming / configuring the various active components on SERES optical frontend. Routines for initialization of the image sensors, setting analog gain, exposure timing, image stream activation / deactivation, frame capture and synchronization are provided. They also implement basic functions to control active illumination via the embedded IR-LED for flood-illumination or the BELAGO dot-pattern projector for structured light operation.

Finally the provided standard C-source Linux device drivers provide a basic implementation of a device tree source file (.dts/.dtsi) which describe the SERES optical frontend hardware configuration and registers it as an available hardware resource within the OS during system boot (e.g. I²C resources, MIPI interfaces). Within this dts-file user can also find suggested configuration settings for supply voltages, drive currents, interface timings and basic operational modes.

Native driver support is available for Khadas EDGE-V with Rockchip RK3399 ISP platform. The driver allows for image sensor basic configuration and passing of raw image data to the ISP. It does not offer any additional image processing capabilities and needs to be loaded and compiled into the ISP's operating system. Note: The Khadas integration does not provide an integration for the dToF multi-zone proximity sensor, which has intentionally left inactive; if additional dToF support is desired by the user, the available device driver source files for the dToF sensor need to be incorporated.

For a fully integrated ready-to-use 3D-vision integration interested users can e.g. deploy a configurable reference design kit, which has been developed on top of SERES optical frontend by ams OSRAM partner Technique. This reference design kit is available for an Ambarella image processing platform.

Visit ams OSRAM download-center to find latest software releases or reach out to the ams OSRAM partners.

9 Circuit description

ams OSRAM provides the complete design package for the SERES optical frontend to interested users after registration in download-center. This way users can reuse the SERES implementation within their own projects or copy parts of the implementation, such as the connector description, to quickly create their own interface adapter board for interfacing between SERES optical frontend and the desired image processing hardware.

9.1 SERES-5.0.x and SERES-5.1.x schematics

Figure 8: SERES-5.0.x and SERES-5.1.x schematics (continued…)

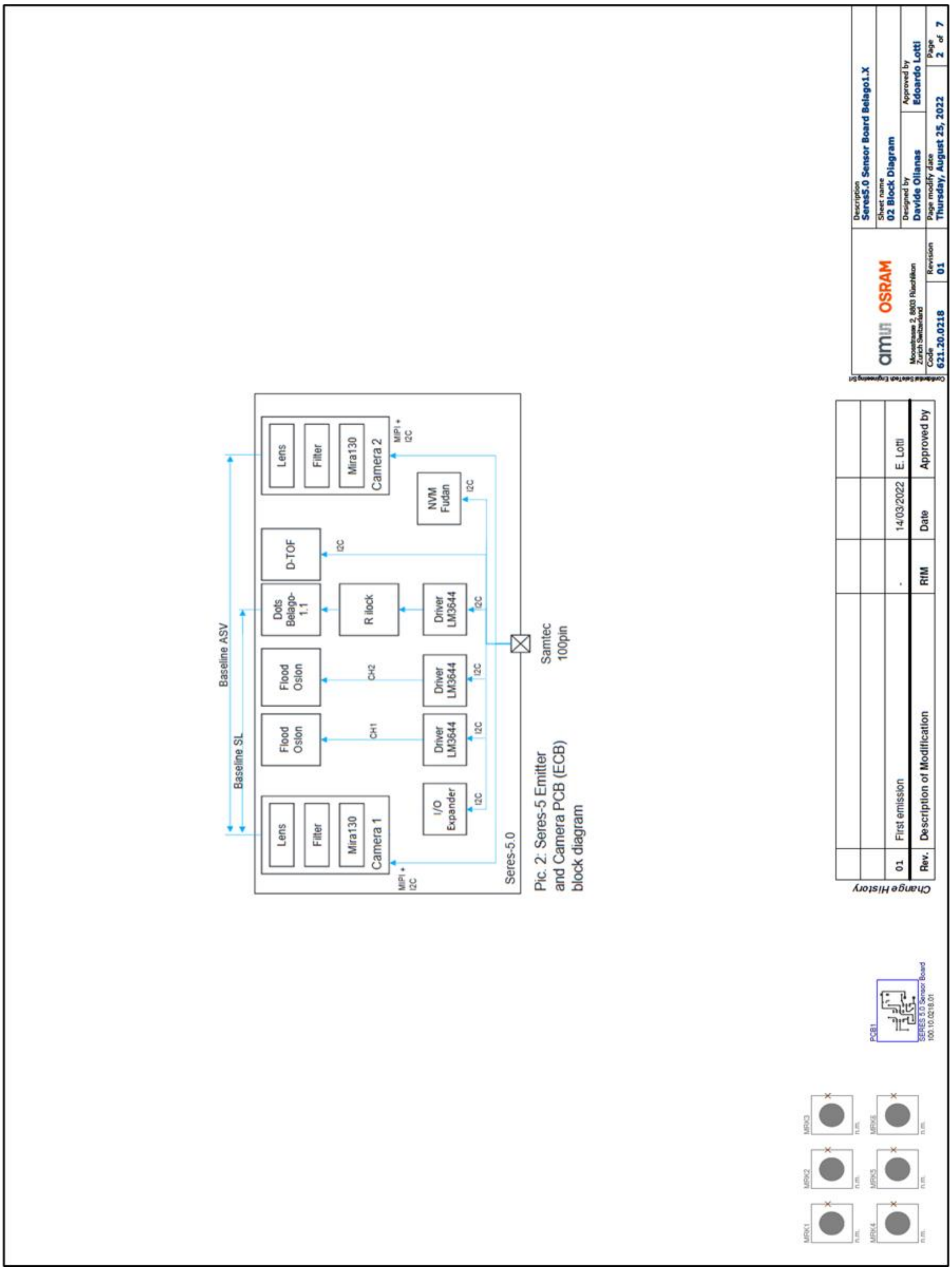


Figure 9: SERES-5.0.x and SERES-5.1.x schematics (continued1…)

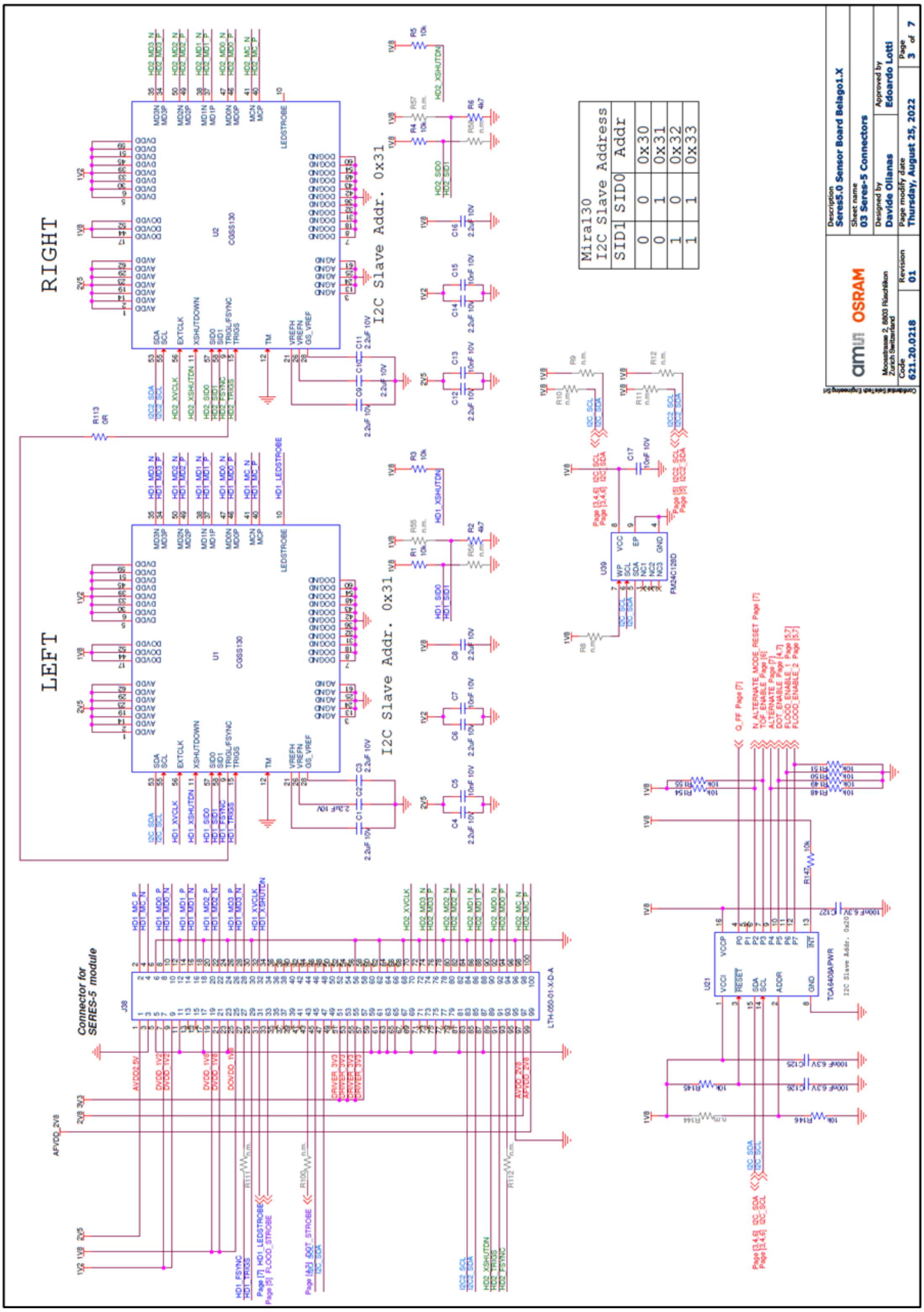


Figure 10: SERES-5.0.x and SERES-5.1.x schematics (continued2…)

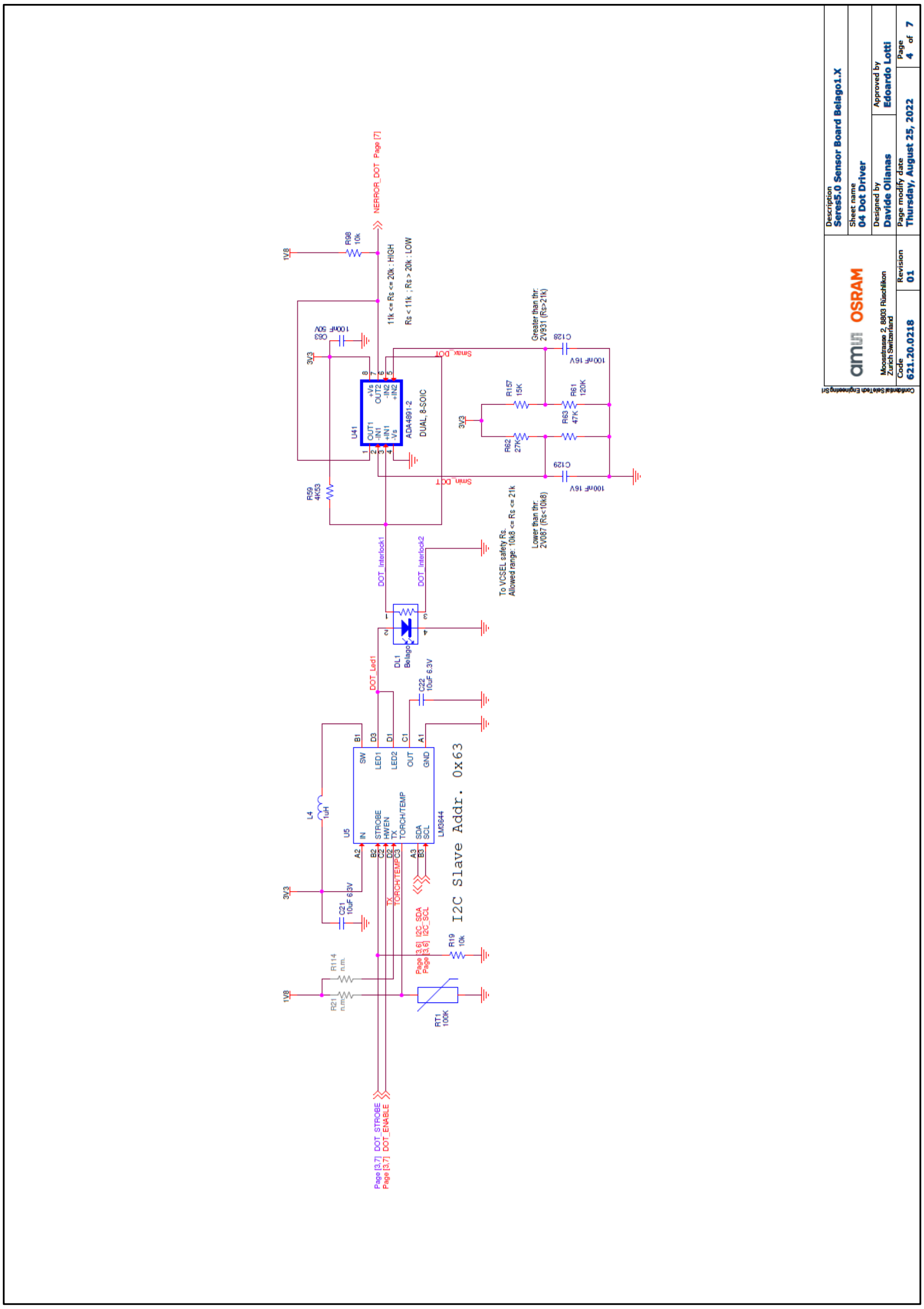


Figure 11: SERES-5.0.x and SERES-5.1.x schematics (continued3…)

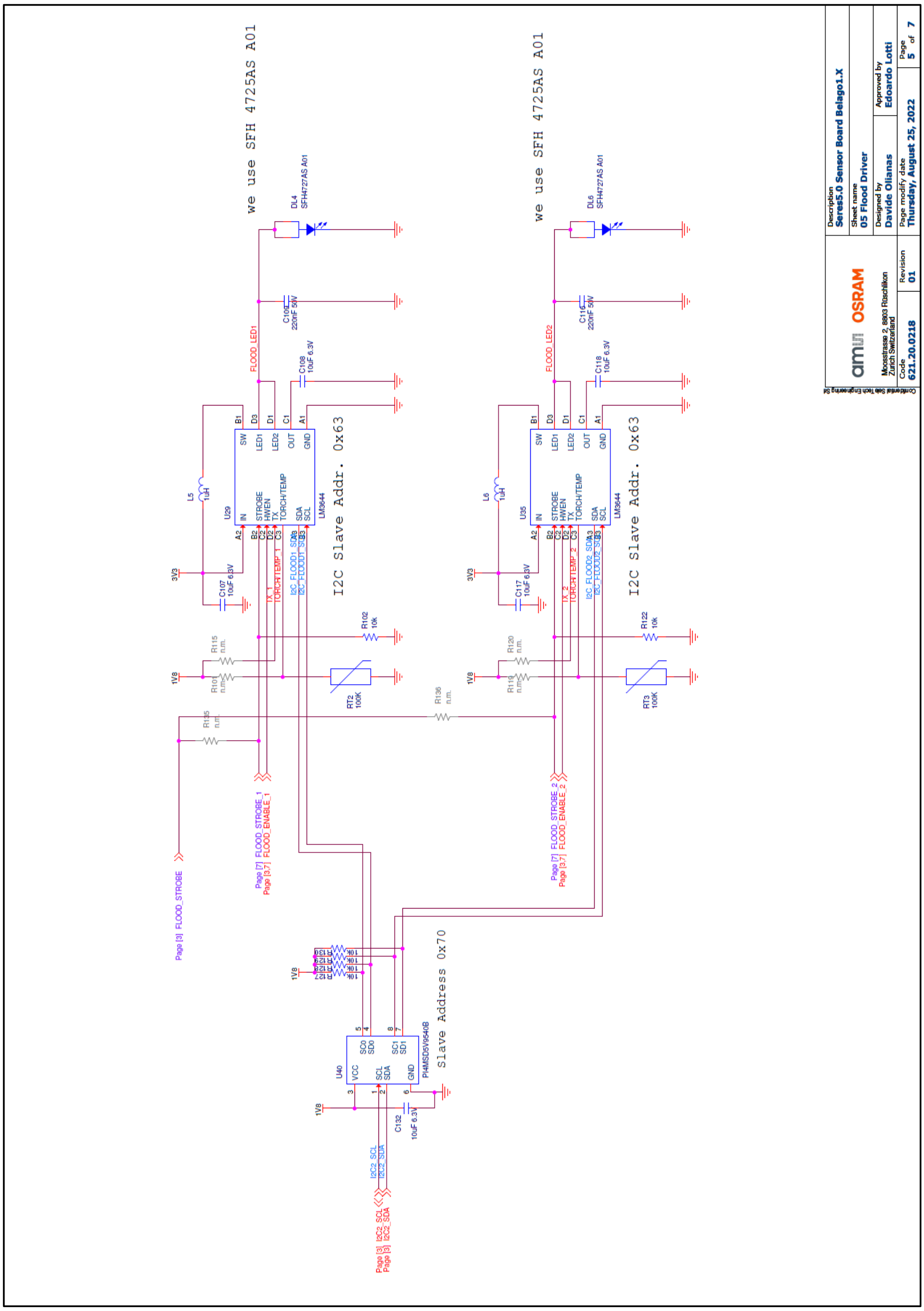


Figure 12: SERES-5.0.x and SERES-5.1.x schematics (continued4…)

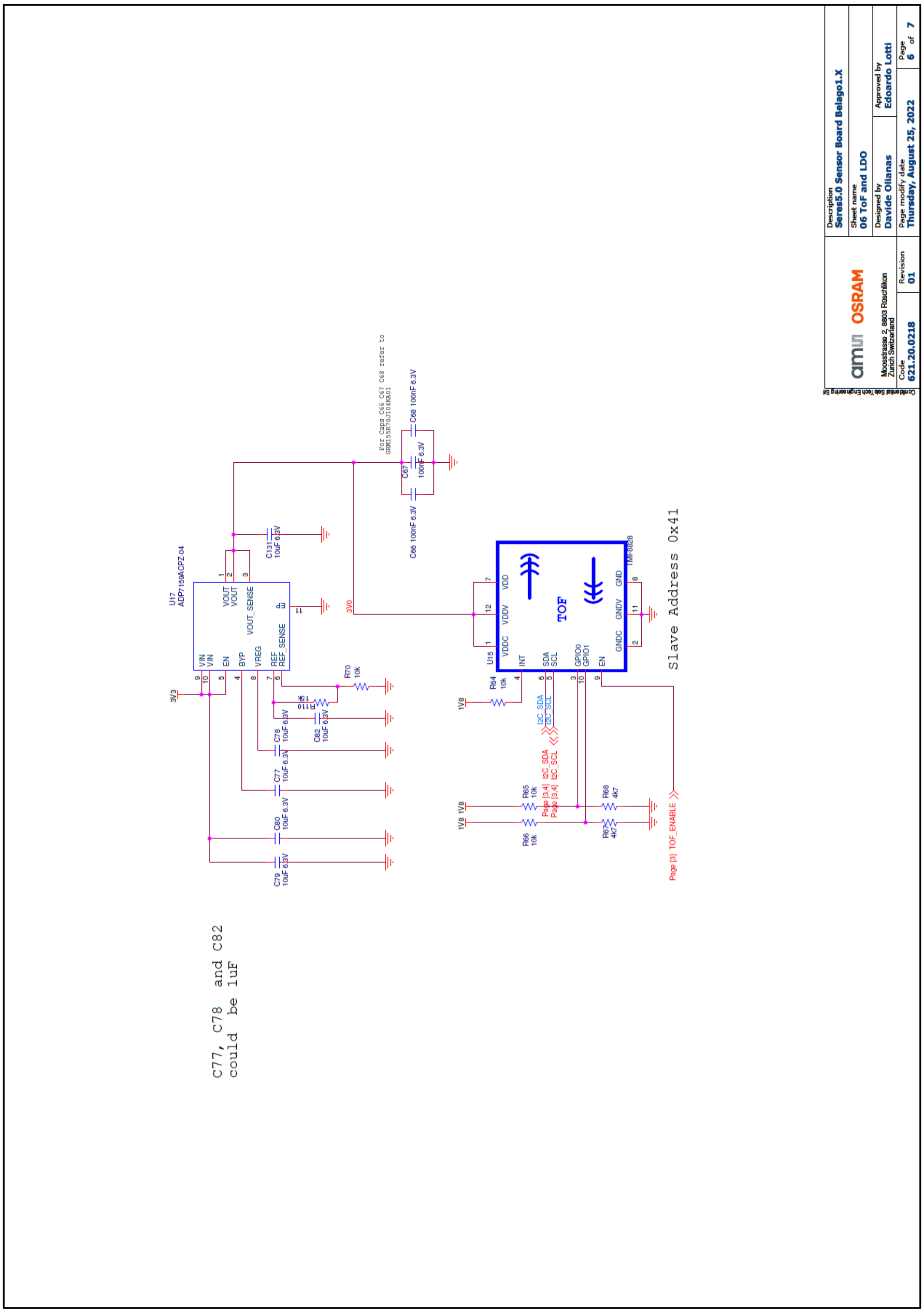
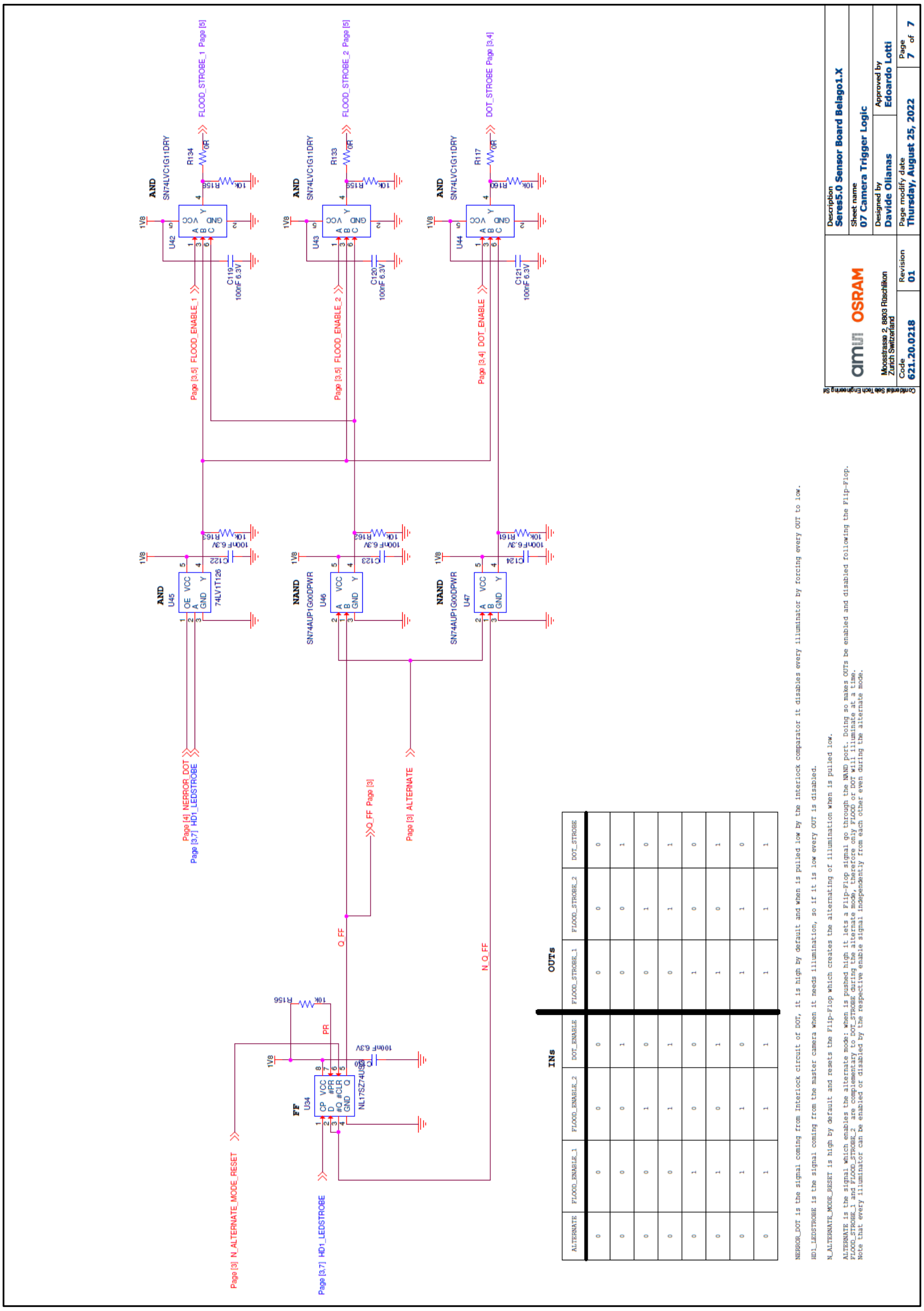


Figure 13: SERES-5.0.x and SERES-5.1.x schematics



9.2 SERES-5.2.x schematics

Figure 14: SERES-5.2.x schematics (continued…)

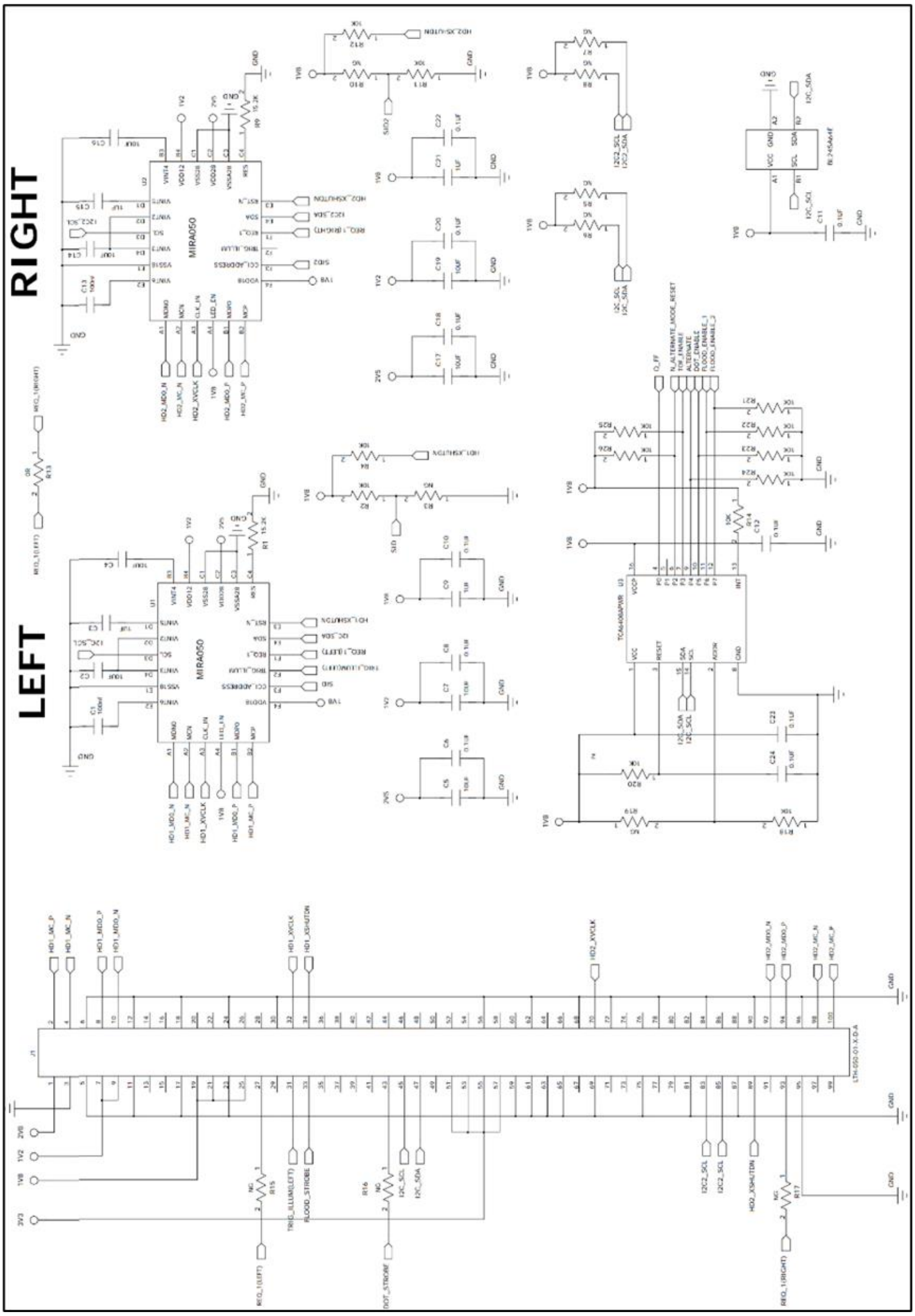


Figure 15: SERES-5.2.x schematics (continued1…)

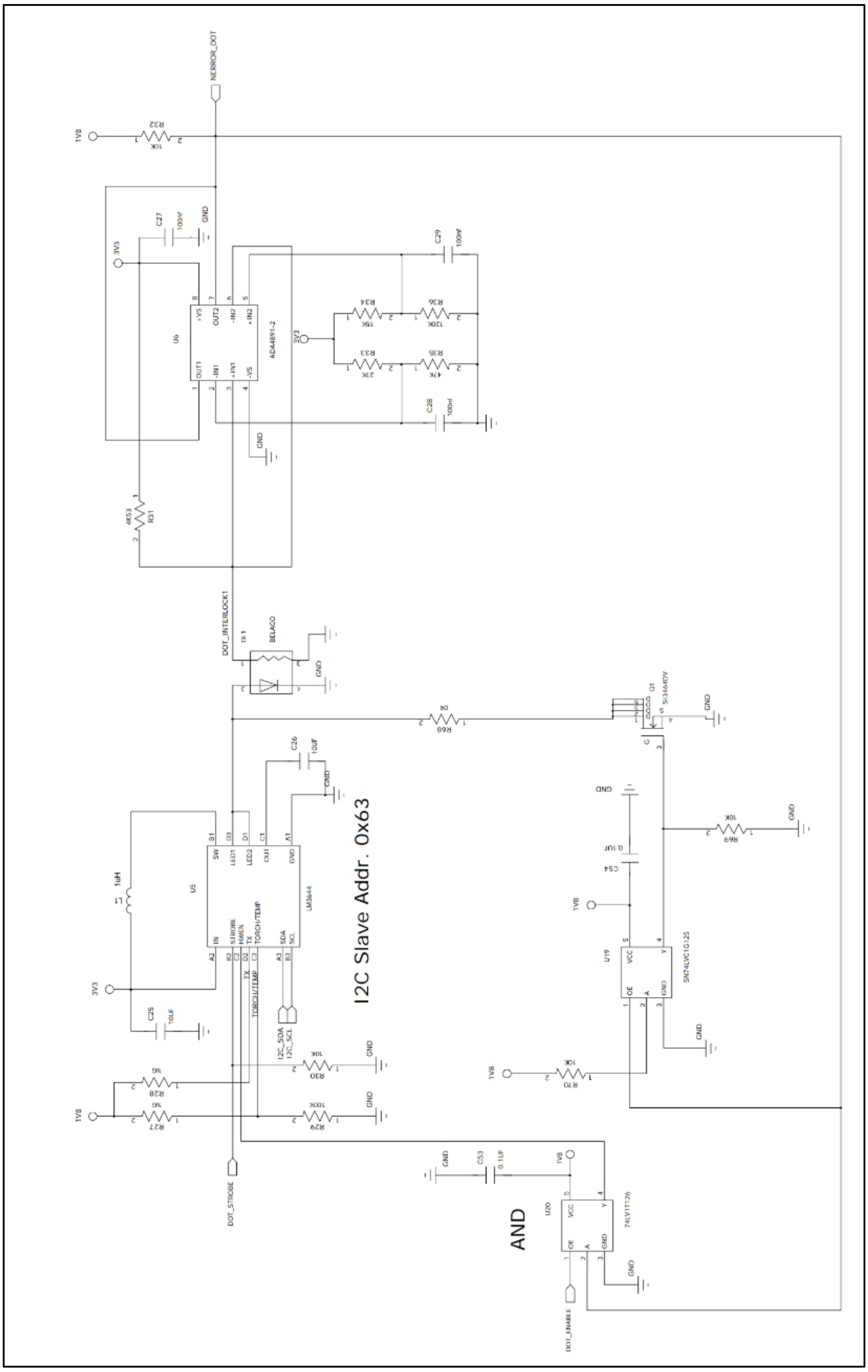


Figure 16: SERES-5.2.x schematics (continued2…)

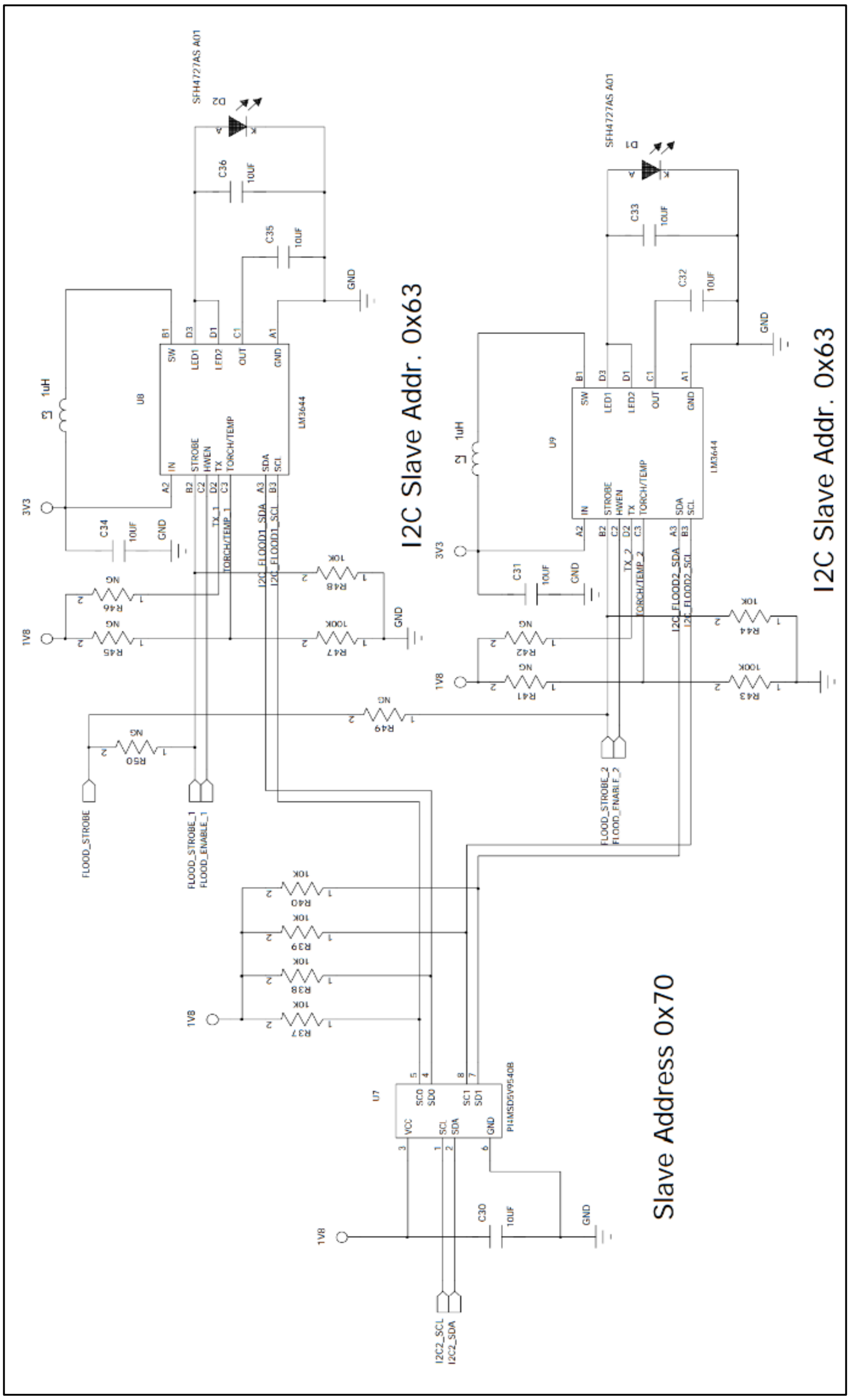


Figure 17: SERES-5.2.x schematics (continued3…)

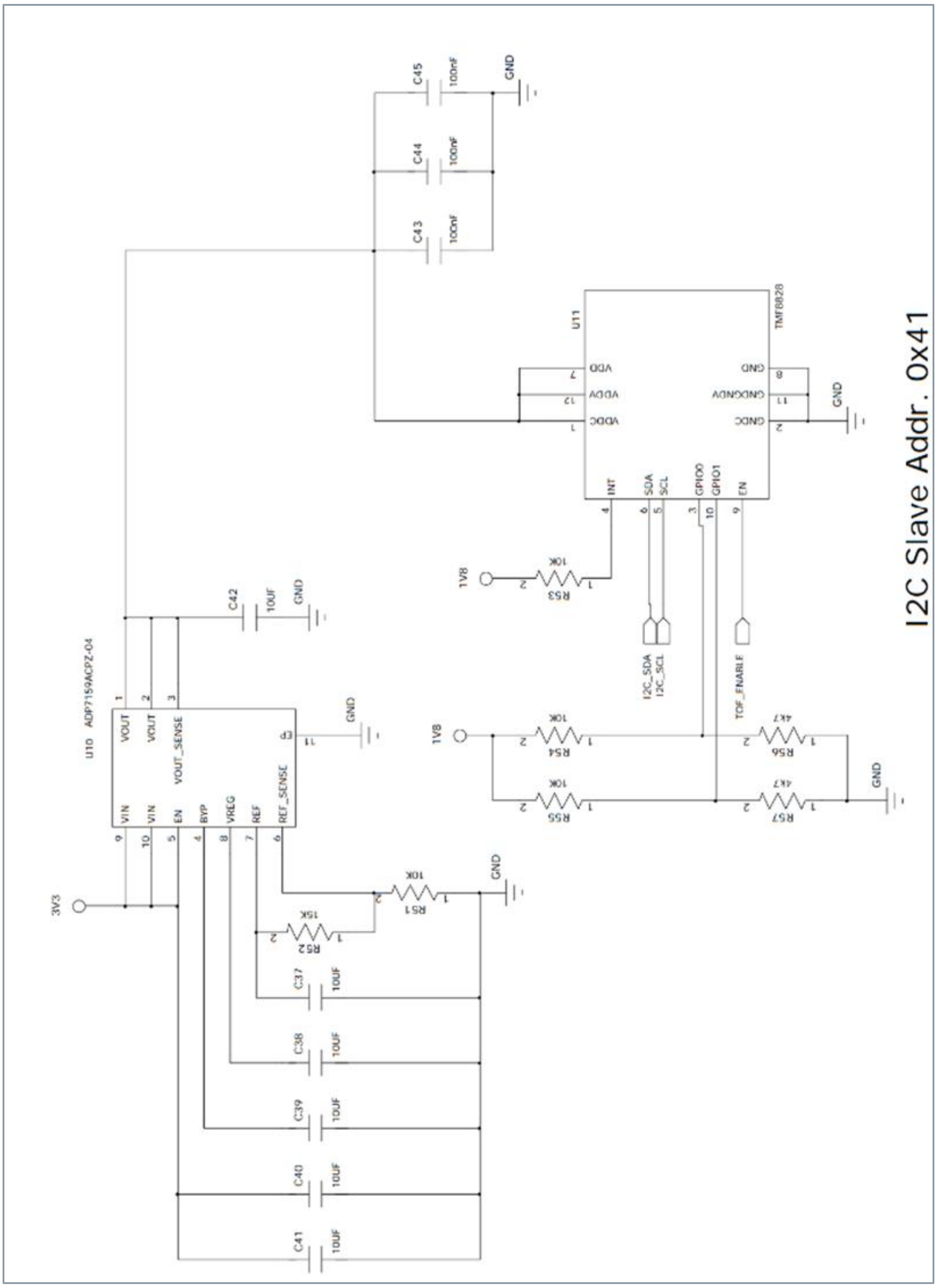
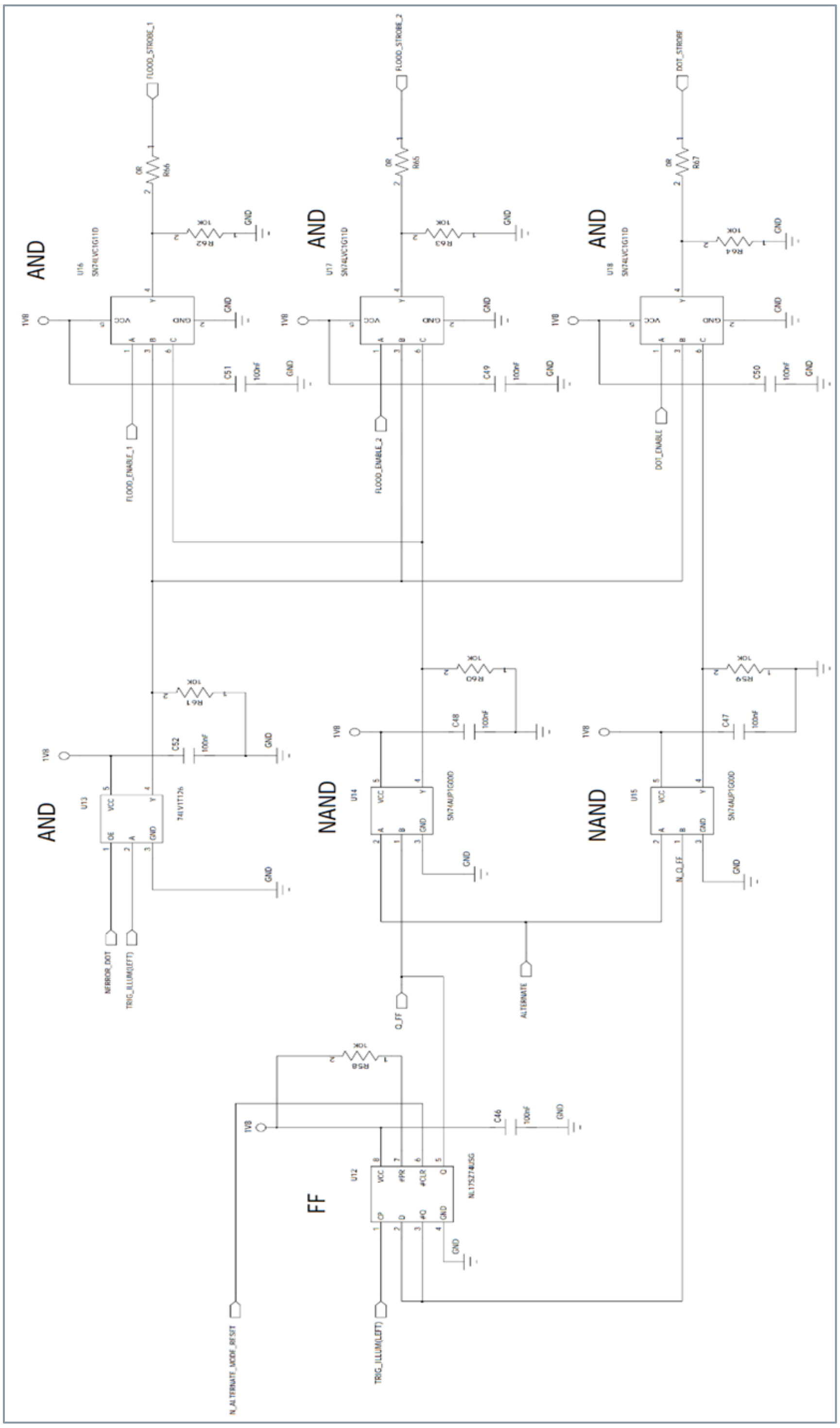


Figure 18: SERES-5.2.x schematics



9.3 Adapter board example (here: Khadas EDGE – V Pro)

Figure 19: Adapter board example (continued…)

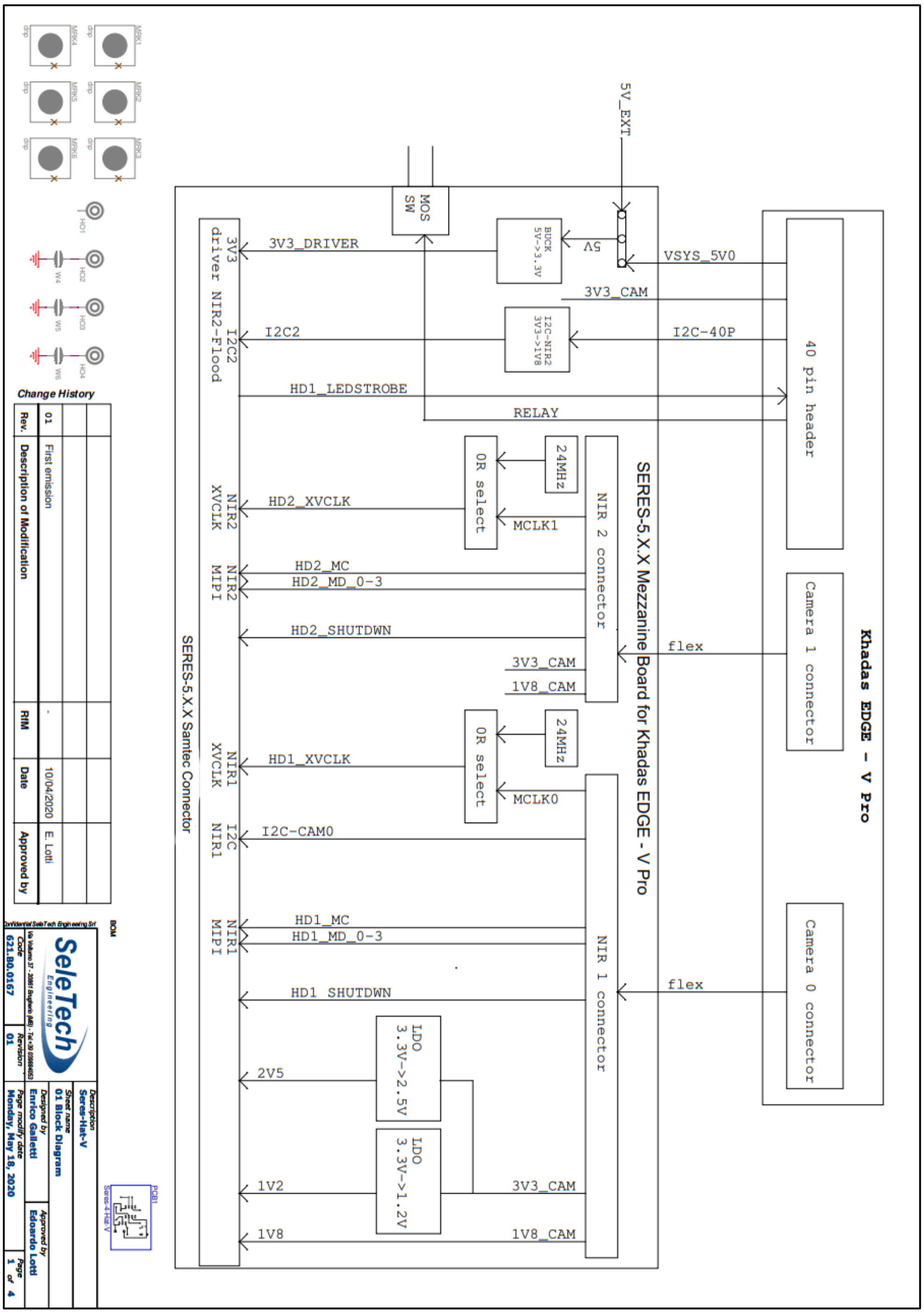


Figure 20: Adapter board example (continued1…)

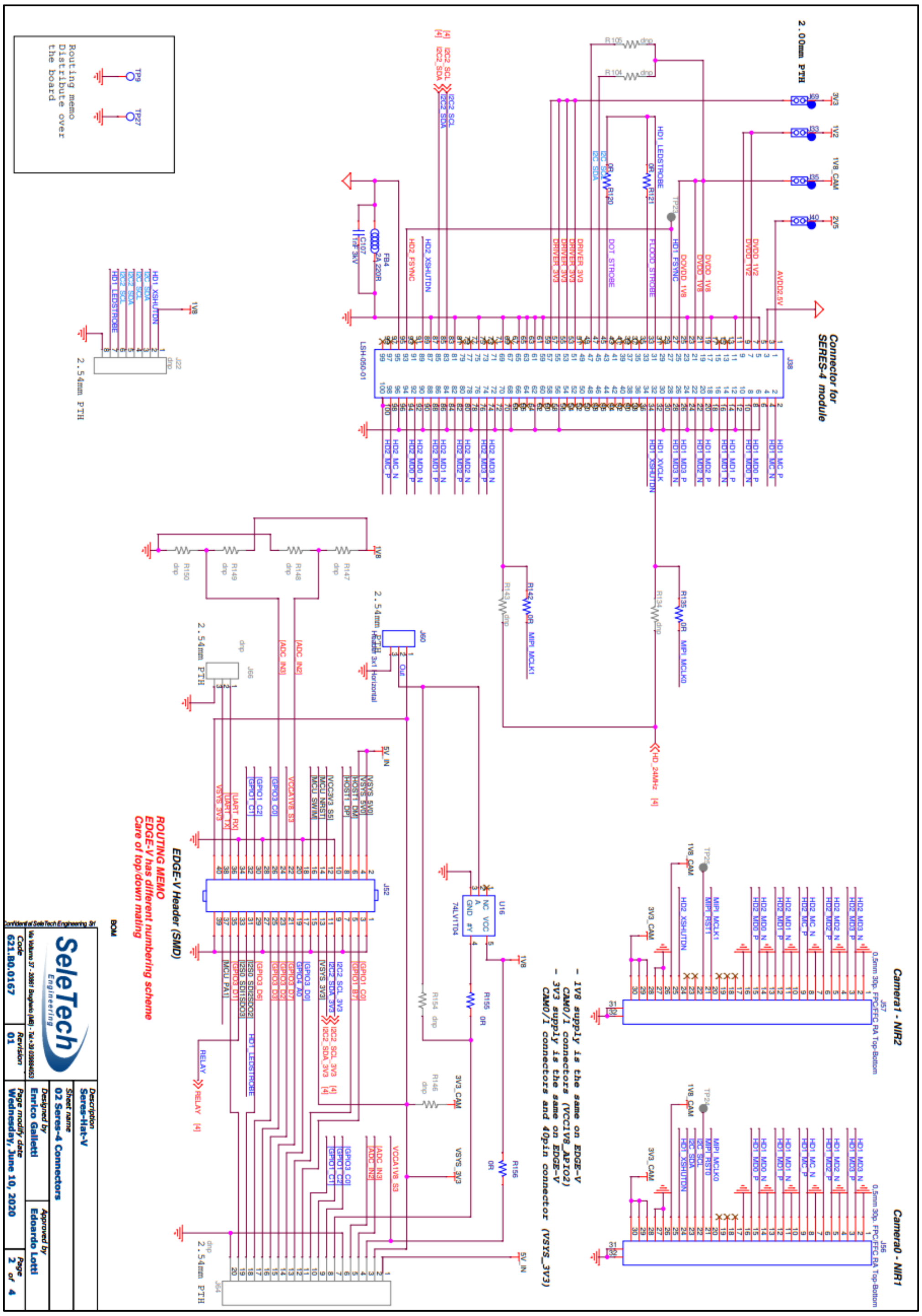


Figure 21: Adapter board example (continued2…)

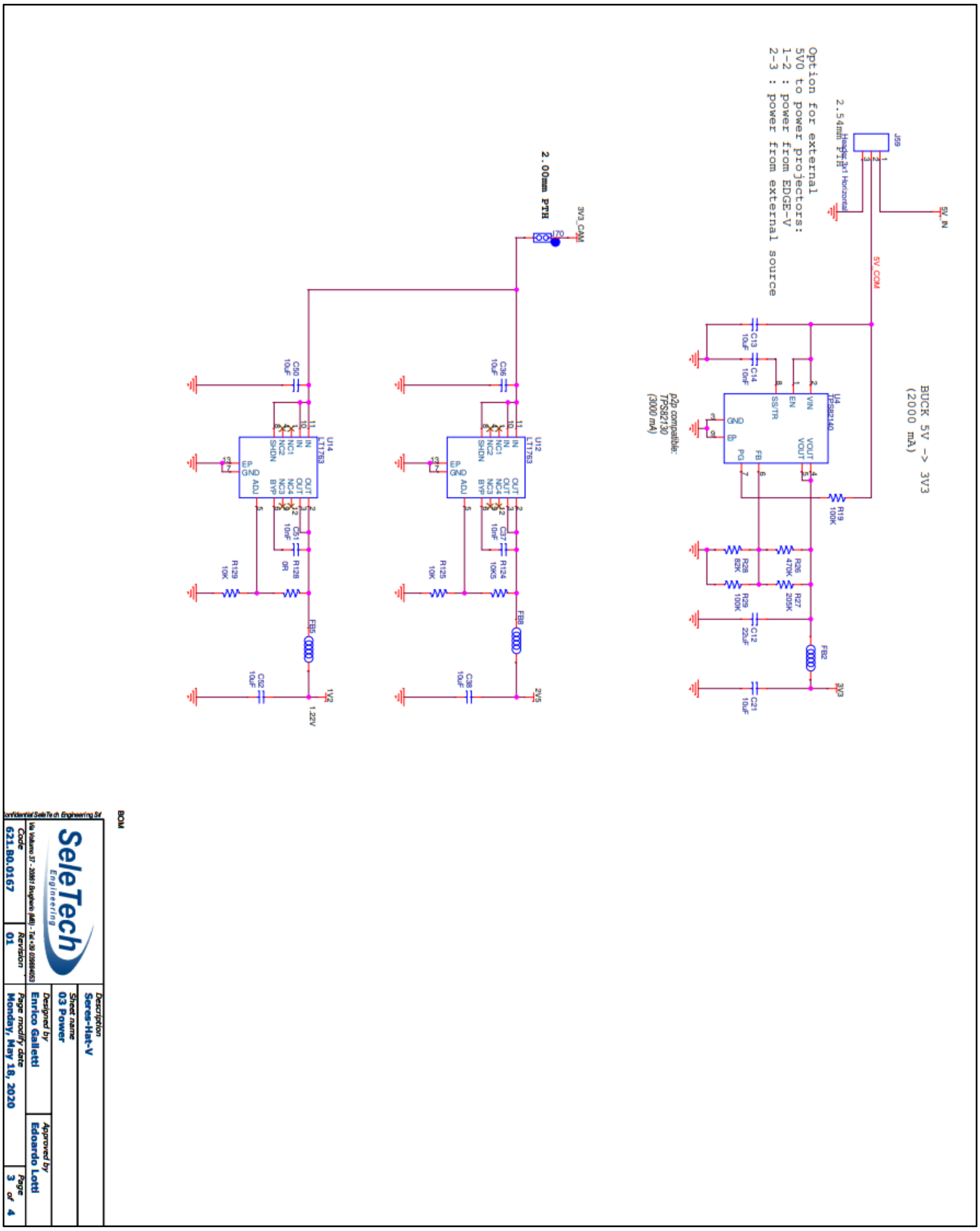
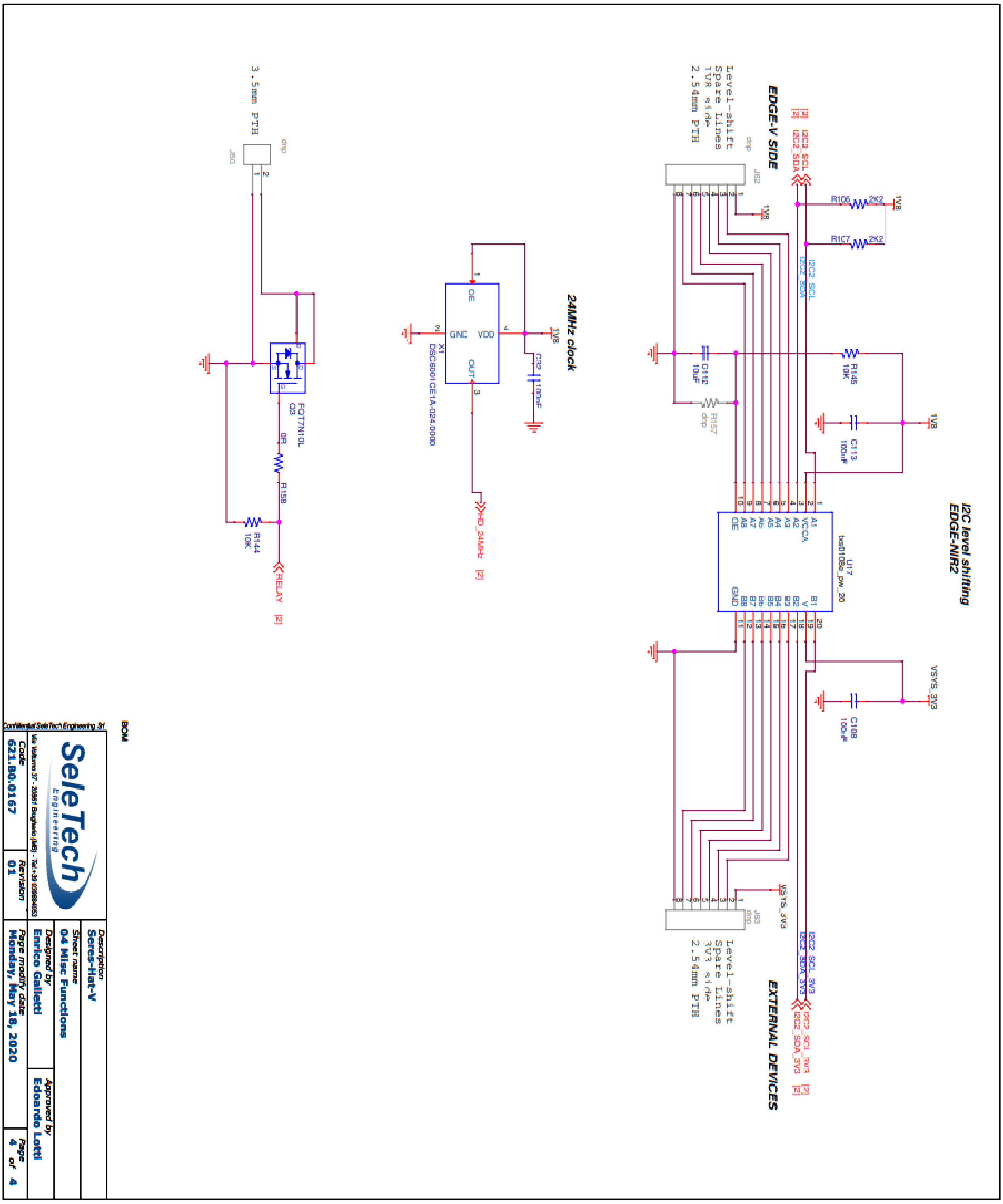


Figure 22: Adapter board example (continued3…)



10 Component list

Table 5: Component list

Product code	Description
Mira220-2QM1WP or -WA	MIRA-220 MONO, 2.2 MPx, CSP Package(1)
Mira220-2QI1WP or - WA	MIRA-220 RGBIR, 2.2 MPx, CSP Package(1)
Mira050-1QM1WB	MIRA-050 MONO, 0.5 MPx, CSP Package(1)
Mira050-1QI1WB	MIRA-050 RGBIR, 0.5 MPx, CSP Package(1)
Mira130-1QM2PP	MIRA-130 MONO, 1.3 MPx, PLCC Package(1)
AQAA-20	Belago1.1 Dot-Pattern Projector
Sampling	Belago1.2 Dot-Pattern Projector
TMF8828-1AM	TMF8828 Multizone Time-of-Flight Sensor
SFH 4725AS	OLSON Black IR-LED
AS1170-ZWLM	2-channel LED or VCSEL Driver IC, recommended replacement for LM3644

(1) For complete overview on product variants refer to ams OSRAM's product finder; all components also available as bare die.

Information:

Hardware samples of all SERES-5.X.X optical frontends are available and can be obtained by ams OSRAM upon request.

Check ams OSRAM website at ams-osram.com for further information on components and supported applications. Please reach out to customer support via ams-osram.com/support or contact local ams OSRAM sales in case of additional requests. Your closest sales offices, distributors and representatives can be found at ams-osram.com/about-us/locations-distribution

11 Revision information

Definitions

Draft / Preliminary:
The draft / preliminary status of a document indicates that the content is still under internal review and subject to change without notice. ams-OSRAM AG does not give any warranties as to the accuracy or completeness of information included in a draft / preliminary version of a document and shall have no liability for the consequences of use of such information.

Changes from previous released version to current revision v1-01	Page
Changes to v1-00	
Initial production version	
Changes from v1-00 to v1-01	
Added section 1.1 “Note on eye-safety”	4

- Page and figure numbers for the previous version may differ from page and figure numbers in the current revision.
- Correction of typographical errors is not explicitly mentioned.

12 Legal information

Headquarters

ams-OSRAM AG

Tobelbader Strasse 30

8141 Premstaetten

Austria, Europe

Tel: +43 (0) 3136 500 0

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