HAILO

Empowering Intelligence

Hailo-15L
SBC (Single Board Computer) Kit
User Guide

Revision 1.0

April 2026

Preliminary

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Revision History

This section describes top-level differences in the versions of this document.

Revision	Date	Description
1.0	April 2026	First release

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1. Overview

1.1. Introduction

Hailo-15L SBC (Single Board Computer) offers a comprehensive platform for developing and prototyping cameras powered by the Hailo-15L AI vision processor (Hailo-15L VPU). It's powerful AI capabilities enable both AI-powered image enhancement and the efficient, full-scale processing of multiple complex deep learning applications.

This user-guide is designed to help the users efficiently utilize the Hailo-15L SBC, walking them through essential hardware setup, software configuration steps, and the execution of inference tasks. Sections 2, 3, and 4 intentionally align very closely with the corresponding sections in the Quick Start Guide. Section 5 includes detailed descriptions for each of the Hailo-15L SBC features.

The Hailo-15L SBC also enables the development and prototyping of a smart camera, showcasing high-quality video streaming and advanced AI inference capabilities including:

- Direct connection with supported camera sensors.
- Versatile interfaces for connecting, testing, and power measuring the Hailo-15L.
- Easy integration with existing customers' platforms.
- Seamless integration with popular software frameworks.

The Hailo-15L SBC kit contains:

- Single Board Computer (SBC) with an integrated Hailo-15L VPU.
- 12V DC power supply, microSD™ card, spacers, heatsink for the Hailo-15L, USB to USB-micro cable
- Complete Yocto Project® based Linux® distribution, a full stack DSP, libraries, Board Support Package (BSP), and drivers

Note: the camera's sensor and accompanying cable are not included in the Hailo-15L SBC kit and shall be ordered from Hailo separately.

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1.2. Hailo-15L SBC Key Features

- Hailo-15L AI vision processor
- Memory
  - 2GB LPDDR4x
  - 8MB QSPI flash
  - 8GB HS200, eMMC 5.1 4bit
- Camera Interface
  - 2x MIPI® CSI RX 1x 4 lanes or 2x 2 lanes “20525-030E-02C” connectors
- Display Interface
  - MIPI-DSI 22 pins female connector
- Connectors and Interfaces
  - MicroSD™ card connector
  - USB2 / USB 3.1 type-A (host mode) connector
  - 10/100/1000 Ethernet RJ45 connector
  - M.2 Key-M PCIe Gen3 x1 slot
  - General purpose header
  - UART header
  - SPI header
  - 12V DC power connector
- Audio
  - Headphone out Jack
  - Mic in Jack
  - Audio codec
- Debug and Control
  - INA231 for power measurements
  - UART: 2 interfaces
  - SPI: 4 controllers
  - I2C: 1interface
  - Debug board connector
  - LEDs including two that are user-controlled
  - Gyro for EIS

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1.3. Hailo-15L SBC Block Diagram

Figure 1 below shows a high-level block diagram of the Hailo-15L SBC.

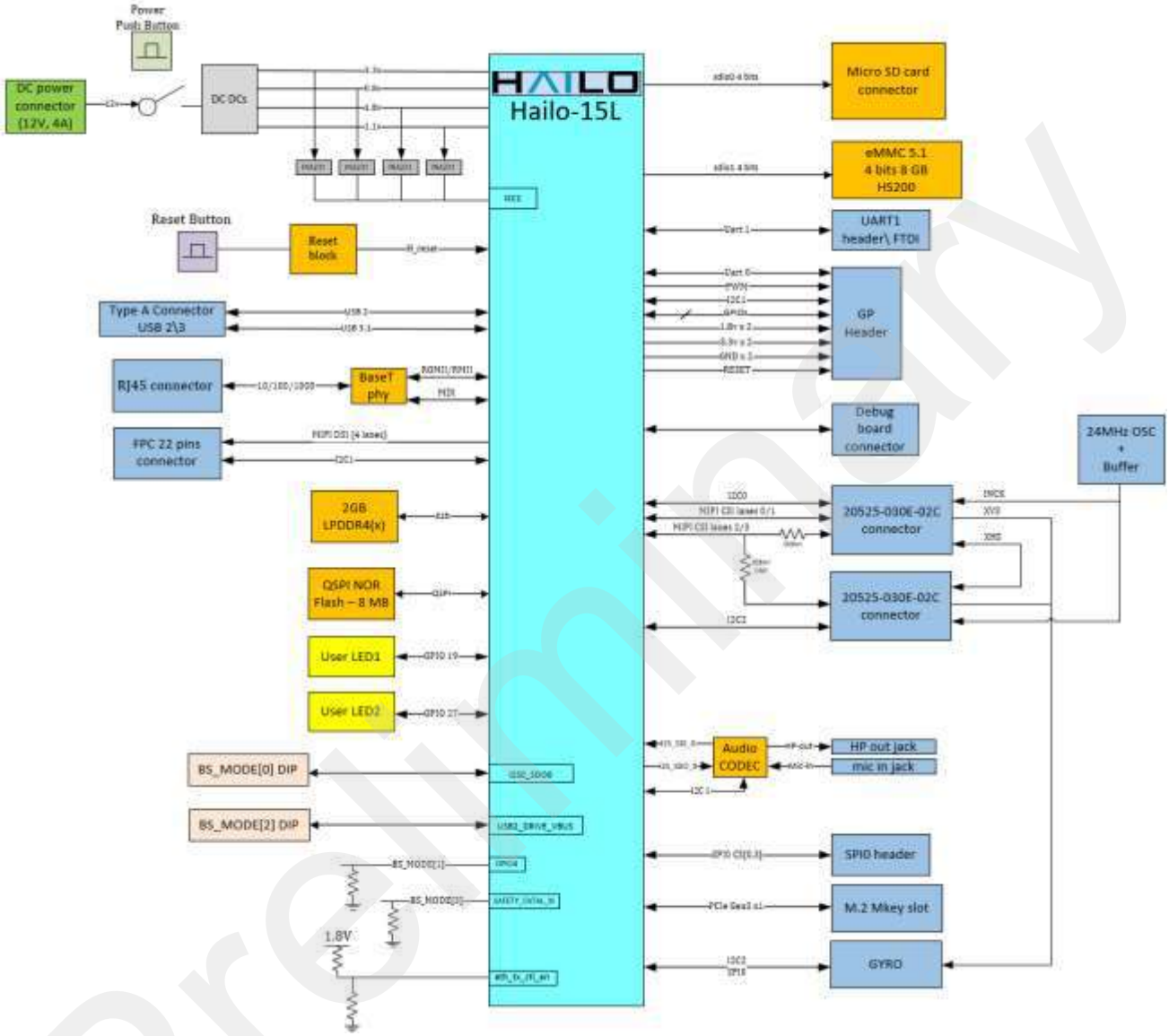


Figure 1. Hailo-15L SBC block diagram

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1.4. Hailo-15L SBC Key Components

Figure 2 and Figure 3 below display the front and rear views of the Hailo 15L SBC, highlighting key component names.

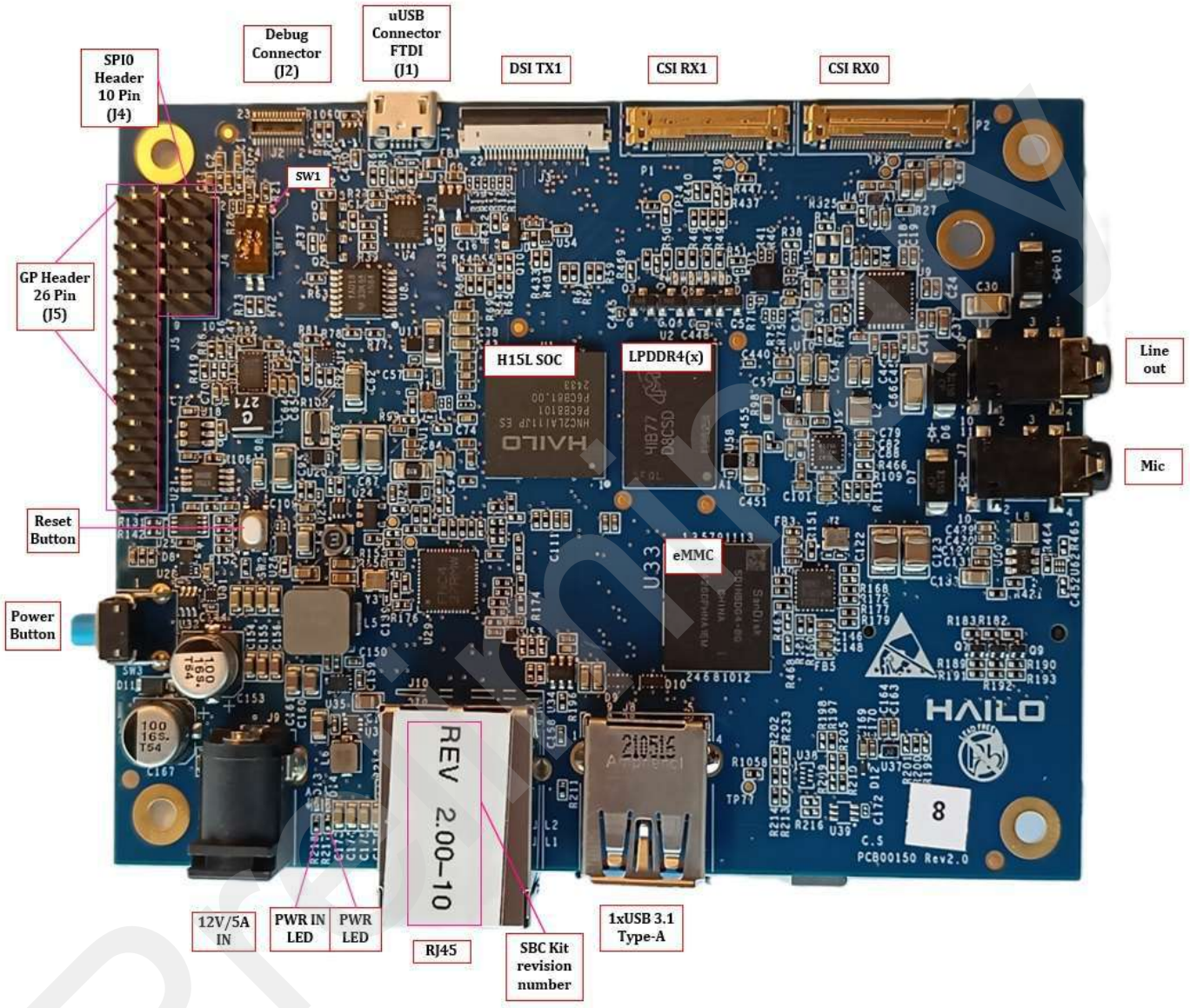


Figure 2. Hailo-15L SBC front view

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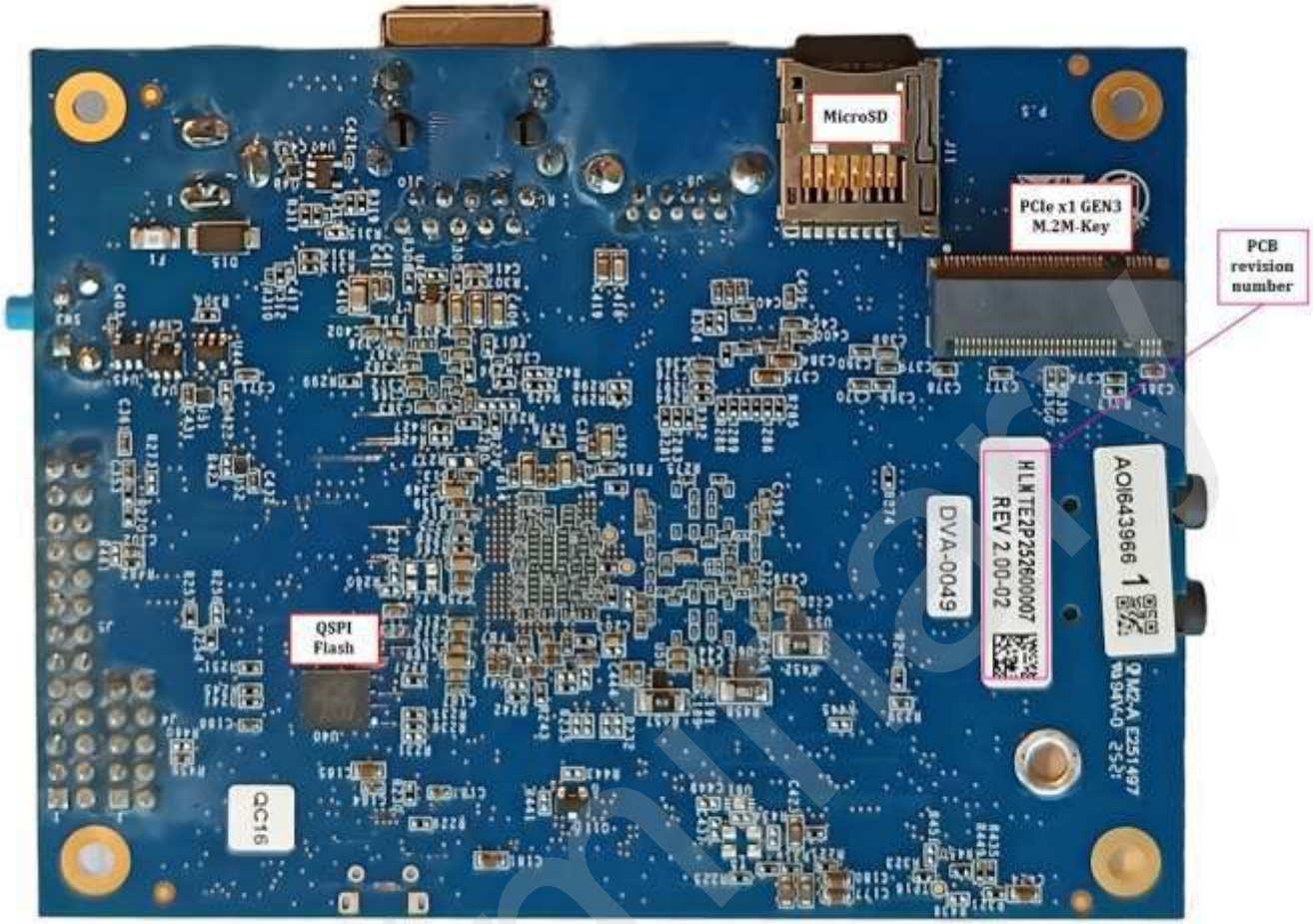


Figure 3. Hailo-15L SBC rear view

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2. Hardware and Software Setup

This section details the hardware and software configuration steps required for use with Hailo-15L SBC Revision 3.0.

2.1. Prerequisites

The following components are required in addition to the Hailo-15L SBC Kit:

- Hailo-15L SBC supported camera sensor module with accompanying cable (shall be ordered from Hailo).
- Ethernet cable RJ45 CAT5 or above.
- X86-64 based computer running Ubuntu® 22 or above ("PC").

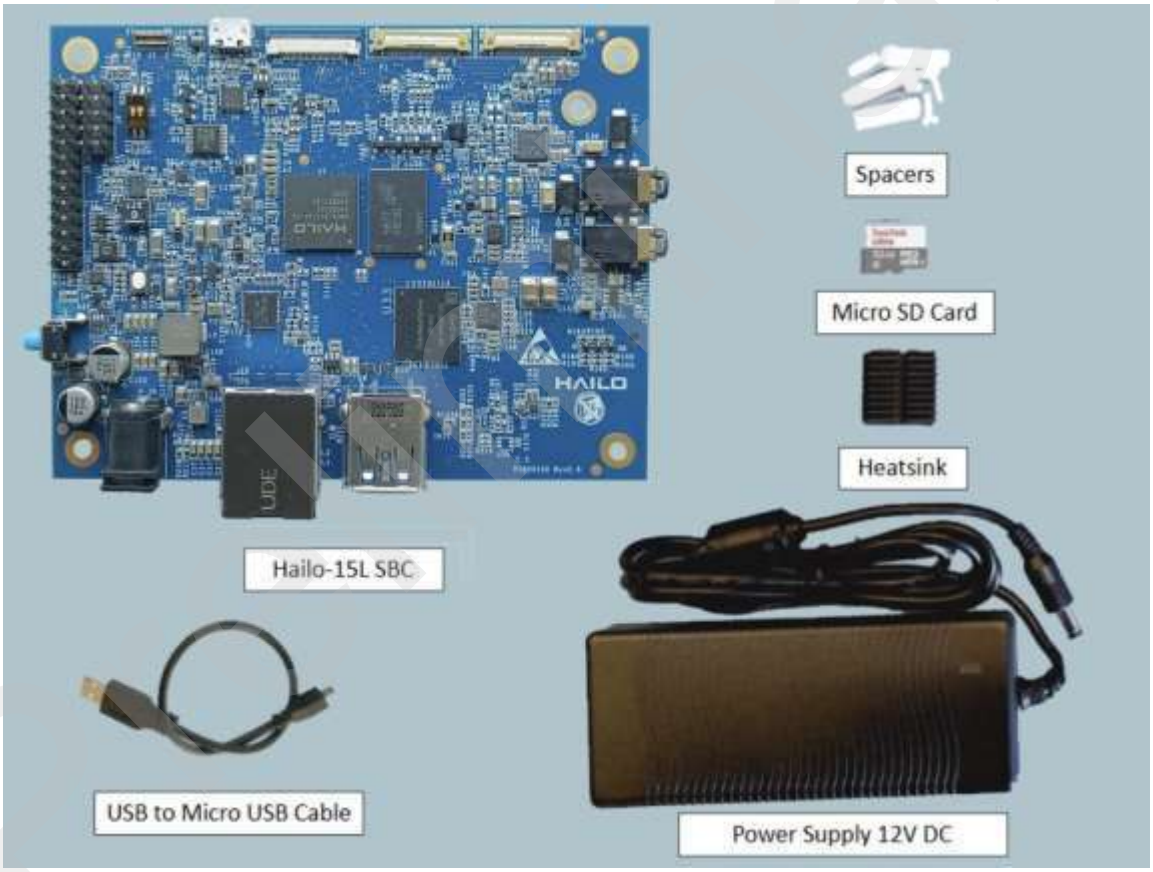


Figure 4. The Hailo-15L SBC kit components

*See Table 20. for the complete list of components included in the Hailo-15L SBC Kit

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2.2. Hailo-15L SBC Kit Software Image

The Hailo-15L SBC kit includes a software image loaded in its eMMC device.

Follow the steps below to verify that the Hailo-15L SBC is loaded with the latest Hailo-15L **software version**.

1. Refer to the Hailo Vision Processor Software Package Release Notes, available in Hailo Developer Zone Link to identify the most up-to-date version of the Hailo-15L software.
2. The Hailo-15L SBC is statically configured with IP address 10.0.0.1 on subnet 10.0.0.0/24. The development host must be assigned an IP address within the same subnet e.g., 10.0.0.2.
3. Login to the Hailo-15L SBC via SSH and the default static IP using the terminal command:

```
ssh root@10.0.0.1
```

(The default password is 'root')

4. Enter the command `cat /etc/os-release`

If the Hailo-15L SBC has been loaded with software version 1.10.1, then continue directly to Section 2.3 Camera Sensor Connection, otherwise follow the steps detailed below in Section 2.2.1 for loading an updated software image to the Hailo-15L SBC kit.

2.2.1. Hailo-15L SBC Software Image Update

The Hailo-15L SBC software image update includes the following steps:

- Configure the Hailo 15L SBC to boot from UART (Section 2.2.3)
- Program the UBoot to the eMMC with the required bootloader and firmware images (Section 2.2.4) This step utilizes a recovery mechanism implemented in the Hailo-15L boot ROM.
- Reconfigure the Hailo-15L SBC to boot from the secondary program loader from eMMC (Section**Error! Reference source not found.**).
- Program the software image to the eMMC (Section**Error! Reference source not found.** 2.2.7).

After the update has completed, the SBC automatically reboots and runs the updated Hailo Vision Processor Software image.

⚠ WARNING ⚠

Follow the steps detailed in this guide exactly as they are described and in the correct order, failure to do so may cause damage to your hardware.

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2.2.2. Hailo-15L Recovery Mechanism

The Hailo-15L has a recovery mechanism implemented in the Boot ROM. It can be used to program a blank or a corrupted eMMC device. Programming requires physical access to the Hailo-15L UART1 port.

2.2.3. Setting the Hailo-15L SBC for Boot from UART

1. Power off the Hailo-15L SBC. See Figure 5

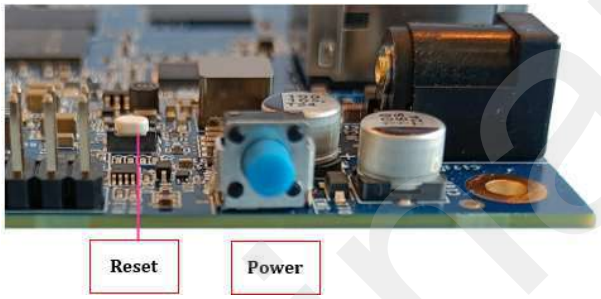


Figure 5. Power and reset buttons in the Hailo-15L SBC

2. If present, use fine tweezers, to remove the orange tape covering the DIP switch.
3. Using the fine tweezers set the SW1 DIP switch (see Figure 6), to set the bootstraps to boot from UART.

   SW1: 1=ON, SW1: 2=OFF.



Figure 6. Setting DIP switch SW1

5. Connect the USB to micro USB cable to the PC.
6. Using the buttons displayed in Figure 5, power-on the Hailo-15L SBC.
7. Using the reset button, reset the Hailo-15L SBC.
8. The Hailo-15L SBC is ready to start the next step in the SW update.

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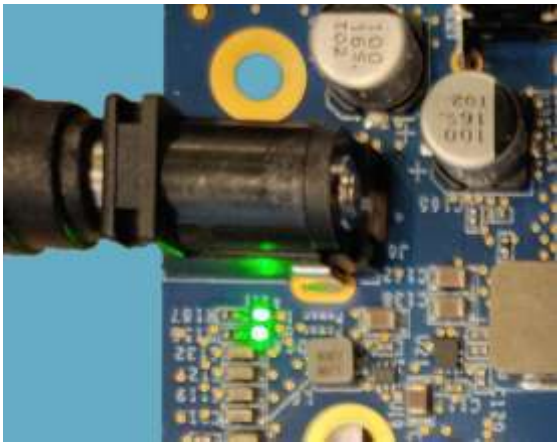


Figure 7. Adjacent green LEDs lighting up

2.2.4. Programming the U-Boot to eMMC

1. Download the Hailo-15L Vision Processor Software Package from Hailo Developer Zone (see Link) as shown in Figure 8.

    2. **Package name:** Hailo-15L Vision Processor Software Package
    File name: *hailo_vision_processor_sw_package_1.11.0_hailo15l.tar.gz*

Note that the **Hailo-15 vision processor software package release notes** document provides briefing for the Vision Processor software package. More details on its content, structure, key components and latest features can be found in the Documents section, accessed via the Documentation tab in the Developer Zone.

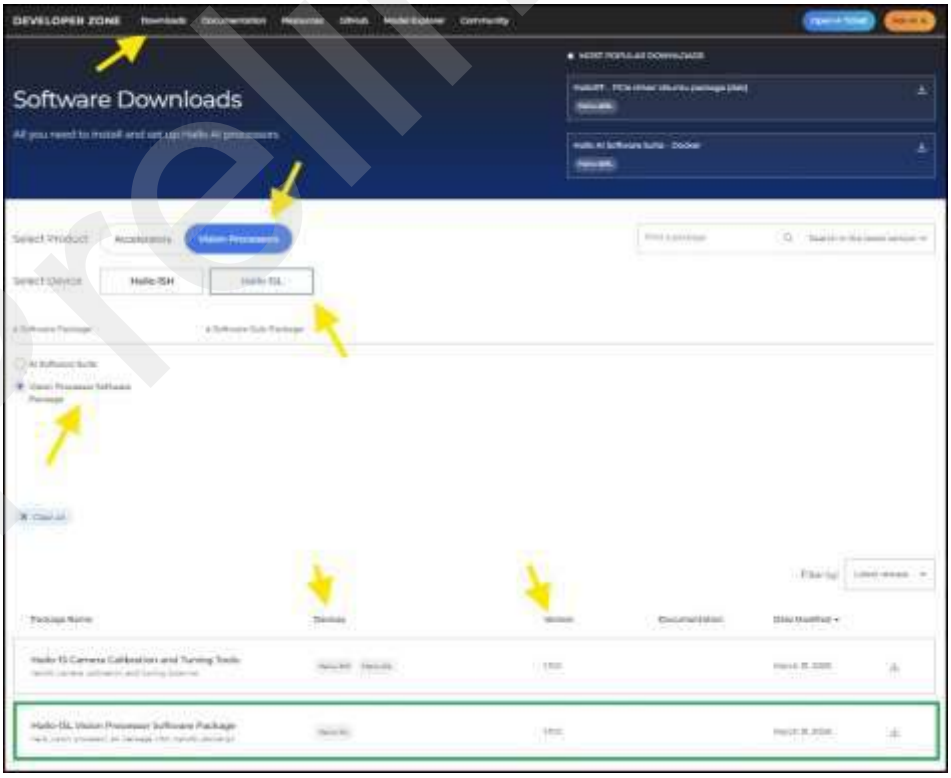


Figure 8. . Software download page in the Hailo Developer Zone

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3. On the development host terminal, run the following commands:

```
pip install tools/hailo15_board_tools-1.10.1-py3-none-any.whl
sudo apt-get install u-boot-tools
```

Notes:

- The .whl file is part of the Hailo *Vision Processor Software Package* under the tools folder.

4. On a development host terminal
    a. Edit (or if it doesn't exist, create) the following file */etc/udev/rules.d/99-usb.rules* and add the following line:

```
SUBSYSTEM=="usb", ATTR{idVendor}=="0403", ATTR{idProduct}=="6015", MODE="0666"
```

    b. Run the following commands:

```
sudo udevadm control --reload
sudo udevadm trigger
sudo adduser $USER plugdev
```

    c. Reboot the host machine

5. On the development host terminal, load the recovery firmware using the following command:

```
uart_boot_fw_loader \
--serial-device-name /dev/ttyUSB0 \
--firmware ./prebuilt/sbc/hailo15l_uart_recovery_fw.bin --h15l
```

The .bin file is part of the *Hailo-15L Vision Processor Software Package* and is located under the prebuilt/sbc folder.

6. On the development host terminal load the eMMC images using the commands below.

7. Note that the files mentioned in the hailo15_emmc_program command below are part of the Hailo *Vision Processor Software Package* and are located under the *prebuilt/sbc* folder

```
 cd prebuilt/sbc
hailo15_emmc_program \
--scu-bootloader ./hailo15l_scu_bl.bin \
--scu-bootloader-config ./scu_bl_cfg_a.bin \
--scu-firmware ./hailo15l_scu_fw.bin \
--uboot-device-tree ./u-boot.dtb.signed \
--bootloader ./u-boot-spl.bin \
--bootloader-env ./u-boot-initial-env \
--customer-certificate ./customer_certificate.bin \
--uboot-tfa ./u-boot-tfa.itb
--serial-device-name /dev/ttyUSB0
--uart-baud-rate 921600
```

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2.2.5. Boot the U-Boot Secondary Program Loader from eMMC

1. Power off the Hailo-15L SBC.
2. Use fine tweezers to set the bootstraps to boot from eMMC by setting the DIP switches to ON as shown in Figure 9

SW1: 1=ON 2=ON

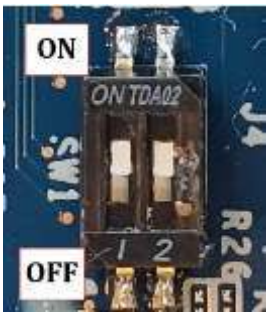


Figure 9. Setting DIP switch SW1 to boot from eMMC

3. Press the power button to power up the Hailo-15L SBC.
4. Press the reset button to reset the Hailo-15L SBC.
   See Figure 10 for the location of the buttons

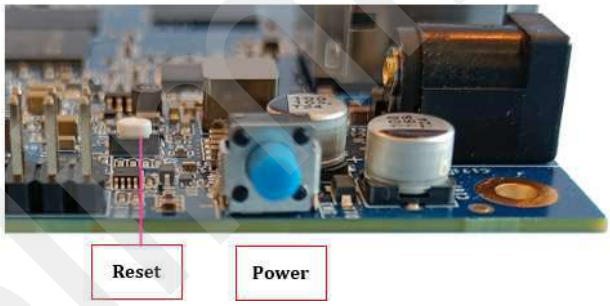


Figure 10. Hailo-15L SBC power and reset buttons

2.2.6. Ethernet Cable Connection

Connect the Ethernet cable to the development host and the Hailo-15L SBC's RJ45 connector as shown in Figure 11.

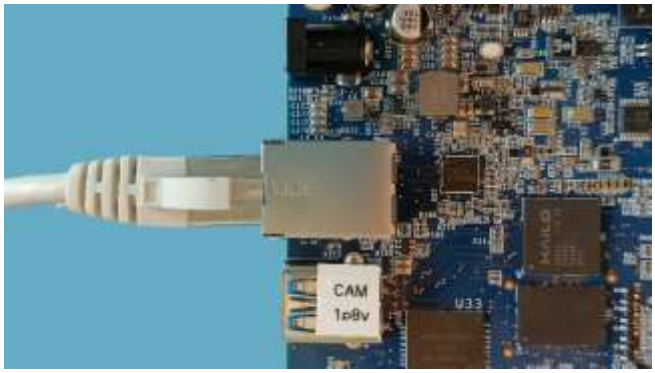


Figure 11. Ethernet RJ45 connector

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2.2.7. Programming the Image to the eMMC

The following sections will describe how to program a pre-compiled image to the eMMC.

2.2.7.1. Setup TFTP Server on Host

1. Install the TFTP server:

```
sudo apt update
sudo apt install tftpd-hpa
```

2. Edit the following file */etc/default/tftpd-hpa* and add the following lines:

```
TFTP_USERNAME="tftp"
TFTP_DIRECTORY="/var/lib/tftpboot"
TFTP_ADDRESS="0.0.0.0:69"
TFTP_OPTIONS="--secure"
```

3. Create the TFTP directory:

```
sudo mkdir -p /var/lib/tftpboot
sudo chmod -R 777 /var/lib/tftpboot
```

4. Restart the TFTP server:

```
sudo systemctl restart tftpd-hpa
```

2.2.7.2. Programming the eMMC

1. Ensure on the development host Ethernet port connected to the Hailo-15L SBC, that its IP address is set to 10.0.0.2 and it is on the same subnet as the Hailo-15L SBC.

(Hailo-15L SBC statically defined at 10.0.0.1 with subnet 10.0.0.0/24)

2. Ensure the dip switches are set to ON. See Figure 9
3. Copy the following FIT image file into the TFTP directory:

```
sudo cp fitImage /var/lib/tftpboot/
```

4. Copy the swupdate files into the TFTP directory:

```
sudo cp swupdate-image-hailo15l-sbc.ext4.gz /var/lib/tftpboot/
sudo cp hailo-update-image-hailo15l-sbc.swu /var/lib/tftpboot/
```

5. Ensure that the USB to Micro USB cable between the host and the SBC is connected and and open a serial console connection to the SBC by entering the command:

```
sudo picocom -b 115200 /dev/ttyUSB0
```

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Note:

If a permission denied error occurs, enter the command:

```
sudo chmod 777  /dev/ttyUSB0
```

and then enter the command:

```
sudo picocom -b 115200 /dev/ttyUSB0
```

6. Reset the Hailo-15L SBC, with the reset button. See Figure 10.
7. The UBoot menu will appear as displayed in Figure 12.
   Select “eMMC Board Init” from the UBoot menu



Figure 12. UBoot Menu

8. UBoot will now download the SW update and will begin the update procedure.
9. Wait for the procedure to be completed by observing the traces below, followed by an automatic device reboot. See Figure 13

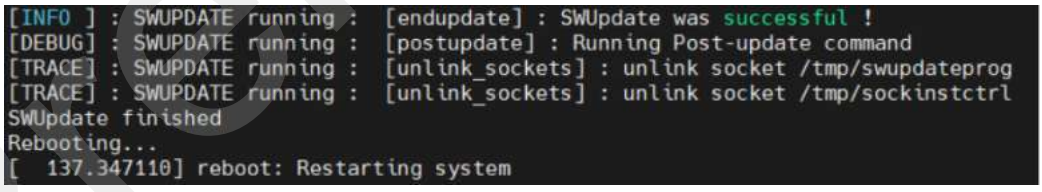


Figure 13. SW update procedure completion

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2.3. Camera Sensor Module Connection

1. Confirm that the SW1 DIP switches are set to their default position:

SW1.1 = ON, SW1.2 = ON as in Figure 14

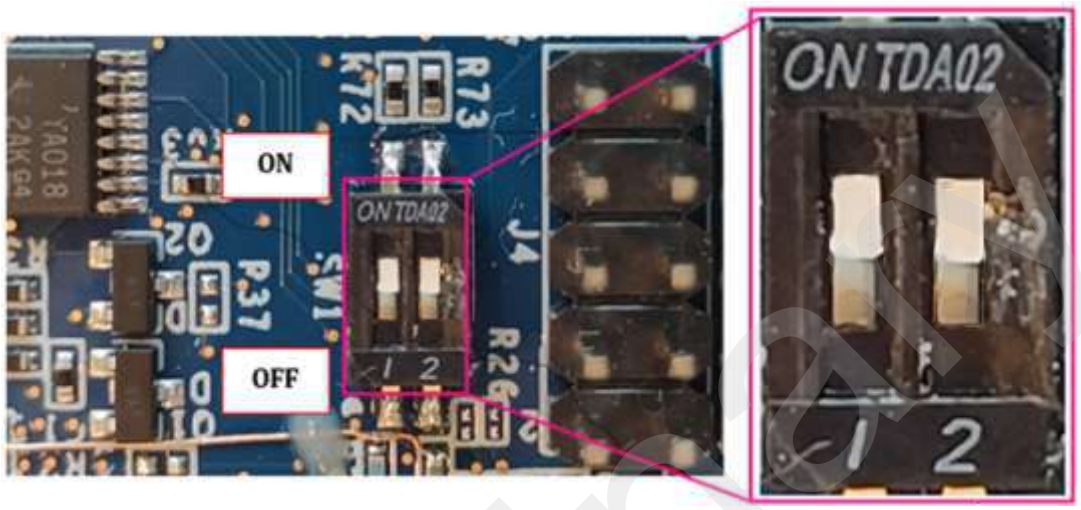


Figure 14. Hailo-15L SBC DIP SW 1

2. Connect the end of the camera sensor module cable to the IMX675 camera sensor module as shown in Figure 15.



Figure 15. Sensor cable connection to the IMX675 camera sensor module

3. Connect the other end of the camera sensor module cable to the MIPI-CSI2 connector labeled ‘P2’ on the Hailo-15L SBC as displayed in Figure 16.

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Figure 16. Camera sensor module cable connection to Hailo-15L SBC P2

2.4. Ethernet Cable Connection

If an Ethernet cable has not yet been connected, connect it to the development host and the Hailo-15L SBC's RJ45 connector as shown in Figure 17.



Figure 17. Ethernet RJ45 connector

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2.5. Power Supply Connection

If power supply has not yet been connected to the Hailo-15L SBC, connect the

Hailo-15L SBC-provided 12v DC power supply to the barrel jack, a single LED will light ON as shown in Figure 18

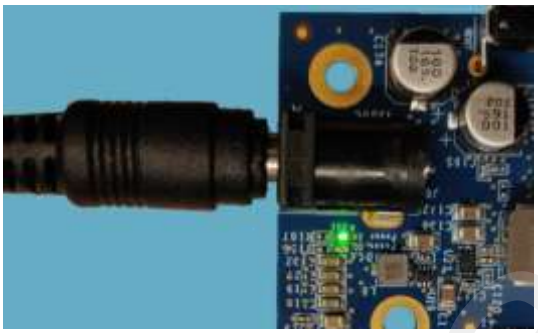


Figure 18. 12V DC power supply barrel jack

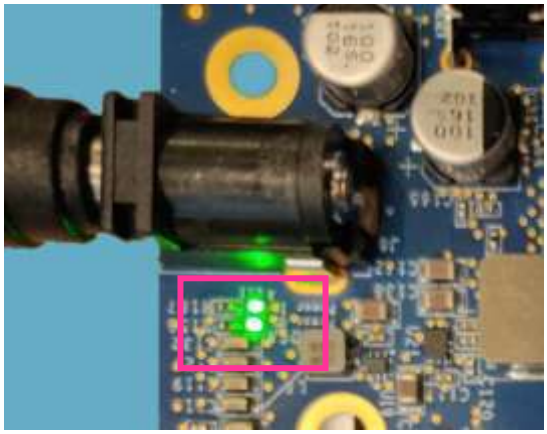
2.6. Powering up the Hailo-15L SBC

1. Press the button labeled 'PWR' to power up the Hailo-15L SBC, the adjacent green LED will light ON. See Figure 19 and Figure 20
2. When powering on the Hailo-15L SBC (OFF → ON), a short press will turn the Hailo-15L SBC ON.

NOTE: When powering off the Hailo-15L SBC (ON → OFF), a long press will turn the Hailo-15L SBC OFF.



Figure 19. Power Button



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Figure 20. Adjacent green LEDs lighting up

3. Running the Hailo Camera Viewer

The Hailo Camera Viewer is a video streaming interface allowing control of standard camera setup parameters such as video resolution, FPS, imaging profiles and preferences, encoding and overlay.

HDR and low-light imaging modes as well as a basic detection pipeline can be operated through functions in the AI & Image Enhancement tabs.

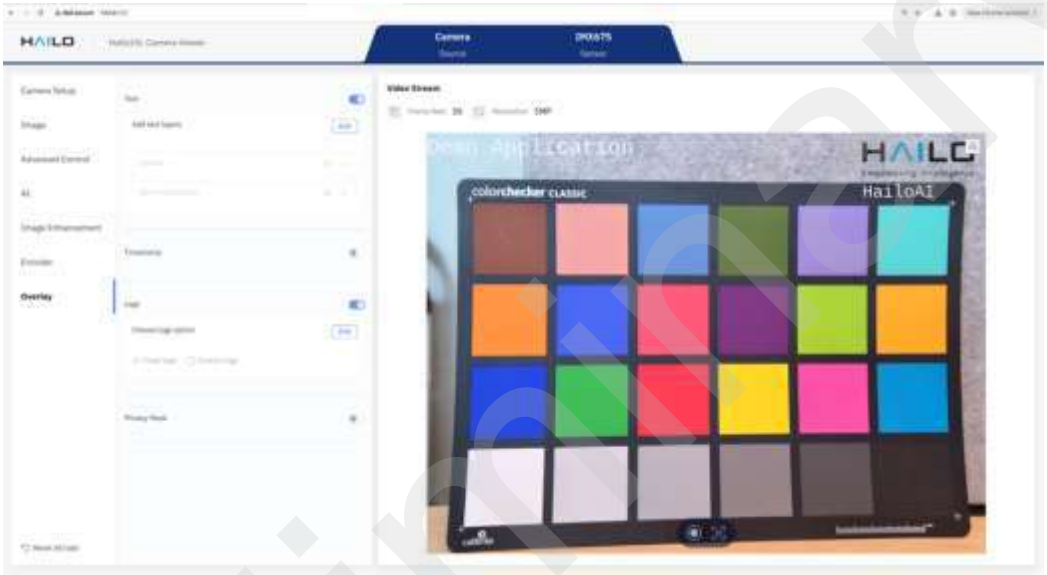


Figure 21. Camera viewer

3.1. Launch the Hailo Camera Viewer

Open a terminal on the host PC and enter the following commands:

1. Connect via SSH:

   `ssh root@10.0.0.1`

   Note: the default password: root
2. Configure the Camera Sensor

   `setup_hailo_sensor.sh`
3. Launch the camera server:

   `camera-viewer-server`

   Leave the camera-viewer-server running; it serves the **Camera Viewer** web UI.
4. Open a browser and navigate to:

   `http://10.0.0.1/#/`

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3.2. Live Video Streaming

The Camera Viewer can be used to demonstrate full pipeline, from video capture through ISP, encoding, streaming, and display.

- In Camera Viewer, click **Play** to start the live stream.

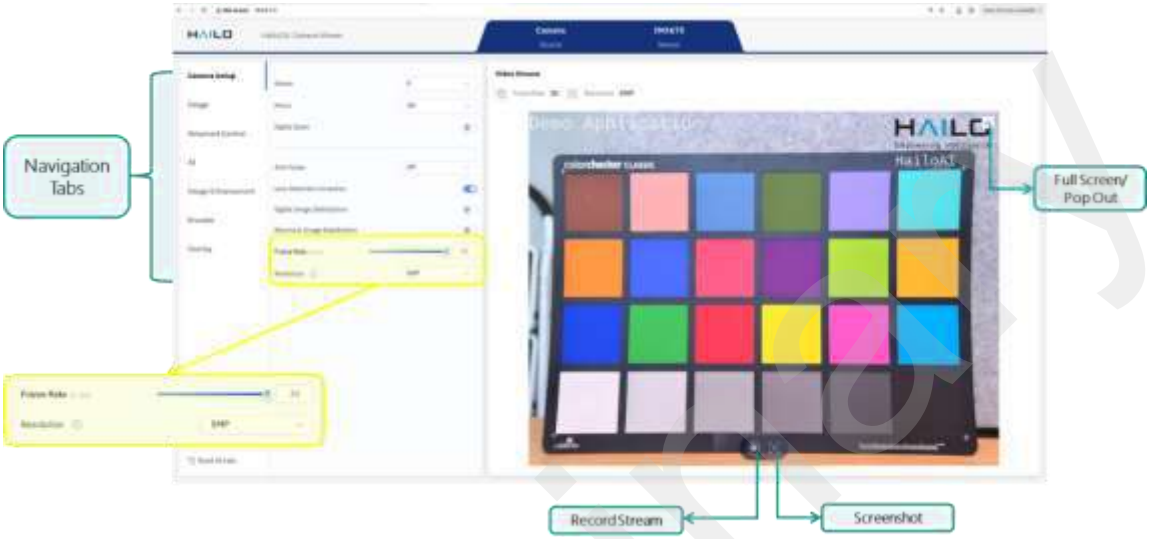


Figure 22. Camera viewer settings

- Configure:
  - Resolution e.g., 1920×1080 (FHD)
  - Frame rate e.g., 25 fps

The selected resolution and frame rate are reflected in the viewer header and the displayed stream updates accordingly. See Figure 22 and Figure 23.



Figure 23. Camera viewer with updated resolution and frame rate setting

Note:

- If the stream does not start, re-run `setup_hailo_sensor.sh` and restart the camera-viewer-server.

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- Basic connectivity check can be done by running `ping 10.0.0.1`

3.3. Object Detection

Object detection can be enabled through the Camera Viewer interface.

Typical capabilities include:

- Real-time detection
- Bounding box overlay
- Class labeling



Figure 24. Camera viewer object detection setting

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4. Hailo-15L SBC Hardware Architecture

This section describes the hardware architecture of the Hailo-15L SBC in detail.

4.1. Power Button

The Hailo-15L SBC is equipped with a power button (SW3). See Figure 25.



Figure 25. Power button

Once the power requirements as described in Section 2.5 are met, a press on the power button will change the power state of the Hailo-15L SBC.

A short press on the power button will turn ON the Hailo-15L SBC.

A long press on the power button will turn OFF the Hailo-15L SBC.

4.2. Reset Button

The Hailo-15L SBC is equipped with a reset button (SW2). See Figure 26.



Figure 26. Reset button

A short press on the button will force the Hailo-15L VPU to reset.

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4.3. Hailo-15 SBC Interface Mapping

Table 1 Lists the interface name for key components and their device part numbers

Table 1. Interface name for key components and their device part numbers

Interface Name	Device Part Number	Device Description
LPDDR4(X)	Micron™ MT53E512M32D1ZW-046 IT:B	LPDDR4X/LPDDR4 2GB
eMMC	SDINBDG4-8G-I2	eMMC 8GB iNAND 7250 eMMC 5.1 WD/SD
Ethernet – RMII/ RGMII	(Microchip) Microsemi® VSC8531XMW-05	Single Port Gigabit Ethernet Copper PHY with RGMII/RMII Interfaces
Audio codec	TI™ TLV320AIC3104	Low-Power Stereo Audio Codec for Portable Audio and Telephony
Temperature sensors	TI™ TMP175A	Temperature Sensor with I2C and SMBus Interface

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4.3.1. Power and Reset

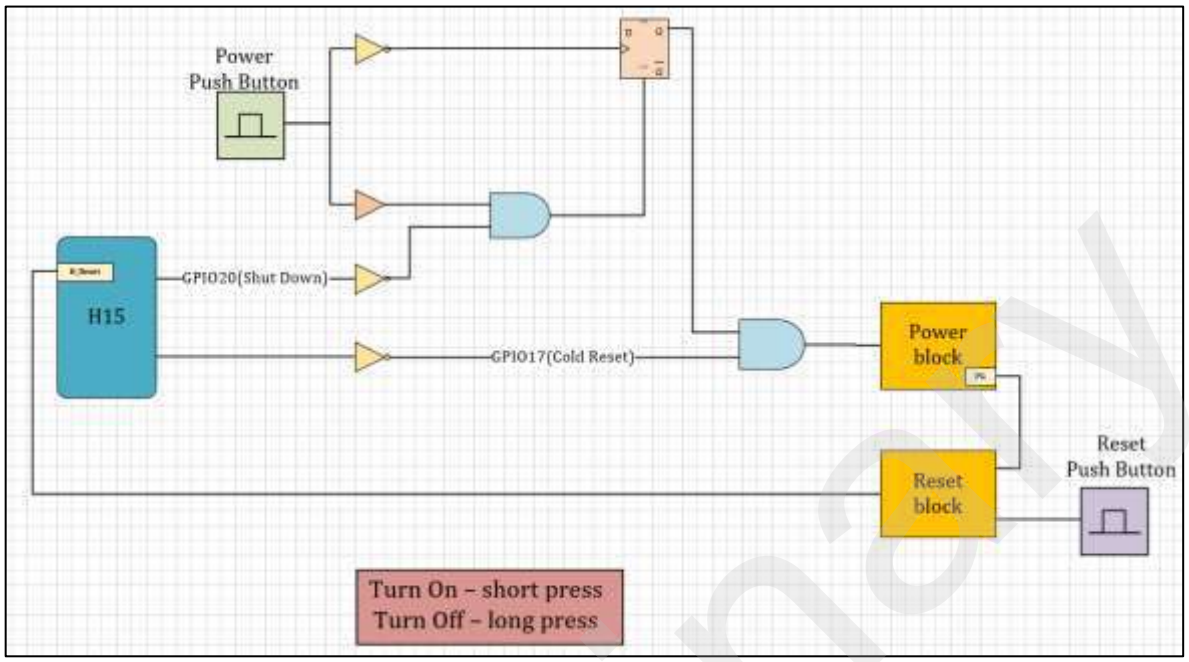


Figure 27. Power and reset circuit

- Power Up: The power supply to the Hailo-15L SBC by the DC Jack (J9) (see Section 2.5 above), will enable the 5V_IN. The AUX power rail will power up the power control logic. At this stage, the Hailo-15L VPU and Hailo-15L SBC power rails are not yet enabled.
- Pressing the power button, See Section 4.1 above, will trigger the power control logic, which will then force the following power up sequence:

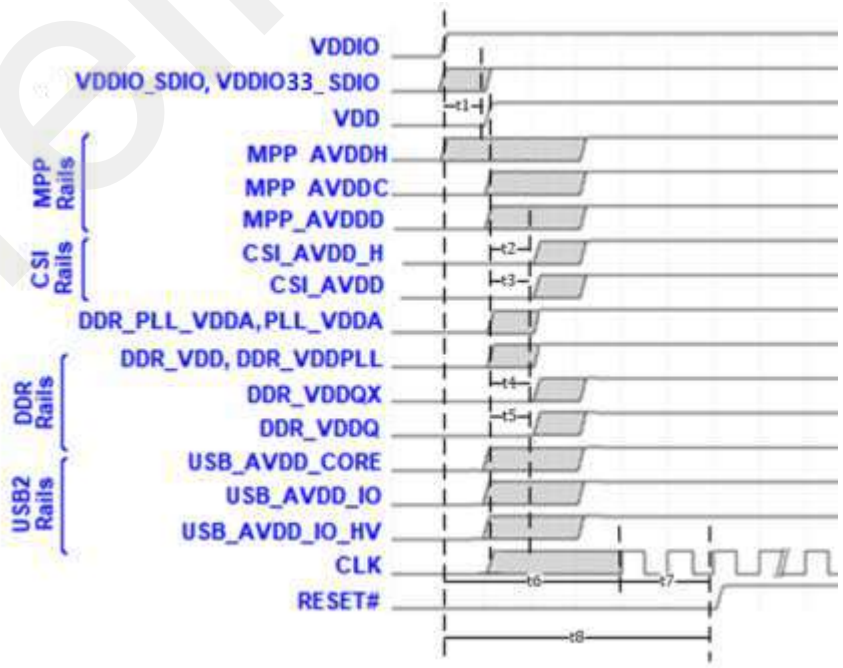


Figure 28. Power up sequence

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Table 2. Power-up sequence timing requirements

	Description	Min	Nom	Max	Units
T1	VDDIO to VDD	1	-	-	us
T2	VDD to CSI_AVDD_H	1	-	-	us
T3	VDD to CSI_AVDD	1	-	-	us
T4	VDD to DSI_AVDD_H	1	-	-	us
T5	VDD to DSI_AVDD	1	-	-	us
T6	DDR_VDD to DDR_VDDQX	1	-	-	us
T7	DDR_VDD to DDR_VDDQ	1	-	-	us
T8	VDD to FUSE_VQPS	1	-		us
T9	VDDIO to Stable Clock	1	-	-	us
T10	Stable CLK to RESET_N de-assertion	100	-	-	us
T11	VDDIO to RESET_N de-assertion	1	-	70	ms

Table 2 lists the power up sequence timing requirements for the Hailo-15L VPU

4.3.1.1. Shut Down

Manually

When the Hailo-15L SBC is already powered up and enabled, a long press on the power button (see Section 4.1) above, will trigger power control logic to de-assert the PS_EN (Power enable) signal.

Both the shutdown and reset buttons will reset external interfaces such as the RGMII, PHY and DRAM

SW Driven

In the event of a forced shutdown due to overheating, the Hailo-15L software will assert a dedicated GPIO (GPIO29 'SHUTDOWN') to trigger the power control logic. The power control logic will disable the Hailo-15L VPU power supplies, by de-asserting the PS_EN (Power enable) signal.

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Notes

- In both cases (manually\software driven), the 5V_IN will remain on.
- A new power up cycle can be initiated by pressing the "power button", as described in Section 4.1 above

4.3.1.2. Reset\ Reboot

Manually

A short press on the reset button (see Section 4.2 above), will trigger the H_RESET_N signal to Hailo-15L VPU.

Software Driven

Using the Linux command 'sudo reboot' will force an internal Hailo-15L VPU reset, similar in behavior as with the H_RESET_N pin assertion.

4.3.2. Over \Under Voltage Protection Circuit

The 12V input is protected by a number of different components:

1. D11 diode protects the input voltage from exceeding more than 13V.
2. The 12V to 5V voltage regulator will enable Vout (5V) when Vin is higher than 9.66V.
3. Fuse F1 will be burnt if there is a surge above 32v or 7A input.
4. D17 is an ESD diode.

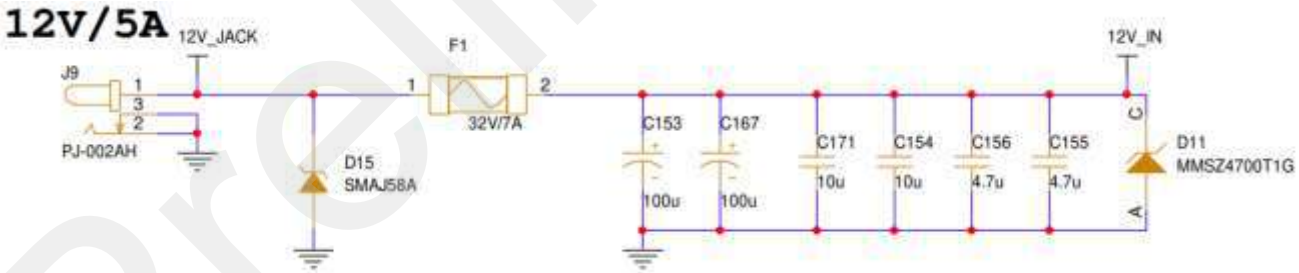


Figure 29. 12V input rail voltage protection

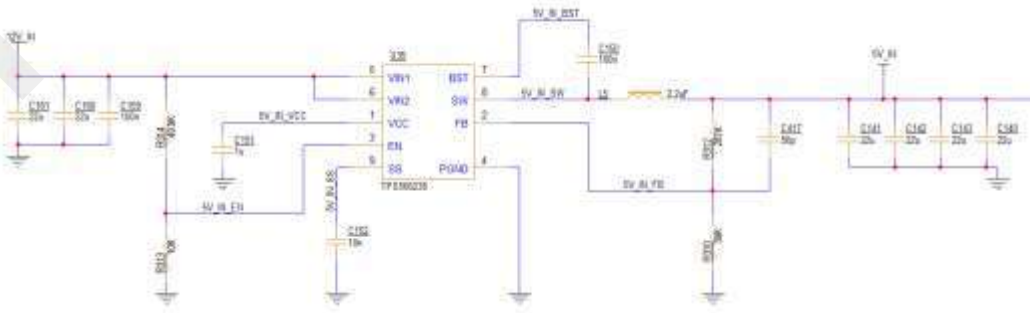


Figure 30. 12V to 5V DCDC is enabled when Vin > 10.09V

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4.3.3. Power Measurements

Several INA231 devices are assembled on Hailo-15L SBC to provide high resolution power measurements. All INAs are connected to I2C1.

Table 3 below describes the real time power measurements capabilities:

Table 3. Power measurement over I2C

Power Source	Voltage Level	Signal Voltage Included	Shunt Resistor Size [Ohm]	INA 231 Address
VDDQX	1.1V	VDD2	0.005	0x42
1P8V_H	1.8V	VDDIO VDDIO_SDIO AVDD_TS, AVDD_VM USB_AVDD_IO MPP_AVDD_H CSI0_RX_AVDDH	0.1	0x40
0P8V	0.8V	DDR_VDD VDD USB_AVDD_CORE MPP_AVDD_C MPP_AVDD_D Main PLL DSP PLL Core PLL DDR PLL AP PLL	0.001	0x41
3P3V_H	3.3V	VDDIO33_SDIO USB_AVDD_IO_HV	0.1	0x44
VDDQX_H	1.1V	DDR_VDDQX	0.1	0x46
VDDQ_H	0.6V	DDR_VDDQ	0.1	0x47
VDDQ	0.6V	VDDQ	0.05	0x48
VDD1_DDR	1.8V	VDD1	0.1	0x49

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4.3.4. GP Headers

The Hailo-15L SBC includes 2.54mm dual row headers J5, which functions as the GPIO header for 26 pins.

The GP headers pinout is displayed in Figure 31, below and described in the schematic diagram in Figure 32 and in Table 4.

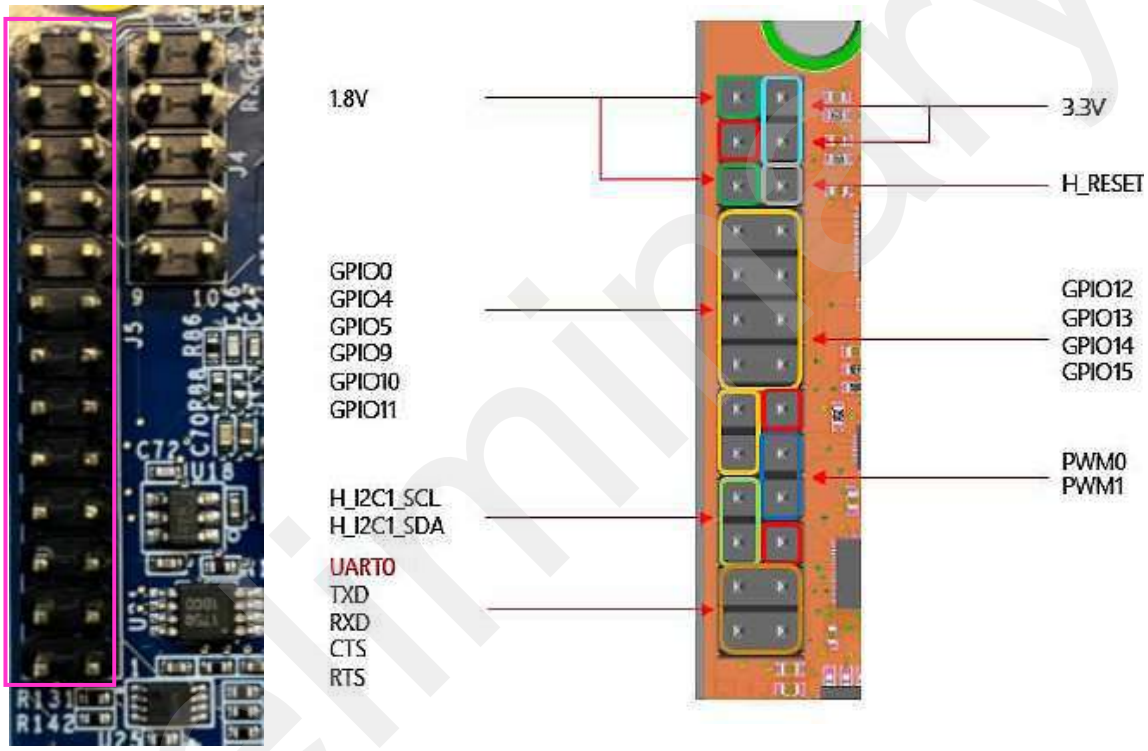
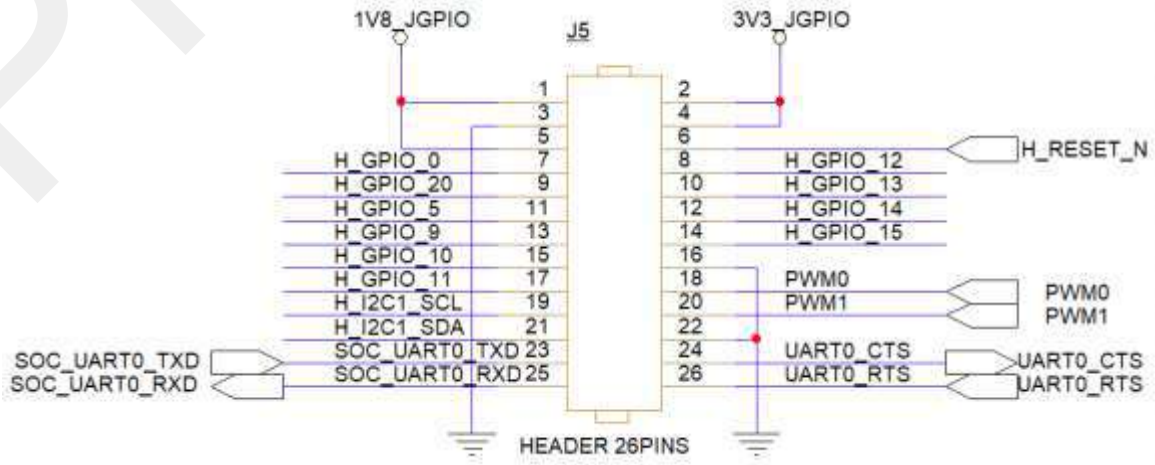


Figure 31. Header images displaying J5 sections pins and their configurations



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Figure 32. Schematic diagram of the header J5, GPIO pin configurations

Table 4. J5 GP connector pinout

Pin Number	Signal	Pin Number	Signal
1	1.8V	2	3.3V
3	GND	4	3.3V
5	1.8V	6	H_RESET_N
7	GPIO0	8	GPIO_12
9	GPIO20	10	GPIO_13
11	GPIO5	12	GPIO_14
13	GPIO9	14	GPIO_15
15	GPIO10	16	GND
17	GPIO11	18	PWM0
19	H_I2C1_SCL	20	PWM1
21	H_I2C1_SDA	22	GND
23	UART0_TXD	24	UART0_CTS
25	UART0_RXD	26	UART0_RTS

Table 5. GPIO pin functional status

Pin Name	Default Direction	Ball Reset State	Signal Name
PARALLEL_PCLK	in	PD	GPIO0
FLASH_DS	in	PD	GPIO5
FLASH_CS2_N	out	PU/High	GPIO20*
GPIO_0	in	PD	sdio0_uhs_sel

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GPIO_1	in	PD	usb_overcurrent_n
GPIO_2	in	PD	uart0_cts_in
GPIO_3	in	PD	uart0_rts_out
GPIO_4	out	Low	gpio[4] {sensor0 reset}
GPIO_5	out	High	boot_rom_failure
GPIO_6	in	PD	sdio0_vdd1_on_out
GPIO_7	in	PD	sdio0_CD
GPIO_8	in	PD	gpio[8] {sensor1 reset}
GPIO_9	in	PD	GPIO9
GPIO_10	in	PD	GPIO10
GPIO_11	in	PD	GPIO11
GPIO_12	in	PD	GPIO12
GPIO_13	in	PD	GPIO13
GPIO_14	in	PD	GPIO14
GPIO_15	in	PD	GPIO15
GPIO_16	in	PD	i2c2_scl
GPIO_17	in	PD	i2c2_sda
GPIO_18	in	PD	gpio[18] {dsi_interrupt}
GPIO_19	in	PD	USER LED 1
GPIO_20	in	PD	spi0_cs0_n
GPIO_21	in	PD	spi0_cs1_n
GPIO_22	in	PD	spi0_cs2_n
GPIO_23	in	PD	spi0_cs3_n
GPIO_24	in	PD	spi0_mosi

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GPIO_25	in	PD	spi0_miso
GPIO_26	in	PD	spi0_sclk
GPIO_27	in	PD	USER LED 2
GPIO_28	in	PD	gpio[28] (cold reset)
GPIO_29	in	PD	gpio[29] (shut down)
GPIO_30	in	PD	PWM[0]
GPIO_31	in	PD	PWM[1]

4.3.5. DIP Switch Configurations

Table 6. below describes the dip switch configuration settings.

Table 6. DIP switch configurations

	Switch1 Mode	Switch2 Mode	Boot Operation	Comments
1	OFF	OFF	Boot from flash	
2	ON	OFF	Boot from UART1	
3	ON	ON	Boot from eMMC (SDIO1)	Default Configuration

Figure 33 below shows the location of the dip switch on the Hailo-15 SBC.

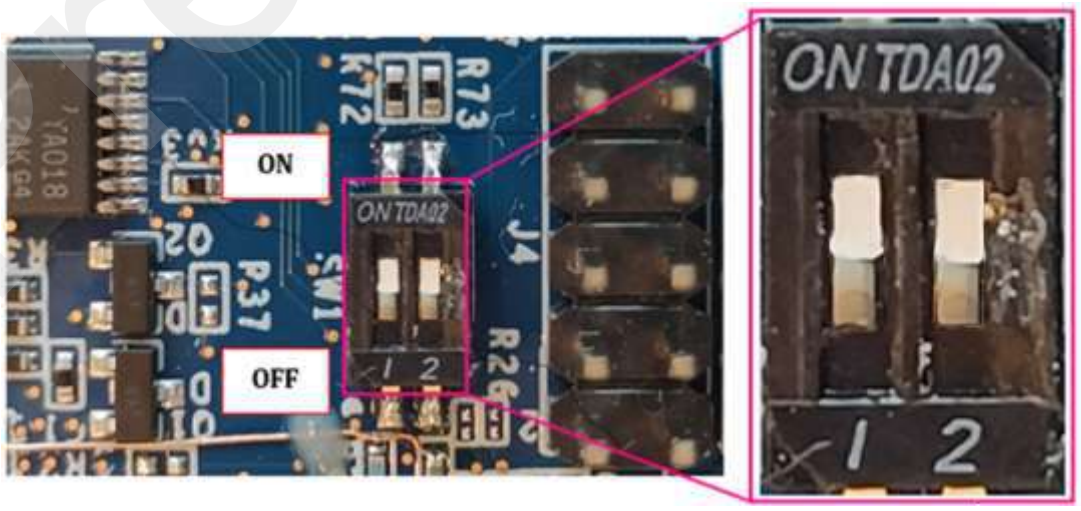


Figure 33 Hailo-15L SBC DIP switch

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4.3.6. LED Descriptions and Indication Status

Table 7. below details the allocation and status indications (OFF and ON) for each of the six LEDs on the Hailo-15L SBC.

Table 7. Power\User LEDs description

LED	Color	ON Status	OFF Status
PWR_IN_LED (D13)	Green	Hailo-15L SBC is supplied with proper input voltage	The Hailo-15L SBC is not receiving any power, or the input voltage is not sufficient
PWR_LED (D14)	Green	The Hailo-15L SBC is powered ON	The Hailo-15L SBC is powered OFF
User LED1 (D4) User LED2 (D3)	Green/ Orange	The definitions can be set by the user	The definitions can be set by the user (The default is OFF)
SAFETY_FATAL_N (D5)	Green	The software init boot was successful	A fatal safety event has been detected or the Hailo-15L SBC is being reset
BOOT_ROM_FAIL (D2)	Red	Boot ROM was completed successfully	Boot ROM failed

Figure 34 below shows the locations of the Power LEDs, PWR_IN_LED (D13) and PWR_LED (D14) on the Hailo-15L SBC.

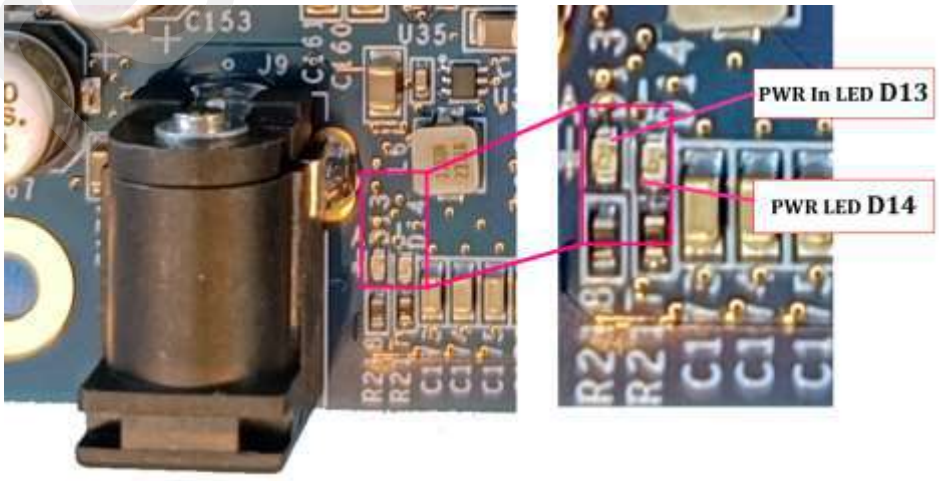


Figure 34. PWR_LED & PWR_IN_LED (D14, D13)

Figure 35 shows the locations of the User_LED1 (D3), User_LED2 (D4), Safety LEDs

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SAFETY_FATAL_N (D5) and BOOT_ROM_FAIL (D2) on the Hailo-15L SBC.

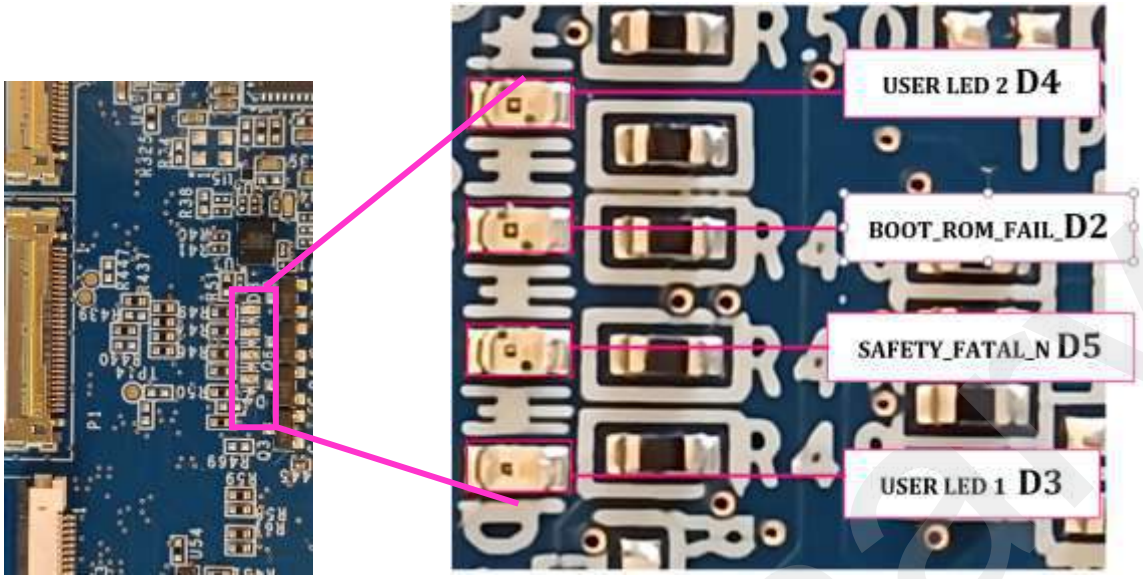


Figure 35. LED Location on the Hailo-15L SBC

4.4. Temperature Sensor

The Hailo-15L SBC includes on-board temperature sensors, TI™ TMP175A, supporting I2C interface.

Table 8. Temperature sensors

I2C BUS	Device\ Function	Location	I2C address
I2C1	U21 - Temperature sensor	Near the Hailo-15 VPU	0x2C (010 1100)

Note: The Hailo-15L VPU contains two internal temperature sensors that can be measured using dedicated Software API.

4.5. Memory

4.5.1. LPDDR4x

The Hailo-15L SBC includes a 2GB, 32-bit wide bus LPDDR4(X) memory (part number Micron™ MT53E512M32D1ZW-046 IT:B). The LPPDR4(x) can operate up to 4266 Mt\s. The memory is dual channel, dual rank topology and connected as described in Figure 36 below:

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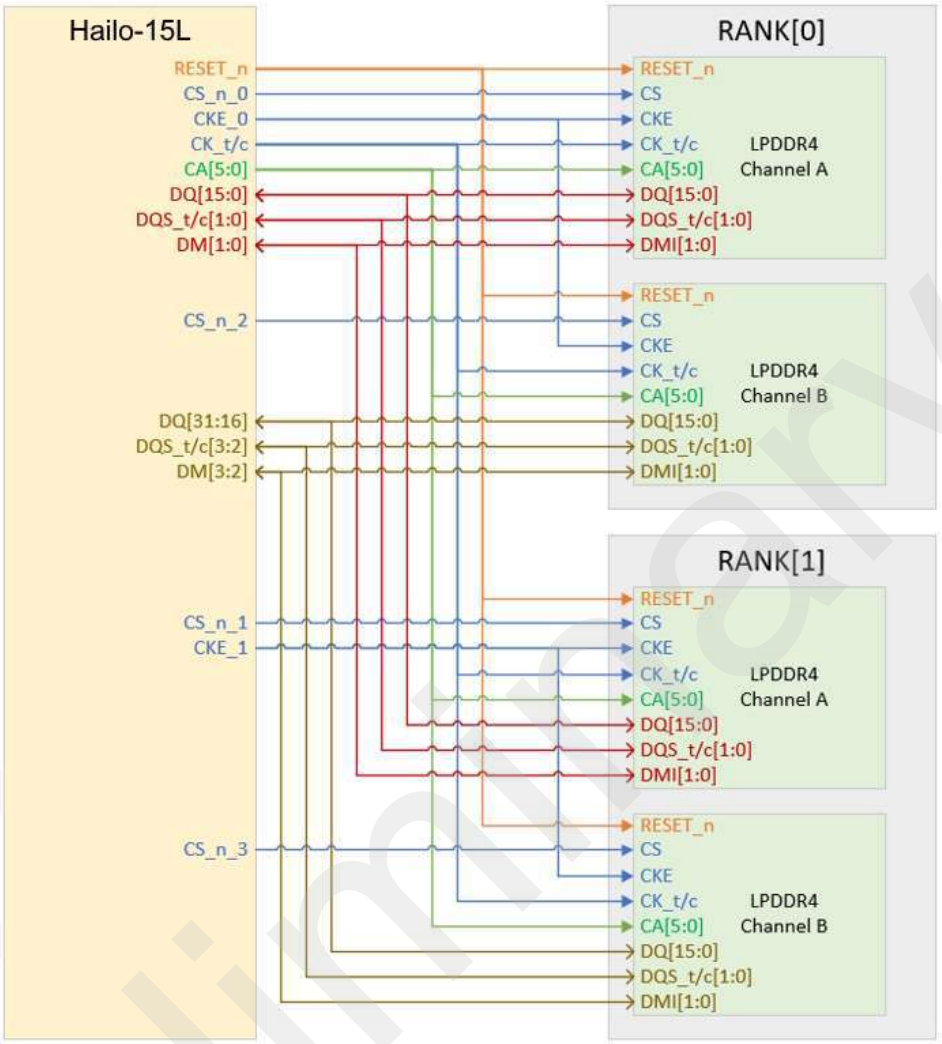


Figure 36. LPDDR4x connectivity

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4.5.2. SDIO

The Hailo-15L VPU supports two 4-bit SDIO ports (SDIO0 and SDIO1) that are connected as described in the connection diagram in Figure 37.

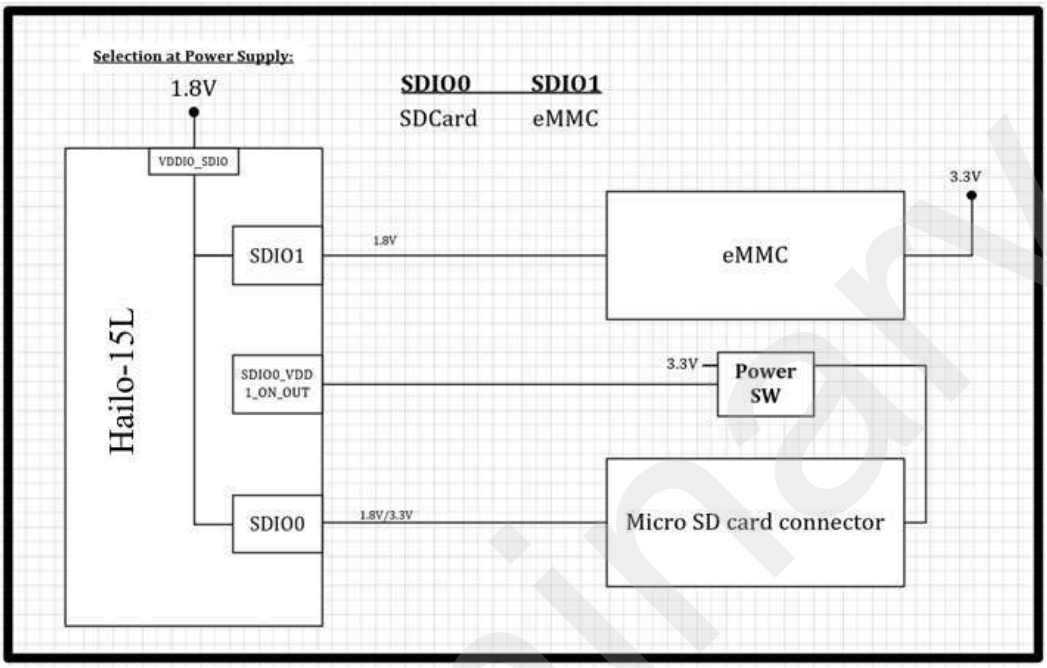


Figure 37. SDIO connection diagram

4.5.2.1. Micro SD-Card

The Hailo-15L SBC supports a Micro SD-Card interface, connected to the SDIO0 port.

4.5.2.2. eMMC

The Hailo-15L SBC supports an eMMC interface, connected to the SDIO1 port.

4.5.2.3. M.2 M-Key

The Hailo-15L SBC includes a M.2 M-Key Module slot connected to a PCIe Gen3 x1 lane in the Hailo-15L VPU.

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4.6. Interfaces and Connectors

4.6.1. SPI

The Hailo-15L VPU supports 4 SPI Chip Selects (CS), allowing support for up-to 4 external SPI\QSPI devices.

The Hailo-15L VPU integrates four SPI controllers, three of them operate in master mode and the fourth controller operates in slave mode. See Table 9.

One of the 4 SPI controllers in the Hailo-15L VPU can be used to control QSPI Flash device.

Table 9. xSPI/SPI controllers available on the Hailo-15L SBC

SPI Controller Name	Module Type	Mode	# of CS	Base address
Flash xSPI (QSPI)	xSPI controller	Master	4 Outputs	CTRL - 0x001C0000 PHY - 0x001C2000
SPI_0	SPI controller	Master	4 Outputs	0x00115000
SPI_1	SPI controller	Master	2 Outputs	0x00115400
SPI_2	SPI controller	Master	2 Outputs	0x00115800
SPI_3	SPI controller	Slave	1 Input	0x00115C00

The Hailo-15L SBC provides access to the SPI0 interface via headers J4 with the pinout arrangement as shown in Table 10 and Figure 38.

Table 10. J4 SPI0 connector pinout

Pin Number	Signal	Pin Number	Signal
1	SPI0_MISO	2	SPI0_MOSI
3	SPI0_CS2_N	4	SPI0_SCLK
5	SPI0_CS3_N	6	SPI0_CS0_N

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7	1.8V	8	SPI0_CS1_N
9	NC	10	GND

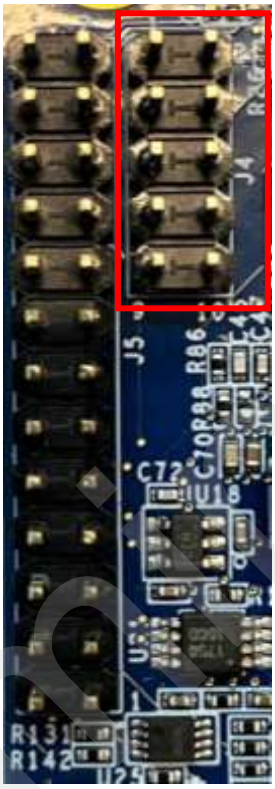


Figure 38. J4 Header with the J4 SPI0 sections pins highlighted

The Hailo-15L SBC includes optional assembly of on-board NOR Flash which is connected to the FLASH_CS0 on the Hailo-15L VPU. See Table 10 and Figure 39.

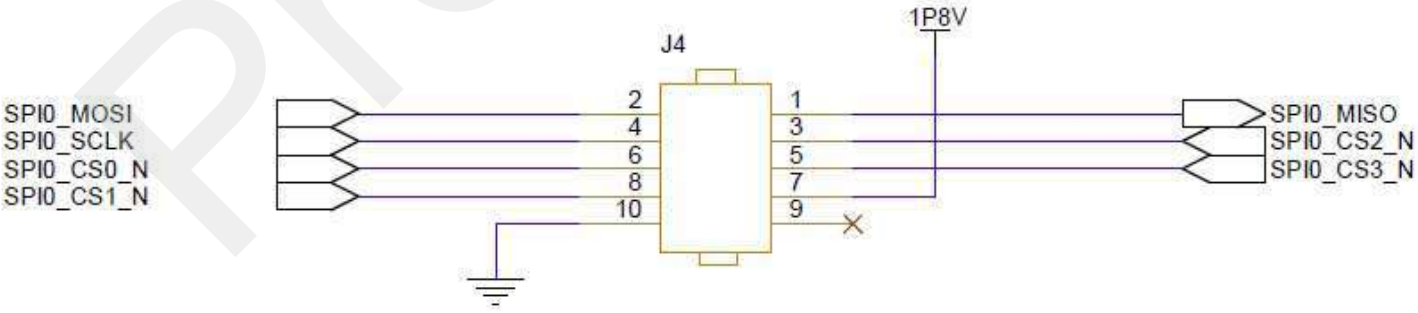


Figure 39. Schematic diagram of the SPIO Connector

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4.6.2. SBC UART Mapping

The Hailo-15L VPU supports two UART ports, UART0 and UART1.

Table 11. UART0 and UART1 connection and Muxing conditions

UART #	Connection #1	Connection #2	Muxing Scheme
UART0	Debug connector (J2) - no FC	GPIO Header (J5) with FC	N/A
UART1	FTDI (U4) uUSB (J1) - no FC	Debug connector (J2) no FC	Mux (U12) from FTDI C_BUS_3

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4.6.2.1. UART0 to GPs Header Connector

For external use, the UART0 interfaces via external GPIO headers J5, it supports the hardware flow control. Refer to the signal in Table 12 below:

Table 12. UART0 header pinout

UART0 Connector J5			
Pin Numbers	**Signal**	**Pin Numbers**	**Signal**
23	UART0_TXD	24	UART0_CTS
25	UART0_RXD	26	UART0_RTS

Figure 40 below shows the location of UART0 on J5 and the position of Pin1.



Figure 40. UART0 location and Pin 1 position

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4.6.2.2. USB to UART Bridge

The Hailo-15L SBC includes a USB to UART bridge (FTDI) to enable a terminal to Linux via UART1. To connect to a terminal, a standard USB type B cable is required to connect to J1 (see Figure 41). When attaching the bridge, use one of the serial consoles with the following serial configuration to enable access to UART1.

Configuration:

Baud rate – 115200

Data bits – 8

Stop bits - 1Parity – None

Flow Control - None



Figure 41. FTDI on-board connection

4.6.3. Debug Connector

On the Hailo-15L SBC the debug connector allows the connection of debugging, testing and development tools.

The following tasks can be performed:

- Access internal Hailo-15L VPU signals, registers, or buses.
- Enable JTAG, SWD (Serial Wire Debug), or UART interfaces.
- Load and run firmware to the Hailo-15L VPU
- Set breakpoints and steps through code during development.
- Perform boundary scan and other Hailo-15L VPU hardware-level tests.

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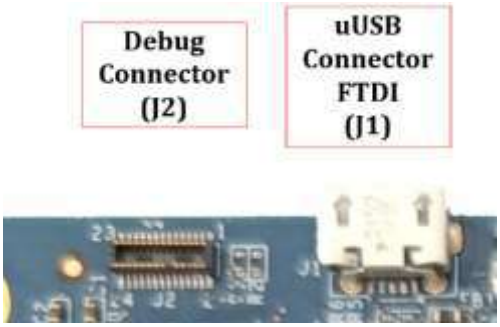


Figure 42. Debug Connector (J2)

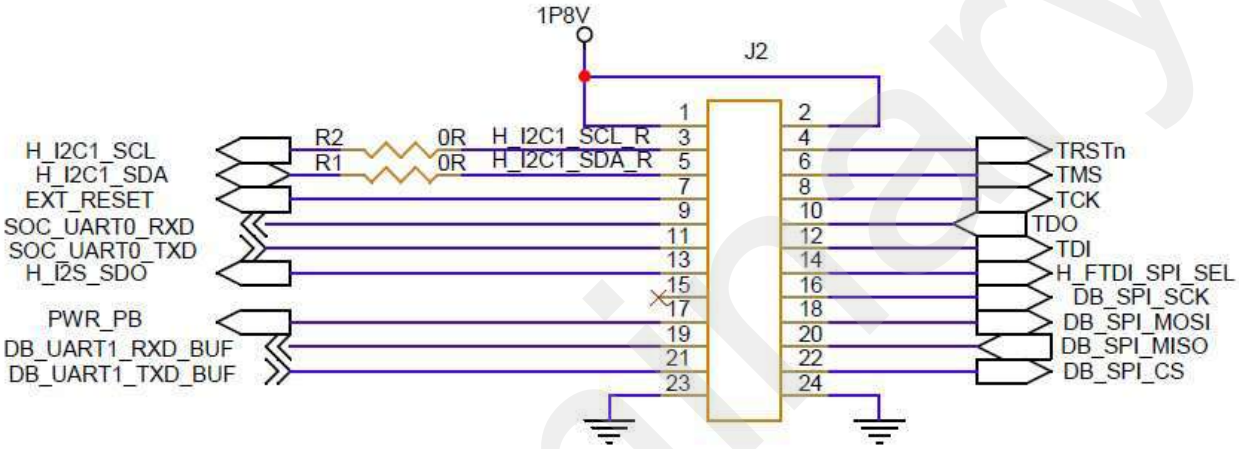


Figure 43. Schematic diagram of the debug connector (J2) pin configurations

4.6.4. I2C

The Hailo-15L VPU supports 3 I2C ports that are utilized in the Hailo-15L SBC in the following ways:

- I2C 0: Used to communicate with a camera connected to CSI RX0 connector.
- I2C 1: General I2C port to communicate with the on-board peripherals.
- I2C 2: Used to communicate with a gyro and with camera connected to CSI RX1 (Optional) .

Note that I2C 1 interface can be accessed via the pin numbers on header J5 as described in Table 13

Table 13. J5 I2C connector pinout

Pin Number	Signal
19	I2C1_SCL
21	I2C1_SDA

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4.6.4.1. I2C Address Mapping

Table 14 below details the mapping for the I2C ports.

Table 14. I2C address mapping

Device	Device P/N	Supply	I2C Port	I2C Address
Camera sensor 0	See Section 6.1 for a list of available camera sensor modules	1.8V	I2C0	0x1a
Camera sensor 1	See Section 6.1 for a list of available camera sensor modules	1.8V	I2C1	0x1a
Audio codec	TI™ TLV320AIC3104	1.8V	I2C1	0x18
Current sensors	INA231 (See Section 4.3.3 for more details)	3.3V	I2C1	0x44
Current sensors	INA231 (See Section 4.3.3 for more details)	3.3V	I2C1	0x40
Current sensors	INA231 (See Section 4.3.3 for more details)	3.3V	I2C1	0x41
Current sensors	INA231 (See Section 4.3.3 for more details)	3.3V	I2C1	0x42
Current sensors	INA231 (See Section 4.3.3 for more details)	3.3V	I2C1	0x46
Current sensors	INA231 (See Section 4.3.3 for more details)	3.3V	I2C1	0x47
Current sensors	INA231 (See Section 4.3.3 for more details)	3.3V	I2C1	0x48
Current sensors	INA231 (See Section 4.3.3 for more details)	3.3V	I2C1	0x49
Temperature sensors	TI™ TMP175A	3.3V	I2C1	0x2c
DSI Display port	Note: this part is not assembled by default	1.8V	I2C1	0x45
Clock Buffer (100MHz)	Diodes PI6CG18201	1.8V	I2C1	0x6a

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DCDC 0.8V	TI™ TPS62872Z0WRXSR	1.8V	I2C1	0x43
GYRO	ST LSM6DSRTR	1.8V	I2C2	0x6a

4.6.5. Gyro for EIS

The Hailo-15L SBC includes an onboard ST LSM6DSR gyroscope used for implementing Electronic Image Stabilization (EIS). The gyro samples are used to detect small camera body movements and to estimate changes in the image sensor's position.

To synchronize the gyro samples acquired using an internal clock with the image exposure time, the gyro uses the sensor's XVS signal. The sample taken immediately after the assertion of XVS signal is marked, enabling the EIS algorithm to correlate gyro data with the exposure time.

4.6.6. EIS with Dual Sensor

When operating in a dual sensor configuration with a single gyro in the system, both sensors must be synchronized so that position information from one gyro and one event recording input can be used for both sensors. Synchronizing the sensors also provides additional benefits when constructing panoramic images.

Dual sensor synchronization can be achieved in several ways:

Master – Master external sync

In this configuration the Master generates the XVS signal and the Master External Sync sensor receives the XVS to initiate frame capture but generates its own XHS signals internally.

Master - Slave

The Master sensor provides both XVS and XHS signals to the Slave sensor.

The Slave waits for XVS to begin frame capture. The Slave also waits for each XHS signal to trigger line capture.

Using a share clock source for both sensors is recommended for improved synchronization, though not strictly required. Cost sensitive designs may use a single crystal oscillator regardless.

Figure 44 and Table 15 below display the dual sensor synchronization support for the Hailo-15 SBC.

The Gyro used in the Hailo-15L SBC is connected by default via I2C, but can be operated via SPI with a few assembly resistors.

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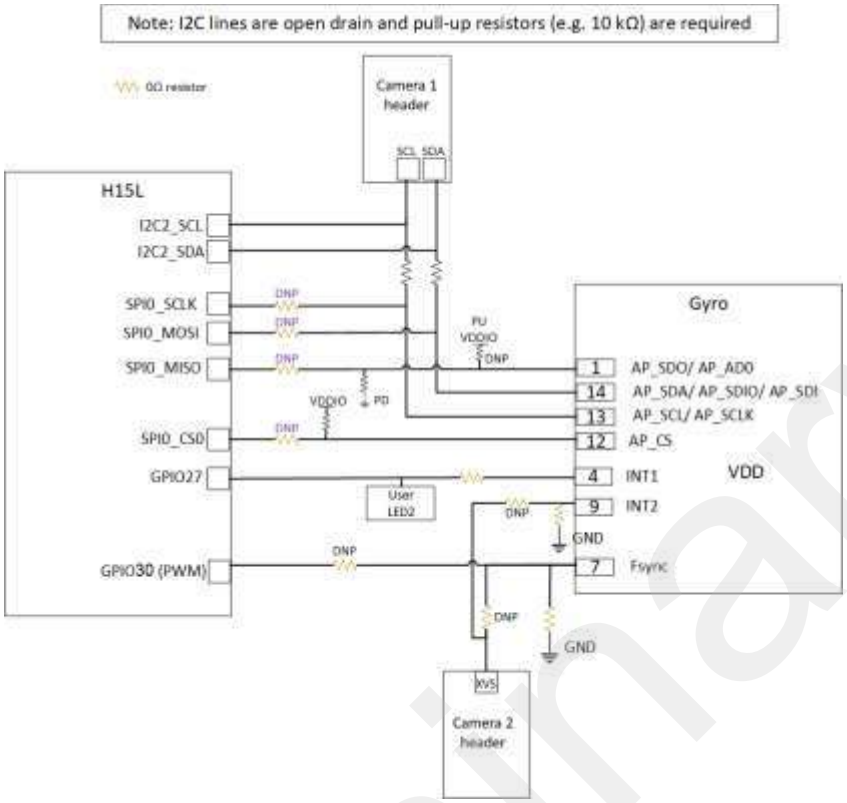


Figure 44. Schematic diagram of the Gyro connection with assembly resistors

Table 15. Resistor settings

Mode	Description	R1	R2	R3	R4	R5
Master-Master (Default)	Master Internal sync - Master Ext sync. sensor1 is generating XVS and synchronizing sensor2	DNP	0 Ohm	0 Ohm	DNP	0 Ohm
Master - Slave ***Pull up Master pin of camera 2**	Master Internal sync is generating both XVS and XSH and synchronizing the slave	DNP	0 Ohm	0 Ohm	0 Ohm	0 Ohm
Host External sync	Both sensors in master External sync receiving sync from Host	0 ohm	0 ohm	0 ohm	DNP	0 Ohm

Note: **Resistors R6, R7 and R8 shall remain in their default settings**

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4.6.7. Ethernet

The Hailo-15L SBC includes by default a RGMII connection between the Microchip Microsemi® VSC8531XMW-05 Single Port Gigabit Ethernet Copper PHY with RGMII/RMII Interfaces and the Hailo-15L VPU.

An RJ45 connector (J10) with integrated magnetics, UDE S22HA0001, Amphenol RJMG201KL263W4T or similarly compatible are used.

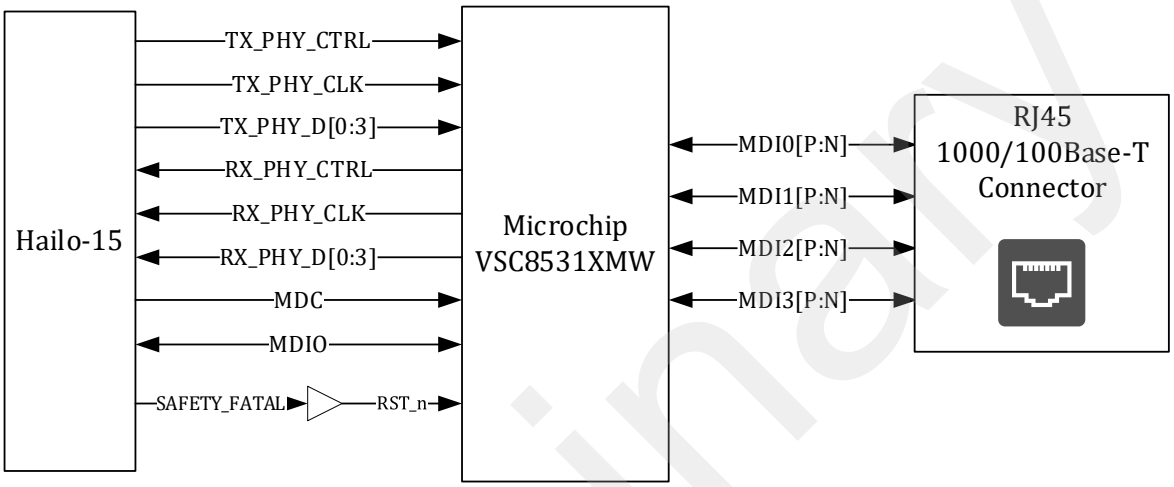


Figure 45. RGMII connection block diagram

4.6.8. USB

The Hailo-15L SBC includes a USB3.1 Gen2 Type A USB connector which operates in Host mode. See Figure 46 below.



Figure 46. USB Connector

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4.6.8.1. Reference Clock

The Hailo-15L SBC includes a Clock Buffer for driving 100 MHz Reference Clock for the MPP ('Multi-Protocol PHY') and to the M.2 Key M slot.

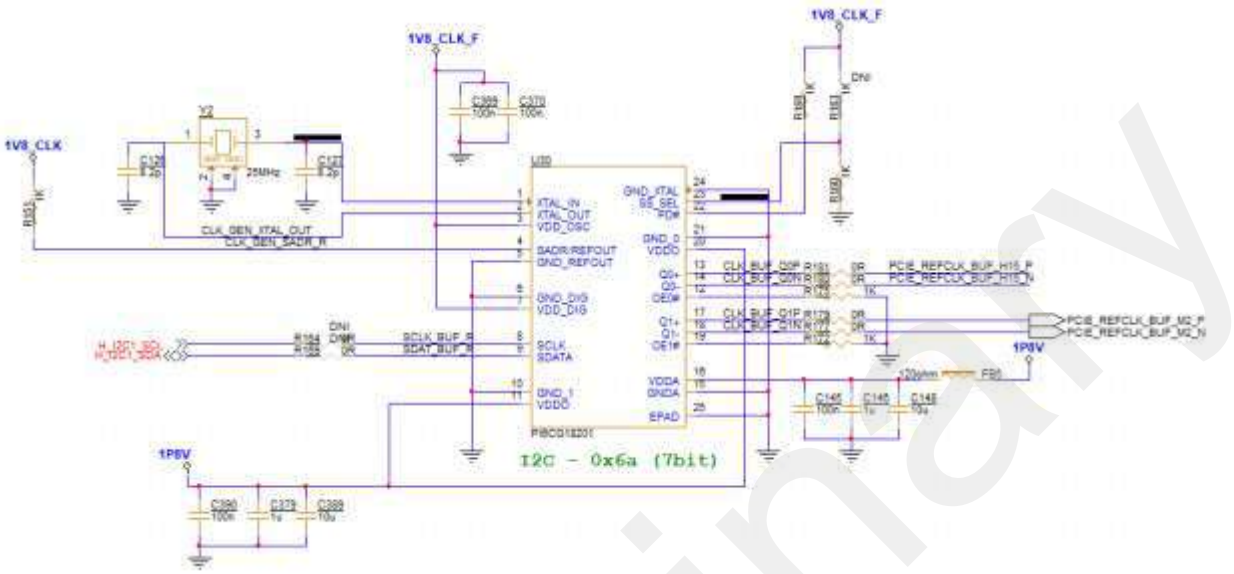


Figure 47. Reference clock circuit

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4.6.9. MIPI CSI RX

The Hailo-15L supports up to 4K@30fps when one sensor is being used. The Hailo-15L VPU includes two MIPI CSI ports, each port with 2 lanes, to support two input streams with a resolution of 5MP#30ps each. Additional sensor configurations are described in the Hailo-15L VPU datasheet.

The Hailo-15L SBC supports the MIPI CSI streams over two 20525-03E-02C connectors.

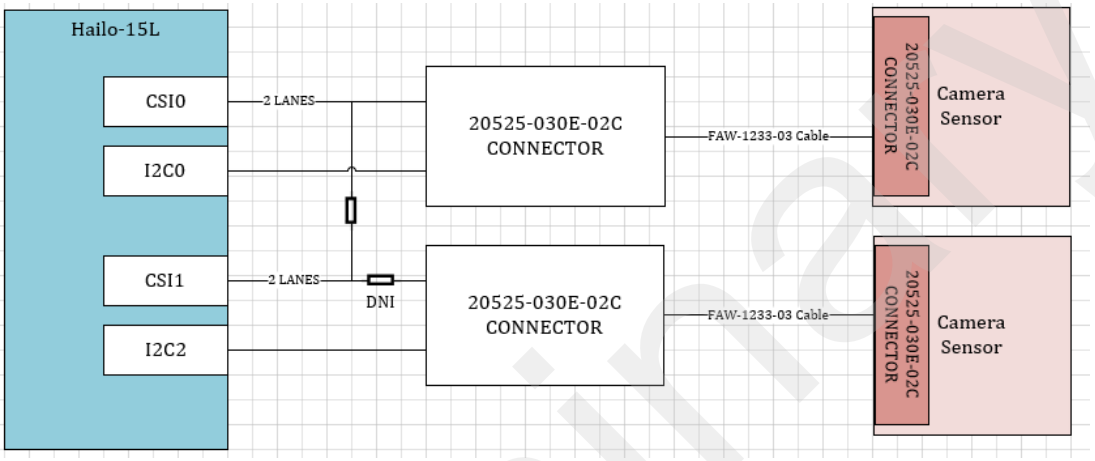


Figure 48. MIPI CSI connectors diagram

4.6.9.1. 20525-03E-02C Connector Pinout

For views of the two MIPI CSI RX0 P1 and CSI RX1 P2 connectors see Figure 49.

Table 16 and Table 17 below list the connector pin connections for the MIPI CSI 0 connector and the MIPI CSI 1 connector.

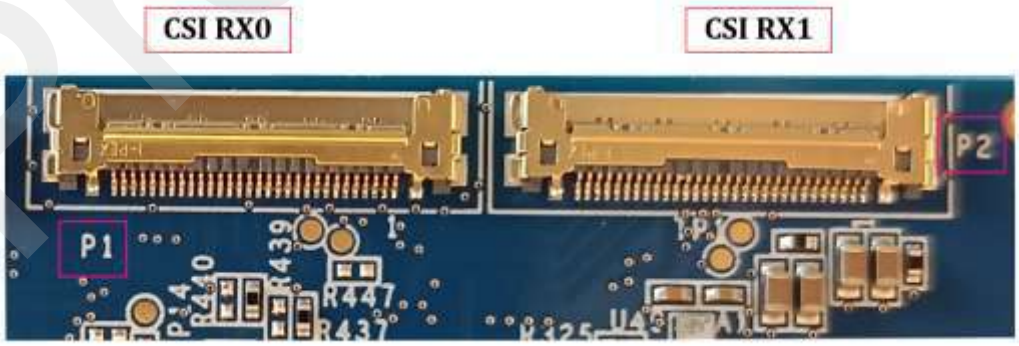


Figure 49. CSI RX0 P1 and CSI RX1 P2 connectors on the Hailo-15L SBC

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MIPI CSI 0 Connector

Table 16. CSI0 pinout

CSI RX 0 connector – P1			
Pin Number	**Signal**	**Pin Number**	**Signal Name**
1	3.3V	16	CAM0_RST
2	3.3V	17	I2C0_SDA
3	3.3V	18	I2C0_SCL
4	5V	19	CAM_XMSTR
5	--	20	CSIRX_0_D2N
6	1.8V	21	CSIRX_0_D2P
7	--	22	CSIRX_0_D0N
8	--	23	CSIRX_0_D0P
9	CAM0_GPIO1 (TP)	24	CSIRX_0_CLK_N
10	CAM_XVS_IMX678	25	CSIRX_0_CLK_P
11	CAM0_GPIO2 (TP)	26	GND
12	CAM_XHS	27	CSIRX_0_D1N
13	CAM_XVS_IMX334(OPT)--	28	CSIRX_0_D1P
14	--	29	CSIRX_0_D3N
15	CAM_CLK(OPT)	30	CSIRX_0_D3P

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MIPI CSI 1 Connector

Table 17. CSI RX 1 pinout

CSI RX 1 connector – P2			
Pin Number	**Signal**	**Pin Number**	**Signal Name**
1	3.3V	16	CAM1_RST
2	3.3V	17	I2C2_SDA
3	3.3V	18	I2C2_SCL
4	5V	19	CAM_XMSTR
5	--	20	--
6	1.8V	21	--
7	--	22	CSIRX_1_D0N
8	--	23	CSIRX_1_D0P
9	CAM1_GPIO1 (TP)	24	CSIRX_1_CLK_N
10	CAM_XVS_IMX678	25	CSIRX_1_CLK_P
11	CAM1_GPIO2 (TP)	26	GND
12	CAM_XHS--	27	CSIRX_1_D1N
13	CAM_XVS_IMX334(OPT)	28	CSIRX_1_D1P
14	--	29	--
15	CAM_CLK(OPT)	30	--

4.6.10. M.2 M-key Slot

The Hailo-15L SBC includes an M.2 M-key socket.

4.6.10.1. M.2 M-Key Slot Connector Pinout

Refer to Table 18 below for a list of M.2 M-key slot connector socket pinouts.

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Table 18. M.2 M-key slot connector pinout

Pin ID	Pin Name	Pin ID	Pin Name
1	GND	2	+3.3V
3	GND	4	+3.3V
5	NC	6	NC
7	NC	8	NC
9	GND	10	NC
11	NC	12	+3.3V
13	NC	14	+3.3V
15	GND	16	+3.3V
17	NC	18	+3.3V
19	NC	20	NC
21	GND	22	NC
23	NC	24	NC
25	NC	26	NC
27	GND	28	NC
29	NC	30	NC
31	NC	32	NC
33	GND	34	NC
35	NC	36	NC
37	NC	38	NC
39	GND	40	SMCLK
41	PERN0	42	SMDAT
43	PERP0	44	NC
45	GND	46	NC
47	PETN0	48	NC
49	PETP0	50	PERST_N
51	GND	52	CLKREQ_N
53	PCIEn_CLK	54	WAKE_N
55	PCIEp_CLK	56	NC
57	GND	58	NC
59	KEY-M	60	KEY-M
61	KEY-M	62	KEY-M
63	KEY-M	64	KEY-M
65	KEY-M	66	KEY-M
67	NC	68	NC
69	NC	70	+3.3V
71	GND	72	+3.3V
73	GND	74	+3.3V
75	GND	76	GND

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4.6.11. Audio

The Hailo-15L SBC includes TI's audio codec, the TLV320AIC3104 is connected to the I2S port in the Hailo-15L VPU I2S.

The Hailo-15L SBC includes 2 standard 3.5mm stereo audio Jacks, CUI SJ2-35954A to support:

- Audio in - Microphone
- Audio out - Headphone

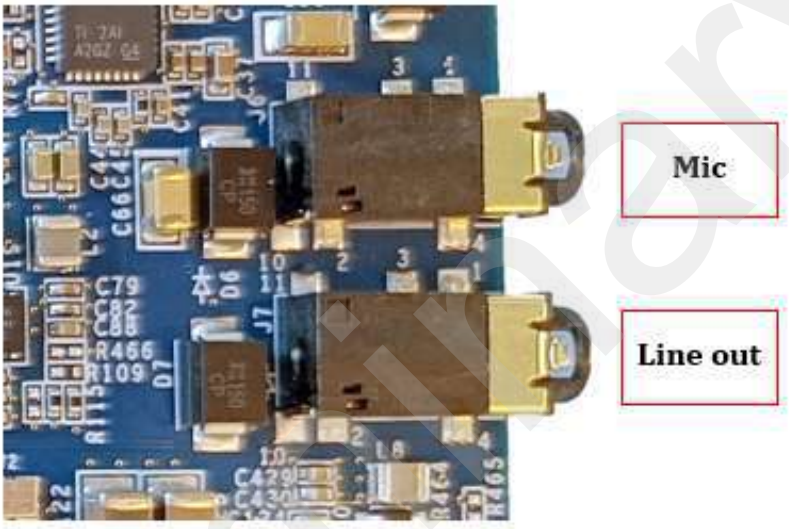


Figure 50. Audio connectors

4.6.12. PWM

The Hailo-15L SBC integrates PWM0/1 controllers connected to GPIOs 30 and 31 on the GPIO header. PWM0 is also connected to the FSYNC pin on the gyro but it is not connected by default and requires a resistor assembly.

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5. Troubleshooting

The steps described in this user guide were verified using Hailo-15L SBC kit, camera module with IMX675 camera sensor and Intel x86-64 based PC with the following software:

1. Ubuntu 22.04 LTS
2. Python 3.8.10 and 3.10.12
3. pyspiflash 0.6.3

Table 19. Troubleshooting problem-cause-solution table

Problem	Possible Cause	Possible Solution
Hailo-15L SBC is unresponsive after power on	Bad or missing eMMC image	• Make sure the DIP switches are set correctly • Re-program the eMMC image
No video on the development host when the demo application is running	Video stream is blocked by the firewall	Check the configured firewall rules. This can be done by using the command: `sudo ufw status`

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6. Hailo-15L SBC Kit Contents

Table 20 below lists the part numbers for the Hailo-15L SBC Kit components.

Table 20. Hailo-15L SBC Kit

Hailo Part Number	Description	Quantity
HSB2LA1C4GA	Hailo-15L SBC Kit	1
PCBA#HSB2LA1C4GA	Hailo-15L SBC PCB	1
MHS00025	Heatsink with Thermal-Pad-T412-28x17 20x30x15	1
	USB to micro-USB cable	1
MECH0006	Screw Round Head Philips M3 Plastic 10.00mm	4
MECH0020	Hex Spacer Threaded M3 Plastic 20.00mm	4
SDC0001	32GB Sandisk Ultra microSDHC Class10 Card 100MB/s	1
PSU000002	Desktop PSU, 100-240VAC C14 , 12V/5A 2.1x5.5x11.0mm	1

Please note that the Hailo-15L SBC kit does not include the camera sensor module and cable which should be ordered separately.

6.1. Supported Camera Sensor Modules

The Hailo-15L SBC supports several camera sensor modules that are fully integrated with the Hailo-15L VPU. These modules utilize a common connector, allowing for direct connection via the FAW-1233-03 cable without the need for an external adaptor board. The modules are available for order as optional accessories from Hailo.

For a complete list of all supported camera sensor modules, please refer to the Hailo-15 Approved Vendor List. This document can be found in the Hailo Developer Zone

The **IMX675 camera sensor module** is the most recommended for use with the Hailo-15L SBC

Note: The camera sensor modules purchased from Hailo includes a built-in oscillator, whereas usually, the vendors module datasheets will not include a description of it.

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