Hardware Manual

*VisionBox AI*

Version 1.0 – January 2023

# Contents

# 1  Handling and Safety Instructions

Depending on the operating conditions, the housing temperature can exceed 60 °C. There is a risk of injury!

Handle with care! The housing, especially heat sinks can have sharp edges. There is a risk of injury!

EMC conformity according to EN/IEC 61000-6-2:2005 is qualified for cable lengths ≤ 30 m.
Electrostatic discharge at unshielded I/O connectors can lead to unexpected events or data errors for the corresponding interface.

Electrical installation should be executed without power applied to the device and connected devices.

**Only open if advised by IMAGO!**
Warranty void if warranty seal is removed or broken.

Please take special note of the **voltage range** which may be applied to the device. Otherwise, permanent damage to the device may result!

**Air Circulation**
When mounting the device within an enclosure, adequate space for air circulation is required. The space above, below and at both sides should be at least 5 cm.

**Avoid extreme environmental conditions** and protect the device from dust, humidity and heat.

Due to the characteristics and physical principles inside flash memory, **SSDs have a finite lifetime** dictated by the number of write operations. Therefore, take care of the regular write operations to prevent an early SSD damage. Ask for the technical data of the used SSD and, if necessary, for support to calculate the lifetime. Inform the user of the system that SSDs are wear parts which must be renewed regularly.

## 2   Introduction

The heart of the VisionBox AI is the powerful NVIDIA Jetson AGX Orin. It comes with up to 12 Arm cores and 2048 CUDA cores. We deliver the VisionBox with an Ubuntu based Linux OS, which gives the customer the ability to use the popular Linux programs, libraries and development tools.

The VisionBox AI provides four Gigabit Ethernet ports and a Camera Link interface. Two Camera Link connectors can be used with two cameras in Base configuration, or one camera in Medium, Full or Deca configuration.

The integrated Real-Time Communication Controller (*RTCC*) ensures proper timing for trigger signals, independently from the operating system. The IMAGO SDK provides a consistent C++ programming interface for controlling the *RTCC*.

Due to its small size, powered by $24V_{DC}$ and without fan, the VisionBox can be mounted into nearly every machine. All components are available for several years for continuous delivery without changes. For series production, IMAGO delivers the VisionBox ready-to-run, including a customer-specific Linux root filesystem, qualified 3rd-party components and acceptance test. A PREEMPT_RT kernel is also available.

## 2.1   Main features

- NVIDIA AGX Orin
  - o 8 or 12-core Arm® Cortex®-A78AE v8.2 64-bit CPU
  - o NVIDIA Ampere architecture with up to 2048 NVIDIA® CUDA® cores and 64 Tensor Cores
  - o Up to 64 GB RAM
  - o 64 GB eMMC flash
- Real-Time Communication Controller *RTCC*:
  - o Controls vision- & automation-specific interfaces:
    - Digital I/Os
    - Encoder
    - Camera trigger
  - o Contains functional units for controlling I/Os in real time:
    - Trigger unit: Creation of trigger signals, derived from other inputs (e.g. encoder)
    - I/O scheduler: applies values stored in a FIFO to outputs in real time (based on trigger event, encoder position, or timer value)
    - Multiplexer: flexible connection of functional units
  - o Operates independently from the OS and the CPU
  - o Easy-to-use high-level API for C++ and Python
- Interfaces
  - o 4x Gigabit Ethernet
  - o Camera Link:
    Support for two cameras in Base configuration or one camera in Medium, Full or Deca configuration
  - o 1x USB-C 3.2 Gen 2
  - o 2x USB-A 2.0
  - o 1x RS-232
  - o Digital I/Os:
    - Isolated inputs and outputs
    - Inputs with adjustable debouncing with *RTCC*
    - Status LEDs
  - o RS-422 I/O optionally, e.g. for encoders
- Housing
  - o Passive cooling
  - o All interfaces on front panel
  - o 24 V DC power input
  - o No moving parts

## 2.2   Configurations

The following table shows available features and interfaces for the VisionBox AI:

| | |
|---|---|
| **Storage** | 64 GB eMMC<br>SD card<br>M.2 2280 M-key (option) |
| **USB** | 1× USB-C 3.2 Gen 2<br>2× USB-A 2.0 |
| **Display** | DisplayPort 1.4a |
| **Ethernet** | 4× 1GbE |
| **Camera Interface** | Camera Link: 2× Base or 1× Medium / Full / Deca configuration |
| **Dig. I/Os** | 8× IN / 8× OUT<br>optionally 16× IN / 16× OUT |
| **UART** | 1× RS-232 |
| **Encoder / RS-422** | One or two connectors with 3× IN and 3× OUT for each |

**Table 1:** Feature overview

Please also ask for OEM configurations.

## 2.3  Block Diagram
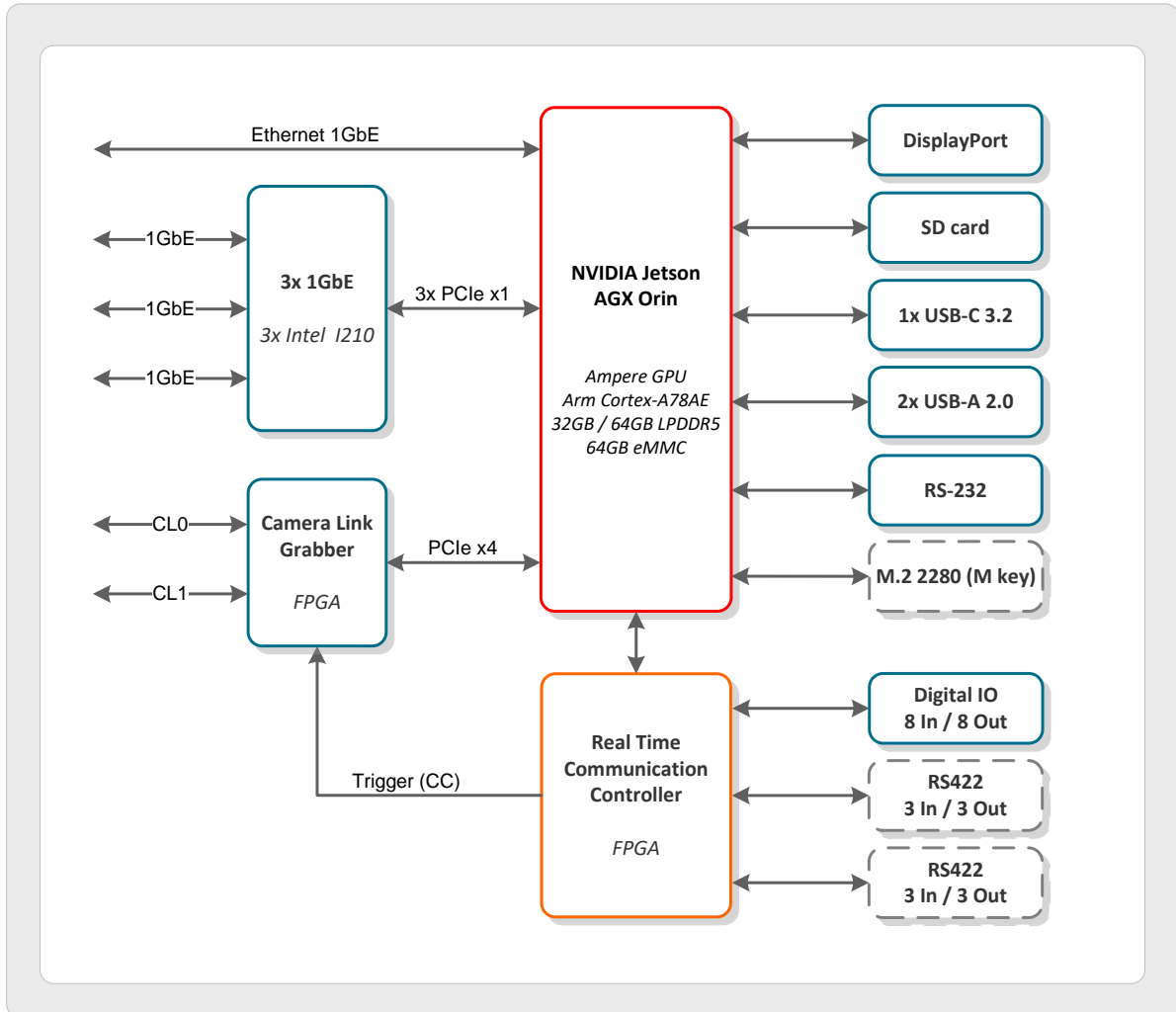


**Figure 1:** Block diagram

# 3   Technical Data

## 3.1   Jetson AGX Orin

The following Jetson AGX Orin models are available for the VisionBox AI:

| | Jetson AGX Orin 32GB | Jetson AGX Orin 64GB |
|---|---|---|
| **CPU** | 8-core Arm® Cortex®-A78AE v8.2 64-bit, 2.2 GHz | 12-core Arm® Cortex®-A78AE v8.2 64-bit, 2.2 GHz |
| **GPU** | NVIDIA Ampere architecture 1792 NVIDIA® CUDA® cores 56 Tensor Cores 939 MHz | NVIDIA Ampere architecture 2048 NVIDIA® CUDA® cores 64 Tensor Cores 1.3 GHz |
| **DL Accelerator** | 2x NVDLA v2.0, 1.4 GHz | 2x NVDLA v2.0, 1.6 GHz |
| **Vision Accelerator** | PVA v2.0 | |
| **Memory** | 32 GB 256-bit LPDDR5, 204.8 GB/s | 64 GB 256-bit LPDDR5, 204.8 GB/s |
| **Storage** | 64 GB eMMC 5.1 | |
| **Real-Time Clock** | Powered by lithium coin cell | |
| **Module power limit** | 40 W | 60 W |

**Table 2:** Jetson AGX Orin models

## 3.2 Operating Conditions

**Power supply:**

| Parameter | | Orin 32GB | Orin 64GB | Unit |
|---|---|---|---|---|
| Supply voltage | | 18…30 | | V |
| Typical power consumption[1] | CPU: idle, GPU: idle | $\approx 16$ | tbd | W |
| | CPU: 100%, GPU: idle | $\approx 26$ | tbd | W |
| | CPU: 100%, GPU: 95% | $\approx 38$ | tbd | W |
| Power supply current rating (value for 24 V supply) | | 2 | tbd | A |

**Environment:**

| Parameter | Value | Unit |
|---|---|---|
| Operating temperature | tbd | °C |
| Operating humidity, relative, non-condensing | 5 … 85 | % |
| Storage temperature | -10 … +70 | °C |
| Storage humidity, relative, non-condensing | 5 … 95 | % |
| Device weight | 2.2 | kg |

**Note:** The maximum allowed temperature is influenced by the actual hardware configuration, the system workload, and the mounting situation. The temperature range should be verified for each application.

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[1] The actual power draw heavily depends on the application. Power supply and cooling requirements should be evaluated by the user.

**RS-232:**

| Parameter | Min | Typ. | Max | Unit |
|---|---|---|---|---|
| RX input voltage range | − 25 | | 25 | V |
| TX output voltage swing (RL = 3 kΩ) | ± 5 | ± 5.4 | | V |
| Data rate, RL = 3 kΩ, CL = 1 nF | | | 250 | kbps |

**Digital Input:**

| Parameter | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|
| Input ~~Maximum C~~current range (limited by internal circuit) | 0 | | 21 | mA |
| Input voltage range | 0 | | 30 | V |
| Threshold Voltage | 6 | | 11 | V |
| Threshold current | | 1 | 5 | mA |
| Input delay | | | 250 | ns |

**Digital Output:**

| Parameter | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|
| Common VCC Supply Voltage ($V_{CEC}$ - $V_{OUT}$) | 0 | | 30 | V |
| Output Current, Saturated Operation ($V_{CEC}$ - $V_{OUT}$) < 1 V | | | 10 | mA |
| Turn-On Time (24 V Common VCC, 10 mA) | | 5 | | µs |
| Turn-Off Time (24 V Common VCC, 10 mA) | | 15 | | µs |

**RS-422:**

| Parameter | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|
| Receiver differential input threshold | -200 | | 200 | mV |
| Receiver input hysteresis | | 45 | | mV |
| Receiver data rate | | | 10 | Mbps |
| Transmitter differential driver output, $R_L$ = 100 Ω | 2 | | | V |
| Transmitter differential driver output, open | | | 3.3 | V |
| Transmitter data rate | | | 2 | Mbps |
| 5V encoder supply output current | | | 500 | mA |

## 3.3 Dimensions
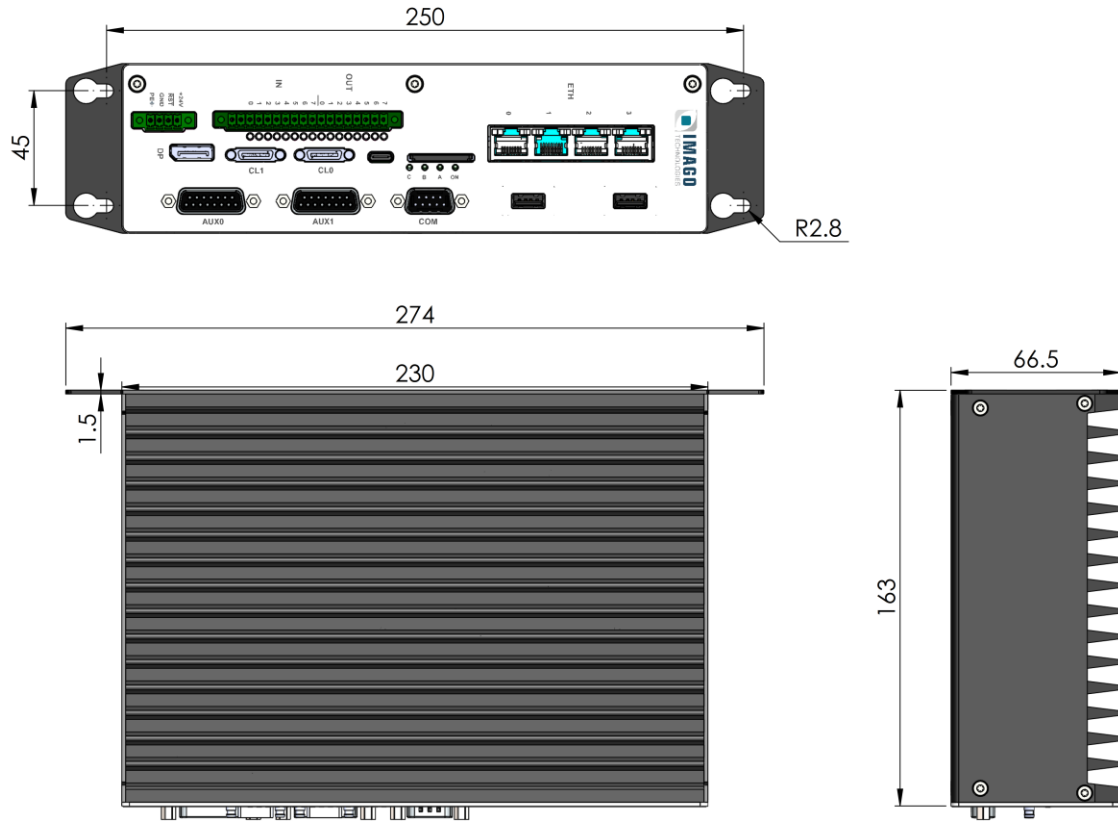
**Figure 2:** Housing dimensions (in mm)

# 4    Power Connector and LEDs

## 4.1    Power Connector
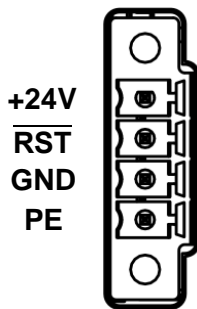


**Figure 3:** Power plug

| Pin | Function |
|-----|----------|
| **+24V** | 24 V power supply |
| **RST** | Reset input, low active |
| **GND** | Ground (power / signals) |
| **PE** | Earth / housing connection |

**Table 3:** Power connector

The VisionBox does not connect ground and the housing with each other to avoid ground loops with other connected devices. It is good practice to connect them at a single point in the facility.

The $\overline{\text{RST}}$ terminal can be pulled to GND to reset the VisionBox during operation. A falling edge will trigger the reset. Leaving the signal floating is the default mode for normal operation.

Phoenix Contact plug component: **MC 1,5/4-STF-3,5** (order no. 1847071)

## 4.2    System LEDs

The computer has four main system LEDs. These LEDs are dual color (bicolor) types. The functionality of the LED A, B and C can be changed by software.



**Figure 4:** Status LEDs

| LED | Color | Function |
|-----|-------|----------|
| **ON** | Green | Power On |
| | Green blinking | USB recovery mode |
| | Red | FPGA configuration error |
| | Orange | System shutdown or reset |
| **A** | Green | User LED 0 |
| | Red | User LED 1 |
| **B** | Green | User LED 2 |
| | Red | User LED 3 |
| **C** | Green | User LED 4 |
| | Red | User LED 5 |

**Table 4:** System LED values

# 5 Interfaces

This chapter describes the interfaces for the VisionBox AI.

## 5.1 RS-232

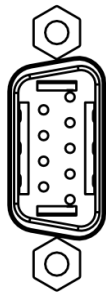A male 9-pin D-sub connector provides one RS-232 UART without flow control.



**Figure 5:** RS-232 D-sub connector

| Pin | Function |
|-----|----------|
| **1** | N/C |
| **2** | RX |
| **3** | TX |
| **4** | N/C |
| **5** | GND |
| **6** | N/C |
| **7** | N/C |
| **8** | N/C |
| **9** | N/C |

The TX and RX signals use the GND pin as reference potential. Make sure that the remote device uses the same GND reference.

The RS-232 interface is normally used as additional console device for Linux. A null modem cable is required to connect the VisionBox to a PC. It can also be configured for use by custom applications.

Default settings for the serial interface:

| Parameter | Value |
|-----------|-------|
| **Baud rate** | *115200 bps* |
| **Parity** | *None* |
| **Data bits** | *8* |
| **Stop bits** | *1* |
| **Flow control** | *None* |

## 5.2  Ethernet

The VisionBox AI comes with four Gigabit Ethernet ports. The first port is implemented using the integrated NVIDIA Jetson Ethernet controller, while the other ports use the Intel I210 controller.
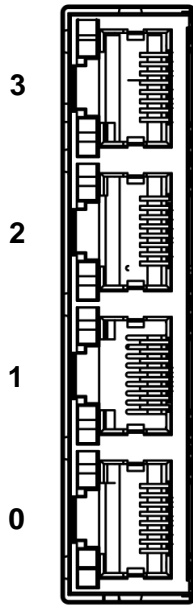


**Figure 6:** Ethernet connector

Assignment of the status LEDs for each port:

| State | Upper LED |
|---|---|
| **No traffic** | *Off* |
| **Traffic** | *Blinking* |

**Table 5:** Upper LEDs

| Link speed | ETH0 | ETH1…ETH3 |
|---|---|---|
| **10 Mbit/s** | *Green* | *Off* |
| **100 Mbit/s** | *Green* | *Off* |
| **1000 Mbit/s** | *Green* | *Green* |

**Table 6:** Lower LEDs

## 5.3  DisplayPort



The DisplayPort interface supports version 1.4a with a data rate of 32.4 Gbit/s. The maximum supported resolution is 8K60. To connect the DP Port with a DVI or VGA monitor, an active adapter is required.

Figure 7: DP connector

## 5.4  USB-A 2.0

The VisionBox AI provides two USB 2.0 Type-A connectors:



**Figure 8:** USB 2.0 Type-A connector

Based on the USB 2.0 specification, each port can deliver 500 mA.

## 5.5  USB-C 3.2

The USB Type-C connector provides SuperSpeed+ transfer mode (USB 3.2 Gen 2) with up to 10 Gbit/s.
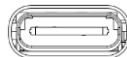


**Figure 9:** USB Type-C connector

The USB-C port can deliver up to 900 mA.

If a PC is connected to the USB-C port during power on, the VisionBox enters USB recovery mode. This is indicated by a green blinking ON LED. Only use this mode if advised by IMAGO. Do not try to flash the Jetson OS image provided by NVIDIA!

## 5.6 Digital I/O

The digital I/O interface provides an input and an output group. Each group has eight signals, and all groups are electrically isolated from each other, as well as from other VisionBox circuits and interfaces.

The following illustration shows the corresponding electrical equivalent circuit for one input and one output group:
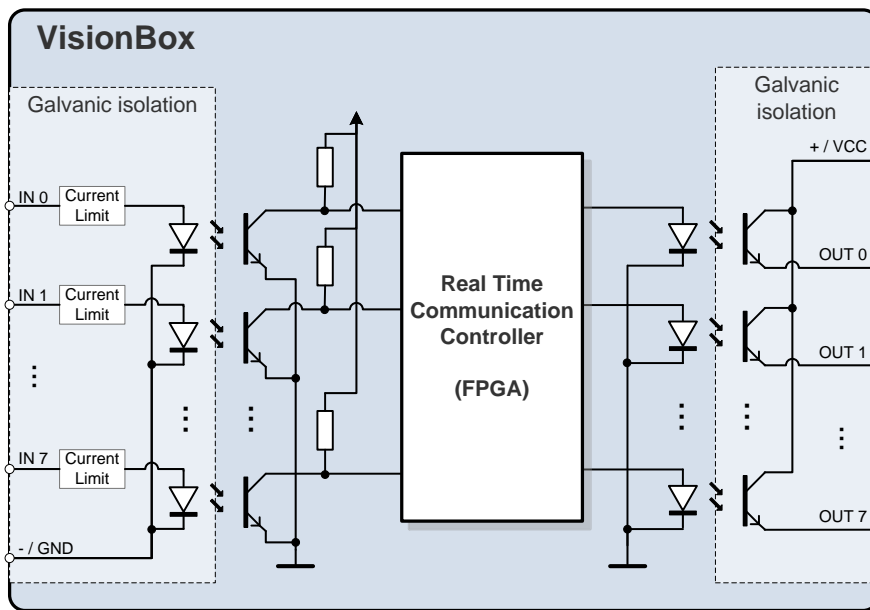


**Figure 10:** Simplified digital I/O circuit

The input group requires external connection of a shared GND reference. For the output group, the user must provide a supply voltage to the VCC pin which is used by all output signals. Every input and output have an LED to show the current state of each channel.
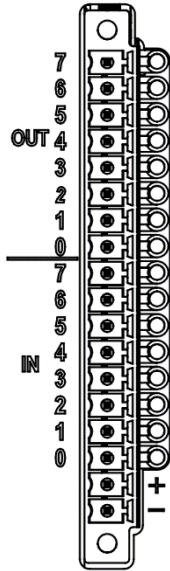
The connector arrangement is shown below:



**Figure 11:** Digital I/O connector

| Pin | Function |
|-----|----------|
| **1** | OUT7 |
| **2** | OUT6 |
| **3** | OUT5 |
| **4** | OUT4 |
| **5** | OUT3 |
| **6** | OUT2 |
| **7** | OUT1 |
| **8** | OUT0 |
| **17** | + / Common VCC of outputs |

| Pin | Function |
|-----|----------|
| **9** | IN7 |
| **10** | IN6 |
| **11** | IN5 |
| **12** | IN4 |
| **13** | IN3 |
| **14** | IN2 |
| **15** | IN1 |
| **16** | IN0 |
| **18** | − / Common GND of inputs |

**Table 7:** Pin assignment dig. I/O

External plug component: Phoenix contact **MC 1,5/18-STF-3,5** (order no. 1847288)

## 5.7  RS-422 Interface

The RS-422 interface can be used to connect additional devices like encoders, sensors and cameras. The behavior is controlled by the Real-Time Communication Controller.

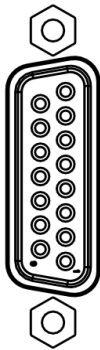The female 15-pin D-sub connector provides three input and three output signals:



**Figure 12:** RS-422 connector

| Pin | Function |
|-----|----------|
| 1 | GND |
| 2 | OUT2+ |
| 3 | OUT1+ |
| 4 | OUT0+ |
| 5 | IN2+ |
| 6 | IN1+ |
| 7 | IN0+ |
| 8 | 5V DC output |
| 9 | OUT2- |
| 10 | OUT1- |
| 11 | OUT0- |
| 12 | IN2- |
| 13 | IN1- |
| 14 | IN0- |
| 15 | GND |

**Table 8:** RS-422 pin assignment

Pins 8 provides a 5 V power supply for RS-422 encoders.

The input and output signals use the GND pins as reference potential. Make sure that connected devices use the same GND reference.

## 5.8   Camera Link

The VisionBox AI has two Mini Camera Link connectors:



**Figure 13:** Mini Camera Link connectors

The Camera Link interface supports the following features:

- Camera Link Dual-Base configuration:
  - 2x Base / 1x Medium Camera Input
  - 2x Serial communication interface
- Camera Link Full / Deca configuration:
  - 1x Base / 1x Medium / 1x Full / 1x Deca Camera Input
  - 1x Serial communication interface
- Camera Control signals (CC) can be controlled by software or by the RTCC.

A different FPGA firmware is used to select between Dual-Base and Full configuration.

# 6 Accessories

This list shows some compatible connectors, shells and plugs to support the device interfaces. Typically, the plugs are not included in the device package.

## 6.1 Third-party Components

| Vendor | Type | Part Number | Usage |
|--------|------|-------------|-------|
| Phoenix | MC 1,5 / 4-STF-3,5 | 1847071 | Power connector |
| Phoenix | MC 1,5 / 18-STF-3,5 | 1847288 | Digital In / Out |

There is also a connector set with plugs available. Please refer to the following table or ask for more details.

## 6.2 IMAGO Accessories

| Order Number | Description |
|--------------|-------------|
| 10005154 | Connector set: 1x 4 Pin power connector, 1x 18 Pin I/O |

More accessories and upgrades are available upon request.

## 7 History

| Revision | Date | Changes | Initials |
|---|---|---|---|
| 1.0 | 23.01.2023 | First version | rg |