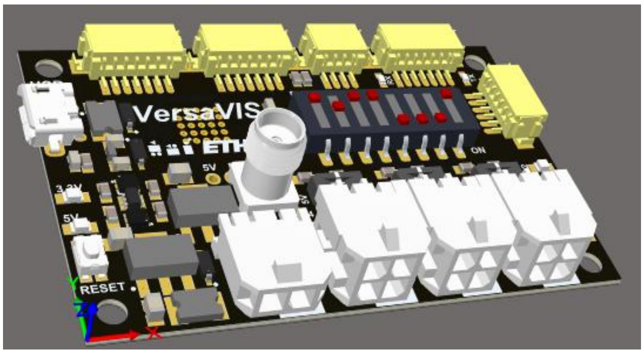
Datasheet



VersaVIS
(Rev 1.1, November 2019)

1 Features

- Supports control of up to 3 independent cameras
- 3.3V/5V camera interfaces
- Support of CMOS, TTL and optoisolated camera interfaces
- Power supply 6V - 15V
- USB host interface
- Arduino® Zero compatible
- Various communications interfaces (2 x SPI, 1 x I^{2}C, 2 x UART, AUXILIARY), Hirose® DF13 connectors
- GPS PPS signal input and external clock input (SMA)
- 4 pin Molex MicroFit® connector for camera interface
- 2 pin Molex MicroFit® connector for power supply
- UART Rx/Tx activity LED
- Reset switch
- Dimensions 62mm x 40mm

2 Applications

- Robotics
- UAVs
- SLAM Applications
- Visual Inertial Platforms

3 Description[1]

Robust and accurate pose estimation is crucial for many applications in mobile robotics. Extending visual Simultaneous Localization and Mapping (SLAM) with other modalities such as an inertial measurement unit (IMU) can boost robustness and accuracy. However, for a tight sensor fusion, accurate time synchronization of the sensors is often crucial. In this context *VersaVIS*, an Open Versatile Multi-Camera Visual-Inertial Sensor Suite aimes to be an efficient research platform for an easy deployment, integration and extension for many mobile robotic applications. *VersaVIS* provides a complete hardware, firmware and software bundle to perform time synchronization of multiple cameras with an IMU featuring exposure compensation, host clock translation and independent and stereo camera triggering. The sensor suite supports a wide range of cameras and IMUs to match the requirements of the application. The synchronization accuracy of the framework is evaluated on multiple experiments achieving timing accuracy of less than 1ms. Furthermore, the applicability and versatility of the sensor suite may be used in multiple applications including visual-inertial SLAM, multi-camera applications, multi-modal mapping and reconstruction and object based mapping.

The *VersaVIS* hardware is designed to support up to three independent cameras for visual inertial sensing. It is based on the Atmel® SAMD21G18 microcontroller as it is used e.g. in the Arduino® Zero. The microcontroller connects trigger and exposure signals to and from the cameras. Cameras may also be triggered in slave mode using the exposure signal from the master camera (CAM 0). The board supports CMOS, TTL and optoisolated camera interfaces. Communication to sensors and other equipment is possible by using SPI, I^2C or UART. As the board is based on the Arduino® Zero it is also fully compatible with the Arduino® IDE software development platform[2]. The *VersaVIS* board can be powered by an external voltage source (6 to 15V) or through USB power.

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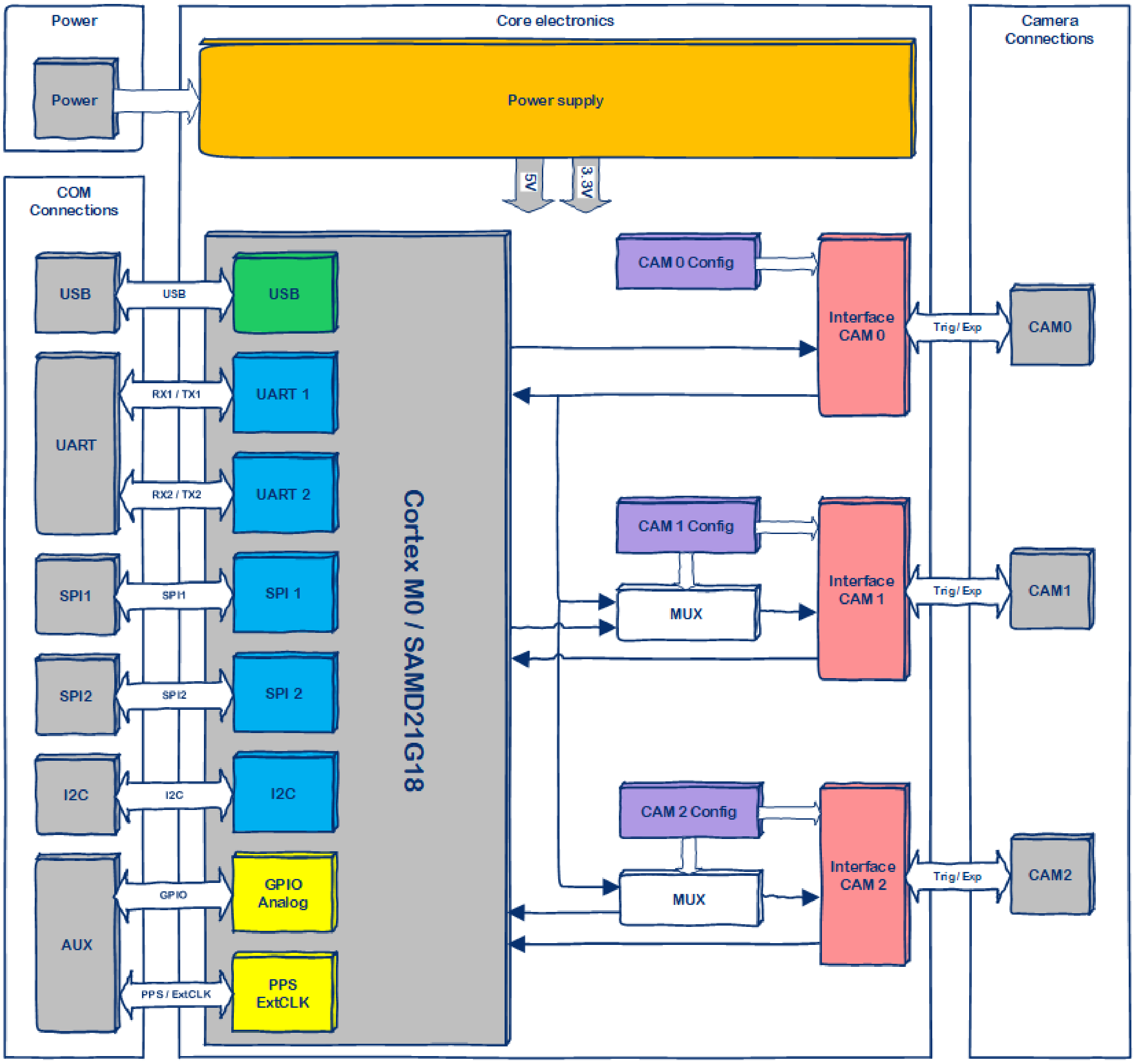
1 Tschopp, F.; Riner, M.; Fehr, M.; Bernreiter, L.; Furrer, F.; Novkovic, T.; Pfrunder, A.; Cadena, C.; Siegwart, R.; Nieto, J. VersaVIS—An Open Versatile Multi-Camera Visual-Inertial Sensor Suite. Sensors 2020, 20, 1439

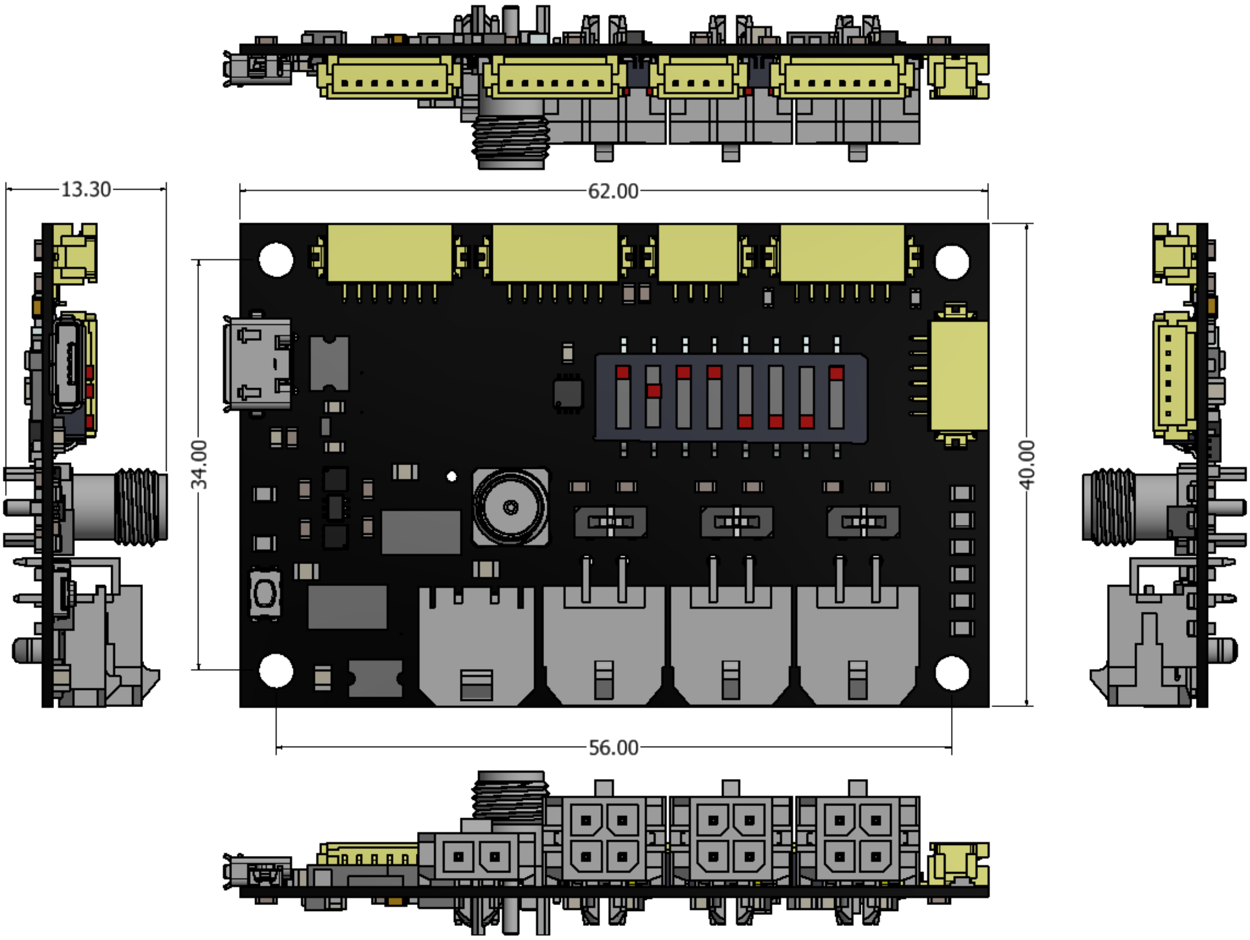
2 To use full functionality of the *VersaVIS* board a board package has to be installed in Arduino IDE board manager

4 Blockdiagram



5 Specifications

5.1 Dimensions



Mounting hole diameter: 3mm

5.3 Electrical

5.3.1 Absolute maximum ratings

Power supply

	Parameter	MIN	MAX	UNIT
V_{CC}	Power Supply Voltage	6	15	V

Camera Interface

	Parameter			UNIT
V_{INCAM}	DC Input Voltage	-0.5	V_{CAM}	V
I_{IN}	DC Output Voltage	-0.5	V_{CAM} + 0.5	°C
I_{IN}	DC Input Current (pull down configuration, V_{CAM} = 5V)		-10	mA
I_{IN}	DC Input Current (pull down configuration, V_{CAM} = 3.3V)		-7	mA
I_{OUT}	DC Output Current (pull up configuration, V_{CAM} = 5V)		10	mA
I_{OUT}	DC Output Current (pull up configuration, V_{CAM} = 3.3V)		7	mA

Communication Interfaces

	Parameter			UNIT
V_{IN}	DC Input Voltage	-.0.6	3.9	V
I_{OUT}	DC Output Current (refer to SAMD21G18 Datasheet)			mA

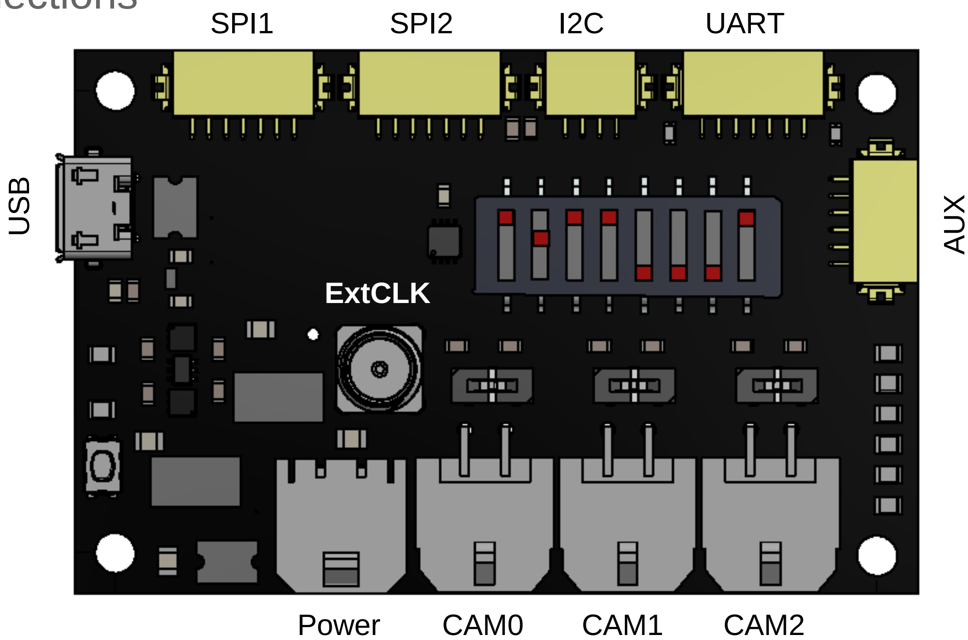
Auxiliary Interface

	Parameter			UNIT
V_{INAUX}	DC Input Voltage	-.0.6	3.9	V
I_{OUT}	DC Output Current (refer to SAMD21G18 Datasheet)			mA

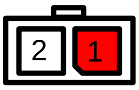
External Clock Interface (SMA connector)

	Parameter			UNIT
V_{INAUX}	DC Input Voltage	-.0.6	3.9	V
Z_{IN}	Input Impedance	50	50	Ω

6 Connections



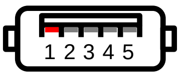
6.1 Power Supply (Board frontal view)



The connector mates with Molex Micro-Fit 3.0 Receptacle Housing, Single Row, 2 Circuits, UL 94V-0, Low-Halogen, Black, Part Number 436450200

Pin	Description	Direction
1	Ground	
2	VCC (6..15V)	In

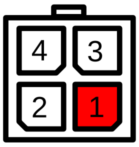
6.2 USB (Board frontal view)



Micro-USB AB

Pin	Description	Direction
1	VCC (5V)	In
2	D-	In/Out
3	D+	In/Out
4	ID	Out
5	GND	

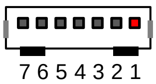
6.3 Camera Interface CAM0, CAM1, CAM2 (Board frontal view)



The connector mates with Micro-Fit 3.0 Receptacle Housing, Dual Row, 4 Circuits, UL 94V-0, Low-Halogen, Black, Part Number 430250400

Pin	Description	Direction
1	VCAM	Out
2	Trigger	Out
3	Exposure	In
4	GND	

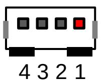
6.4 SPI1 /SPI2 Interface (Board frontal view)



The connector mates with Hirose Connector Socket Housing, 7 Circuits, 1.25mm, Part Number Socket DF13-7S-1.25C

Pin	Description	Direction
1	5V	Out
2	SCK (Serial Clock)	Out
3	MISO (Master In slave OUT)	In
4	MOSI (Master Out Slave IN)	Out
5	SS (Slave Select)	Out
6	DR (Data Ready)	In
7	GND	

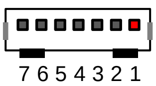
6.5 I^{2}C Interface (Board frontal view)



The connector mates with Hirose Connector Socket Housing, 4 Circuits, 1.25mm, Part Number DF13-4S-1.25C

Pin	Description	Direction
1	5V	Out
2	SCL (Serial Clock)	Out
3	SDA (Serial Data)	In/Out
4	GND	

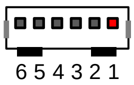
6.6 UART Interface (Board frontal view)



The connector mates with Hirose Connector Socket Housing, 7 Circuits, 1.25mm, Part Number Socket DF13-7S-1.25C

Pin	Description	Direction
1	5V	Out
2	TX1 (Transmit)	Out
3	RX1 (Receive)	In
4	GND	
5	TX2 (Transmit)	Out
6	RX2 (Receive)	In
7	GND	

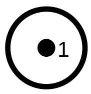
6.7 Auxiliary Interface (Board frontal view)



The connector mates with Hirose Connector Socket Housing, 6 Circuits, 1.25mm, Part Number Socket DF13-6S-1.25C

Pin	Description	Direction
1	PPS (Pulse per Second)	In
2	DAUX1 (GPIO digital)	In/Out
3	DAUX2 (GPIO digital)	In/Out
4	AAUX1 (Analog channel)	In
5	AAUX2 (Analog channel)	In
6	GND	

6.7 External Clock Interface (Board frontal view)

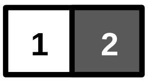


The connector mates with any SMA RF Connector

Pin	Description	Direction
1	ExtClk (External Clock)	In
Shell	GND	

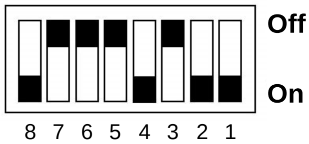
7 Configuration

7.1 DIP Switch Settings Camera Supply (CAM0 / CAM1 / CAM2)



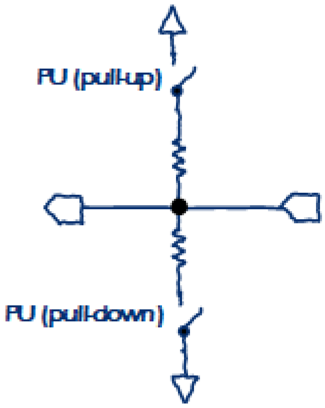
Position	Name	Description
1	5V	Camera Supply 5V (VCAM)
2	3.3V	Camera Supply 3.3V (VCAM)

7.2 DIP Switch Settings Camera Mode



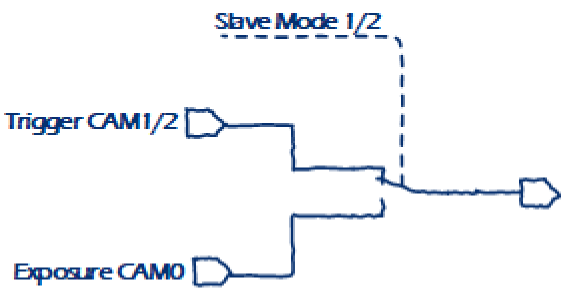
#	Name	Description
1	PD0	Pull-Down Exposure Camera 0 (CAM0)
2	PU0	Pull-Up Exposure Camera 0 (CAM0)
3	PD1	Pull-Down Exposure Camera 1 (CAM1)
4	PU1	Pull-Up Exposure Camera 1 (CAM1)
5	PD2	Pull-Down Exposure Camera 2 (CAM2)
6	PU2	Pull-Up Exposure Camera 2 (CAM2)
7	SL1	Slave Mode Camera 1 (CAM1)
8	SL2	Slave Mode Camera 2 (CAM2)

7.3 Pull-Up / Pull-Down Settings Exposure Signal

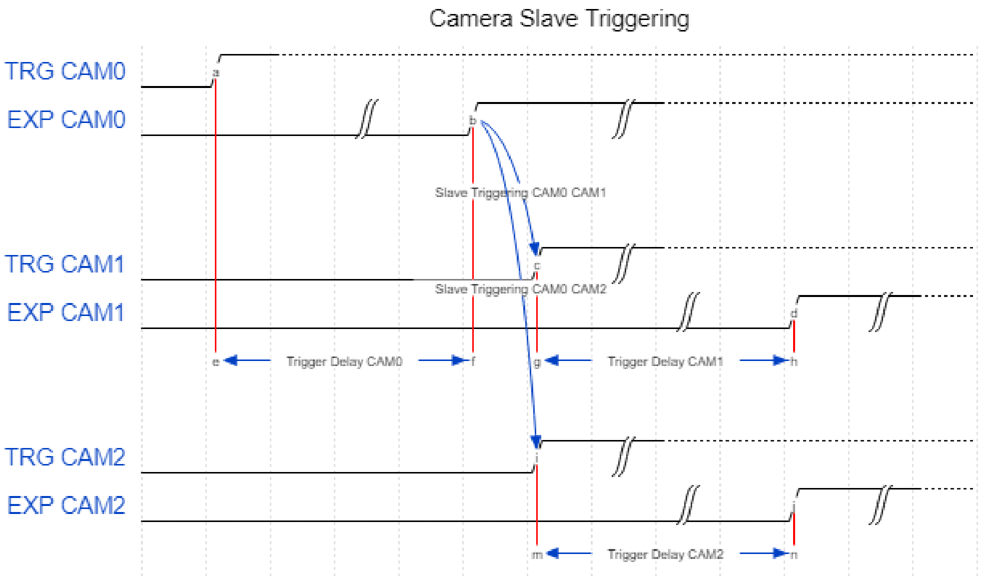


Depending on the requirements of the connected camera, the exposure signal has to be pulled-up to VCAM or pulled-down to GND or even none of the before mentioned. This can be achieved by setting switch PDx (pull-down) to ON or PUx (pull-up) to ON or both to OFF. The internal pull-up/pull-down resistance is 470Ω.

7.4 Slave Mode of Trigger signals (CAM1 / CAM2)



The trigger signals for CAM1 and CAM2 can be driven by the exposure signal of CAM0. This is called the Slave Mode. Slave Mode is on if switch SL1 (for CAM1) or SL2 (for CAM2) are in ON position.



Exposure signal of CAM0 triggers CAM1 and CAM2, DIP switch SL1=ON, SL2=ON

8 Camera Control Signals

Cameras usually have two types of GPIOs for triggering and capturing exposure time:

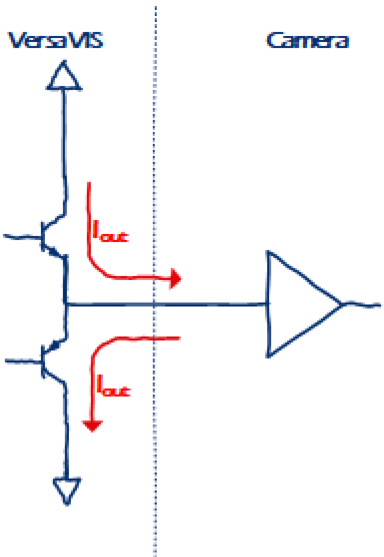
- Logic IOs
- Optoisolated IOs

Depending on your application either of these interface topologies might be chosen. In any case, it is vital to know exactly how your cameras GPIO interface work in order to avoid damage in your camera.

8.1 Trigger signal

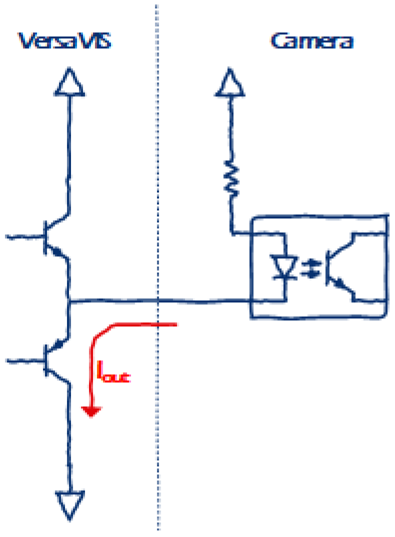
The *VersaVIS* board is designed such that you can trigger cameras with logic inputs or optoisolated inputs. Logic inputs usually consume only very small amount of current (up to some µA) whereas optoisolated inputs consume up to 20mA of current. To transmit electrical signals galvanicaly isolated, the most common used devices are optocouplers consisting of a pair of photodiode and phototransistor. This is useful to avoid ground loops in systems that may cause functional failure of your system. This is useful to avoid ground loops in complex systems, which can massively affect the function of a system.
The trigger outputs of the *VersaVIS* board are designed such that they can be connected to either logic inputs or optoisolated inputs by providing up to +/- 50mA of current.

8.1.1 Driving logic trigger inputs



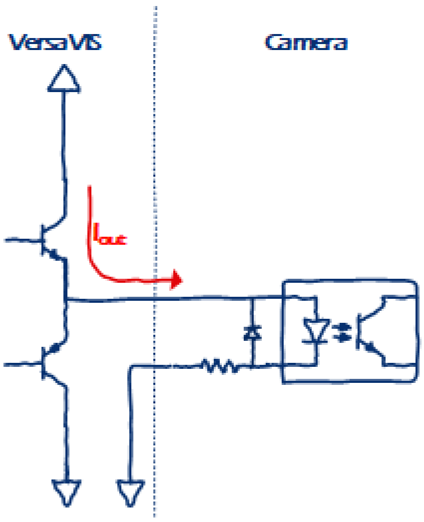
If your camera is using logic signal inputs for triggering this might look similar as shown on the left. The *VersaVIS* output stage is designed as a push-pull buffer, capable of driving +/- 50mA of current. The current can either flow into the logic input of the camera (sourcing) or from the camera into the *VersaVIS* output stage (sinking). Common logic inputs are sourcing or sinking only small amounts of current (a few nanoampere CMOS logic or a few microampere for TTL logic), so the current is more or less negligible and information on a “high” or “low” signal is only determined by the applied voltage to the logic input. Logic inputs can easily be damaged by applying voltages exceeding the internal power supply voltage of the logic input. It is therefore important to set VCAM (*VersaVIS* camera voltage) of each respective camera channel to correct value (see 7 .1 DIP Switch Settings Camera Supply (CAM0 / CAM1 / CAM2).

8.1.2 Driving optoisolated trigger inputs with Pull-Up



If your camera is using optoisolated signal inputs for camera triggering, this may look similar to the one shown on the left. The *VersaVIS* output stage is designed as a push-pull buffer that can drive +/- 50mA current. The current can either flow to the logic input of the camera (sourcing) or from the camera to the *VersaVIS* output stage (sinking). Optoisolated inputs work with optocouplers for signal transmission. Here information is transmitted by the light emitted by an infrared diode and received by a phototransistor. Since there is no electrical connection between transmitter and receiver, this is called galvanically isolated signal transmission. Since the light emitting diode of the camera input is tied to the *VersaVIS* VCAM voltage, current can only flow if the lower transistor of the *VersaVIS* output stage is turned on. It therefore sinks current from the camera input to ground (GND). Usually the camera manufacturer installs a series resistor to the diode, which designed such that the maximum load current of the photodiode cannot be exceeded. If there is no series resistor you might have to install your own to protect the input. In this configuration, setting the *VersaVIS* output to “low” sinks a current from the optocoupler input that causes the diode to light up and in turn sends a "high" signal to your phototransistor. The signal received at the camera input is thus inverted.

8.1.3 Driving optoisolated trigger inputs with Pull-Down

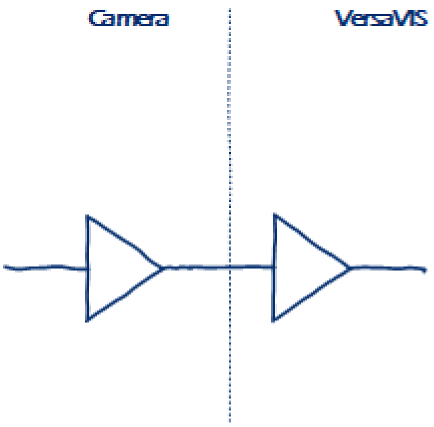


If your camera is using optoisolated signal inputs for camera triggering, this may look similar to the one shown on the left. Since the photodiode of the camera input is connected to ground (GND) in this case, the current can only flow when the upper transistor of the *VersaVIS* amplifier is switched on. It therefore sources current from the camera voltage (VCAM) to the camera input. Usually the camera manufacturer installs a series resistor to the diode, which designed such that the maximum load current of the photodiode cannot be exceeded. If there is no series resistor you might have to install your own to protect the optocoupler input. In this configuration, setting the *VersaVIS* output to “high” sources a current to the optocoupler input that causes the diode to light up and in turn sends a "high" signal to your phototransistor. The signal received at the camera input is thus not inverted.

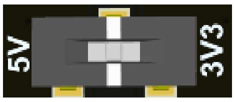
8.2 Exposure signal

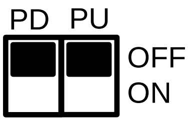
The VersaVIS board is designed such that you can receive exposure signals of cameras with logic outputs or optoisolated outputs. Logic outputs are usually designed as open collector/drain or push-pull outputs (details can be found in the following sections). Optoisolated outputs are usually implemented as two-port transistor outputs. *VersaVIS* board is designed such that different configurations can be set by a DIP switch.

8.2.1 Exposure logic signal output with buffer

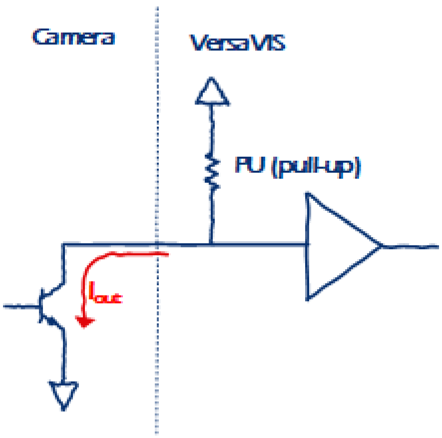


If your camera is using logic signals outputs with buffer as exposure signal, this may look similar to the one shown on the left. The camera output is designed as a pure logic output and the *VersaVIS* input stage is designed as a logic buffer. In this configuration it is vital that the camera logic output voltage level matches the *VersaVIS* input logic level. This level can be either 3.3V or 5.0V and can be set by pushing the camera voltage selector to the correct position (see below). There is no pull-up or pull-down resistor needed for this configuration.

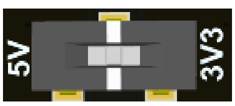


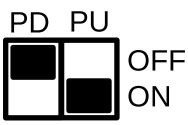


8.2.2 Exposure logic signal output with open collector/drain

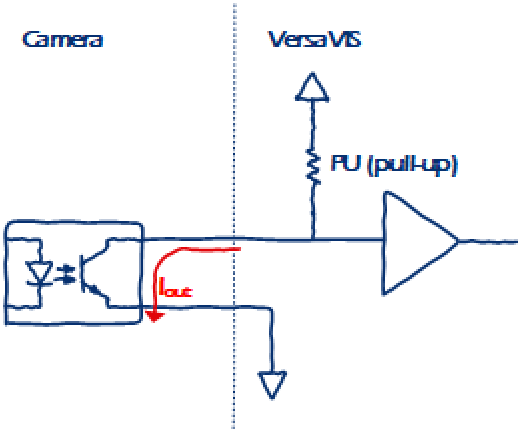


If your camera is using logic signals outputs in open collector/drain configuration as exposure signal, this may look similar to the one shown on the left. The camera output is designed as an open collector/drain output and the *VersaVIS* input stage is designed as a logic buffer. In this configuration a pull-up resistor on the *VersaVIS* board is mandatory to provide the camera output transistor with current. If the camera output transistor is turned on it sinks current through the pull-up resistor while pulling its collector/drain to GND. If the camera output transistor is off there is no current flowing through the pull-up resistor and the collector/drain of the camera output transistor is pulled to VCAM. The pull-up resistor acts as a current to voltage converter. In this configuration the level of VCAM may be set on your choice to 3.3V or 5.0V. VCAM can be set by pushing the camera voltage selector to the desired position (see below).

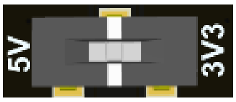


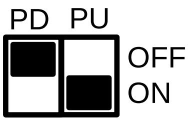


8.2.3 Exposure optoisolated two-port signal output with pull-up

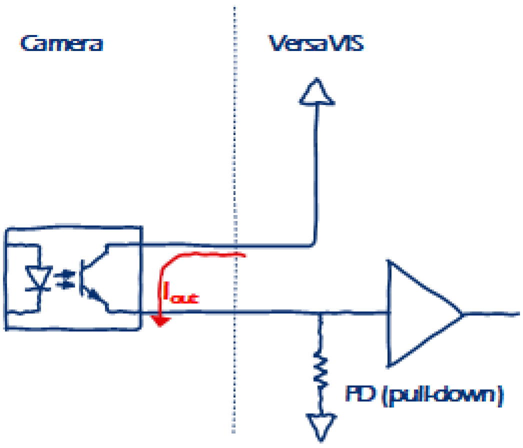


If your camera is using using optoisolated two-port signal output with pull-up configuration as exposure signal, this may look similar to the one shown on the left. The camera output is designed as a two-port transistor output and the *VersaVIS* input stage is designed as a logic buffer. In this configuration, a pull-up resistor on the *VersaVIS* board is mandatory to provide the camera output opto-transistor with current. If the camera output transistor is turned on, it sinks current through the pull-up resistor while pulling its collector/drain to the emmiter/source voltage, which in this case is GND. If the camera output transistor is off there is no current flowing through the pull-up resistor and the collector/drain of the camera output transistor is pulled to VCAM. The pull-up resistor acts as a current to voltage converter. In this configuration, the level of VCAM may be set on your choice to 3.3V or 5.0V. VCAM can be set by pushing the camera voltage selector to the desired position (see below).





8.2.4 Exposure optoisolated two-port signal output with pull-down



If your camera is using using optoisolated two-port signal output with pull-down configuration as exposure signal, this may look similar to the one shown on the left. The camera output is designed as a two-port transistor output and the *VersaVIS* input stage is designed as a logic buffer. In this configuration a pull-down resistor on the *VersaVIS* board is mandatory to provide the camera output optotransistor with current. If the camera output transistor is turned on, it sources current through the pull-down resistor while pulling its collector/drain to VCAM. The current then generates a voltage across the resistor. If the camera output transistor is off there is no current flowing through the pull-down resistor and the emitter/source/drain of the camera output transistor is pulled to GND as the resulting voltage across the resistor is zero. The pull-down resistor acts as a current to voltage converter. In this configuration, the level of VCAM may be set on your choice to 3.3V or 5.0V. VCAM can be set by pushing the camera voltage selector to the desired position (see below).