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CE

BASLER Fg2dPci

Digital PCI Framegrabber

Hardware Manual

BASLER Vision Technologies AG

ID-Nr.: DA031202
Date 02/00
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1 Overview

The BASLER Fg2dPci is a double channel PCI framegrabber board designed for area and line scan cameras with digital output.
The board features a freely programmable microcontroller, the Custom AVR, with 16 digital pins and an incremental encoder input.
In addition, 3 universal I/O ports for flashlights or links to other boards can be connected.

A driver software is available, the BASLER Vision Toolbox.

This documentation covers PCB version 1.1 of the BASLER Fg2dPci. It describes the hardware.

1.1 Cameras

The BASLER Fg2dPci can be used with area scan and line scan cameras. It can definitely be used with all BASLER cameras. The framegrabber was tested with the BASLER A113 using the BASLER VISION TOOLBOX.

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1.2 Assembly Version

The BASLER Fg2dPci framegrabber comes in a full assembly version.

ID Number: CF020602 Version 1.1; PCB: ED014002

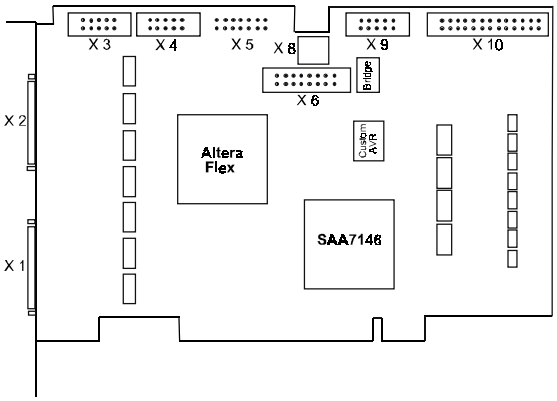


Figure 1-1: Full assembly version

1.3 Requirements

The board only operates reliably when the following system requirements are met:

- Computer: PC/Mac PCI bus computer, PCI bus version 2.1 or later. The board is tested for PentiumII™ only.
- Driver software only runs under Windows NT™ 4.0, SP 3 or later
- Camera: The driver software supports line and area scan cameras designed for Basler's own standard 8 Bit RS644 LVDS on an IEE1284C Plug.

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1.4 In This Shipment

A BASLER Fg2dPci board shipment includes

- the BASLER Fg2dPci board
- the manual BASLER Fg2dPci Hardware
- the BASLER Vision Toolbox which includes the software driver and its documentation

1.5 Precautions

Read this chapter carefully before unpacking and using the board.

1.5.1 Life Support Applications

These products are not designed for use in life support appliances, devices, or systems where malfunction of these products can reasonably be expected to result in personal injury. Customers using or selling these products for use in such applications do so at their own risk and agree to fully indemnify BASLER for any damages resulting from such improper use or sale.

1.5.2 Handling Precautions

Static electricity can damage boards. Adhere to the following precautions when handling BASLER boards:

- Keep the board in the antistatic packaging as long as it is not used
- Touch a grounded surface before removing the board from its packaging. This discharges any electricity that may have built up in your body.
- Handle the board by its edges or connectors.
- Avoid touching any components.



Caution!

Failure to follow these precautions can cause severe equipment damage.

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1.5.3 Environmental Requirements

Operation temperature	+5°C … +60°C; +41°F ... +140°F
Operation humidity	5% … 85%, relative, non-condensing
Storage temperature	-10°C … +70°C; +14°F ... +158°F
Storage humidity	5% … 95%, relative, non-condensing

1.5.4 Installation Precautions

In order to avoid equipment damage follow these directions to install the board in the computer:

1. Turn off the computer and any attached peripheral devices.
2. Select a PCI-bus slot on the PC motherboard.
3. Press the board firmly into the motherboard.
4. Secure all cable screws to ensure adequate shielding. All cables used to connect the computer and peripherals must be shielded, grounded, and securely fastened.

1.5.5 Precautions When Connecting a Camera



Caution!

Make sure that camera or framegrabber are not powered when connecting the camera to the framegrabber. Otherwise the camera or the framegrabber are damaged.

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1.6 Specifications

The board features two independent camera inputs. Area and line scan cameras can be connected to these inputs.
The maximum resolution of line scan cameras is 4096 pixel per line at camera input A and 8192 pixel per line at camera input B.
Each processed pixel can have a maximum depth of 8 bits. The maximum pixel frequency specified by the chip manufacturer is 32 MHz. Internal tests at Basler have proven that the board can be operated at a frequency of 60 MHz since Basler operates the chip in monochrome mode, not in color mode. The effective data rate should not exceed 50 MB per channel.
The camera inputs are designed for the LVDS level (RS644 standard).
In addition, a serial interface for communication between the cameras is integrated.
The camera data are led into a preprocessing unit (Altera Flex) and transferred into the PC with a PCI-Bus DMA controller (Philips SAA7146).

The full extent of the board's specifications should be derived from the specifications of the SAA7146A microcontroller. Its specifications can be found in the Internet (see Section 1.7).

Feature	BASLER Fg2dPci
Board size	163 mm by 108 mm 4.9 by 3.8 inches
Power requirements (typical)	500 mA at +5V
DIO output power	Max. voltage: 60V Max. current: 1A Power: 3W Total power of all outputs: 12W

Table 1-1: Specifications

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1.7 Further Documentation

The driver software is covered in the BASLER VisionToolbox Online help.

The low level communication protocol between PC and Custom AVR and Altera Flex and the SAA microcontroller is described in the Low Level Communication Manual.

Further information on the microcontrollers used can be obtained from the following addresses:

Altera Flex:

Altera Corporation
101 Innovation Drive
San Jose, CA 95134
Phone:(408) 544-7000
FAX: (408) 544-7755
http://www.altera.com/html/products/f10k.html

SAA microcontroller:

Philips Semiconductors
Postbus 90050
NL 5600 PB Eindhoven
Phone: +44-181-7305020
FAX: +31-40-2724825 - NL
http://www-eu2.semiconductors.com/pip/SAA7146

Custom AVR AT90S8515 microcontroller:

Atmel Corporation
2325 Orchard Parkway
San Jose, Ca 95131
Phone: (408) 441-0311

http://www.atmel.com/atmel/acrobat/doc0841.pdf

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2 Functional Description

The block diagram shows the most important components on the framegrabber board.

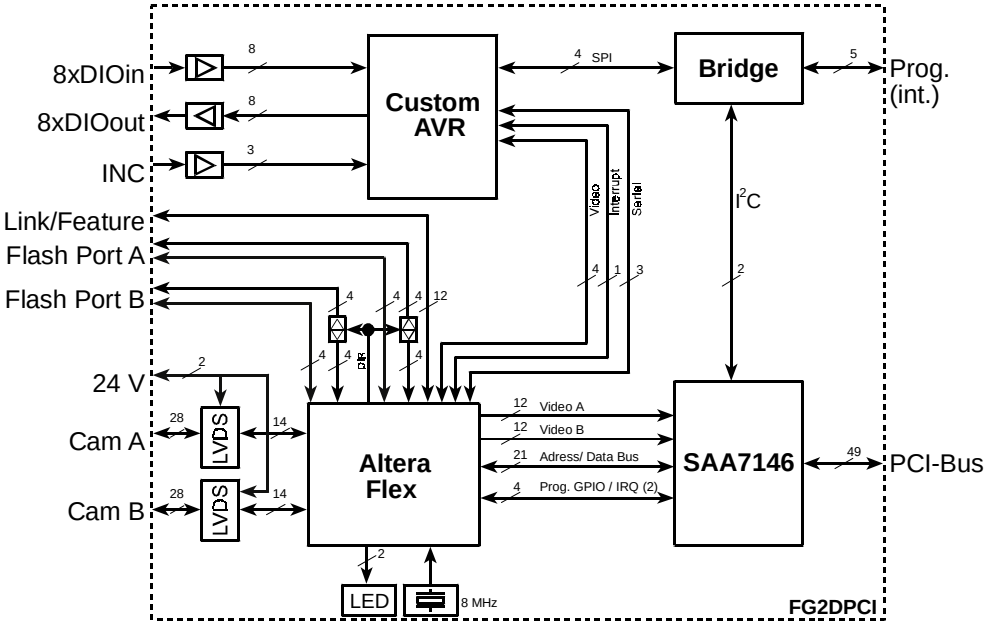


Figure 2-1: Block diagram of framegrabber board

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The main components of the board are:

- a double-channel DMA controller Philips **SAA7146**. For a full list of features and a functional description, see the Philips SAA7146 documentation.
- a Altera **Flex** logic component for signal matching, signal preprocessing and controlling the I/O interfaces.
- an AVR microcontroller Atmel AT90S8515, referred to as **Custom AVR**.
- a **Bridge** used for communication between SAA7146 and Custom AVR.

2.1 External Signals and Connections

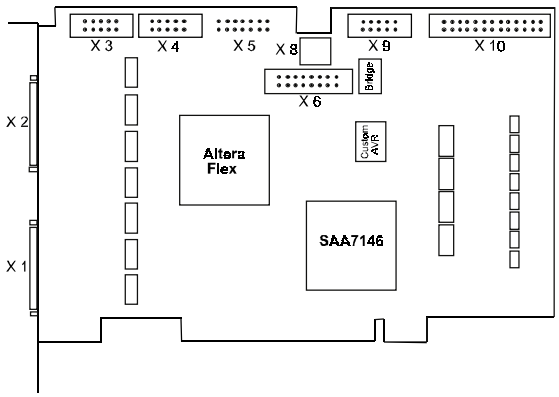


Figure 2-2: Connectors on framegrabber

The BASLER Fg2dPci is interfaced to external circuitry via several connectors (see Figure 2-1 and Figure 2-2):

- video data and control (digital camera, output power supply, serial communication). See section 2.1.1.
- digital IO accessible by Custom AVR. See section 2.1.7.
- incremental encoder, accessible by Custom AVR. See section 2.1.6.
- flash ports. See section 2.1.2.
- link/ feature port. See section 2.1.3.

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In addition, there are the following internal signals (see Figure 2-1):

- GPIO for programming the Altera Flex. See section 2.2.2.2.
- Video signals between Altera Flex and SAA7146. See section 2.2.3.1.
- Adress and Data Bus between SAA7146 and Altera Flex. See section 2.2.3.2.
- Interrupt, video and serial line between Custom AVR and Altera Flex. See sections 2.2.2.2, 2.2.2.1 and 2.2.2.3.
- I^2C interface between SAA7146 and Bridge. See section 2.2.5.
- SPI (serial peripheral interface) between Custom AVR and Bridge. See section 2.2.4.

2.1.1 Video Inputs X1/2

The framegrabber board supports two digital video inputs, CamA and CamB. CamA and CamB have the same pin assignment.

The connector plug is a female HDcentronics IEEE 1284C.

Pin	Name	Direction	Description
1	Video Data Bit 0	In	LVDS +
2	Video Data Bit 1	In	LVDS +
3	Video Data Bit 2	In	LVDS +
4	Video Data Bit 3	In	LVDS +
5	Video Data Bit 4	In	LVDS +
6	Video Data Bit 5	In	LVDS +
7	Video Data Bit 6	In	LVDS +
8	Video Data Bit 7	In	LVDS +
9	GND	Out	Computer Ground
10	Pixelclock	In	LVDS +
11	LVal	In	LVDS +
12	FVal	In	LVDS +
13	EXSync	Out	LVDS +
14	reserved	-	-

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Pin	Name	Direction	Description
15	RxD	In	Serial LVDS + Not yet implemented
16	TxD	Out	Serial LVDS + Not yet implemented
17	Camera Power Supply (Ground)	Out	24 Volts from X8 / Pin 2
18	Camera Power Supply (Positive)	Out	24 Volts from X8 / Pin 1
19	Video Data Bit 0	In	LVDS -
20	Video Data Bit 1	In	LVDS -
21	Video Data Bit 2	In	LVDS -
22	Video Data Bit 3	In	LVDS -
23	Video Data Bit 4	In	LVDS -
24	Video Data Bit 5	In	LVDS -
25	Video Data Bit 6	In	LVDS -
26	Video Data Bit 7	In	LVDS -
27	GND	Out	Computer Ground
28	Pixelclock	In	LVDS -
29	LVal	In	LVDS -
30	FVal	In	LVDS -
31	EXSync	Out	LVDS -
32	reserved	-	-
33	RxD	In	Serial LVDS -
34	TxD	Out	Serial LVDS -
35	Camera Power Supply (Ground)	Out	24 Volts from X8 / Pin 2
36	Camera Power Supply (Positive)	Out	24 Volts from X8 / Pin 1

The 8bit data of the camera ports represent the gray values of the pixel that can range from 0-255.

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The BASLER Fg2dPci evaluates the LVal signal (Line valid) and, with matrix cameras, also the FVal signal (Frame valid). Type of camera and image section are set in the Altera Flex.

Some BASLER cameras provide a serial interface with LVDS standard levels. It can be used directly via the framegrabber. The serial interface is not yet implemented.

2.1.2 Flash Ports X3/4

Simple I/O controls can be realized via the Flash Ports.

Pin	Name	Direction	Remark
1	Data Bit 0	I/O	Buffered TTL (5V, max 20 mA)
2	Data Bit 1	I/O	Buffered TTL (5V, max 20 mA)
3	Data Bit 2	I/O	Buffered TTL (5V, max 20 mA)
4	Data Bit 3	I/O	Buffered TTL (5V, max 20 mA)
5	Data Bit 4	I/O	Unbuffered 3.3 V
6	Data Bit 5	I/O	Unbuffered 3.3 V
7	Data Bit 6	I/O	Unbuffered 3.3 V
8	Data Bit 7	I/O	Unbuffered 3.3 V
9	VCC	Out	5 Volts via 10 Ohm Resistor
10	GND	Out	Computer Ground

Each port is assigned to one camera channel and has 8 lines. The 8 lines can be used as 8 output lines, as 8 input lines or as 4 output and 4 input lines.

Via the RAM integrated into the Alera Flex, complex bit sequences can be output. Parallel to outputting bit sequences, the exposure of the camera is controlled via the ExSync signal. A typical application is timed flashing and grabbing.

The port functions are controlled by programming the registers of the Altera Flex.

X3 and X4 are ports for flashlight control. X4 is Port A, X3 is Port B.

For more details, see the Low Level Communication manual.

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2.1.3 Link/Feature X5 (Not Yet Implemented)

The Link/Feature connector can be used for two purposes:

- as a third 8 bit data input on TTL level basis for simple cameras.
- as a communication connection to other grabbers. 2 further boards can be connected through the link port. A master board is able to send data to the 2 slave boards for example to control image grabbing.

The function of this port is given by the Altera Flex program.

Pin	Link Function	Feature Function	Direction	Remark
1	Status Bit 1	Pixel CLK	I/O	Unbuffered 3.3V
2	Status Bit 0	Data Valid	I/O	Unbuffered 3.3V
3	Register Bit 1	FVAL	I/O	Unbuffered 3.3V
4	Register Bit 0	LVAL	I/O	Unbuffered 3.3V
5	Data Bit 7	Data Bit 7	I/O	Unbuffered 3.3V
6	Data Bit 6	Data Bit 6	I/O	Unbuffered 3.3V
7	Data Bit 5	Data Bit 5	I/O	Unbuffered 3.3V
8	Data Bit 4	Data Bit 4	I/O	Unbuffered 3.3V
9	Data Bit 3	Data Bit 3	I/O	Unbuffered 3.3V
10	Data Bit 2	Data Bit 2	I/O	Unbuffered 3.3V
11	Data Bit 1	Data Bit 1	I/O	Unbuffered 3.3V
12	Data Bit 0	Data Bit 0	I/O	Unbuffered 3.3V
13	GND	GND		Computer Ground
14	GND	GND		Computer Ground

2.1.4 X6 Programmer

The programmer connector is used by Basler to program the Bridge.

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2.1.5 X8 Camera Power Supply

Pin	Name	Direction	Remark
1	Power Supply (Positive)	In	24 Volt to X1/2
2	Power Supply (Ground)	In	24 Volt to X1/2

To power the camera, 24V can be supplied externally via a female screw-type terminal block accessible from inside the PC housing. The following signals are assigned to the connector:

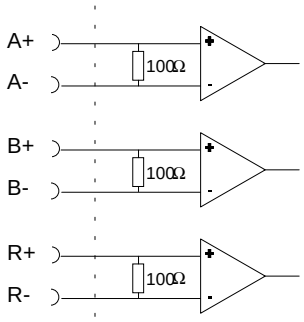
- + 24V, PC-GND

The power supplied is then output via the respective Camera connector (see section 2.1.1 'Video Inputs X1/2').

To prevent different electrical potentials, be sure that your Camera Ground is connected to the Computer Ground or Earth. With R 105 on the PCB, the Camera GND is set to the Computer GND.

2.1.6 X9 Incremental Encoder

An incremental encoder with track A, track B and track R can be connected to the peripheral block. The corresponding input lines IncA, IncB and IncR are designed according to RS422 standard. The incremental encoder can be supplied with +5V or +12V (max. 200 mA each) directly from the card.



The incremental encoder can be operated in two modes which can be set via the PC via the I^2C bus commands:

- **Interrupt mode:** The 16 Bit counter T1 of the Custom AVR can be addressed directly via IncA. In this case, the analog comparator can be used to cause an interrupt with a pulse on line IncR. The reference voltage required on line IncB for this mode of operation is supplied by the Bridge. The track B signal from the incremental encoder is separated from the input line and set to 2.5V by using an I2C command (see the Low Level Communication documentation). It is thus possible to cause an interrupt with the IncR signal via the analog

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comparator input of the Custom AVR.



Bridge program version information:

Setting IncB to 2.5V via the I2C command is only possible from **Bridge program version 1.10** or higher.

- **Polling mode:** If the signals are evaluated four times, that is, by evaluating the rising and falling edges of IncA and IncB, they have to be polled via the software.

The differential lines for the incremental encoder are accessible via connector X9 on the board. The following signals are assigned to the DSUB9 connector. Pin assignment X9 refers to the pin assignment on the board, Ad Pin refers to the pin assignment of an available adapter to an additional end-bracket:

X9 Pin	Ad* Pin	Direction	Description
1	1	IN	IncA+
2	2	IN	IncA-
3	3	IN	IncB+
4	4	IN	IncB-
5	5	IN	IncR+
6	6	IN	IncR-
7	7		Digital GND
8	8	OUT	5V, computer-supplied, max. 200 mA
9	9	OUT	12V, computer-supplied, max. 200 mA
10	-	n.c.	

*adapter 10 pin to 9 pin SUBD connector

2.1.7 X10 Digital I/O

The digital IO is accessible and used exclusively by the Custom AVR. All lines are connected to the Custom AVR.

Pin	Direction	Description
1		Digital GND

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Pin	Direction	Description
2	Digital IN	In0 to Serial input RxD / PD0
3	Digital IN	In1 to Serial input TxD / PD1
4	Digital IN	In2 to PD2, interrupt line
5	Digital IN	In3 to PD3, interrupt line
6	Digital IN	In4 to PD4
7	Digital IN	In5 to PD5
8	Digital IN	In6 to PD6
9	Digital IN	In7 to PD7
10	Digital OUT	Out0 to PC0, signal line (collector)
11	Digital OUT	PC0, GND (emitter)
12	Digital OUT	Out1 to PC1, signal line (collector)
13	Digital OUT	PC1, GND (emitter)
14	Digital OUT	Out2 to PC2, signal line (collector)
15	Digital OUT	PC2, GND (emitter)
16	Digital OUT	Out3 to PC3, signal line (collector)
17	Digital OUT	PC3, GND (emitter)
18	Digital OUT	Out4 to PC4, signal line (collector)
19	Digital OUT	PC4, GND (emitter)
20	Digital OUT	Out5 to PC5, signal line (collector)
21	Digital OUT	PC5, GND (emitter)
22	Digital OUT	Out6 to PC6, signal line (collector)
23	Digital OUT	PC6, GND (emitter)
24	Digital OUT	Out7 to PC7, signal line (collector)
25	Digital OUT	PC7, GND (emitter)
26	n.c.	

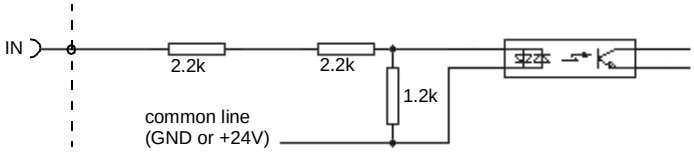
The I/O lines are accessible via a flat cable connector at X10 on the PCB. It is possible to connect to a DSUB25 female connector on a separate end-bracket via a flat cable. Then, the following signals are assigned to the DSUB25 connector:

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- In0, In1, ..., In7
- Common digital line (+24V or GND) for all input signals
- C.Out0, C.Out1, ..., C.Out7 (”Collector”)
- E.Out0, E.Out1, ..., E.Out7 (”Emitter”)

2.1.7.1 Digital Inputs (In0..In7)

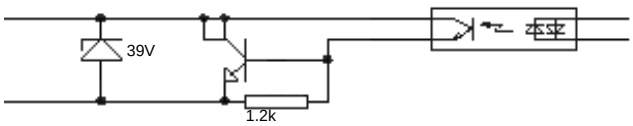
These interface groups consist of 8 digital inputs (one byte). The inputs are opto-decoupled. All 8 inputs are connected to a common line which can either be +24V or 0V. The optocouplers have two antiparallel LEDs. The switching thresholds of the inputs depend on the variance of the different optocouplers. The logical signal definition is undefined in a range of 13V to 16V. The input bit is **logical 1** below 13V, and **0** above 16V. The input resistance is 5.6 kΩ.



Only inputs In2 and In3 can cause an interrupt in the Custom AVR. The other input lines must be polled cyclically if required.

2.1.7.2 Digital Output (Out0..Out7)

The digital output interface group consists of 8 digital opto-decoupled output lines. The poles of the respective output transistors are accessible as separate lines. As a result, the user can choose whether to operate the transistors in pull-up or in pull-down mode. There is no protection against short-circuiting.



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The output lines are accessible via the same cable/connector used for the input lines.

Max. voltage of a single output:	60V
Max. current of a single output:	1A
Power of a single output:	3W
Total power of all outputs:	12W

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2.2 Internal Signals and Connections

2.2.1 Port Assignment of Custom AVR

Port	Custom AVR	Direction	Frame-grabber	Description
PA0		IN	IN0	Digital input
PA1		IN	IN0	Digital input
PA2		IN / OUT		Serial connection to Flex
PA3		IN / OUT		Serial connection to Flex
PA4		IN / OUT		Serial connection to Flex
PA5		IN	FVAL B	optional: FVal B
PA6		OUT	IRQOUT	Interrupt input atFlex
PA7		IN	LVAL B	optional: LVAL B
PB0	T0 (8 Bit)	IN	LVAL A	optional: LVAL A
PB1	T1 (16 Bit)	IN	IncA	Incremental encoder track A
PB2	AIN0	IN	IncB, 2.5V	Incremental encoder track B or 2.5V
PB3	AIN1	IN	IncR	Incremental encoder track R (Reset)
PB4	\SS2	IN	\SS2	SPI Acknowledge to Bridge
PB5	MOSI	IN	MOSI	SPI Data input to Bridge
PB6	MISO	OUT	MISO	SPI Data output to Bridge
PB7	SCK	IN	SCK	SPI Clock to Bridge
PC0		OUT	Out0	Digital output
PC1		OUT	Out1	Digital output
PC2		OUT	Out2	Digital output
PC3		OUT	Out3	Digital output
PC4		OUT	Out4	Digital output
PC5		OUT	Out5	Digital output
PC6		OUT	Out6	Digital output
PC7		OUT	Out7	Digital output
PD0	RxD	IN	RxD	RxD to Flex
PD1	TxD	IN	TxD	TxD to Flex
PD2	INT0	IN	In2	Digital input (and interrupt line)

Table 2-1: Port assignment of Custom AVR (selection of connections)

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Port	Custom AVR	Direction	Frame-grabber	Description
PD3	INT1	IN	In3	Digital input (and interrupt line)
PD4		IN	In4	Digital input
PD5		IN	In5	Digital input
PD6		IN	In6	Digital input
PD7		IN	In7	Digital input
	\RESET	IN	\RESET	Reset from Bridge
	ICP	IN	FVAL A	FVAL A from Flex
	OC1B	OUT		Command to Bridge to apply 2.5V to IncB

Table 2-1: Port assignment of Custom AVR (selection of connections)

2.2.2 Signals Between Altera Flex and Custom AVR

2.2.2.1 Video (FVal and LVal)

The Altera Flex sends the FVal (Frame valid) and LVal (Line valid) video signals from each channel to the Custom AVR so that the Custom AVR can keep track of them.

2.2.2.2 Custom AVR Interrupt

The Custom AVR can send an interrupt to the SAA7146. There is one Interrupt line from Custom AVR to the Altera Flex. The Altera Flex forwards the signal to the SAA7146 via the GPIO2 and GPIO3 signals to the SAA7146.

2.2.2.3 Serial (Not yet implemented)

There will be 3 serial lines to enable the exchange of more complex commands between Custom AVR and Altera Flex.

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2.2.3 Signals Between Altera Flex and SAA7146

2.2.3.1 Video A / B

Video A / B are the video data and synchronization signals that the Altera Flex transfers to the SAA7146.

2.2.3.2 Address / Data Bus

This bus is used for the communication between Altera Flex, SAA7146 and thus the PC and the driver software.

2.2.3.3 Programming GPIO / IRQ (2)

There are four lines. The lower three lines are used while programming the Altera Flex. After programming, the lower 2 lines are not allowed to be used since this would damage the program. The upper two lines can now be used as interrupt lines.

2.2.4 SPI (MOSI, MISO, SCK, \SS2, \RESET)

The Custom AVR communicates with the PC via the Serial Peripheral Interface (SPI) and a handshake line (SS2). The Philips SAA7146 provides an I^2C interface and an external interrupt input. The SPI is connected to this interface via a Bridge which converts the protocol. The \RESET line is used to set the Custom AVR into download mode for programming it. Communication is handled by the driver software. For detailed information see the Low Level Communication PC Custom AVR Manual.

2.2.5 I^2C Interface

The Philips SAA7146 provides an I^2C interface which can only be operated in master mode. The Bridge can be addressed via this interface. In addition, the Custom AVR can be set to download mode via this interface and the Bridge.

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2.3 Status LED of Altera Flex

LED color	Description
Red and green	No program loaded in Altera Flex
Green	Program is being loaded
Not illuminated	Program is loaded. This is the normal state of the LED.

2.4 Camera Cable HPC36p (3m)

The 3m camera cable HPC36p connects Basler cameras to the BASLER Fg2dPci. The cable can be used to connect the following cameras:

- BASLER A113/A113P/A113C/A113CP
- BASLER L1x0 in single output mode
- BASLER L2x0 in single output mode

It has the Basler order no. **1000005377**.

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