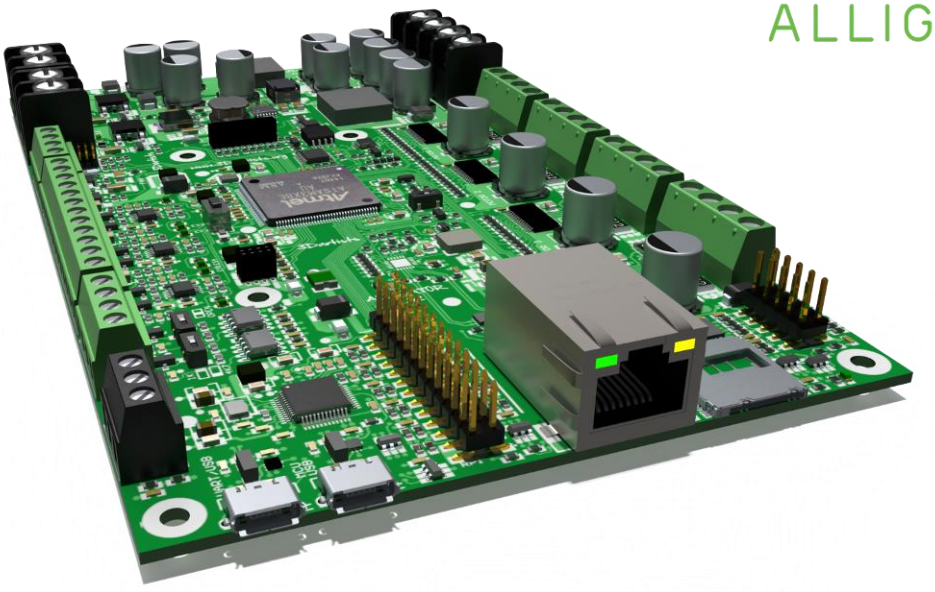
3D Artists

Alligator Board Rev.2

The New Generation Electronic for 3D printers

For Makers and Professionals

ALLIGATOR



Alligator Board Rev.02

3D Printer Electronic Board

User Manual

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Document Status: **Draft**
Release Date: **October 2014**

This document discusses and illustrates the features, capabilities, and configuration requirements of the Alligator Board Rev.02. It is intended for technicians who are designing 3D printing solution with the Alligator Board.

Disclaimer

Related Information

Documents

[DOC-01]	*3D-SCH000001-R02.pdf*	**Schematic Files**: schematic files of the Alligator Board (rev02)
[DOC-02]	*3D-SCH000002-R01.pdf*	**Schematic Files**: schematic files of the Piggy Expansion Module (rev01)

Webpages

[WEB-01]	*www.3DAsrtists.org*	**Product information**: describes the 3D Artists products features, benefits, and typical applications. This webpage also provides links to other product-related information located on the 3D Artists website.
[WEB-01]	*https://github.com/3Dartists*	**3D Artists GitHub Page:** The repository stores the designs files related to the 3D Artists products, including the Alligator Board. Part of the published material is the schematic files.

Document Status Information

3D Artists technical documents are classified as either *Draft*, *Advanced* or *Final*:

Draft:	The draft documents contain information about the product which may be incomplete and a revision is required. This type of manual is subject to frequent updates
Advanced:	The advanced documents are near to be the final revision, but still subject to be revised in same parts
Final:	The final documents contains information about the final revision of the product and is subject to change only if an error is detected

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Summary

Overview

The new generation electronic for 3D printer.

The Alligator is designed to be a complete and reliable solution as RepRap 3D printer electronic control board. The base module features everything you need to build a standard 3D printer, and with the expansion piggy this is the most complete solution for complex 3D printer.

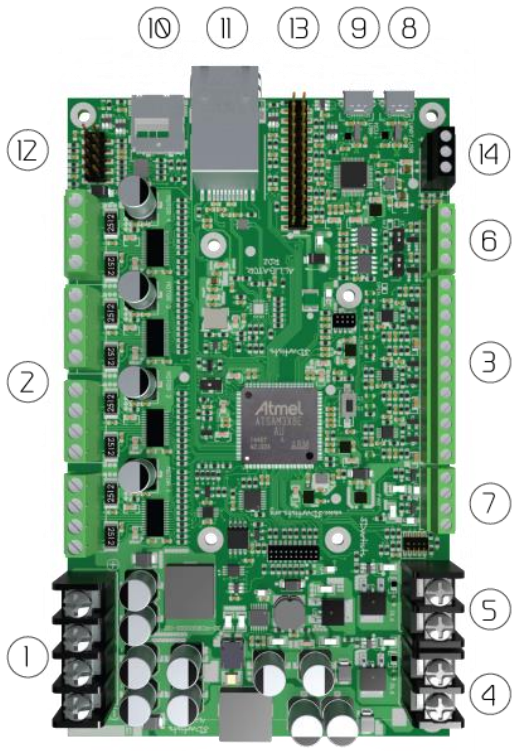
It is based on the 32 bit Cortex M3 ATSAM3X8EA microcontroller, the same CPU of Arduino Due. This represents a big step forward towards greater computing power, compared to the existing solution based on 8 bit mcu. This means that this product is well suited for any kind of 3D printer, and is the ideal solution for Delta models, which require more complex calculus for its coordinates resolution.

The professional design of every part takes care of the needs of the most exigent makers, ensuring best performances in your application.

Alligator Board Fetures

- 32 bit ARM Cortex M3 **ATSAM3X8EA** cpu running @ 84MHz (same Arduino Due cpu)
- Power supply: **12V÷24V**
- 4 on board stepper motor driver (DRV8825)
  - **Firmware configurable current** up to 2.5A (no trimmer)
  - **Firmware configurable step size** 1/16 or 1/32
- **6 end-stop inputs** compatible with both mechanical and optical/magnetic solution
- High current hot-end and bed heater output with **high current connectors** (up to 20A)
- 2 precision RTD measurement input, with configurable excitation current
- Dual output FAN driver
- Native USB OTG port
- USB to Virtual Com Port interface
- **10/100 Ethernet** port, with unique **MAC** address (pre-programmed on-board chip)
- microSD Card slot
- 26pin **Raspberry-PI** interface with power
- 10 pin general purpose expansion connector with **firmware selectable** +3V3/+5V logic levels (for LCD or other custom add-ons)
- 3 PWM outputs, configurable for RGB led, servo motor or custom applications
- 32Mbit of FLASH memory
- 64Kbit of EEPROM
- Expansion connectors for Optional Piggy Module Board
- **Filtered Power supply**
- **EMI** and **ESD** protection on all interfaces
- **High expansion interfaces capabilities**

Base Module Features



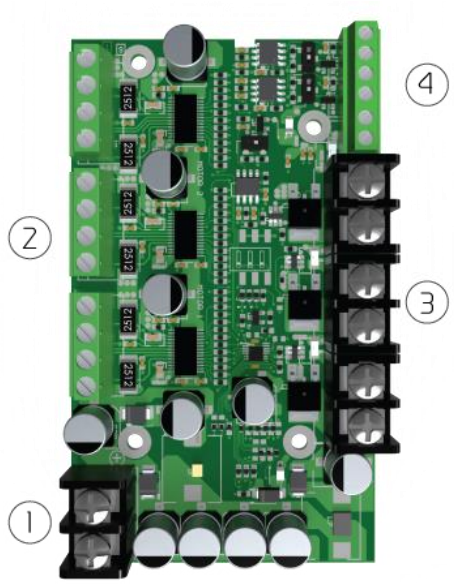
CPU Cortex M3 Atmel ATSAM3X8EA-AU
32Mbit (4Mbyte) of flash memory
640Kbytes of EEPROM memory

High Current connector for power input, bed and hot-end heaters
Filtered power supply to reduce EMI suscettivity
ESD protected I/O

1. Power Input 12-24Vdc
2. 4x Stepper Motor driver based on Texas Instrument DRV8825
   - Up to 2.5A current, firmware configurable (no trimmer)
   - Firmware Configurable microstep size (1/16 or 1/32)
3. 6x End-Stop input compatible with both mecahnical and optical/magnetic solution
4. High current Hot-End Heater driver output (High-Current connector)
5. High current Bed Heater driver output (High-Current connector)
6. 2x Precision analog input for temperature measurement with RTD (or thermocouple with external adapter)
7. 2x External FAN output with PWM speed control
8. 1x USB to Virtual COM port interface (micro USB connector)
9. 1x Native microcontroller USB OTG port, firmware configurable (micro USB connector)
10. microSD Slot
11. 10/100 Ethernet Port with unique MAC address pre-programmed chip
12. Expansion connector with 3 UART, or 6 GPIO, with firmware selectable +3V3/+5V logic levels
13. 26pin Raspberry-PI Compatible expansion connector
14. 3x Generic PWM open drain output for general purpose application (i.e. RGB LED)

Figure 1 – Alligator Board Base Module

Optional Expansion Piggy Module Features



1. Power Input 12-24Vdc
2. 3x Stepper Motor driver based on Texas Instrument DRV8825
   - Up to 2.5A current, firmware configurable (no trimmer)
   - Firmware Configurable microstep size (1/16 or 1/32)
3. 3x High current Hot-End Heater driver output (High-Current connector)
4. 3x RTD precision analog input with selectable excitation current

Figure 2 – Alligator Board Piggy Expansion Module

Board Dimensions

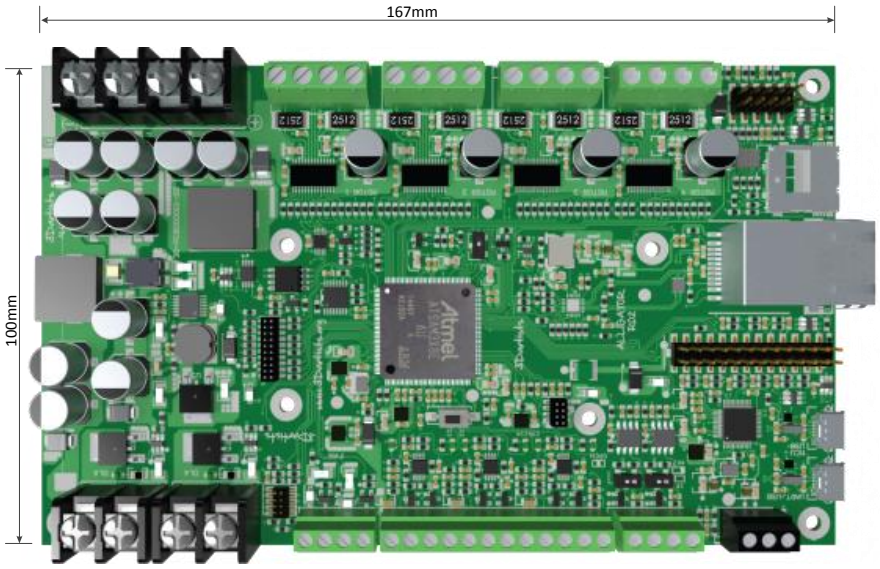


Figure 3 – Alligator Board Base module dimensions

Alligator Board details and Configuration

Power Supply

The board can be powered with a regulated power supply in the range +12V, +24V.

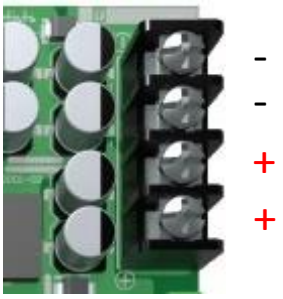


Figure 4 – Power supply High Current connector

Bed and Hot-End heaters

Both the bed heater and the hot-end heaters can be connected to the board using the high current connector as in Figure 5.

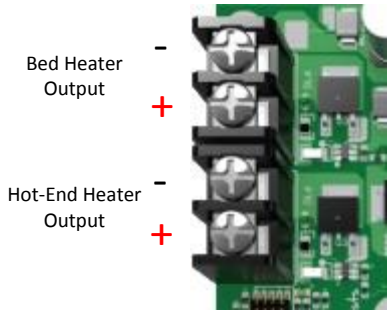


Figure 5 – Hot-End and Bed heaters High Current connectors

Voltage Output	Same as Main Power Supply Input
Maximum Current Output (Bed + Hot-End)	20A

Table 1 – High Current Output electrical characteristics

Note. The maximum current load for the high current output (bed + hot-end) is 20A. Then, for example, if you use a 8A hot-end heater, you should use a bed heater with a maximum current consumption of 12A.

Note. Both bed and hot-end heaters outputs are driven at power input supply voltage. Thus, pay attention to not connect a 12V heaters when powering the board at 24V and vice-versa.

Motor Drivers

The base board features four motor driver, implemented using the Texas Instrument DRV8825 controller. The configuration of the motor current can be via firmware, because the reference voltage required by the DRV8825 is generated using a DAC controlled by the microcontroller via an SPI interface. In this way the user can configure the motor current in a more accurate way, respect to the solution based on trimmers. This solution guarantees to the user that each motor has a precise current value, very important especially in delta architectures. The DRV8825 can be configured via firmware to operate at 1/16 step size or at 1/32 step size.

On Board Motor driver	4
Maximum Motor Current	2.5A
Current selection mode	Firmware selectable in the range 0÷2.5A
Motor step size	Firmware selectable 1/16 or 1/32

Table 2 – Base Module Motor Driver features

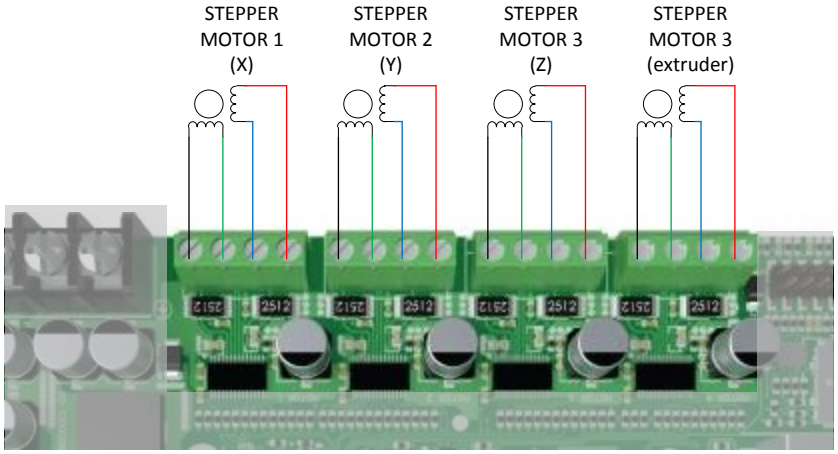


Figure 6 – Motor Driver interface

End Stop interface

The board features three identical block of end-stop interface, with two input on each one, for a total of six digital inputs. Each group makes available a regulated and filtered +5V supply voltage, useful to power active end-stop solutions, such as optical or magnetic ones. The presence of six channels allow the user to connect up to two end-stop for each axis, using for example a maximum and minimum position for each one.
The Figure 7 shows an example of connection for a complete set of end-stop. The user can also use only three inputs, with only one end-stop for each axis.

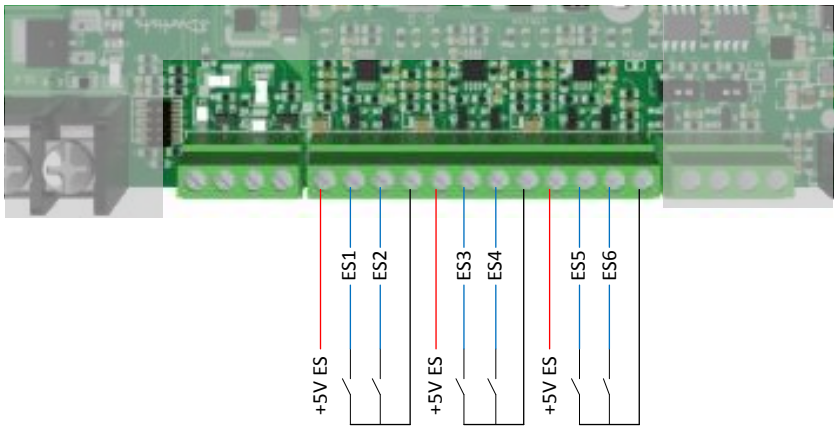


Figure 7 – End Stop Interface

RTD Analog input

The board features two RTD inputs, which can be used to be connected to the bed and hot-end thermistors.

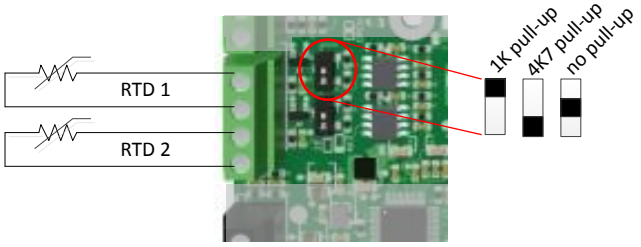


Figure 8 – RTD temperature sensor interface

The pull-up resistor can be selected acting on the dedicated dip-switch, as shown in the picture. It is also possible to directly connect an external analog source to the board input, positioning the dip-switch in the middle position, with no pull-up resistor. This option is useful to connect a thermocouple with its adapter, as shown in the following figure.

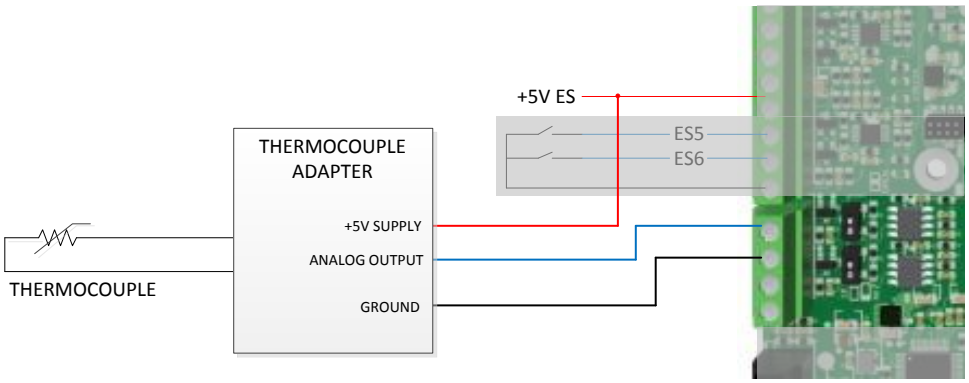


Figure 9 – Thermocouple connection example

FAN driver output

Two FAN can be connected to the board to the relative connector. In many cases the printer needs only one FAN to cool down the melted plastic just printed, but if you want to connect an additional FAN you can. Both the FAN can be driven with a variable PWM via standard G-CODE commands.

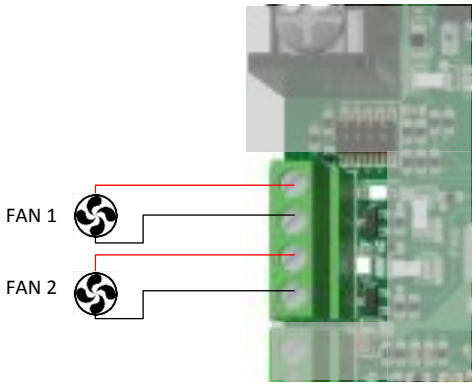


Figure 10 – FAN driver interface

Expansion Connectors

General Purpose Expansion Connector

The Alligator Board features a general purpose expansion connector (J14), with seven GPIO (six of them connected to three microcontroller UART, then configurable as serial interface). An external LCD or any custom expansion can be connected to this connector. The voltage levels of the signals is firmware selectable, and can be set either to +3.3V or to +5V, depending on what kind of external module is connected. The electrical level of the digital lines can be selected acting on the *EXP_VB_SEL* line, as in Table 3.

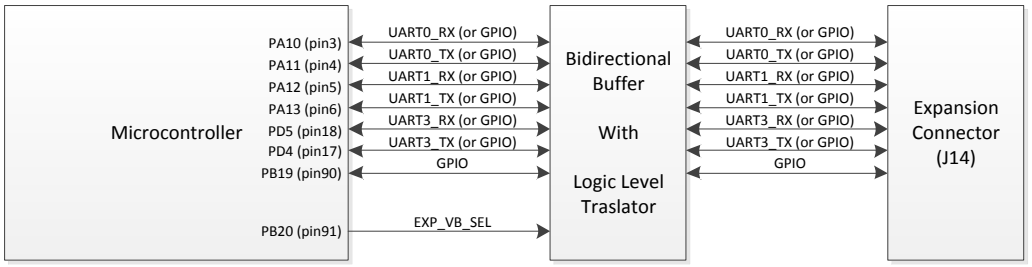
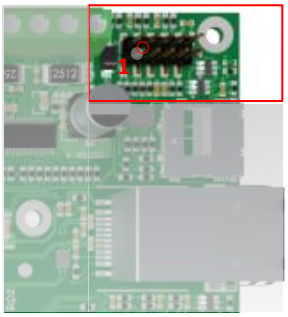


Figure 11 – General Purpose Expansion Connector GPIO block diagram

EXP_VB_SEL value	GPIO Electrical Level
0	+5V
1	+3.3V

Table 3 – General Purpose Expansion Connector GPIO Voltage Selection

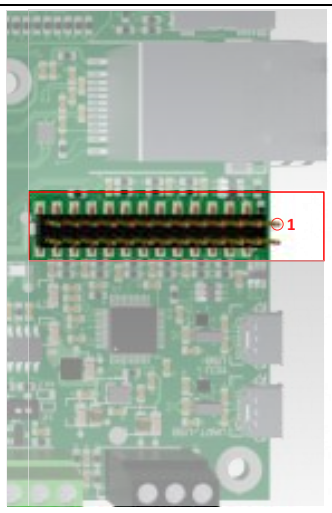


Function	PIN		Function
+5V	1	2	+3V3
USART0_TX (or GPIO)	3	4	EXP_GPIO
USART0_RX (or GPIO)	5	6	USART1_TX (or GPIO)
USART2_TX (or GPIO)	7	8	USART1_RX (or GPIO)
USART2_RX (or GPIO)	9	10	GND

Table 4 – General Purpose Expansion Connector Pin-Out

Raspberry-PI Interface

Through J15 connector, the alligator board can be directly connected to a Raspberry-PI module with a standard 26pin flat cable. The +5V available on pin 2 and pin 4 is able to power-on the Raspberry-PI without the need to use an external dedicated power supply.



Function	PIN		Function
n.c.	1	2	+5V
n.c.	3	4	+5V
n.c.	5	6	GND
n.c.	7	8	RPI_UART0_TX
GND	9	10	RPI_UART0_RX
ERASE_CMD	11	12	RPI_GPIO_1
RPI_GPIO_2	13	14	GND
RESET_CMD	15	16	RPI_GPIO_4
n.c.	17	18	RPI_GPIO_5
n.c.	19	20	GND
n.c.	21	22	RPI_GPIO_6
n.c.	23	24	n.c.
GND	25	26	n.c.

Table 5 – Raspberry-PI Expansion Connector Pin-Out

Piggy Expansion Module Connectors

The alligator board has two expansion connector (J12 and J16) dedicated to the Optional Piggy Expansion Module (Figure 12).

Figure 12 – Piggy Expansion Connectors details

The J12 connector is used for the three additional motor driver signals of the Piggy Expansion, as in Table 6. The J16 connector is used for the three analog signal of the RTD.

Function	PIN		Function
MOTOR_nRESET	1	2	DAC_SCLK
n.c.	3	4	DAC_DIN
n.c.	5	6	DAC_nSYNC_EXP
MOTOR_DIR5	7	8	HE_HEAT_EN2
MOTOR_STEP5	9	10	HE_HEAT_EN3
MOTOR_DIR6	11	12	HE_HEAT_EN4
n.c.	13	14	MOTOR_nFAULT
MOTOR_STEP6	15	16	+5V
MOTOR_DIR7	17	18	+3V3
MOTOR_STEP7	19	20	GND

Table 6 – J12 Piggy Expansion Connector (digital)

Function	PIN		Function
+3V3_ANA	1	2	RTD_VALUE5
AGND	3	4	RTD_VALUE4
AGND	5	6	RTD_VALUE3
AGND	7	8	AGND

Table 7 – J16 Piggy Expansion Connector (analog)

Note. If you do not mount the Optional Expansion Piggy, these two connector can be used also with custom expansion board, or wired out for other applications.

Expansion Connectors Summary

In the following table a summary of the expansion capabilities of the Alligator Board is explained.

Signal Name	Available On Connector / Pin	High Level Voltage	Note
USART0_TX (or GPIO)	J14 / pin 3	Firmware selectable +3.3V / +5V	
USART0_RX (or GPIO)	J14 / pin 5	Firmware selectable +3.3V / +5V	
USART1_TX (or GPIO)	J14 / pin 6	Firmware selectable +3.3V / +5V	
USART1_RX (or GPIO)	J14 / pin 8	Firmware selectable +3.3V / +5V	
USART2_TX (or GPIO)	J14 / pin 7	Firmware selectable +3.3V / +5V	
USART2_RX (or GPIO)	J14 / pin 9	Firmware selectable +3.3V / +5V	
EXP_GPIO	J14 / pin 4	Firmware selectable +3.3V / +5V	
ERASE_CMD (RPI_GPIO_0)	J15 / pin 11	+3.3V	
RPI_GPIO_1	J15 / pin 12	+3.3V	Available as GPIO only if Raspberry-PI is not connected to the Alligator Board
RPI_GPIO_2	J15 / pin 13	+3.3V	
RESET_CMD (RPI_GPIO_3)	J15 / pin 15	+3.3V	
RPI_GPIO_4	J15 / pin 16	+3.3V	
RPI_GPIO_5	J15 / pin 18	+3.3V	
RPI_GPIO_6	J15 / pin 22	+3.3V	
MOTOR_nRESET (or GPIO)	J12 / pin 1	+3.3V	Available as GPIO only if the Piggy module is not installed on the Alligator Board
P_GPIO	J12 / pin 3	+3.3V	
MOTOR_DIR5 (or GPIO)	J12 / pin 7	+3.3V	
MOTOR_STEP5 (or GPIO)	J12 / pin 9	+3.3V	
MOTOR_DIR6 (or GPIO)	J12 / pin 11	+3.3V	
MOTOR_STEP6 (or GPIO)	J12 / pin 15	+3.3V	
MOTOR_DIR7 (or GPIO)	J12 / pin 17	+3.3V	
MOTOR_STEP7 (or GPIO)	J12 / pin 19	+3.3V	
HE_HEAT_EN2 (or GPIO)	J12 / pin 8	+3.3V	
HE_HEAT_EN3 (or GPIO)	J12 / pin 10	+3.3V	
HE_HEAT_EN4 (or GPIO)	J12 / pin 12	+3.3V	
MOTOR_nFAULT (or GPIO)	J12 / pin 14	+3.3V	
EXT_PWM1 (or GPIO)	J5 / pin 3	+3.3V	Configurable also as PWM output
EXT_PWM2 (or GPIO)	J5 / pin 2	+3.3V	Configurable also as PWM output
EXT_PWM3 (or GPIO)	J5 / pin 1	+3.3V	Configurable also as PWM output
RTD_VALUE5	J16 / pin 2	Analog input only	Available as GPIO only if the Piggy module is not installed on the Alligator Board
RTD_VALUE4	J16 / pin 4	Analog input only	
RTD_VALUE3	J16 / pin 6	Analog input only	

Table 8 – Expansion Connector summary

USB Interfaces and Debug Port

The Alligator Board features two USB interfaces (see Figure 13 for details):

- Native microcontroller USB port (USB OTG port)
- USB/UART VCP (Virtual Com Port)

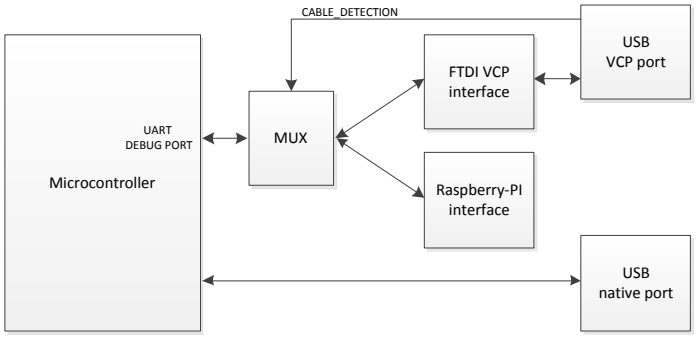


Figure 13 – USB interfaces and Debug UART block diagram

The Native USB port is directly connected to and controlled by the microcontroller.
The USB VCP interface is implemented using an FTDI USB to UART converter, connected to the debug UART of the microcontroller. The debug UART of the microcontroller is connected also to the raspberry-PI connector through a multiplexer. In this way the Alligator Board can be controlled and programmed either using a standard PC or via the Raspberry-PI. The multiplexer is controlled with this logic:

- when the USB connector is unplugged into the USB-VCP connector, the debug UART signals are routed to the raspberry connector. In this way if the Raspberry-PI is connected to the Alligator Board it can either control and also reprogram the cpu firmware, without any other connections or configuration.
- when the USB connector is plugged into the USB-VCP connector, the debug UART signals are routed to USB to UART converter. In this way the user can control the 3D printer using a standard PC

Note: If you connect the USB cable to the FTDI port (ref.8 on Figure 1), the raspberry UART is not available. The user can continue to use the Raspberry-Pi signals excepts for the RPI_UART0_TX (pin 8) and RPI_UART0_RX (pin 10)

Warning: Native port has OTG function, they are directly connected to 5V power! Do not connect Native USB port to the PC in presence of 12-24V power input. Communicate with Alligator and with your printer only from the USB/UART port. Native port should be used only as Host OTG.
Native port connected directly to the PC can be used only for board testing without 12-24V power input (for expert users only!)

Generic PWM outputs

The board features three generic PWM outputs, that can be used for example to connect a LED for printer illumination, which can be a single color LED (white for example) using only one channel, or an RGB LED using all three channel. These outputs can be also configured via firmware to control servo motors or any kind of general purpose application.

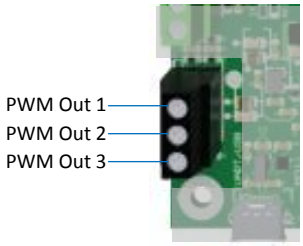


Figure 14 – PWM output interface

JTAG debug port

For expert users, a JTAG port is available. This port can be used to debug or program the Alligator board, using the preferred IDE and JTAG adapter.

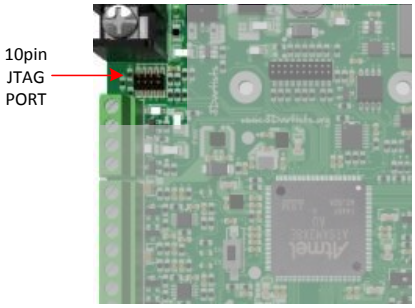


Figure 15 – JTAG Connector

Microcontroller Flash ERASE

The Alligator Board microcontroller flash can be erased in the following two ways:

[OPTION A] – Acting on the S4 Dip-Switch
[OPTION B] – Through the Raspberry-PI header

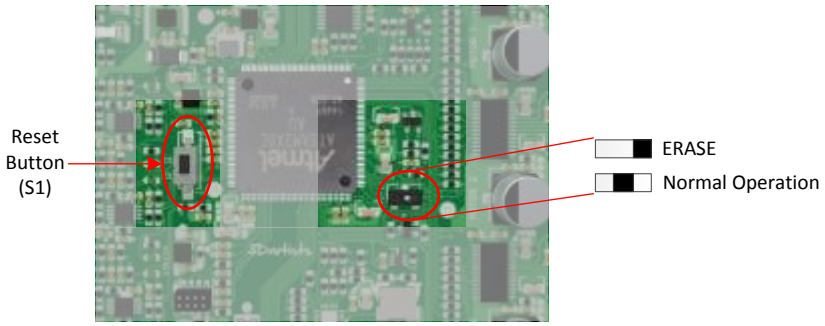


Figure 16 – S4 Dip-Switch configuration

[OPTION A] – To erase the microcontroller using the S4 dip-switch:

- Turn on the Alligator Board
- Move the S4 dip-switch in *ERASE* Mode (see Figure 16)
- Push the reset button (S1)
- Wait for the flash erase operation to be completed (about 1s)
- Move the S4 dip-switch in *Normal Operation* Mode (see Figure 16)
- Push the reset button (S1)

[OPTION B] – To erase the microcontroller using the ERASE_CMD signal available on the Raspberry-PI expansion connector:

- Turn on the Alligator Board
- Set a Low Logic Level (<1V) on the ERASE_CMD signal (pin 11 of J15 connector, see Table 5)
- Wait for the flash erase operation to be completed (about 1s)
- Set a High Logic Level (+3.3V) on the ERASE_CMD signal (pin 11 of J15 connector, see Table 5)

Expansion Piggy

Motor Drivers

The Expansion Piggy module board features three motor driver, implemented using the Texas Instrument DRV8825 controller. The configuration of the motor current can be via firmware, because the reference voltage required by the DRV8825 is generated using a DAC controlled by the microcontroller via an SPI interface. In this way the user can configure the motor current in a more accurate way, respect to the solution based on trimmers. This solution guarantees to the user that each motor has a precise current value, very important especially in delta architectures. The motor driver step-size is fully configurable for each motor S2 dip-switch (see Table 10 for details)

On Board Motor driver	3
Maximum Motor Current	2.5A
Current selection mode	Firmware selectable in the range 0÷2.5A
Motor step size	Fully configurable via dip-switch

Table 9 – Piggy Expansion Module Motor Driver features

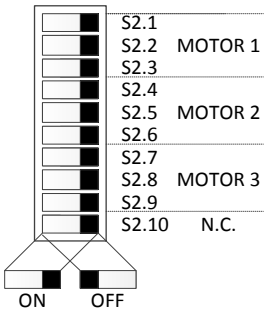


Figure 17 – S2 Dip-Switch configuration

Step Mode	S2 Configuration								
	Motor 1			Motor 2			Motor 3		
	S2.1	S2.2	S2.3	S2.4	S2.5	S2.6	S2.7	S2.8	S2.9
Full Step	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF
1/2 Step	ON	OFF	OFF	ON	OFF	OFF	ON	OFF	OFF
1/4 Step	OFF	ON	OFF	OFF	ON	OFF	OFF	ON	OFF
1/8 Step	ON	ON	OFF	ON	ON	OFF	ON	ON	OFF
1/16 Step	OFF	OFF	ON	OFF	OFF	ON	OFF	OFF	ON
1/32 Step	ON	OFF	ON	ON	OFF	ON	ON	OFF	ON

Table 10 – Piggy Expansion Module Motor Step size settings

Typical Application

Alligator Board Base Module Typical Wiring Diagram

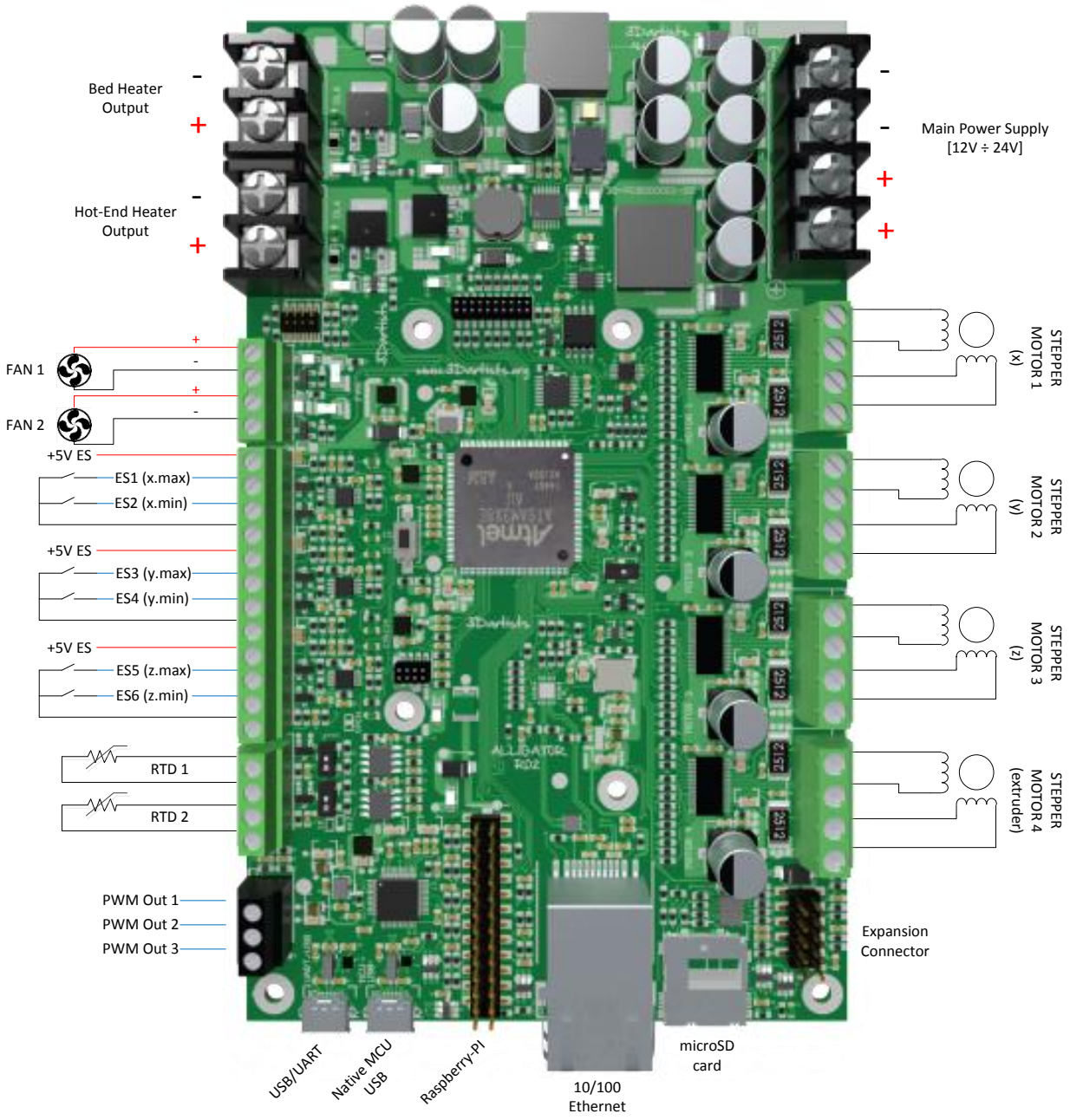


Figure 18 – Alligator Board Base Module Wiring Diagram

Alligator Board Piggy Expansion Module Typical Wiring Diagram

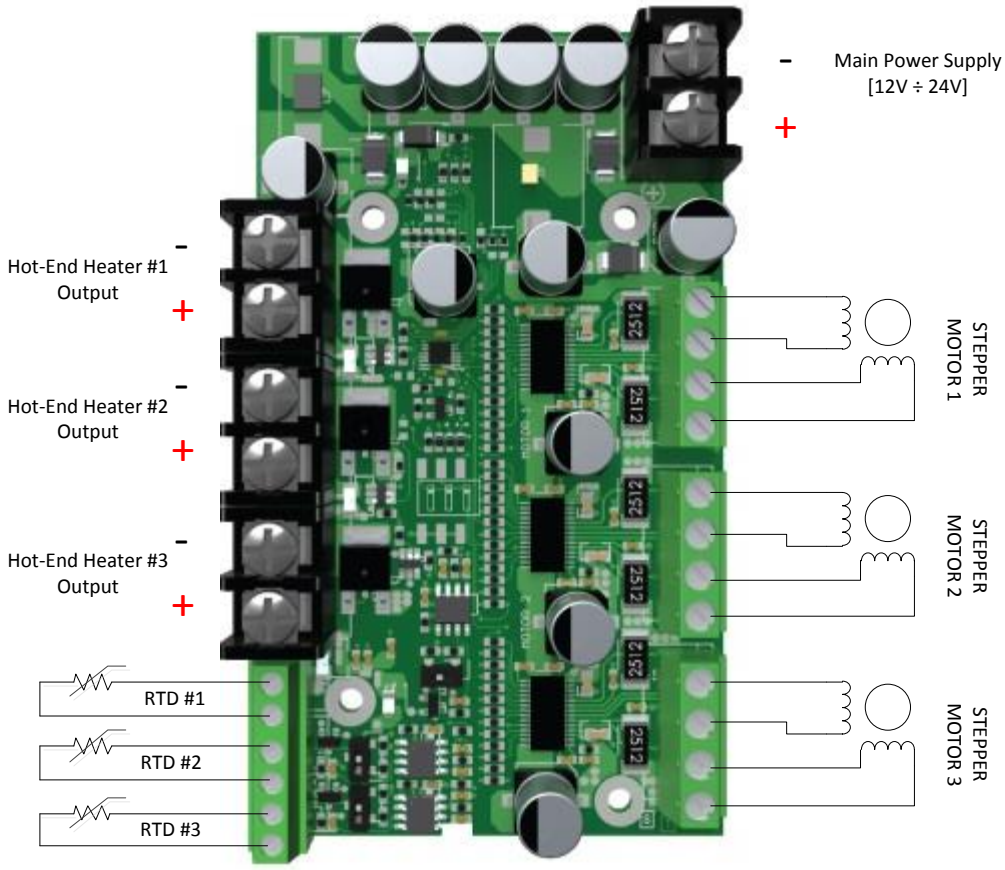


Figure 19 – Alligator Board Piggy Expansion Module Wiring Diagram