

SPEBlox

Tiny 1000 Mbps Single Pair Ethernet Converter

MPN: BB-SPE-F-1

Datasheet

October 2023
Board revision F

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1 General Information

1.1 Functionality and Features of SPEBlox

SPEBlox is the world's first gigabit (1000BASE-T) to Single Pair Ethernet (1000BASE-T1) converter in a tiny (30mm x 30mm) form factor, designed for direct integration into space-constrained networks.

It functions as a transparent bridge between standard gigabit ethernet networks and single pair ethernet networks, working out of the box with one-step hardware configuration and no software configuration.

1.1.1 Features

- 1 x 1000M (1000BASE-T) standard ethernet port
- 1 x 1000M (1000BASE-T1) single pair ethernet
- Input voltage range from 5 to 40V
- Reverse protected voltage input
- Transient protected voltage input
- -40°C to 85°C operation range
- 30mm x 30mm board size
- Molex PicoBlade connectors for power and 1000BASE-T port
- Molex PicoBlade connector for 1000BASE-T1 (SPE) port
- Automatic MDI-X crossover
- Unmanaged (out-the-box) functionality
- Embedded microcontroller to support customized firmware upload for managed switch functions
- Port Activity Indicators

1.1.2 General Information

Voltage Input	5V to 40V DC (65V absolute max)
Voltage Output	None
Supported Protocols	1000BASE-T, 1000BASE-T1 (100BASE-TX is not supported)
Number of ports	1 x 1000BASE-T, 1 x 1000BASE-T1
Power Consumption	1.4W at full data rate
Weight	10 grams
Size	30 mm x 30 mm x 11 mm
Operating Temperature	-40°C to +85°C
Storage Temperature	-55°C to +125°C

Table 1: General Information

1.1.3 General Operating Instructions and System Bring-up

SPEBlox is designed for use in commercial and industrial environments, operating from a nominal supply voltage of 24V, but with the ability to operate from as low as 5V and as high as 40V (60V can be achieved with active cooling).

1000BASE-T1 (singled pair ethernet, SPE) operates using full duplex communication (using echo cancellation) over a single pair of balanced copper cabling between two physical layer transceivers (PHYs). This communication requires the designation of a master PHY and a slave PHY. A master PHY uses a local clock to determine the timing of transmitter operations, whereas a slave PHY recovers the clock from the received signal and uses this for transmitter operations.

Therefore on SPEBlox it is necessary to configure the 1000BASE-T1 PHY on each board to be either a master PHY or a slave PHY. This is done by way of a small solder jumper on the back of the board, shown in figure 1 below.

Standard gigabit Ethernet, 1000BASE-T, also uses a master/slave scheme, however this is automatically negotiated and handled without needing to be explicitly set.

Daisy-chaining in 1000BASE-T1 is not possible. Only two PHYs can form a connection, and they must be a master slave pair.

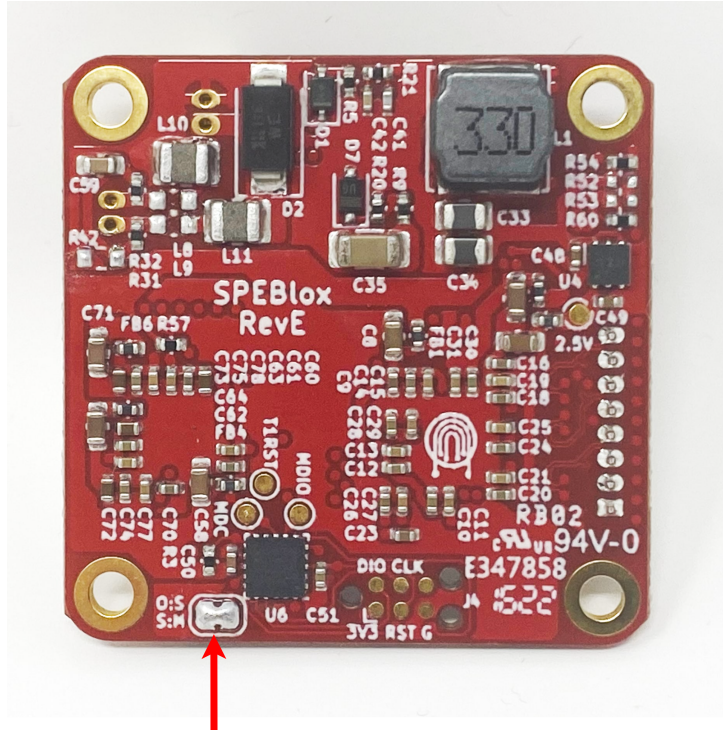


Figure 1: Red arrow showing the location of the master/slave jumper on SPEBlox

Solder jumper closed (soldered): 1000BASE-T1 PHY is **master**

Solder jumper open (unsoldered): 1000BASE-T1 PHY is **slave**

With this in mind, the steps to configure two SPEBlox for a connection are below.

- 1) Configure one SPEBlox as master by shorting the jumper on SPEBlox. You will need a soldering iron and a small amount of solder for this.
- 2) Configure one SPEBlox as slave by opening the jumper on SPEBlox. SPEBlox will usually ship with this jumper unsoldered. If this is the case, you can skip this step.
- 3) Connect each SPEBlox to a standard 1000BASE-T gigabit ethernet port using the supplied RJ45 to Picoblade cables. After power is applied to the board, D10 will flash when the 1000BASE-T link is established.
- 4) Connect the two SPEBlox together via their SPE 1000BASE-T1 port. This connection use your single pair transmission medium. After power is applied to the board, D12 will flash when the 1000BASE-T1 link is established.

- 5) Apply a voltage between 5-40V to both SPEBlox. The power LED will illuminate if the onboard 3.3V rail is valid.
- 6) SPEBlox takes approximately 1-2 seconds to complete bootup, which includes configuration of the onboard PHYs via the onboard STM32 microcontroller.
- 7) After bootup, the master/slave indicator LED (D3) will blink continuously **green** if the board is a master, and **red** if the board is a slave. (Please refer to 2.1 Board Map for the location of this LED).
- 8) You should now be able to communicate between the two 1000BASE-T devices, with the SPEBlox acting as a transparent bridge between the two devices.

Shorting a solder jumper requires a bit of practice. It is crucial to avoid keeping heat on the pads for periods longer than 15 seconds, as this can cause the pads to delaminate.

We suggest studying “PCB solder jumper” methods online before attempting this on SPEBlox.

If you do not see a D12 flash, then it means the SPE link has not been established. The most common cause of this is the transmission medium is too long, or otherwise unsuitable.

1.1.4 Cable Range

The actual range achievable on the single pair ethernet connection depends heavily on the type of cable used, and the number of discontinuities in the cable. Therefore it is not possible to state a specific range. Table 2 below shows a number of test results we have performed, along with indicative lengths.

Maximum transmission distance specified in 1000BASE-T1 specification	40 meters
Maximum distance achieved using a single pair of balanced 28AWG CAT5E unshielded twisted pair cable (UTP)	20 meters
Maximum distance achieved using unbalanced untwisted, 18AWG power wiring	1 meter

Table 2: SPE length ranges

1.2 Safety Information

- This device can operate on voltages near and above 40V. Please read this manual before operating.
- This device is provided “as is”. In-application testing prior to integration is recommended.
- This device is provided as an electronic circuit board, and requires integration into chassis for full ingress protection.
- Do not use this product in wet environments without integrating into a chassis.
- Do not operate this product beyond the rated temperature and voltages.

1.3 Block Diagram

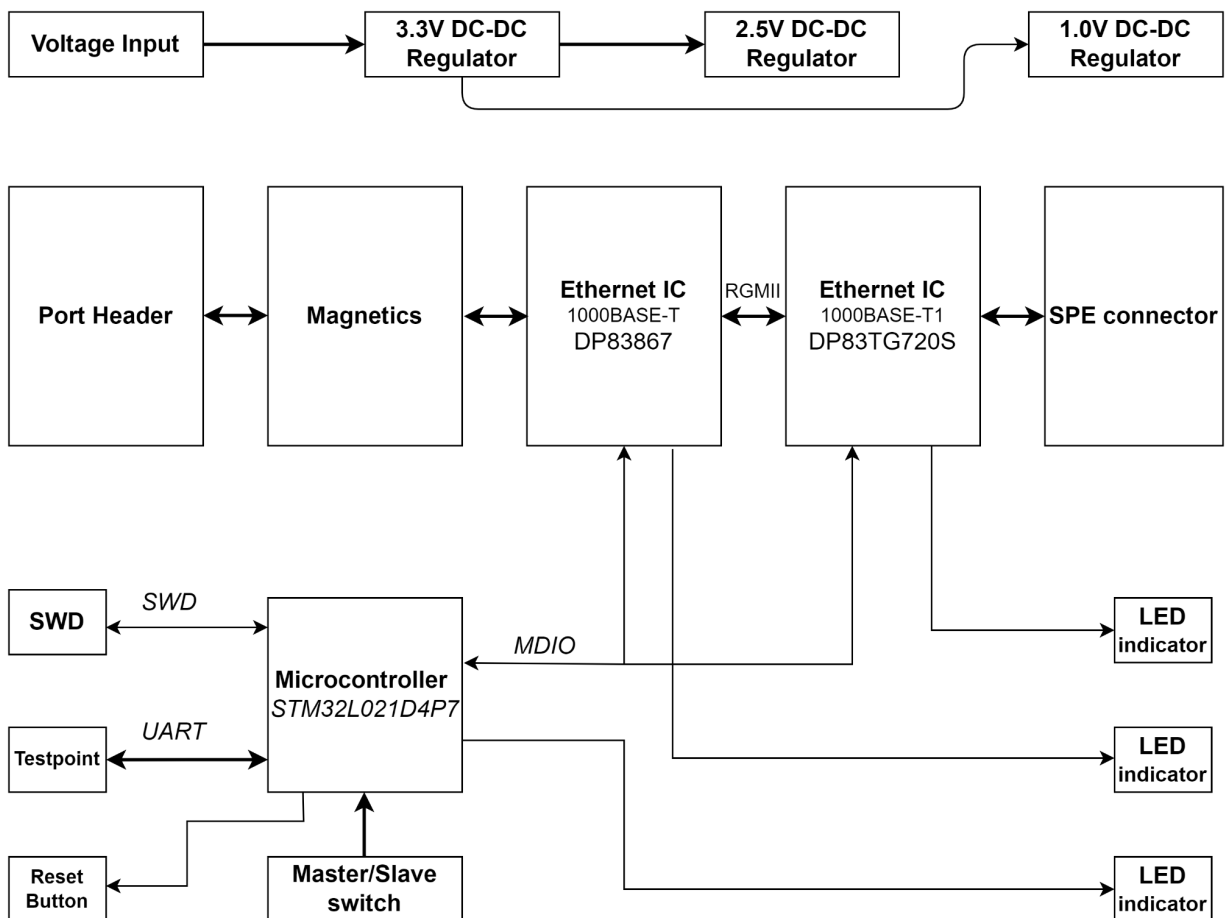


Figure 2: SPEBlox Block Diagram

1.4 Included Equipment

The product includes the following:

1 x SPEBlox board

1 x Molex PicoBlade to RJ45 8-way Shielded Twisted Pair cables (300mm)

1.5 RoHS Certification of Compliance

SPEBlox complies with the RoHS (Restriction of Hazardous Substances Directive) Certificate of Compliance.

2 Hardware Interfaces

2.1 Board Map

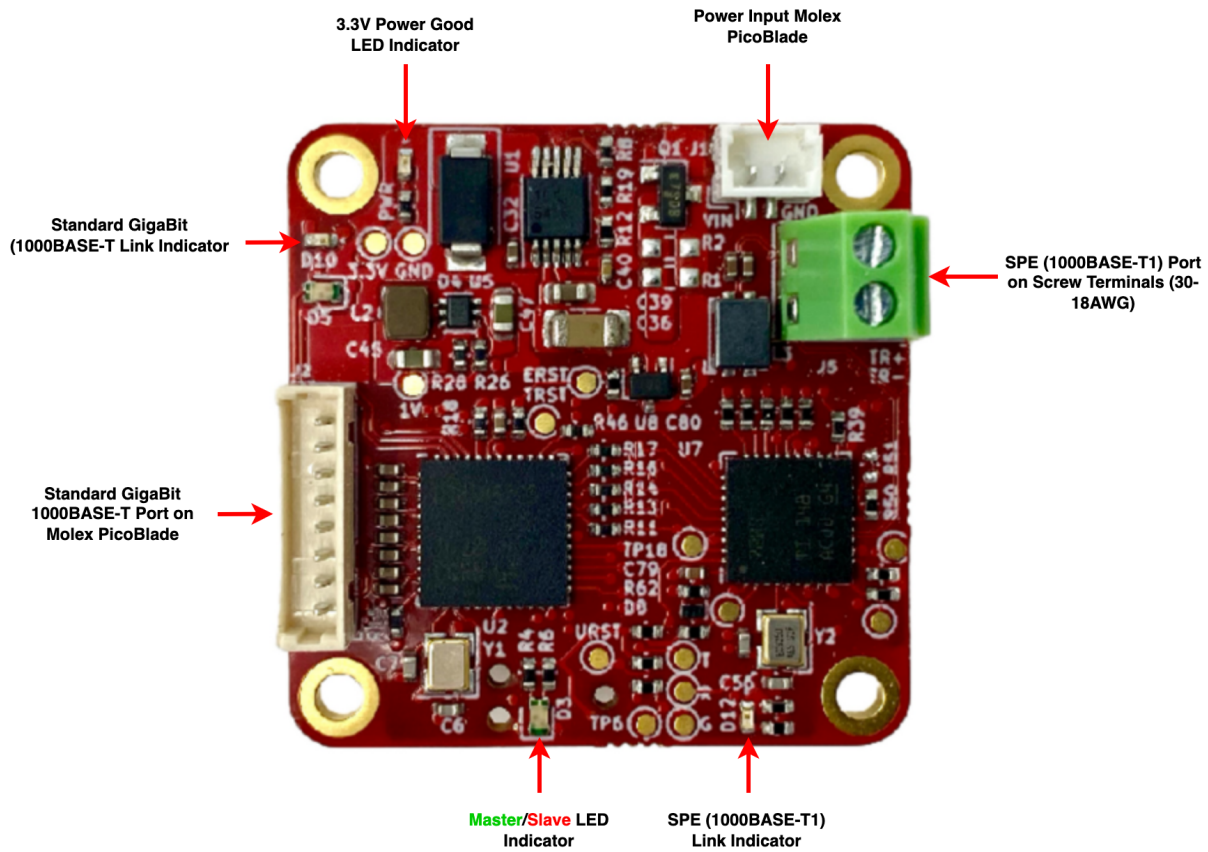


Figure 3: SPEBlox Board Map (front)

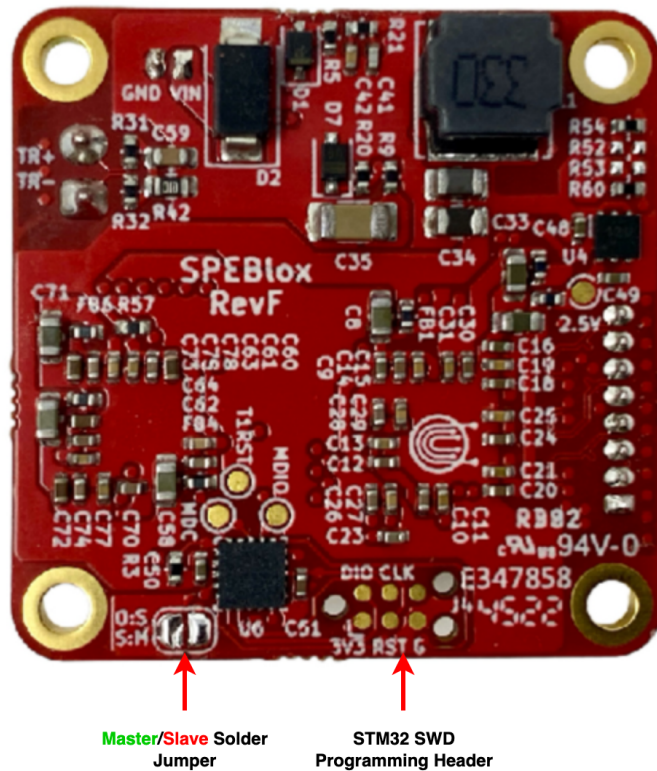


Figure 4: SPEBlox Board Map (back)

2.2 Connectors and Pinouts

2.2.1 Voltage Input

The top right connector is the voltage input terminal. Be careful to not confuse this connector with the SPE port, which is below it. The voltage input has the following features:

- Voltage input range from 5 to 40V
- Maximum transient input of 65V
- Transient voltage protection above 66.3V
- Reverse polarity protection

The pinout of the voltage input connector is shown in figure 5 below.



Figure 5: Voltage input header pinout

Connector part numbers

Connector on board	Mating header	Crimp used	Wire used
530470210	510210200	500798000	UL1061, 28AWG

Table 3: Voltage input connector pinout and part numbers

Cable pinout



Figure 6: Voltage input cable pinout (red = V+, black = GND)

2.2.2 Ethernet Port

The gigabit ethernet connector on SPEBlox has eight pins corresponding to the eight signals required for 1000BASE-T which are A-, A+, B-, B+, D-, D+, C+, C-.

Figure 7 below shows the pinout of the signals. Note that this pinout is unified across all our products, meaning you can use the same cable as with our GigaBlox series (BB-PBRJ1-8-0.3).

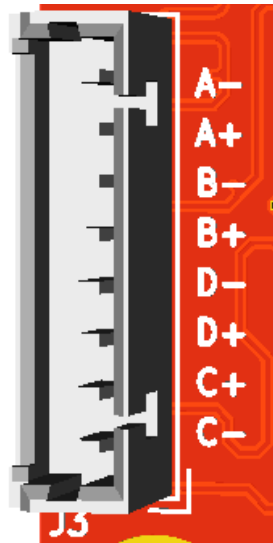


Figure 7: Ethernet port pinout

Connector on board	Mating header	Crimp used	Wire used
530470810	0510210800	500798000	UL1061, 28AWG

Table 4: Ethernet connector pinout and part numbers

Cable pinout

Cable 1
8p Picoblade to RJ-45 300mm

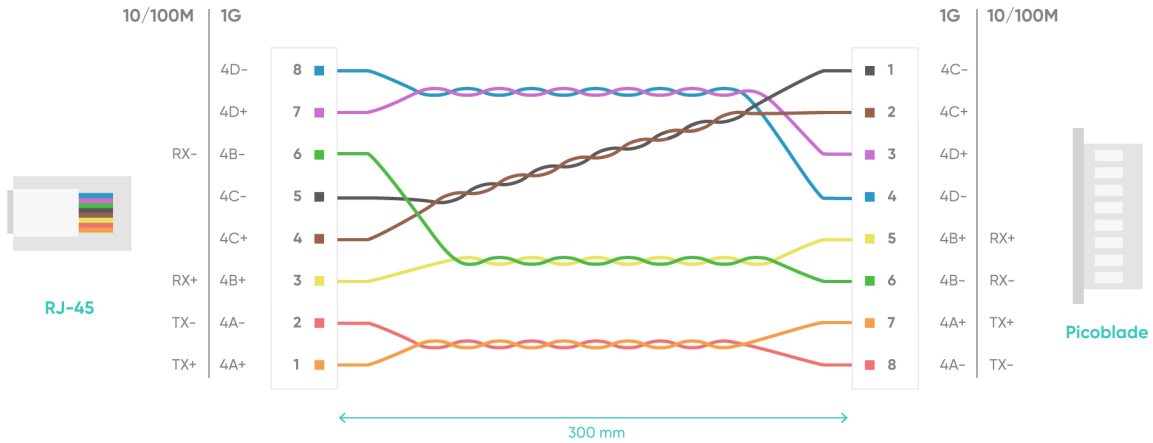


Figure 8: Ethernet cable pinout

2.2.3 SPE Port

The SPE (1000BASE-T1) Port uses a screw terminal to allow full flexibility of cable types.

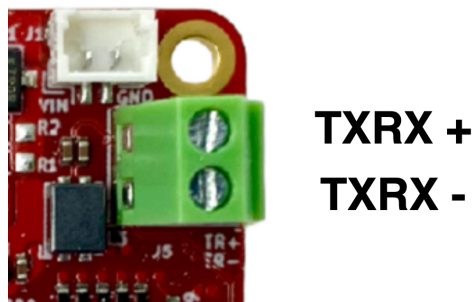


Figure 9: SPE port pinout

Connector on board	Mating header	Crimp used	Wire used
Würth Elektronik 691210910002	NA	NA	30 to 18AWG

Table 5: SPE Screw Terminal connector pinout and part numbers

The use of a screw terminal allows the user to use any type of cable for the SPE connection, as long as the wire gauge is between 30-18AWG. As a general suggestion, we recommend customers to use 28AWG UL1061 wires in a twisted pair, which is very similar to standard ethernet CAT6 cabling.

2.2.4 SWD Programming Header

A programming header on the back of the board allows the STM32L011F4U6 on SPEBlox to be programmed over SWD.



Figure 10: SWD programming header pinout

This header allows access to the SWD port on the onboard STM32 microcontroller, and requires the use of a 6-pin needle adapter such as the [J-Link 6-pin needle adapter](#) along with an in-circuit programmer such as the [J-Link](#).

SPEBlox comes loaded with configuration firmware, therefore we do not recommend reprogramming the onboard STM32 unless you are attempting to access some of the more advanced features of the SPE PHY.

2.3 Other Interfaces

2.3.1 LEDs

There are five LEDs on SPEBlox in total. Two of these LEDs are dual color LED, meaning there are a total of seven LED signals on this board.

The 3.3V Power Indicator LED (**Green**) indicates that voltage is present on the 3.3V line. It should be solid green in normal operation.

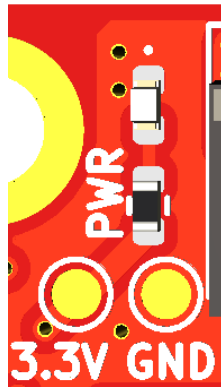


Figure 11: Power Indicator LED

The Dual color LEDs indicate Master/Slave status of device. If SPEBlox is configured as a slave it will flash **Red**; if configured as slave, it will flash **Green**.

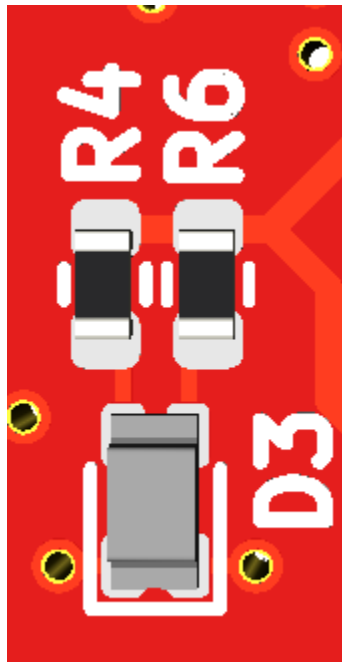


Figure 12: Master/Slave Indicator LED

There is a single LED to indicate SPE activity. This LED indicates link status (**Green**) and blinks for TX/RX Activity.

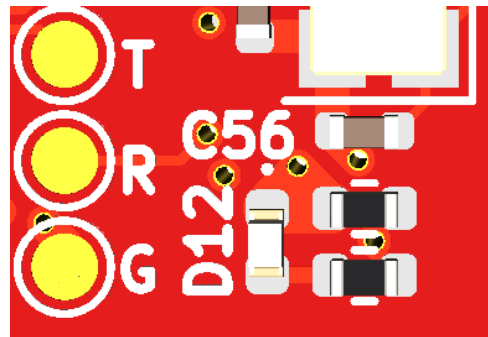


Figure 13: SPE Indicator LED

LED D10 blinks **Green** when 100BASE-T/1000BASE-T link and activity is present.

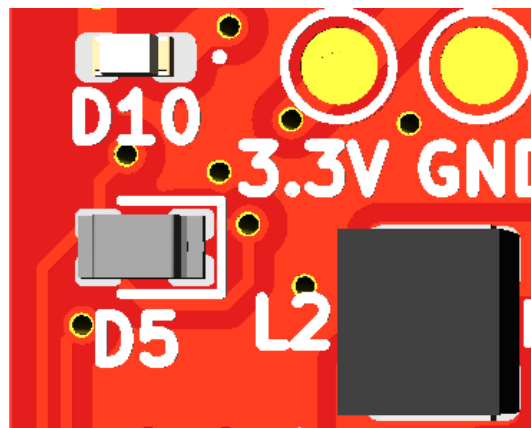


Figure 14: Port Indicator LEDs

2.3.2 Master/Slave configuration via Solder Jumper

In order for two SPEBlox devices to communicate with each other, one needs to be configured as the Master device and the other as a Slave device. An onboard Solder jumper is used to set whether a board is master or slave. Closing the solder jumper configures the device as master while opening it configures it as Slave. The configuration of the board can be verified by the Master/Slave LED indicator D3.

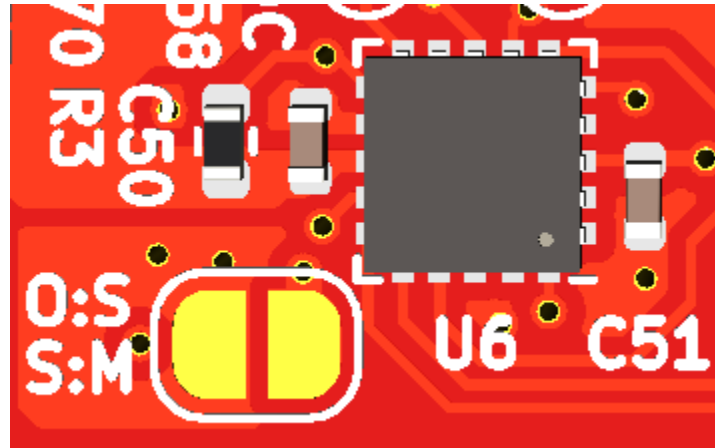


Figure 15: Master/Slave selection

3 Software Interfaces

3.1 UART

Pins PA0 (UART2_RX) and PA9 (UART2_TX) on the onboard STM32L011F4U6 are exposed on test points. Currently there is no UART interface implemented on the onboard STM32, these test points can be used if a UART interface is later implemented.

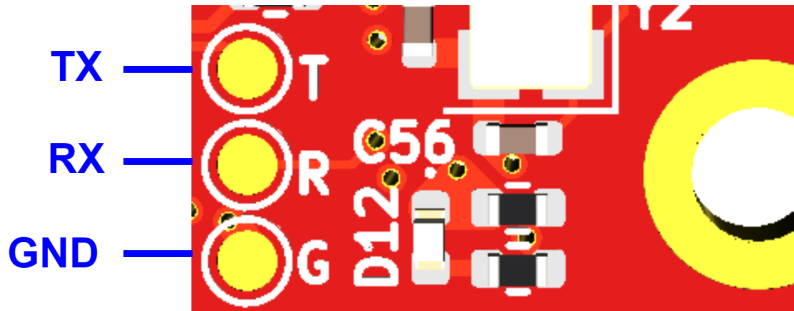


Figure 16: UART Testpoint

4 Device Configuration

4.1 Unmanaged Converter

To use SPEBlox in an unmanaged application you only need set the boards to slave and master mode by the onboard jumper; no other configuration is required. Simply connect a voltage to the voltage input, connect two SPEBlox devices via the SPE port, and connect downstream devices.

The onboard STM32 is preloaded with configuration firmware. This firmware can be modified to vary link parameters such as drive strength, autonegotiation etc. In most cases these parameters should not be varied, however specialist applications may require specific implementations. Please get in touch with us at info@botblox.io for firmware development support.

4.2 Compatibility with other products

SPEBlox can be combined with our gigabit ethernet products by way of a picoblade to picoblade 8-way twisted pair cable. This requires no additional setup, and allows the construction of hybrid 1000BASE-T and 1000BASE-T1 networks.

Figure 17 below illustrates this kind of setup.

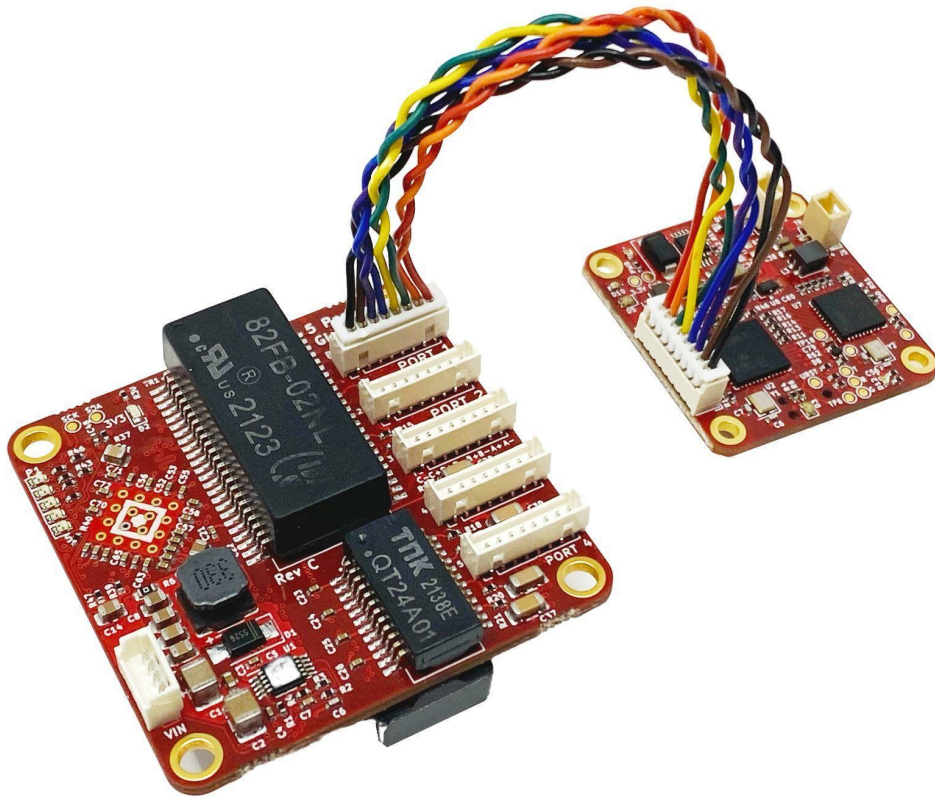


Figure 17: A direct connection between GigaBlox and SPEBlox.

Figure 18 shows the pinout of this cable. This cable needs to be custom manufactured, however we generally keep a stock available; please contact info@botblox.io for a quote. Alternatively a

standard untwisted 8-way Molex PicoBlade cable can also be used for this purpose, MPN: 2181130801; this cable is widely available, which is suitable for cable runs below 1 meter.

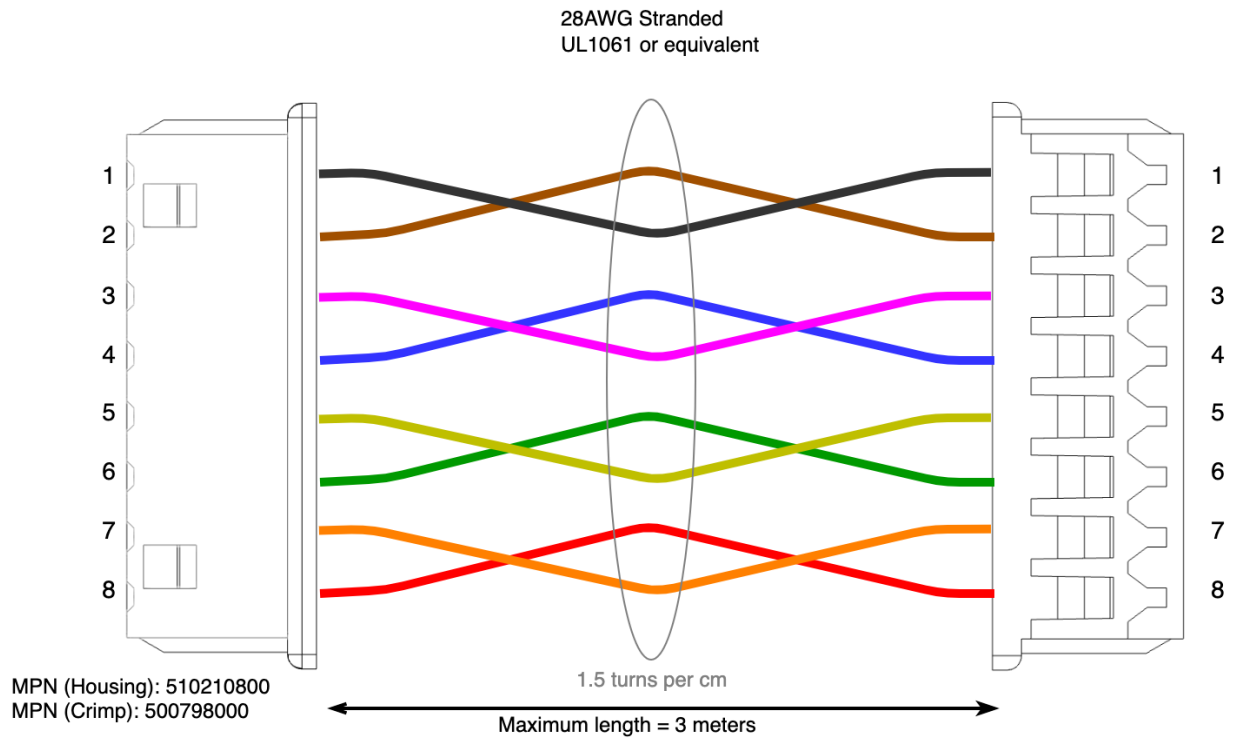


Figure 18: The wiring diagram for the picoblade to picoblade cable, used for connecting our gigabit switches directly to SPEBlox

SPEBlox can also be used with other third-party gigabit ethernet devices.

5 Device Characteristics

5.1 Operating Conditions

5.1.1 Absolute Maximum Ratings

Operating in these ranges will reduce the lifetime of the device.

Voltage Input Maximum	65V
Storage Temperature	-55°C +125°C
Operating Temperature	-40°C +85°C

Table 6: Absolute maximum ratings

The voltage regulation circuitry onboard SPEBlox can tolerate up to 65V, however we do not recommend running the board from a voltage above 40V, due to the density of components and associated temperature rise.

6 Datasheet Changelog

Date	Datasheet Version	Author	Notes
14/12/2022	F_A	Josh Elijah	Initial release
25/10/2023	F_B	Jaclyn Li	Table 1.1.2 General Information and Table 5.1.1 Operating Conditions updated to be correct values.

Table 7: Datasheet changelog

7 Contact

If you have any questions regarding this product, please contact us:

info@botblox.org

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8 Certificate of Conformity

The full text of the Certificate of Conformity of this product is available at the following web address. <https://botblox.io/documentation/>