PiXtend V2 -L-

kontron

Version History

Version	Date	Description	Editor
1.00	07 August 2018	Document created	TG
1.01	09 August 2018	Small corrections to the spelling and formatting	TG
1.02	24 May 2019	Value for the "smallest digital step" for analog current inputs corrected	TG
1.03	01 October 2019	Information regarding Raspberry Pi Model 4 B added	TG
1.04	08 June 2021	Corrections to the layout and formatting, additional safety information added	Tur
1.05	19 February 2024	Added PiXtend V2 -L- ePLC Basic Pi4/Pro Pi4 models with Raspberry Pi 4B	Tur
1.06	20 March 2024	Corrected technical specification concerning PWM and cable length	Tur
1.07	16 August 2024	Rework various sections	Tur

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1. About this Documentation

Keep this documentation in a safe place for future reference!

This documentation is part of the product and is to be kept for the entire duration of the product's usage. If the product is passed on or sold, this document must be handed over to the next user; this also includes any updates and/or changes to this documentation.

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1.1. Scope of Application

This documentation applies only to the software components specified in the table of contents and to the following PiXtend V2 -L- devices types:

- PiXtend V2 -L- Extension Board (Article number: 50199 001)
- PiXtend V2 -L- ePLC Basic (Article numbers: 50199 002 and 50199 011)
- PiXtend V2 -L- ePLC Pro (Article numbers: 50199 003 and 50199 012)

- PiXtend V2 -L- ePLC Basic Pi4 (Article numbers: 50199 018 and 50199 019)
- PiXtend V2 -L- ePLC Pro Pi4 (Article numbers: 50199 022 and 50199 023)

The documents for the previous series "PiXtend V1.x", "PiXtend V2 -S-" and other documents can be found on our website at https://www.pixtend.de/downloads/.

1.2. Copyright

This documentation, including all texts and pictures, is protected by copyright. The written approval of Kontron Electronics GmbH, D-72636 Frickenhausen, Germany, must be obtained for any other use, translation into other languages, archiving or other alteration.

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The rights of all companies and company names mentioned herein as well as products and product names lie with the respective companies.

1.4. Symbols

1.4.1. General symbols

NOTICE	NOTICE indicates a particular characteristic.
⚠CAUTION	CAUTION indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.
⚠DANGER	DANGER indicates a hazardous situation which, if not avoided, will result in death or serious injury.

1.4.2. Special warning symbols

HOT surface!
Do NOT touch! Allow to cool before servicing.

Electric Shock!
This symbol and title warn of hazards due to electrical shocks (> 60V) when touching products or parts of products. Failure to observe the precautions indicated and/or prescribed by the law may endanger your life/health and/or result in damage to your equipment.

ESD Sensitive Device!
This symbol and title inform that the electronic boards and their components are sensitive to static electricity. Care must therefore be taken during all handling operations and inspections of this product in order to ensure product integrity at all times.

2.   Important Information

This chapter contains information on legal principles, the intended use of the product described here, the technical condition at delivery and important safety instructions.

2.1.   Subject to Change

Kontron Electronics GmbH reserves the right to revise or amend this documentation in whole or in part if this serves the technical progress or if existing software components are changed or new ones have been created. The latest version of this documentation is always available at https://www.pixtend.de/downloads/.

2.2.   Intended Use

PiXtend V2 -L- is used in combination with the single-board computer "Raspberry Pi" (Raspberry Pi Foundation, UK registered charity 1129409), which is already included in the product (PiXtend V2 -L- ePLC Basic/Pro, PiXtend V2 -L- ePLC Basic Pi4/Pro Pi4) or has been bought by the customer as an accessory (PiXtend V2 -L- Extension Board).

The PiXtend V2 -L- system fulfills the function of a programmable logic controller (PLC) or an electrical measuring, control, regulating and laboratory device. It can read and evaluate sensors and control actuators. It can also communicate with other control and computer systems via a serial data connection. The logic programming of inputs and outputs can be done, among other things, with the software "CODESYS V3" from the company 3S Smart Software Solutions GmbH. Kontron Electronics also provides components for other programming languages and systems from the areas of IT and home automation that customers can use. Instructions and examples have been created by Kontron Electronics for this purpose.

PiXtend V2 -L- devices are designed for dry indoor environments - protection classes IP20 (ePLC Pro and ePLC Pro Pi4) and IP00 (Extension Board and ePLC Basic/ePLC Basic Pi4). Operation outdoors and in humid/wet rooms is not permitted, except when PiXtend devices are installed in a suitable housing. The devices are not designed for hazardous areas or safety critical systems/installations.

PiXtend V2 -L- devices can be used in industrial/commercial environments, in educational facilities and in residential areas alike.

PiXtend V2 -L- offers the possibility, under certain conditions, of switching dangerous voltages. Working on dangerous voltages is only permitted for qualified personnel (the requirements may differ from country to country). If in doubt, the use of dangerous voltages is prohibited.

Apart from this, PiXtend is suitable for all persons aged 14 and over who have read and understood the safety data sheet and the manuals. Use in educational facilities must be supervised by qualified and authorized personnel. Power supplies and accessories used must be approved for the country in which the PiXtend V2 -L- system is to be installed and used.

2.3. Technical Condition

PiXtend V2 -L- is supplied with a pre-defined configuration, independent of its model:

- "SPI_EN" switch activated → Communication between PiXtend & Raspberry Pi is activated.

- "PI_5V" switch activated → PiXtend & Raspberry Pi are supplied by the same voltage regulator on PiXtend (input voltage 12 - 24V DC). No separate power supply needs to be connected to the Raspberry Pi.

- All digital inputs are configured for 24V (no jumper is set).

- All analog inputs are configured for 0 to 10V (no jumper is set).

- "CAN" / "AO" Jumper is set to "AO" → analog outputs active, CAN inactive.

- RS485 "A" / "M" Jumper is set to "A" → automatic send/receive switching.

- Termination resistors for RS485 and CAN are not set (no jumper).

- The micro-controller firmware is always the latest version released by Kontron Electronics. The current version can be found on our website www.pixtend.de.

The ePLC models include additional configurations:

ePLC Basic & Pro, ePLC Basic Pi4 & Pro Pi4

- Contents of the SD card
  ◦ The contents are stated in the order, e.g. "CODESYS Control Demo" or "PiXtend Basic" (C / Python / Node-RED).
  ◦ Our dealers always receive and ship the SD card "CODESYS Control Demo."

- All ePLC devices include the Raspberry Pi 3 B+, except if the model is a Pi4 model. These include a Raspberry Pi 4 B.

ePLC Pro & ePLC Pro Pi4

- Housing → stainless-steel cover and DIN rail housing pre-assembled.

If you need a different version or a different hardware and software combination (e.g. devices with custom jumper configuration with other Raspberry Pi models...), please contact us directly (info@pixtend.de).

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2.4. Certifications

This product has been designed and manufactured in accordance with applicable European directives and is therefore marked with the CE symbol. The intended use is described in this document. A safety data sheet is included with each product in paper form (multilingual).

Warning:
Changes and modifications to the product, as well as a non-compliance with the information contained in the manuals and safety data sheets, will lead to the loss of certification.

The symbol of the crossed-out waste bin (WEEE symbol) means that this product must be recycled separately from any household waste as electrical waste. Ask your local municipal administration to find the nearest recycling station.

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2.5. Information according to the German Battery Act (BattG)

PiXtend V2 -L- modules contain an integrated battery/button cell (technology: lithium metal).

Make sure that your old batteries/accumulators, as prescribed under law, are disposed at a municipal collection center or at a local retailer. Disposal with normal household waste is prohibited and violates the Battery Act. The disposal is free of charge. You are welcome to return the batteries/accumulators purchased from us free of charge after use. Batteries/accumulators returned to us must have sufficient postage in any case.

Battery/accumulator returns should be addressed to:

Kontron Electronics GmbH
Max-Planck-Str. 6
D-72636 Frickenhausen, Germany

Batteries and accumulators that contain hazardous substances should be labeled clearly with the crossed-out waste bin symbol. Additionally, the chemical name of the relevant pollutants should be located under the crossed-out waste bin symbol. For example: (Pb) lead (Cd) cadmium (Hg) mercury.

PiXtend V2 -L- batteries do not contain any of the above-mentioned pollutants.

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2.6. Safety information

2.6.1. Overview

Read the complete document and the safety and connection instructions before mounting or connecting the PiXtend V2 -L-. Save this document even after you have set up all components.

⚠CAUTION Kontron Electronics GmbH does not accept any liability for damage of any kind resulting from disregarding the data sheets and operating instructions. The guarantee and warranty claim will be void if the data sheets and operating instructions are disregarded**.**

- PiXtend may only be operated with the specified voltage (24V DC ±20%) and a power supply with the VDE and CE mark (for Europe). The power supply must comply with the legal requirements of the country in which PiXtend is used.

- The device is only designed for use in dry and clean rooms and is not suitable for outdoor use or in damp areas.

- The permissible operating temperature is between 0° C and 50° C [1].

- PiXtend, the Raspberry Pi as well as all cables, connectors and power supplies must be kept away from liquids.

- The PiXtend modules must not be used in the vicinity of flammable liquids, gases or dusts.

- Only original or recommended spare parts may be used for repairs.

- Except for the connection strips of the relay, no 230V, 115V alternating voltage or any other dangerous voltage greater than 50V may be connected anywhere else. Working on dangerous voltages is only permitted by trained personnel with the legal authority of the respective country.   Caution: Dangerous to life!

- PiXtend and the accessories are to be kept out of reach of children under 14.

- The operation in schools, hobby workshops and educational facilities is to be supervised by trained personnel.

2.6.2. ESD - Electrostatic Discharge

NOTICE

ESD Sensitive Device!

Electronic boards and their components are sensitive to static electricity. Therefore, care must be taken during all handling operations and inspections of this product, in order to ensure product integrity at all times.

Do not handle this product out of its protective enclosure while it is not used for operational purposes unless it is otherwise protected.

Whenever possible, unpack or pack this product only at EOS/ESD safe workstations. Where a safe workstation is not guaranteed, it is important for the user to be electrically discharged before touching the product with his/her hands or tools. This is most easily done by touching a metal part of your system housing.

It is particularly important to observe standard anti-static precautions when changing piggybacks, ROM devices, SD cards, jumper settings etc. If the product contains batteries for RTC or memory backup, ensure that the product is not placed on conductive surfaces, including anti-static plastics or sponges. They can cause short circuits and damage the batteries or conductive circuits on the product.

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[1]Please note the additional information in chapter 6 Technical Data and Connection Instructions.

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⚠ CAUTION

PiXtend V2 devices are not designed for safety critical systems.
Before use, check the suitability of Raspberry Pi and PiXtend V2 for your application. The default settings have been selected to meet the requirements of most applications.

⚠ DANGER

Caution is required when handling and, especially, when experimenting with the process data. The connected sensors and actuators may assume undefined states or output incorrect values if handled incorrectly.
If a machine, a device or a process is controlled or regulated by the PiXtend V2, dangerous conditions can occur. Make yourself aware of possible sources of danger before starting.
If in doubt, disconnect the connections to the devices, sensors, motors, etc. from the power supply in order to minimize dangers to people and the machine.
The control bytes are not saved permanently. After a reset or power cycle, all previous settings are erased and the next action is only executed by the PiXtend V2 again when the onboard micro-controller receives a command.

NOTICE

It is recommended not to start the PiXtend V2 automatically during the development of a control program.

2.7. Disclaimer

The information contained in this documentation has been compiled, checked and tested with the greatest possible care with the software and hardware described herein. Nevertheless, discrepancies cannot be ruled out completely. Kontron Electronics GmbH is not liable for any damages that may result from the use of the software, software components, hardware or the steps described in this documentation.

2.8. Contact Information

Our postal address:

Kontron Electronics GmbH
Max-Planck-Str. 6
D-72636 Frickenhausen, Germany

How to reach us:

Telephone: +49 7022 40570
info@kontron-electronics.de
www.kontron-electronics.de

2.9. Assistance

A lot of information, tips and tricks can be found in our support forum at: https://www.pixtend.de/forum/.

If any questions remain unanswered, please first check the FAQs on our website. If your question is still not answered, contact us by e-mail (support@pixtend.de). You will receive an answer as soon as possible.

The latest versions of all documents and software components can be found in the download section of our website: https://www.pixtend.de/downloads/.

3. Package contents

Please check the package contents after receiving PiXtend equipment and accessories.
On the following pages, you will find lists of contents and images with an overview of the contents.

Be careful when unpacking and handling electronic components such as the PiXtend V2 -L- (without housing parts) and the Raspberry Pi. Electronic components on the modules can be damaged by electrostatic discharge.

The components may only be touched at the edges of the circuit boards, on mechanical screw connections or plug connectors. Avoid direct contact with electronic components and solder contacts/soldering surfaces.

We check each device and accessory before delivery (quality control, weight check). If a component is missing, please let us know by e-mail (info@pixtend.de) and we will immediately send you a replacement.

It is not necessary to return the product due to a missing component.

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3.1. PiXtend V2 -L- Extension Board

Article number: 50199 001, PiXtend V2 -L- an extension board for the Raspberry Pi

Pieces	Description	Additional Information	Part Below
1	PiXtend V2.x -L- module, completely assembled		1
4	Screw, cross-head	M2.5 x 6 mm	2
1	Ribbon cable	40-pin	3
24	Jumper (2 jumpers already set during assembly)	Standard, black	4
1	Safety data sheet	multi-lingual	5

Table 1: Package contents: PiXtend V2 -L- Extension Board (Article number 50199 001)
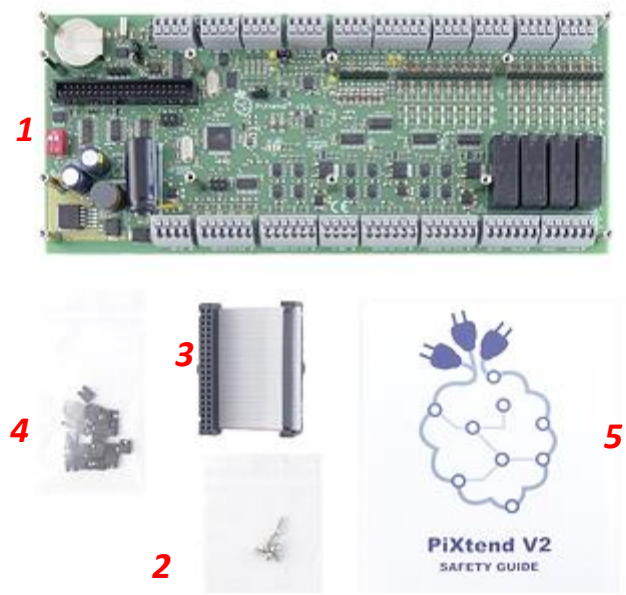

Figure 1: Package contents - PiXtend V2 -L- Extension Board (Article number 50199 001)

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3.2. Housing parts

3.2.1. DIN rail housing

Article number: 30199 006

Pieces	Description	Additional Information	Part Below
1	Basic profile	235 x 105 x 25.5 mm	1
2	Side panel		2
2	Locking bracket		3
1	Ground terminal		4
4	Screw for the side panel, cross-head	long	5
2	Screw for the locking bracket, cross-head	short	6

Table 2: Package contents: DIN rail housing [30199.006]

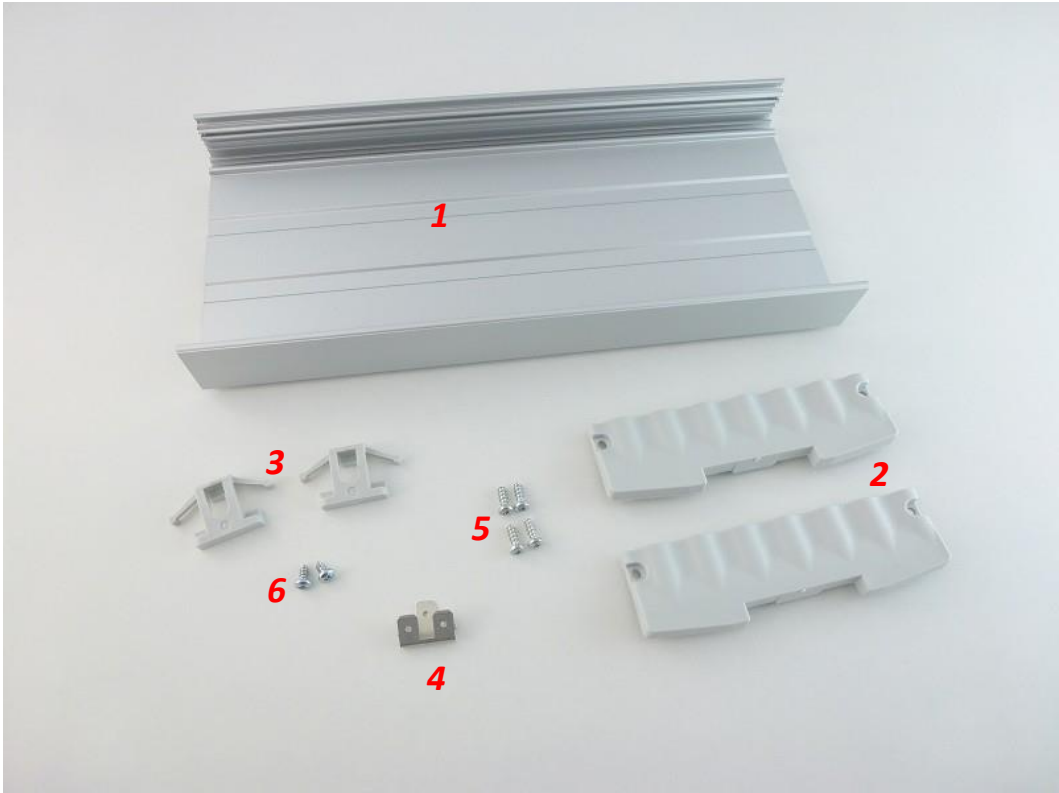

Figure 2: Package contents – DIN rail housing (Article 30199 006)

3.2.2. Stainless-steel Cover

Article number: 30199 005

Pieces	Description	Additional Information	Part Below
1	Stainless-steel cover with connection labeling, two parts	241 x 102 x 35.2 mm	1
6	Screw, cross-head	M2.5 x 6 mm	2
2	Screw, cross-head	M2.5 x 20 mm	3
2	Spacer with external thread	M2.5 x 15 mm	4

Table 3.1: Package contents: Stainless-steel cover (Article 30199 005)
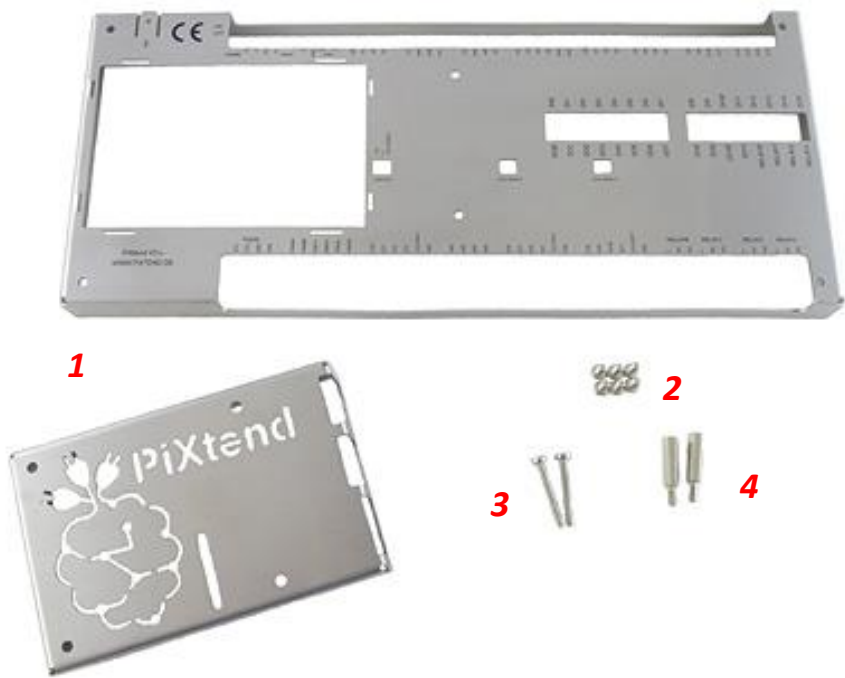

Figure 3.1: Package contents – Stainless-steel cover (Article 30199 005)

3.2.3.   Stainless-steel Cover Pi4

Article number: 30199 012

Pieces	Description	Additional Information	Part Below
1	Stainless-steel cover with connection labeling, two parts	241 x 102 x 35.2 mm	1
7	Screw, cross-head	M2.5 x 6 mm	2
2	Spacer with internal/external thread and middle gap	M2.5_SW4	3
2	Spacer with external thread	M2.5 x 15 mm	4
1	Heat sink PiXtend V2 -L/S- Pi4	Ø25xH13,20 mm	5
1	Thermalpad PiXtend V2 -L/S- Pi4	Ø25x1,50mm	6

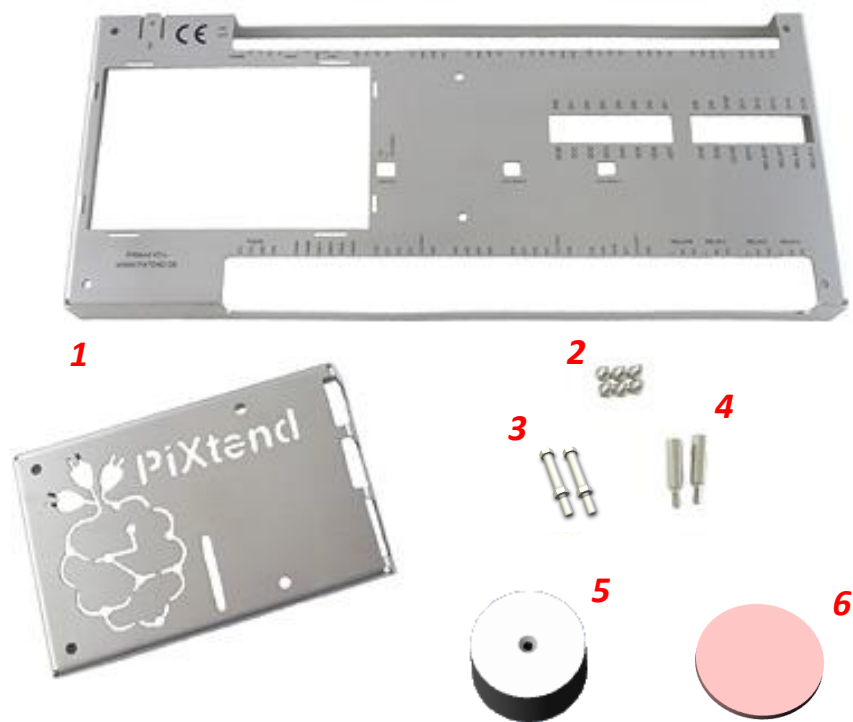Table 3.2: Package contents: Stainless-steel cover (Article 30199 012)

Figure 3.2: Package contents – Stainless-steel cover (Article 30199 012)

3.3. ePLC Modules

3.3.1. ePLC Basic/ePLC Basic Pi4

Article number: 50199 002 and 50199 011, PiXtend V2 -L- as a complete unit with RPi 3B+ – without housing parts

Article number: 50199 018 and 50199 019, PiXtend V2 -L- as a complete unit with RPi 4B – without housing parts

Pieces	Description	Additional Information	Part Below
1	PiXtend V2.x -L- ePLC Basic unit (consists of PiXtend V2 -L-, Raspberry Pi, micro SD card)	fully assembled and ready for use	1
1	Adapter card	micro SD to SD	2
24	Jumper (2 jumpers already set during assembly)	Standard, black	3
1	Safety data sheet	multi-lingual	4

Table 4: Package contents: PiXtend V2 -L- ePLC Basic (Article numbers 50199 002, 50199 011, 50199 018 and 50199 019)

Figure 4: Package contents - PiXtend V2 -L- ePLC Basic/ePLC Basic
(Article numbers 50199 002,50199 011, , 50199 018 and 50199 019)

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3.3.2. ePLC Pro/ePLC Pro Pi4

Article number: 50199 003 and 50199 012, PiXtend V2 -L- as a complete unit with RPi 3 B+ – with housing parts

Article number: 50199 022 and 50199 023, PiXtend V2 -L- as a complete unit with RPi 4B – with housing parts

Pieces	Description	Additional Information	Part Below
1	PiXtend V2.x -L- ePLC Pro unit (consists of PiXtend V2 -L-, Raspberry Pi, micro SD card, DIN rail housing, stainless-steel cover)	fully assembled and ready for use	1
1	Adapter card	micro SD to SD	2
24	Jumper (2 jumpers already set during assembly)	Standard, black	3
1	Safety data sheet	multi-lingual	4

Table 5: Package contents: PiXtend V2 -L- ePLC Pro/ePLC Pro Pi4 (Article numbers 50199 003, 50199 012, 50199 022 and 50199 023)
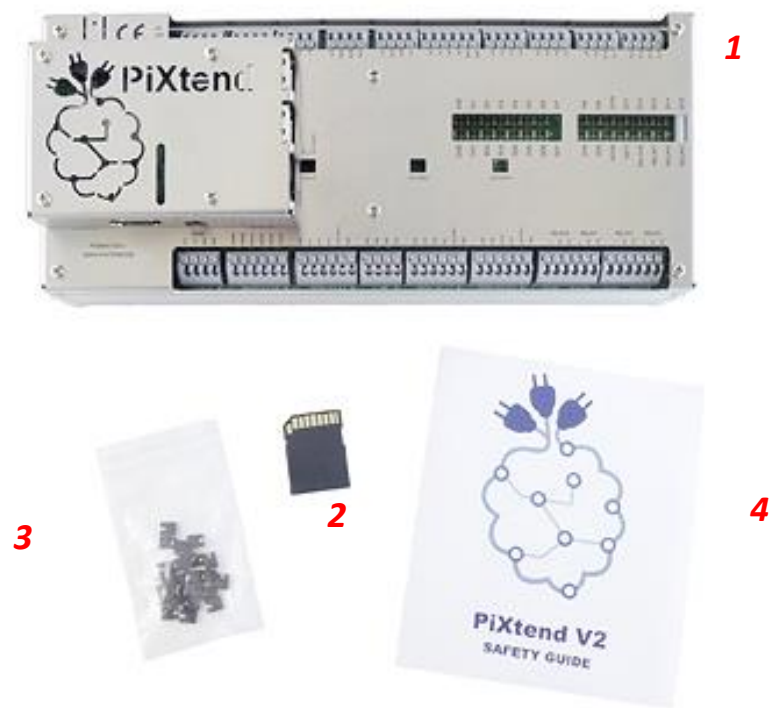

Figure 5: Package contents - PiXtend V2 -L- ePLC Pro/ePLC Pro Pi4
(Article numbers 50199 003, 50199 012, 50199 022 and 50199 023)

4. Assembly

In this chapter, you will learn how to install the Raspberry Pi computer and the housing parts. The installation steps contain important information and are described below and are illustrated with pictures.

If you have purchased a PiXtend V2 -L- ePLC, you can skip this chapter because the Raspberry Pi and the housing parts (ePLC Pro/ePLC Pro Pi4) have already been pre-installed.

NOTICE   While reading through the installation instructions, please always take particular notice of installation and safety instructions that are marked with warning signs.

Be careful when handling electronic components such as the PiXtend V2 -L- (without housing parts) and the Raspberry Pi. Electronic components on the modules can be damaged by electrostatic discharge.

The components may only be touched at the edges of the circuit boards, on mechanical screw connections or plug connectors. Avoid direct contact with electronic components and solder contacts/soldering surfaces.

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4.1. Raspberry Pi

If you purchased a PiXtend V2 -L- Extension Board without a Raspberry Pi, follow the steps in this section. If you have a PiXtend V2 -L- ePLC device, you can go directly to the chapter Installation.

4.1.1. Tools

The following tools are required to install the Raspberry Pi:

- Phillips PH1 Screwdriver

- Optional: Torque wrench with Phillips PH1 bit (set to 0.4 Nm)

4.1.2. Assembly

The Raspberry Pi and PiXtend V2 -L- are quick and easy to connect together.

You need the 40-pin ribbon cable that is included in the package. **Plug the side of the ribbon cable with the strain relief (see figure 6) into the PiXtend.**
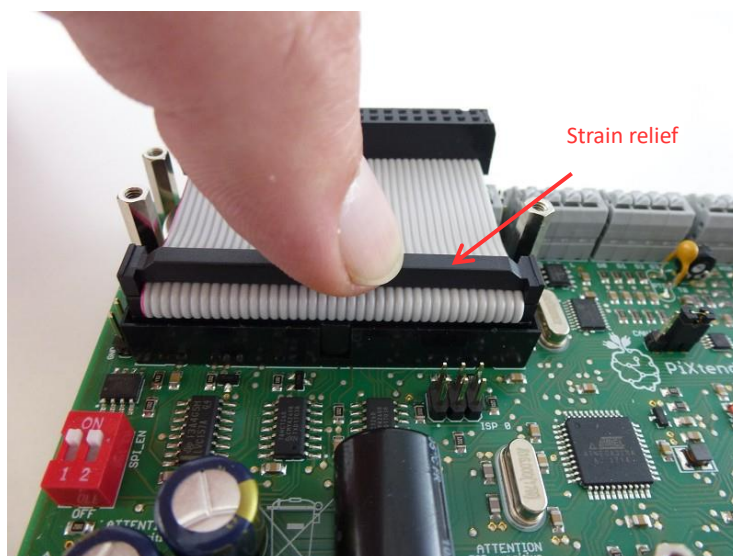

Figure 6: Ribbon cable connected to the PiXtend V2 -L-.

Make sure that the plug connector is plugged in straight so that it does not jam; it is possible to plug in with little effort.
The Raspberry Pi computer can then be attached to the other side of the ribbon cable (figure 7). Turn the Raspberry Pi upside-down for this connection. The 40-pin pin strip of the Raspberry Pi is plugged into the connector of the flat ribbon cable.

It is a good idea to work with both hands, in order to prevent the wide connector from being jammed or bent. Also avoid direct contact between soldering points and electronic components on the Raspberry Pi and PiXtend circuit boards.
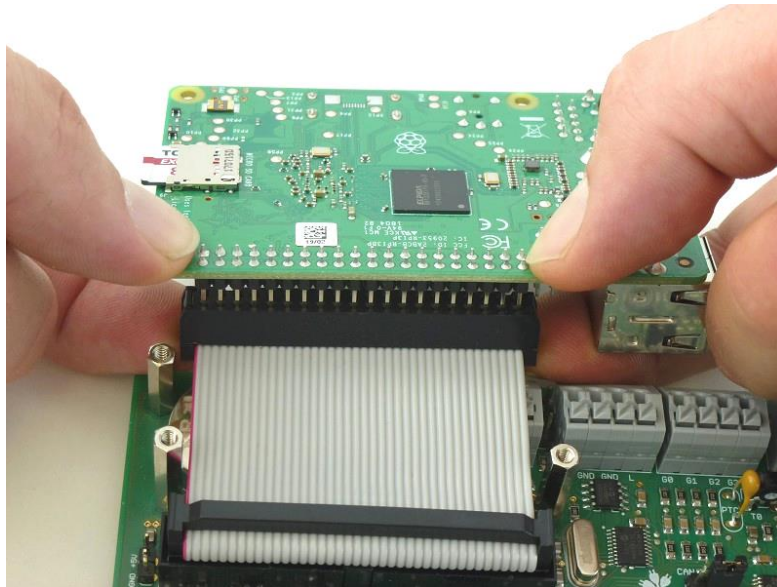
Figure 7: Raspberry Pi connection

Now the Raspberry Pi can be turned right-side up and placed on the four spacers of the PiXtend V2 -L-board. The Raspberry Pi is screwed onto the spacers with the four enclosed M2.5 x 6 mm cross-head screws.

If the PiXtend V2 -L-stainless-steel cover is to be installed afterwards, the Raspberry Pi cannot be screwed onto the spacers now.
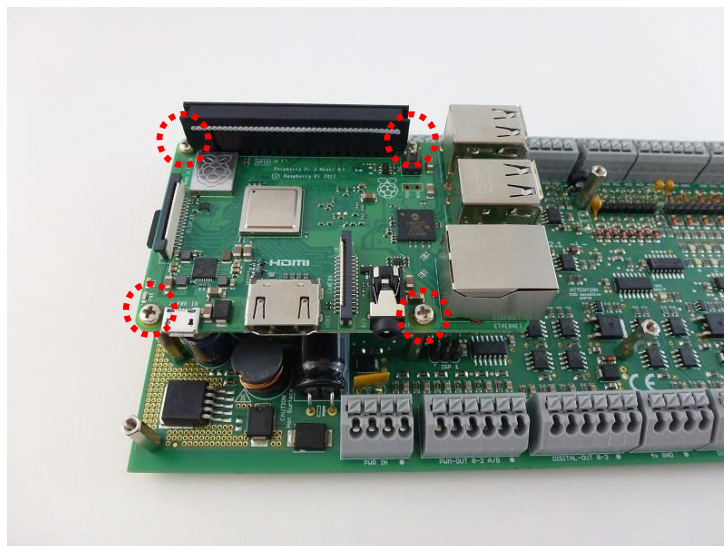

Figure 8: Screwing the Raspberry Pi to the PiXtend V2 -L-

Tighten the small screws gently. If you have a torque wrench, set it to 0.4 Nm.

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4.2. Housing parts

In this section, you will learn how to mount the DIN rail housing and the stainless-steel cover. The housing parts are optional accessories for the PiXtend V2 -L- extension board or ePLC Basic/ePLC Basic Pi4.

Especially when working with dangerous voltages (greater than 50V), the housing parts are required to be used (stainless-steel cover and DIN rail housing).

4.2.1. Tools

The following tools are required for assembling the DIN rail housing:

- Phillips PH1 Screwdriver

- possibly a regular hammer or a rubber hammer

When installing the stainless-steel cover, we recommend the following tools:

- Phillips PH1 Screwdriver

- Socket wrench or wrench, SW4

- Optional: Torque wrench with Phillips PH1 bit (set to 0.4 Nm)

Pliers can also be used instead of a wrench. Avoid pliers with rough contact surfaces as these can damage the surface of the spacers (only relevant for the appearance).

4.2.2. DIN rail housing

Connect the ground terminal first. It does not matter which side of the aluminum profile the ground terminal is connected to. The only thing to consider here is that the PE grounding connection will be connected to this terminal later. Depending on the installation position, one side may therefore be more suitable than the other.

Figure 9: Ground terminal (before being pressed into place)

Put the ground terminal in the center of the aluminum profile and press it into place with your thumb. The side of the terminal, which only has one contact tab, points outwards (see figure 9).

If the claw cannot be pressed by hand (too hard), then a regular hammer or rubber hammer can be used.

Next, a side panel of the housing is screwed on the side on which the ground terminal has just been connected.
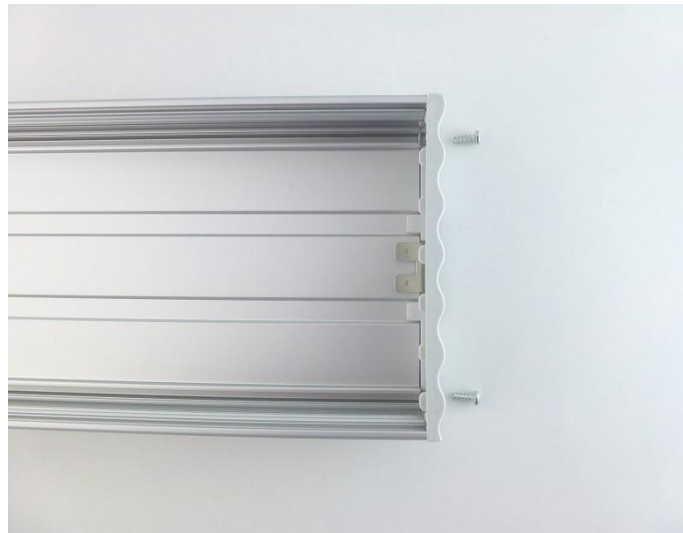
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Figure 10: Mounting of the side panel

The metal screws used cut a thread into the aluminum profile during the initial mounting of the side panel. Therefore, make sure that the screws are carefully tightened and screwed as straight as possible.

From the other side, on which the side panel has not yet been mounted, slide the locking bracket into the back of the profile (figure 11). On the back of the profile, there is only one place where the locking bracket can be placed.

Figure 11: Placing the locking bracket

If the DIN rail housing is installed later in a cabinet or control box (horizontal mounting of the housing), the locking bracket is located at the bottom.

The locking brackets are each positioned so that they are approximately 4-5 cm from the end of the profile. Then they are fastened with the small screws:

//25

Figure 12: Screwing the locking brackets into place

Now we can insert the PiXtend V2 -L- board into the profile.
The profile has several "levels" into which boards can be inserted. We use the top level:
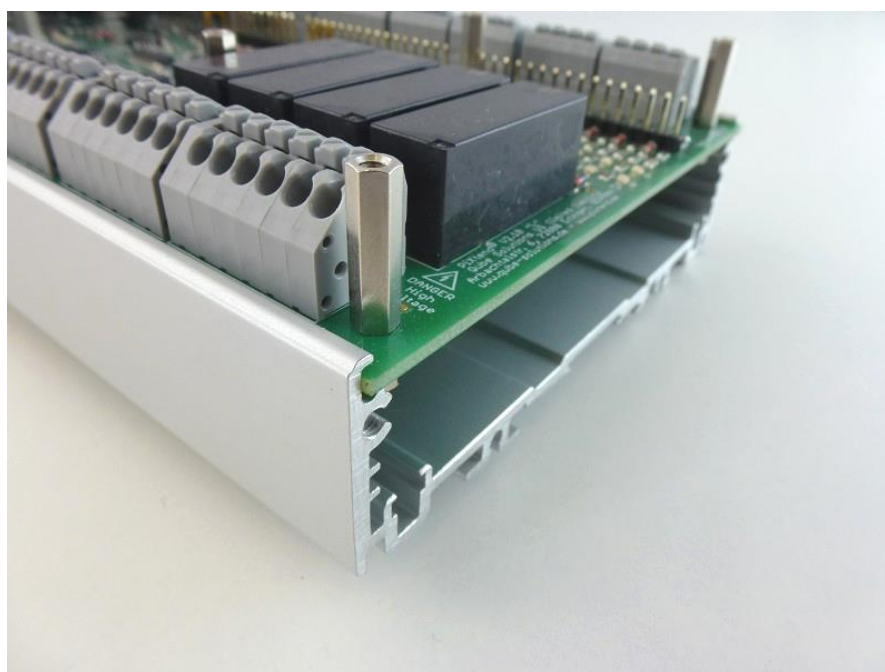

Figure 13: Connecting the PiXtend and housing profile together

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Before inserting the circuit board, take a look at the locking bracket. This marks what will become the bottom (if the housing is installed horizontally).

The outer dimensions of the circuit board were specially designed for these housings. It is intended that the circuit board fits rather tightly into the housing.

If the module is completely inserted, the second side panel can be mounted and attached with the remaining two screws. Do not be surprised that the board is still slightly above the profile. This small overhang is covered by the side panel.

The PiXtend V2 -L- module now looks as follows:

Figure 14: Assembled DIN rail housing

Figure 15: Assembled DIN rail housing - back

In a cabinet or control box, where dangerous voltages are also used, it is necessary that all accessible metal parts are grounded (connected to PE). This includes the PiXtend V2 -L- DIN rail housing.

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Before mounting the housing on a DIN rail, the grounding connection (PE) should always be connected to the ground connection:

Figure 16: DIN rail housing with grounding connection (PE)

The connection is made with a "flat plug" (width 6.35 mm).

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Lastly, the complete device can be mounted on a standard 35 mm DIN rail. The profile is attached to the top of the DIN rail (figure 17) and then pressed flat - this causes the locking bracket to snap in.
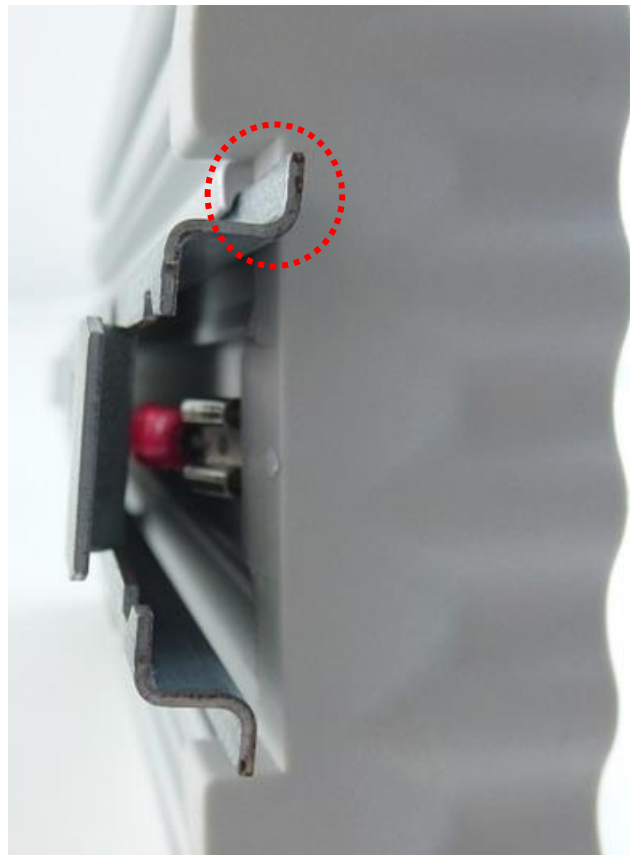

Figure 17: Housing mounted on the DIN rail

During disassembly, the entire device is pushed upwards. The locking bracket springs in and the device detaches itself from the DIN rail.
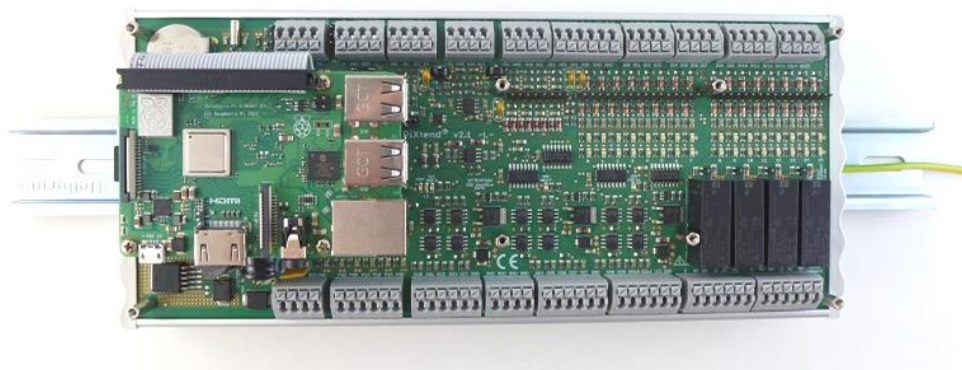

Figure 18: Completed DIN rail mounting

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4.2.3. Stainless-steel Cover

The stainless-steel cover protects your Raspberry Pi and PiXtend V2 -L- from direct contact. It also protects the user from accidental contact with live, voltage carrying parts.

The stainless-steel cover is especially designed for the shape and the connections of the Raspberry Pi models B+, 2 B, 3 B & 3 B+. The stainless-steel cover Pi4 is especially designed for the shape and the connections of the Raspberry Pi 4 B model. Other models cannot be used due to their special mechanics or the position of the connections.

After mounting the cover, all connections and jumpers are no longer accessible. Before assembling, you should consider the following points:

- Which voltages should be configured for the analog inputs (AI0 - AI3) and the digital inputs (DI0 - DI15)?
    - o   Remove or insert the jumpers accordingly.
- The switch "5V_PI" needs to be set to "ON". The power for Raspberry Pi and PiXtend V2 -L- then comes from a shared power supply. There is no opening in the cover for a separate connection to the Raspberry Pi for power (micro USB or USB-C port).
- Are CAN or analog outputs (AO) to be used?
    - o   Set jumper accordingly.
- If **RS485** is used - should the send and receive switch operate automatically or manually?
    - o   Set jumper accordingly.

For information on jumpers, switches, and their effects, please refer to chapter 5 Installation.

After setting the jumpers and switches, assembly of the stainless-steel cover can begin.

If the Raspberry Pi has already been screwed onto the PiXtend V2 -L-, the four screws need to be unscrewed[2].
If necessary, disconnect the cables from your PiXtend system (PiXtend and Raspberry Pi).

The Raspberry Pi can be lifted off the spacers while the flat ribbon cable remains connected:

Figure 19: Raspberry Pi unscrewed from the PiXtend
(ribbon cable remains connected)

The stainless-steel cover consists of two parts: The large, lower part of the cover is twisted so that it can be guided over the Raspberry Pi and placed on the six spacers on the PiXtend V2 -L- board (figure 20).

---

[2]If the Raspberry Pi has not yet been connected/mounted, please refer to the instructions for connecting the ribbon cable.

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The second, small cover part is placed over the Raspberry Pi later

Figure 20: Lower part of the cover

Now the Raspberry Pi can be placed on the four spacers again. The two M2.5 x 15 mm spacers with external threads are screwed in according to figure 21 (with 0.4 Nm).
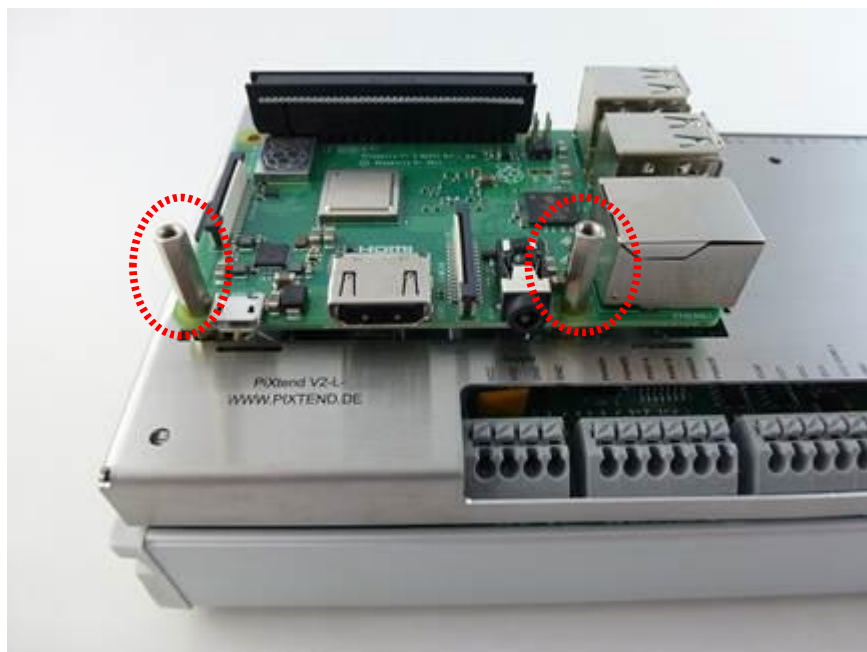

Figure 21: Two spacers screwed into the Raspberry Pi

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The lower part of the cover is fastened to the PiXtend using the six M2.5 x 6 mm screws supplied. If you have a torque wrench, set it to 0.4 Nm:
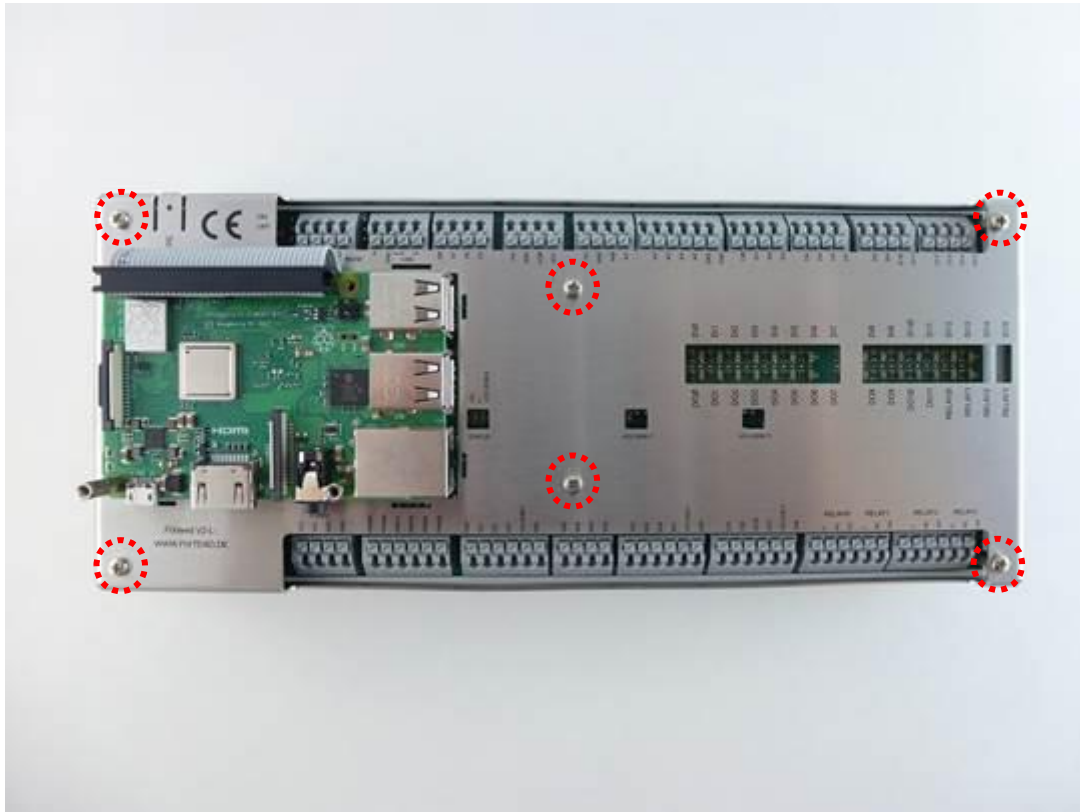

Figure 22: Screw points for the lower part of the cover

Before the upper part of the cover is placed over the Raspberry Pi, check the flat ribbon cable connecting the Raspberry Pi and PiXtend.

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In order to mount the upper part of the cover (with the PiXtend logo), the flat ribbon cable has to be close to the board of the Raspberry Pi. Press the ribbon cable against the 40-pin connector to obtain the following result:
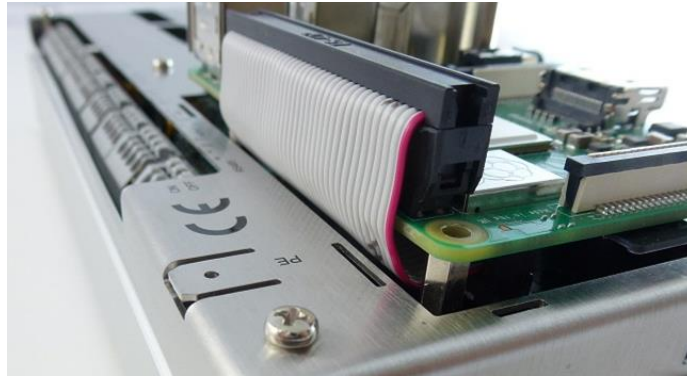

Figure 23: Optimal routing of the ribbon cable

Also make sure that the ribbon cable does not touch the lower part of the cover and that there is a gap of at least 1 mm:
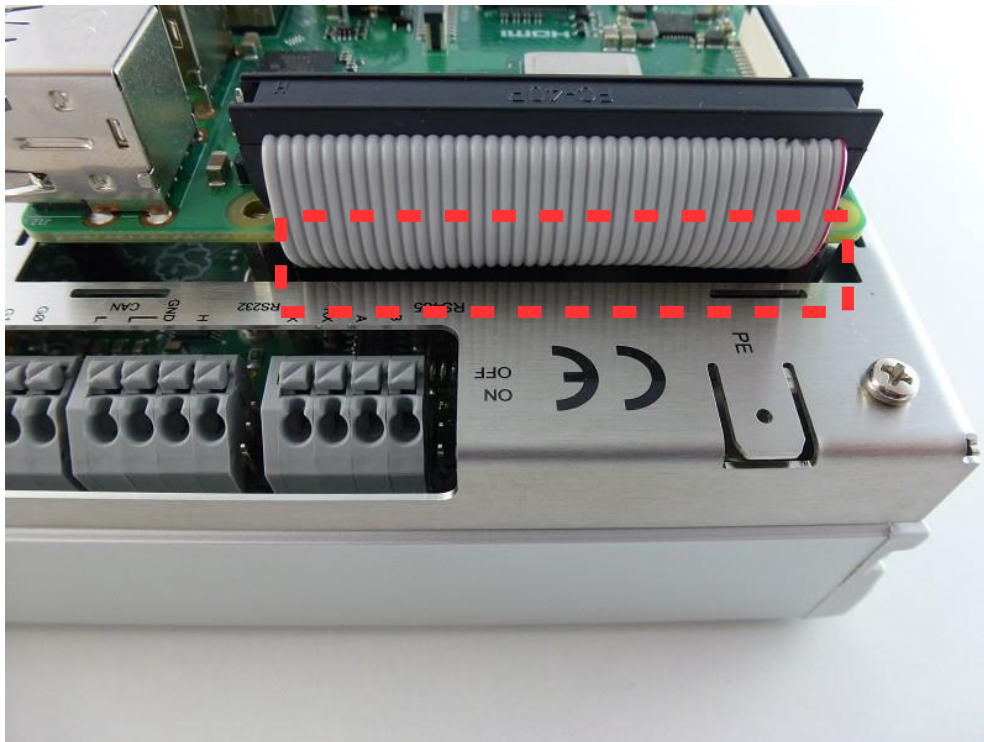

Figure 24: Safety gap between the ribbon cable and cover

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For all PiXtend V2 -L- ePLC Basic Pi4/Pro Pi4 models, the upper part of the cover must be combined with the aluminum heatsink and the thermal pad.

Insert the heatsink into the upper cover from the bottom, make sure the screw hole of the heatsink is pointing upwards. Now align the screwhole with the center hole of the upper cover part (red circle). Hold both pieces tight.
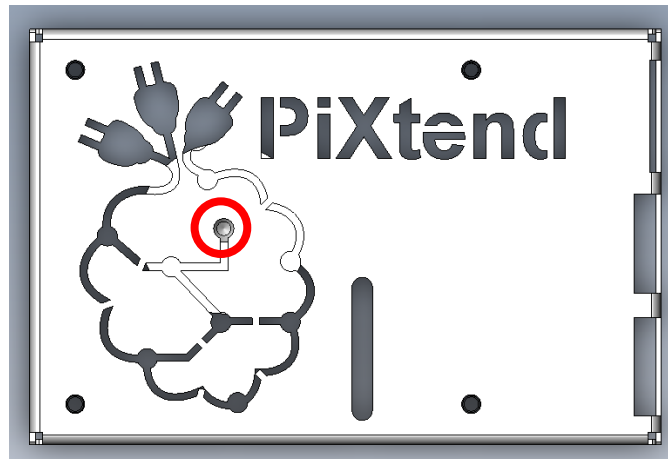
Use one of the M2,5 x 6 mm screws to fix the heatsink to the upper cover part, creating one single part.
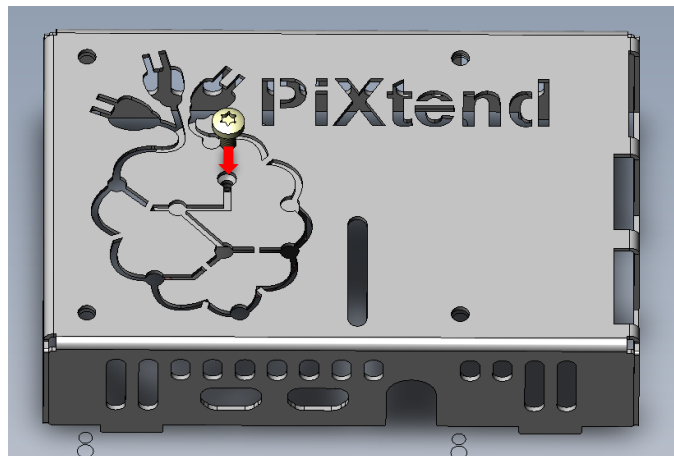
Remove the protective foil from one side of the thermal pad and place the exposed side centered on the Raspberry Pi's CPU. Gently press on the thermal pad to make it stick to the CPU, but do not apply any kind of pressure on the CPU or the Raspberry Pi pcb.
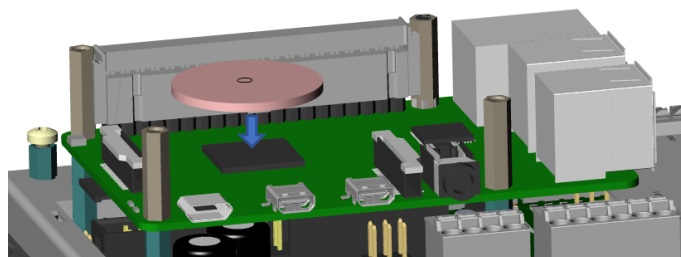
Now remove the protective foil from the top side of the thermal pad to allow a direct contact between the aluminum heat sink and the thermal pad/CPU later.

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The next step is to mount and screw in the M2.5_SW4 spacers (position 3 in the cover set).
Place the screw/threaded side of the spacer in the left and right screw hole next to the 40-pin header plug. Slowly lift the spacer into an upright position so that the 40-pin plug is between the top and bottom part of the spacer and reaches in the gap.
Once the spacer is in place screw it in (preferably with 0,4 Nm).

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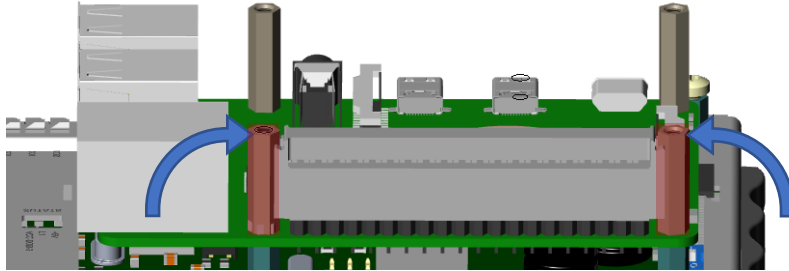
Now the upper part of the cover can be carefully placed on the Raspberry Pi.

Make sure that the eight "noses" of the upper part of the cover are in the slots of the lower cover.

Two of the four M2.5 x 6 mm screws which have been used to connect the Raspberry Pi and PiXtend are to be used here to fasten the upper cover on the previously installed 15 mm spacers:
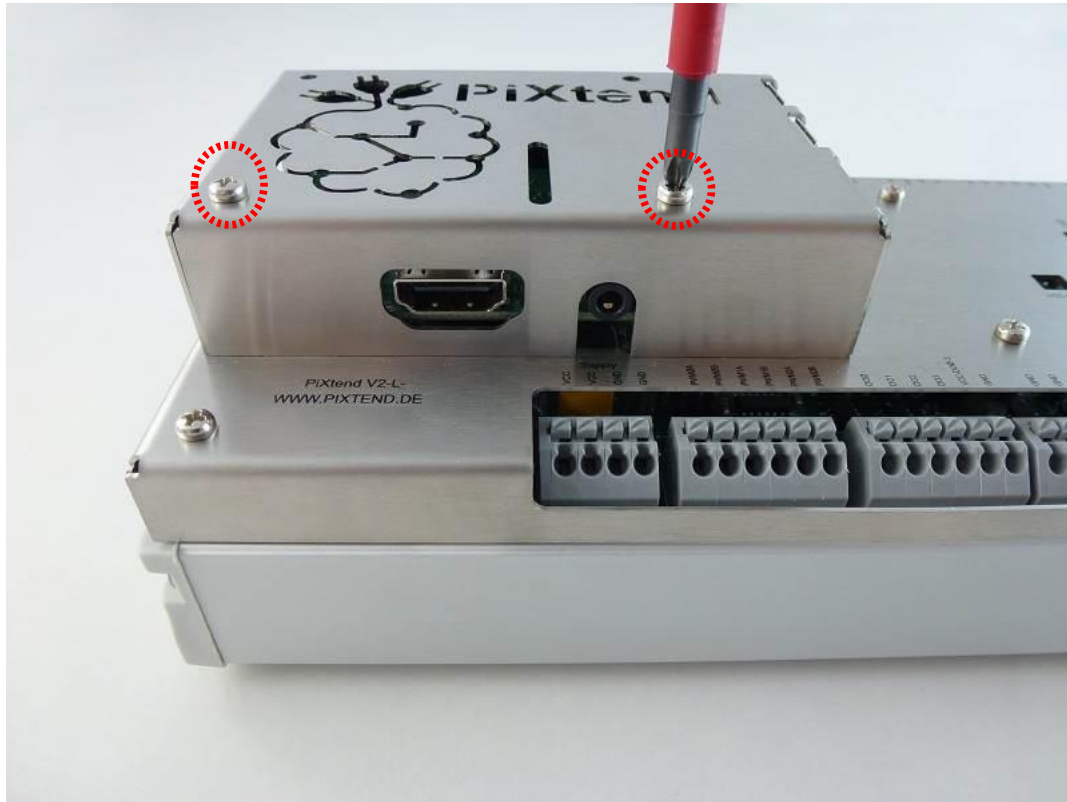

Figure 25: First step of mounting the upper cover

Tighten the small screws gently (0.4 Nm).

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The two remaining 20 mm screws are inserted as vertically as possible through the upper part of the cover (figure 26) and attached by hand. The long screws must reach through the holes of the Raspberry Pi to the spacers. Do not use any force to insert the screws, attach them gently.

For PiXtend V2 Pi4 devices:

> With the PiXtend V2 Pi4 the two 20 mm have been replaced with M2,5 x 6 mm screws, because to new special spacer have been introduced and these long screws are no longer needed, the cover now also rests on these new spacers. Use the remaining two 6 mm screws to fully mount and fixate the cover to the device.

If you have a torque wrench, set it to 0.4 Nm.

Figure 26: Completely assembled stainless-steel cover

4.2.4. Safety instructions for working with dangerous voltages

When connected to the relay on the PiXtend V2 -L- with mains voltage (115/230V AC) or other dangerous voltages greater than 50V, the stainless-steel cover must be connected to a grounding connection (PE).

Cables and devices with dangerous voltages must only be connected by trained and legally qualified personnel.

The stainless-steel cover has a special grounding connection (PE). This is marked with the designation "PE" and is designed for common cable lugs or flat blade receptacles (width 6.35 mm).

Figure 27: Grounding connection (PE) on the PiXtend V2 -L- cover

The following points must be observed for the reliable connection of the grounding connection to the cover and for safe use of the PiXtend V2 -L-:

- Except for the connection strips of the relay, no dangerous voltage (greater than 50V) may be connected anywhere else.

- Connect cable cross-section to the relay accordingly to the outer cross-section (at least one line with 1.5 mm²).

- Use a cable (stranded wire or wire) with the typical green/yellow color coding to connect the grounding terminal.

- Use flat receptacles with a "snap-in nose", which snaps into the cover and protects against unintentional loosening/removal.

- Check that the flat receptacle has a tight fit.

- All poles of the outer conductors are to be projected with line fuses (depending on the cross-section used) and with a residual current circuit breaker.

- No mains voltage or other dangerous voltage (greater than 50V) may be connected to the PiXtend relays without a residual current circuit breaker.

- The grounding connection must meet the legal requirements of the respective country in which PiXtend is to be used.

If you are unsure, contact a locally certified electrician or contact your local authorities.

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5. Installation

This chapter describes step-by-step all points to install your PiXtend V2 -L-. Please read the entire chapter first and observe the relevant connection notes in chapter 6 Technical Data and Connection Instructions before you work with your PiXtend V2 -L- system.

See chapter 5.1 for information on jumpers and switches on PiXtend V2 -L-. The PiXtend V2 -L- board can be configured with just a few simple steps.

After the board has been configured, create an SD card from one of the provided SD card images with the "Basic Image" (C / Python / Node-RED) or "CODESYS Control Demo" for your Raspberry Pi.

If you have a PiXtend V2 -L- Extension Board - without a Raspberry Pi -, a separately purchased Raspberry Pi must be installed before the initial installation. The assembly instructions can be found on in this document.

After the preparatory work, your PiXtend V2 -L- system is ready to start and can be connected to a suitable power supply. Here are some important tips for the correct and secure connection.

5.1. Set the jumpers and switch positions

The jumpers and switches determine the function and the configuration of PiXtend V2 -L-. For initial installation and tests, all jumpers and switches are preset at the factory. It is not necessary to adjust the factory settings.

Figure 28: Switch – "SPI_EN"

- Switch "SPI_EN":

  This is the most important switch! It must always be set to "ON" for normal operation. In the "OFF" position, the Raspberry Pi and PiXtend V2 -L- cannot communicate. The name "SPI_EN" stands for "SPI (Serial Peripheral Interface) Enable".

- Switch "PI_5V":

  This switch is used to decide whether or not the 5V supply of the PiXtend V2 -L- and Raspberry Pi should be connected. If you connect only one power supply to the PiXtend V2 -L- and the Raspberry Pi does not have its own power supply, the switch should be set to "ON".
  The recommended configuration is "ON", i.e. the setting for the common power supply via the voltage regulator on the PiXtend V2 -L-.

For further information, please refer to chapter 6 Technical Data and Connection Instructions.

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Figure 29: "PI_5V" in the "ON" position

⚠CAUTION   If the "PI_5V" jumper is in the "ON" position, the Raspberry Pi must not be connected to another power supply. Possible compensating currents between the power supply units can result in malfunctions, overheating of components or their defect!

If you want to use a separate power supply for the Raspberry Pi, set the "PI_5V" switch to "OFF".

However, for the sake of simplicity we recommend using only one power supply for the entire PiXtend V2 -L- system and setting the switch to "ON" as shown in figure 29.

All jumpers and pin blocks shown in the following images correspond to the factory default settings.

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Jumper5V/10V (analog inputs)

Each analog input has two pins, which can be connected to each other by a jumper. The two left pins belong to AI0, the next two pins belong to AI1, etc.

If no jumper is plugged in, the analog input is in the measuring range 0 – 10V (factory default setting). If a jumper is plugged in, the range of the input changes to 0 – 5 V.

The reduction of the voltage range can make sense if only small signals up to a maximum of 5V are to be measured. In this case, the full resolution is available for the reduced measuring range.
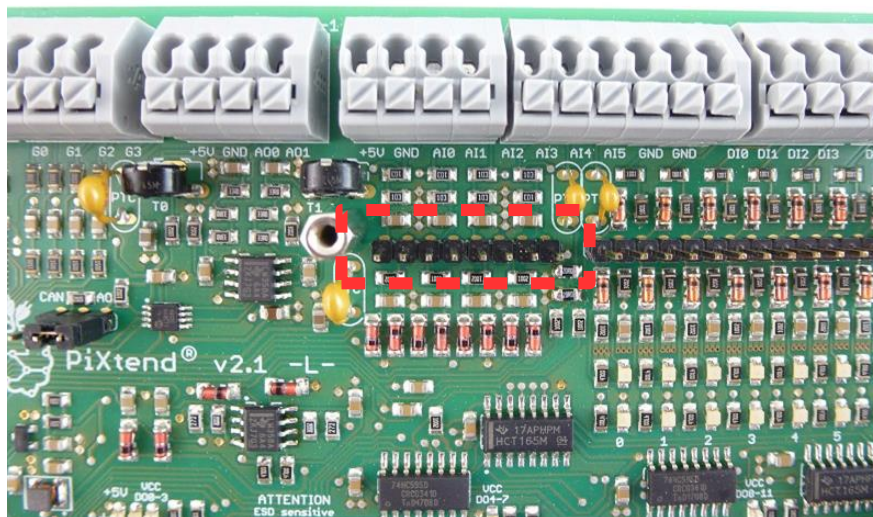

Figure 30: Jumper - analog voltage inputs in 10V range (factory default)

If you are still unsure how high the voltage at the analog inputs can be, do not insert a jumper and remain in the 0 – 10V range.

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Jumper 5V/24V (digital inputs)

Each digital input has two pins, which can be connected to each other by a jumper. The two left pins belong to DI0, the next two pins to the right belong to DI1, etc.

If two pins of different channels are incorrectly connected, this does not lead to a defect. However, signals from one input are transmitted to the other, which can lead to unexpected behavior.
Check the correct jumper setting before a signal is connected to the inputs.

If no jumper is plugged in, the analog input is in the 24V range (factory default setting). If a jumper is plugged in, the input is in the 5V range. The switching levels of the inputs are adapted according to this setting.
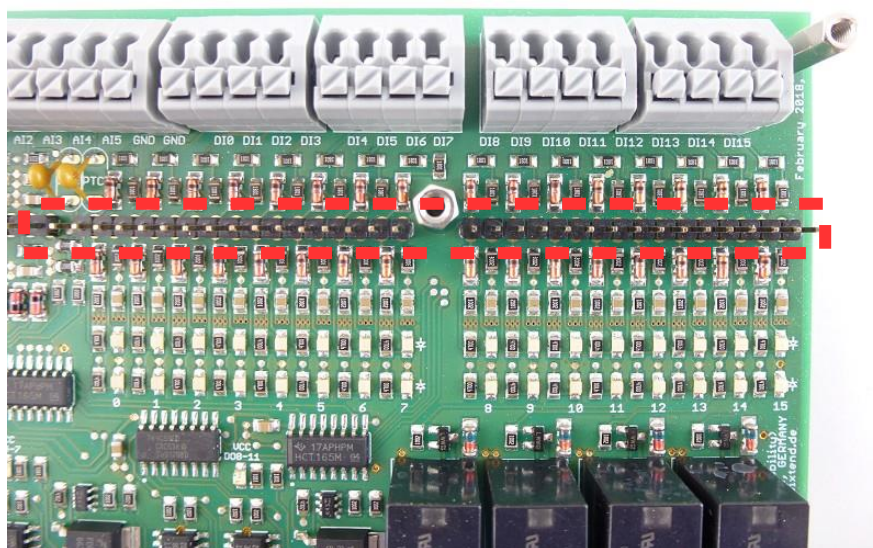

Figure 31: Jumper - digital inputs in 24V range (factory default)

If you are still unsure which voltages are connected to the digital inputs, do not insert a jumper and remain in the 24V range.

Jumper Automatic/Manual (RS485)

By default, this jumper in the "A" (automatic) position - the middle pin is connected by a jumper to the side with the inscription A, as shown in figure 32.

This is the recommended setting for send/receive switching of the RS485 interface. Only insert this jumper if absolutely necessary for your application.
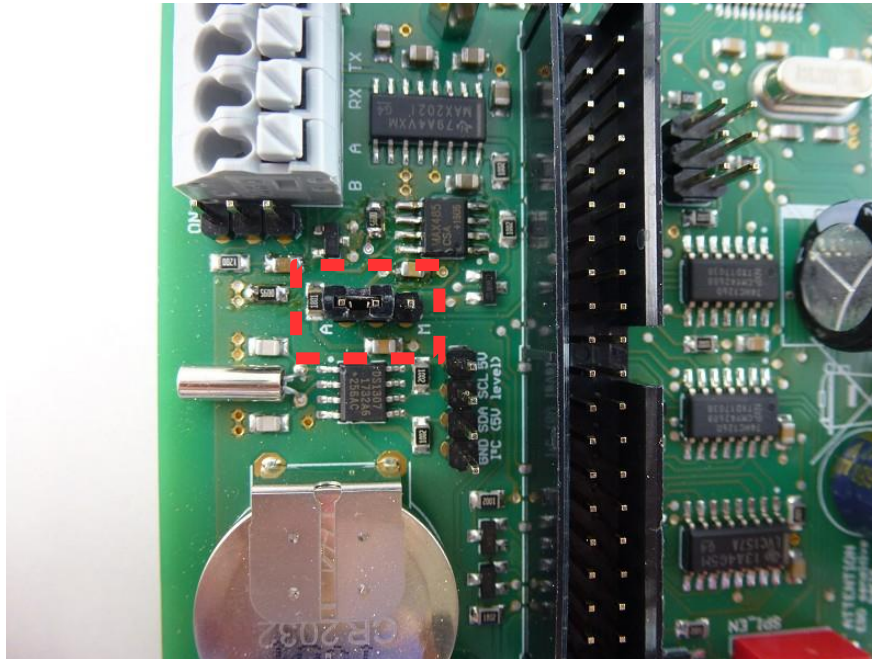

Figure 32: Jumper – Automatic/Manual - RS485

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Jumper for RS485 & CAN bus termination

In addition to the connection blocks for RS485 and CAN, there is another three-pin connection strip for each (figure 33). No jumper is plugged in with factory default setting - the termination with a 120 Ω terminating resistor is not active.

By inserting the jumper between the middle pin and the pin with the label ON, the termination is activated. Whenever PiXtend represents the first or last node of a bus, it is recommended to activate the termination.
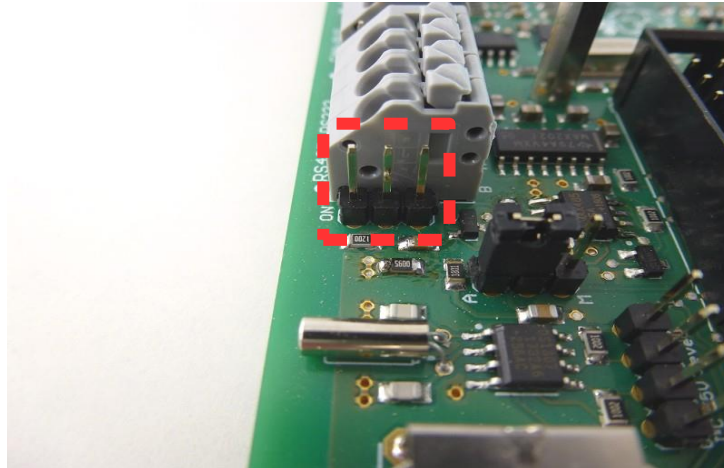

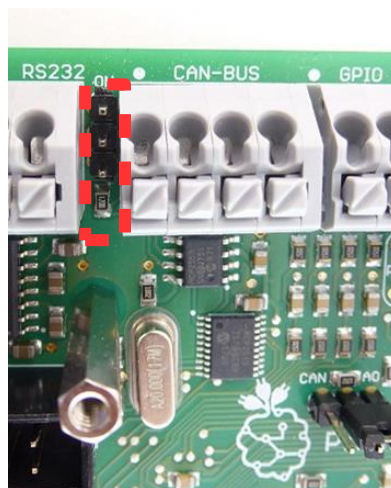Figure 33: Jumper – RS485 termination

Figure 34: Jumper – CAN termination

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Jumper for preselecting AO or CAN

This jumper is used to choose between AO (analog outputs) and the CAN bus. The functions cannot be used in parallel - a preselection is required. The analog outputs are selected with the factory default settings - the jumper is connected to the middle pin and the pin labeled AO (figure 35).

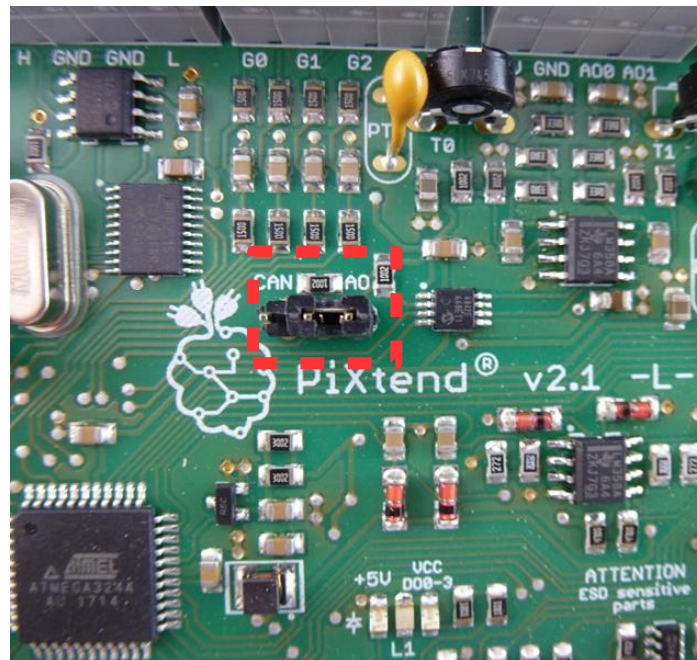If you want to use CAN, change the jumper so that the middle pin is connected to the pin labeled CAN.

Figure 35: Jumper – AO/CAN – set to AO

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5.2. Preparing an SD card

If you have ordered a pre-installed SD card from our shop, you can start right away and preparing your own SD card is not necessary.

However, if you want to prepare an SD card for your Raspberry Pi nevertheless, you will find information on how to do that in this chapter.

We provide various SD card images in our download section at https://www.pixtend.de/downloads. Depending on the type of image you want, the images always include a current version of the Raspbian operating system and also one of the following pre-configured options:

- **PiXtend V2 Basic Image** with PiXtend Linux Tools including the C-library (pxdev), PiXtend Python Library (PPL) and Node-RED

- CODESYS Control Demo with CODESYS V3.5 Runtime Extension for the Raspberry Pi & PiXtend

Always use an SD card or SD image from Kontron Electronics for your first tests. Our images are tested extensively and are pre-configured with all required settings. Our cards will ensure that the device is up and running quickly.
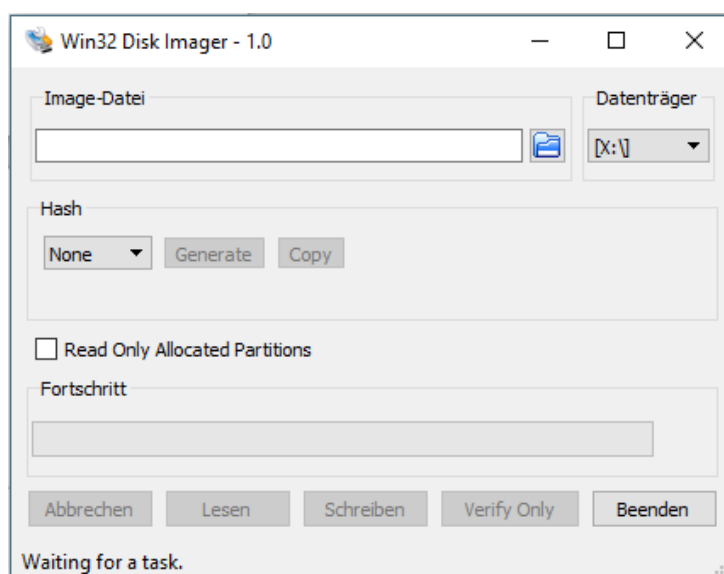

Figure 36: Software - Win32DiskImager

A PC with an SD card reader is required to transfer one of our images to a blank SD card. We recommend the open source program "Win32DiskImager" as software for writing to SD cards. The program runs under Microsoft Windows and can be downloaded free of charge from http://sourceforge.net/projects/ win32diskimager/

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NOTICE The program *Win32DiskImager* needs to be run with administrator rights or under an administrator account to get access to local drives; otherwise, there is a possibility that the SD card is not written to at all or is written incorrectly!

To prepare an SD card or transfer one of our images to your own SD card, perform the following steps:

- Insert the SD card into the card reader.

- Wait for Windows to recognize the media.

- Open the workspace/This PC or Windows File Explorer and note the drive letters of the SD card – this must be specified later on in the Win32DiskImager program.

- Open and extract the zip file with the SD card image from our download section.

- Start the Win32DiskImager program with administrator rights.

- Select the extracted image file (*.img) in Win32DiskImager under "Image file".

- Select the drive letter of the SD card under disk.

⚠CAUTION If you select the wrong disk drive, all data can be lost as soon as you have started the writing process in the Win32DiskImager program.
It is best to remove all removable media (such as USB sticks or USB hard disks) before you start the writing process, maybe even before you start the Win32DiskImager program.

- Once you have completed all settings, start the writing process by clicking on "Write".

- Wait until the writing process has been completed.

After a successful transfer of the image to the SD card, it can be ejected from the PC and inserted into the SD card slot of the Raspberry Pi.

If you see a window opening during or after the creation of the SD card, with or without content, or an error message appears that says that a drive cannot be accessed, or you are prompted to format the media, click on the "Cancel" button and close any windows that may have appeared on these dialogs.

This is no error in such situations. You get these messages because Microsoft Windows is not able to read the SD card because it is intended for the Raspbian operating system. As mentioned, remove the SD card from the PC and insert it into the SD card slot of the Raspberry Pi. The next step is to connect the power supply before starting the Raspbian operating system.

5.3. Connecting the power supply

The PiXtend V2 -L- can be operated with a wide range of power supplies that provide a stabilized output voltage of 12 - 24V DC (DC). When working directly at a desk with the device, it is easiest to just use a simple plug-in power supply. If the PiXtend V2 -L- is installed in a control box or cabinet, a power supply for DIN rail mounting is recommended.

Please also refer to section 5.4 Connection of alternative power supplies in this document if you want to use power supplies other than those described below.

The exact requirements for a power supply can be found in chapter 6 Technical Data and Connection Instructions.

Always ensure that the power supply used complies with the legal requirements of the country in which it is used!

On the following pages, we will show you how to connect a standard plug-in power supply to the PiXtend V2 -L-.

Figure 37: Package contents of a power supply from our online shop

Most of the plug-in power supplies are equipped with a female connector socket 2.1 mm (inside) x 5.5 mm (outside). This means that connection to the terminals on the PiXtend V2 -L- is not directly possible.

We therefore have put together a set which contains all the required individual lines for the connection to the PiXtend (figure 37). The set can be ordered from our online shop.

The set contains the following components:

- Plug-in power supply - fixed output voltage - 24V DC, 1.04 A
- Adapter from female socket to terminal blocks
- Connection wires red and blue - 0.75 mm², 10 cm length

The adapter is plugged into the female connector socket. The two wires can be plugged into the adapter without tools. To do this, the buttons on the adapter must be pressed down.

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Connect the red wire (+) to the connector with the red button, and the blue wire (-) to the connector with the black button:

Figure 38: Wire connection to the adapter

The colors and the polarity of the power supply match the power supply and adapter from our shop. If you are using your own power supply and adapter, check which connection is + (12 - 24V DC) and - (GND). The assignment of the plug connectors is not always the same.

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| NOTICE | Please note the polarity when using your own power supply. The polarity can be found in the operating manual of the power supply unit or can be checked with a voltage measuring device. |

Now the connection cables can be connected to your PiXtend V2 -L-. Connect the red wire to one of the terminals labeled "VCC" and the blue wire to "GND" - see figure 39.
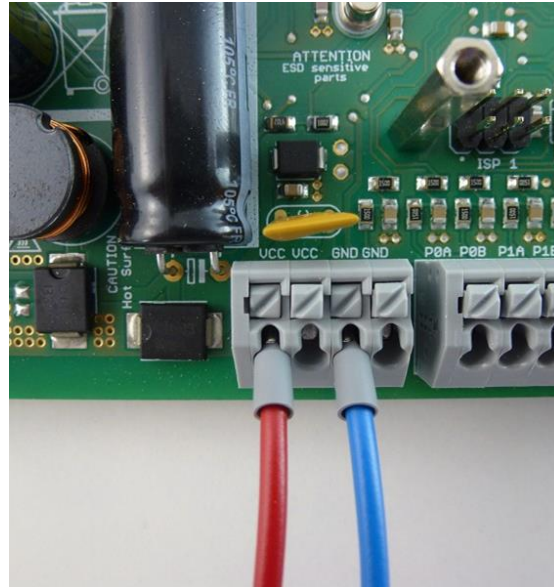

Figure 39: Power connection to the PiXtend V2 -L-

There are two set terminal block connections for the supply voltage ("POWER SUPPLY IN") on the PiXtend V2 -L-, 2x VCC and 2x GND. It is not necessary to connect all four terminals, also it is irrelevant which of the respectively same terminals is used.

The double version of the terminals means that both VCC and GND can be looped (to another device or, for example, to "VCC DO" - the supply of the digital outputs).

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Figure 40: Power supply connected to the PiXtend V2 -L-

This leads to simpler and therefore more favorable wiring.

If the connection cables are reverse-poled, the device will not be damaged. The PiXtend V2 -L- has polarity protection, which prevents damage to components. However, the PiXtend V2 -L-only works if the cables are connected correctly.

NOTICE   Check the enclosed safety instructions of the respective manufacturer before using the power supply for the first time!

The power supply can now be plugged into a 115 or 230V AC socket.

The green LED with the label "+5V" starts to light up and signals the presence of the operating voltage on the PiXtend. If you also supply power to the Raspberry Pi via the PiXtend V2 -L- power supply and a functionally active SD card has already been inserted, the computer will automatically boot.

5.4. Connection of alternative power supplies

Apart from the plug-in power supply described in detail in the previous section, other power supplies can also be used with the PiXtend V2 -L-. Another example - a DIN rail power supply - will be shown in the following section. Please always observe the associated safety instructions before applying voltage to power supplies or your PiXtend V2 -L- module.

NOTICE	Please ensure that the power supply complies with the legal requirements of your country before purchase. If in doubt, ask the manufacturer or dealer for approval. Always observe the safety instructions of the respective power supply, which must be enclosed in printed form.
⚠DANGER	While you are working on the connection wires of a power supply, the power supply must never be plugged in!

If the PiXtend V2 -L- is to be used in a control box, cabinet or laboratory set-up, a DIN rail power supply is suitable for the voltage supply. This type of power supply usually has to be connected or wired to mains voltage.

⚠CAUTION	Because the power supply usually is connected to mains voltage, be sure to observe the manufacturer's safety and connection instructions. Work on the power supply (115/230V AC) is only permitted by authorized personnel!

The following figure shows a 60W DIN rail power supply, which can be used with the PiXtend V2 -L-:
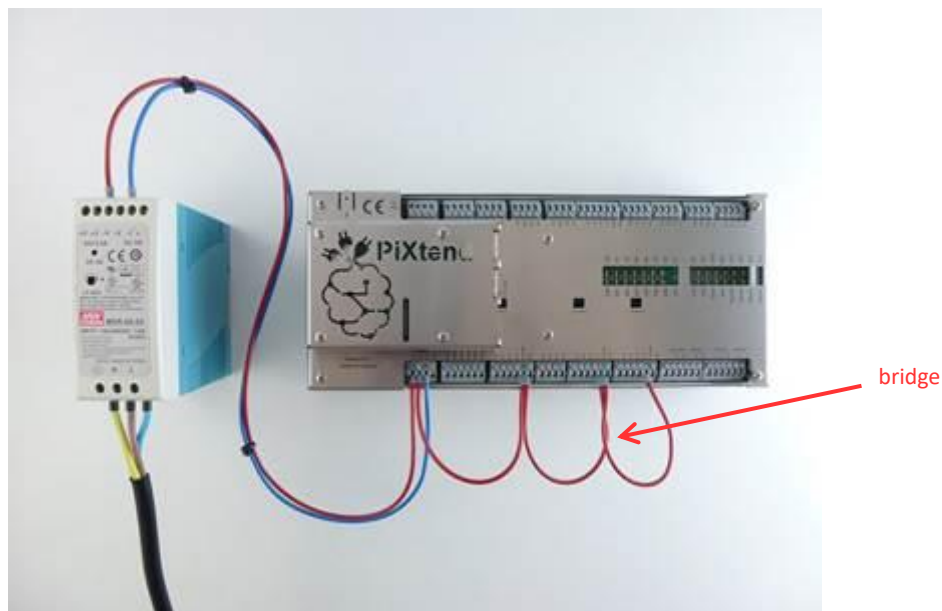

Figure 41: 24V; 2.5 A DIN rail power supply connected to the PiXtend

Figure 41 shows in addition to the regular connection of the supply voltage to "VCC" and "GND" also a bridge from "VCC" to the three "VCC DO" connections. This supplies the 12 digital outputs of the PiXtend with a single power supply. It is not necessary to bridge the GND connections, as all GND connections on the PCB are connected to each other.

The connection shown here with bridges to the DO supplies ("VCC DO") is just one example. You can work on any of the three "VCC DO" connectors with a different voltage, if necessary or useful for your application.

Next to "VCC DO" there is a GND connection, which is used when an additional power supply (e.g. for other voltages) is to be used to supply the digital outputs.

With the illustrated power supply (figure 41), the voltage can still be set exactly to 24.0V with a small screwdriver. This should be done before the voltage is applied to the PiXtend V2 -L-. To do this, measure the output voltage of the power supply using a voltmeter or multimeter.

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5.5. Troubleshooting

If the PiXtend V2 -L- system does not behave as expected, you can find troubleshooting tips in this section.

Problem
After connecting the power supply to the PiXtend V2 -L-, nothing happens. The green LED "5V" does not light up.

Troubleshooting
Check that the power supply is correctly polarized and set to a voltage between 12 and 24V DC.

Problem
The green LED "5V" lights, but the Raspberry Pi does not start, its LEDs remain dark.

Troubleshooting
Check that the "PI_5V" switch has been set to the "ON" position (assuming that you want to power the PiXtend and Raspberry Pi via a shared power supply).

Is the 40-pin flat ribbon cable correctly inserted? Check that there is a tight fit on both sides - on the PiXtend and on the Raspberry Pi.

Problem
The digital outputs appear not to work. In the "1" or "true" state, there is no voltage at the output or the connected device does not react. However, the LED of the respective output lights up.

Troubleshooting
The digital outputs must be supplied separately with voltage (connections "VCC DO" (+) and "GND" (-) on the respective connector "DIGITAL OUT"). Four digital outputs each have a single supply connection (VCC DOx-x).

If no voltage is applied here, there is no voltage at the outputs. The respective LED "VCC-DOx-x" on the PiXtend V2 -L- signals the presence of voltage at the associated connection (range 5 - 30V).

The status LEDs of the digital outputs also light up in the active state if no voltage was applied to VCC-DOx-x.
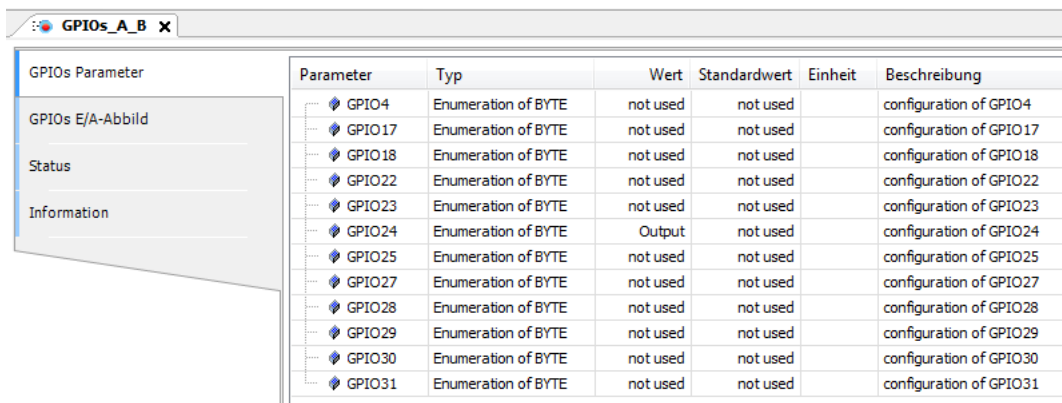
Problem

The green LED "5V" lights up and the Raspberry Pi boots normally. However, the data exchange between the Raspberry Pi and PiXtend V2 -L- does not seem to work (for example, relays or outputs cannot be set).

Troubleshooting

Check whether the "SPI_EN" switch is set to "ON". This makes communication between the Raspberry Pi and PiXtend V2 -L- possible.

If you are working with CODESYS and have created your own project, always ensure that the GPIO24 (of the Raspberry Pi) is configured as an output and set to logical "1" (TRUE) (see figure 42). The GPIO24 is the signal which is transmitted via the "SPI_EN" switch and activates the data transmission.

Parameter	Typ	Wert	Standardwert	Einheit	Beschreibung
GPIO4	Enumeration of BYTE	not used	not used		configuration of GPIO4
GPIO17	Enumeration of BYTE	not used	not used		configuration of GPIO17
GPIO18	Enumeration of BYTE	not used	not used		configuration of GPIO18
GPIO22	Enumeration of BYTE	not used	not used		configuration of GPIO22
GPIO23	Enumeration of BYTE	not used	not used		configuration of GPIO23
GPIO24	Enumeration of BYTE	Output	not used		configuration of GPIO24
GPIO25	Enumeration of BYTE	not used	not used		configuration of GPIO25
GPIO27	Enumeration of BYTE	not used	not used		configuration of GPIO27
GPIO28	Enumeration of BYTE	not used	not used		configuration of GPIO28
GPIO29	Enumeration of BYTE	not used	not used		configuration of GPIO29
GPIO30	Enumeration of BYTE	not used	not used		configuration of GPIO30
GPIO31	Enumeration of BYTE	not used	not used		configuration of GPIO31

Figure 42: GPIO24 configured as an output

If the problem is not resolved, please note the following:

If we are troubleshooting such an error, we use the SD images (CODESYS Control or Basic Image) from our website. These are tested extensively at Kontron Electronics with all settings already adjusted.

If you want to use your own Raspbian system, please remove this SD card and use one of ours first to check and ensure proper communication. After that, you can switch back to your own system.

5.6. Error LED "L1" Signals

Some error situations do not allow the micro-controller to communicate its state to the Raspberry Pi and the governing software component, e.g. with faulty communication or the micro-controller's watchdog being activated. For these situations an LED (L1) was placed on the PiXtend V2 -L- board to help the user to determine the source of a problem.

The meaning of the different LED (L1) signals can be found below:

State (Signal)	Meaning	Possible solutions
Off	Ready, no errors	-
On/Blinking very fast	Communication error (SPI)	Check the switch "SPI_EN", check the software component used for correct operation, only one program at a time is allowed to communicate with the micro-controller. In C programs, the input and output structure variables must be declared globally or locally with the keyword "static".
Blinking fast (0.2 s)	Watchdog has been activated.	Shutdown the RPi and turn off all power supplies (power cycle). The PiXtend micro-controller needs to restart in order to get it to work again.
Fading (3 s)	AC/Retain error	The supply voltage is too low and the Retain function is activated, no Retain data can be saved. Check if the supply voltage has 24 volts.
Pulsing (5 s)	Shutdown (safe state)	The micro-controller is entering or is in safe state. The bit 0 within the control byte UCCtrl1 was set. See the Software Manual for more information.

Table 6: LED L1 signaling of error states

6. Technical Data and Connection Instructions

This chapter describes the technical data for the PiXtend V2 -L-.

6.1. Overview – Connections and Functions

Digital I/Os
- 16x digital inputs
- 16x digital outputs
- 6x PWM/servo outputs
- 4x Relays
- 4x GPIOs, usable as input or output / with DHT sensors

Analog I/Os
- 4x analog voltage inputs
- 4x analog current inputs
- 4x analog voltage outputs

Serial interfaces
- RS232, RS485, CAN
- I²C

Miscellaneous
- Voltage regulator
- Connection to the Raspberry Pi
- Retain System
- Mechanics
- PiXtend microcontroller
- Real Time Clock (RTC)

6.2. Information about the entire system

The PiXtend system was developed as an extension for the Raspberry Pi 3 B+ (hereinafter also referred to as "RPi"). We recommend using this model and have based all instructions, software and data sheets on it. In addition to this module, the Raspberry Pi models 1 B+, 2 B and 3 B can also be used (electrically and mechanically compatible). The model 4 B can be used, but please check the notes starting on page 62.

Property	Value	Comment
Product group	Extension board	Extension board – without RPi
	Completely assembled device	ePLC – Basic/Pro with RPi ePLC – Basic Pi4/Pro Pi4 with RPi
Ambient temperature	0 – 50° C [3] -20 – +70° C	in operation during transport and storage
Relative humidity	0 – 85 % (not condensing)	In operation or during transport and storage
Dimensions	236.3 x 101.8 x 27 mm 236.3 x 101.8 x 45 mm 245 x 105 x 67 mm	Extension Board ePLC Basic/ePLC Basic Pi4 ePLC Pro/ePLC Pro Pi4
Weight	ca. 248 g ca. 299 g ca. 790 g ca. 299 g ca. 790 g	Extension Board ePLC Basic ePLC Pro ePLC Basic Pi4 ePLC Pro Pi4
Power consumption	max. 1.2A at 12V DC max. 0.6A at 24V DC	without loads at digital outputs and relays
Protection class	IP00 IP20	Extension Board, ePLC Basic/ePLC Basic Pi4 ePLC Pro/ePLC Pro Pi4
Pollution (according to EN 61010-1)	Pollution degree 1 Pollution degree 2	Extension Board, ePLC Basic/ePLC Basic Pi4 ePLC Pro/ePLC Pro Pi4
Max. altitude	2000 meters about sea level	in operation

Table 7: Technical specifications – PiXtend V2 -L- modules

During operation, the PiXtend must be installed in a suitable housing to avoid direct or unintentional contact with the electronic components and conductor paths. We offer the corresponding housing parts specially designed for PiXtend. This manual provides all the information you need to operate your PiXtend reliably and safely.

---

[3]Please note the additional information starting on page 63.

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6.2.1. Thermal Considerations

The PiXtend V2 hardware (without Raspberry Pi computer) has been designed for use in industrial environments and is designed for ambient temperatures from 0° C to 55°C - without restrictions.

The Raspberry Pi computer has not been specifically designed for industrial use but can be used for many applications in this environment. An important aspect is the ambient temperature at which the computer is used.

We have carried out detailed climate tests and developed appropriate application scenarios, the results of which are presented below.

General information about Raspberry Pi & CODESYS

The Raspberry Pi 3 B and 3 B+ computers have an application processor with four processor cores (ARM Cortex-A53). The chip also includes a graphics processor with two cores (Broadcom Dual Core VideoCore IV).

If all of the cores have 100% utilization, the internal temperature of the chip reaches its maximum temperature (85°C) at room temperature (25°C) and prevents further heating by means of built-in mechanisms - the CPU performance is limited. However, the above-mentioned utilization of 100% on all cores is not realistic nor is a practical application of a computer-based control.

From our experience with Linux-based CODESYS controls, we can conclude following:

- CODESYS V3 by default always uses only one processor core, except if the user chooses the Multi Core option explicitly when installing the Raspberry Pi CODESYS runtime.
    - o The thermal load from the control application is reduced to one processor core by default
    - o When using the Multi Core option, the user risks a 100% utilization of the whole system, which can lead to performance degradation of the system.

- The total load on the processor core running the CODESYS runtime should not exceed 80%. If, for example, the processor's utilization is up to 90/95%, the whole system becomes unstable. Tasks are not processed at the desired time anymore and under certain circumstances low-priority tasks are no longer executed at all.
    - o Regardless of the ambient temperature and the specific device, the CPU utilization of a computer-based controller should not go over 80%.

- The graphic processors are not utilized, even when using the CODESYS web visualization directly on the device.

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With this knowledge, we have defined the following application case:

Software

- The first processor core (CPU0) is used by CODESYS.
- All other processor cores (CPU1, CPU2, CPU3) are only minimally used by the Linux system (other tasks) and are on the average at <= 5 % utilization.
- Standard *Raspbian Stretch Linux* with CODESYS Runtime. - CODESYS program with I/O handling, CODESYS web visualization, trend elements for displaying different diagnostic values (temperatures, utilization, CPU frequency, etc.).
- Additional load is generated by the calculation of trigonometric functions (sine, cosine, tangent).
- The calculations for load generation are executed every 10ms.
- The maximum appropriated load is fixed at 75%.
- The load indicated in the following table was triggered at room temperature (25° C).

Hardware

- PiXtend V2.1 ePLC -L- on DIN rail housing, horizontal mounting, without stainless-steel cover
- Raspberry Pi 3 B - original, without heat sink or other modifications

Results

Load for CPU0 at 25° C	Load for CPU0 (trigonometric calculation)	Max. permissible ambient temperature
75%	17.25 million per second	45° C
66%	15 million per second	50° C
33%	7.3 million per second	55° C*

Table 8: Thermal considerations - results and recommendations

* 55 °C ambient temperature is not recommended. At these temperatures, other chips on the Raspberry Pi 3 B & 3 B+ leave their specified range (memory, Ethernet/USB controller). We did not find any problems or failures of the mentioned chips in our tests. Nevertheless, continuous and reliable operation at 55° C ambient temperature cannot be guaranteed.

We have found in our series of measurements that the stainless-steel cover leads to a temperature increase to the processor of a maximum of 5° C. If you use the PiXtend V2 -L- with stainless-steel cover, then 5 °C must be subtracted from each of the ambient temperatures above.

Conclusion

The PiXtend V2 -L- and Raspberry Pi 3 B can also be used at elevated ambient temperatures of up to 50 °C. It is important to note that at these temperatures the full theoretical calculation performance is no longer available. In most cases, this is also not necessary for an application in automation technology.

As our measurements have shown, for example, that 15 million trigonometric calculations per second are available at 50°C. For a 10 ms PLC cycle, this corresponds to 150,000 calculations per cycle.
These calculations are possible in addition to an average CODESYS program (with visu, trends and I/O tests). However, no internal or customer projects have required such high computing power.

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The results obtained with CODESYS can also be transferred to other programs/programming systems (C / Python / OpenPLC ...). We used CODESYS as this is a typical PLC application.

If you are unsure about your specific application in your device or machinery, we will be glad to advise you. Upon request, we will provide you with a CODESYS function block, which allows you to check and log the CPU load, temperatures, etc. in your application.

Addition from March 2018:

The measurements were repeated with the Raspberry Pi model 3 B+. This had improved thermal properties compared to the model 3 B (without plus). Nevertheless, we recommend that you do not exceed the environmental conditions specified in this chapter. This ensures that your PiXtend V2 -L- will always remain in a reliable and predictable operating condition.

Addition from October 2019:

The Raspberry Pi 4 B (1/2/4/8 GB RAM) can be used with PiXtend V2 -L-. However, due to its strong self-heating, the maximum ambient temperature is reduced to 35° C. The exact maximum cannot be stated generally. It depends on several factors (CPU load, number of processor cores with load, USB data throughput [especially USB 3.0], ohmic loads on USB ports, data throughput and network load over Gigabit Ethernet, use of wireless technologies, software components like the power management of the CPU...).
If you are considering using the PiXtend V2 -L- with the model 4 B and have any questions, please contact support@pixtend.de.

6.2.2. Power supply
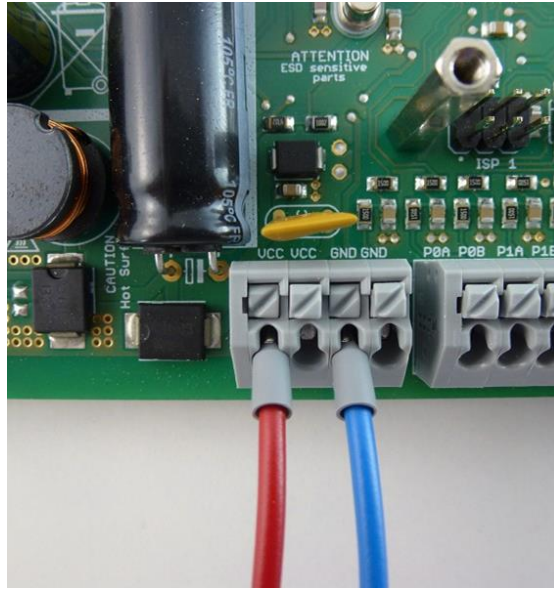
Figure 43: Terminal block for the power supply

The central voltage regulator on PiXtend V2 -L- can supply both the PiXtend and the Raspberry Pi with power with one connection.

An external power supply provides the PiXtend with a voltage of 12 - 30V DC and a maximum current of 1.2A. The voltage regulator on the PiXtend produces stabilized and short-circuit-proof 5V DC voltage. The majority of the circuit parts on the PiXtend V2 -L- are supplied with 5V. There are some that use 3.3V. In these cases, the 3.3V needs to come from the Raspberry Pi.

The 5V from PiXtend is passed on to the Raspberry Pi via the 40-pin ribbon cable connection. The Raspberry Pi therefore does not require a separate power source.

If necessary, however, the 5V of PiXtend and Raspberry Pi can also be separated. The DIP switch with the label "PI_5V" is available for selection.

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Property	Value	Comment
Type of voltage regulator	switching regulator	Step-down / buck converter
Switch frequency	52 kHz	fixed frequency, internal oscillator
Input voltage	12 - 24V DC	rated input voltage
	30V DC	maximum input voltage
Output voltage	5.1V DC	±5% of the rated voltage
Output current	max. 2.4A	
Output ripple	typical < 10 mV	
Power reserve according to IEC 61132-2	min. 10ms	24V supply with 2A load
Short circuit and overload protection	Yes	Thermally with 3A output current, self-resetting
Cooling Cooling ePLC Pro Pi4 models	Yes Yes	passive heat sink (circuit board) passive heat sink with thermal pad
Reverse polarity protection	Yes	up to -30V
EMC surge/burst protection	Yes	transil diode, bidirectional
Electrical isolation	No	
Status display	LED (green)	labeling: "+5V"
Permissible cable length	< 30 m	

Table 9: Technical data – voltage regulator (internal)

⚠CAUTION   Operate the PiXtend only within the defined voltage and load ranges. A continuous overload can lead to permanent damage of electronic components!

Burn Hazard!
Depending on the load and ambient temperature, the voltage regulator, circuit board and diodes of the voltage regulator can have temperatures of up to 75° C.
Avoid direct contact!

Connection instructions
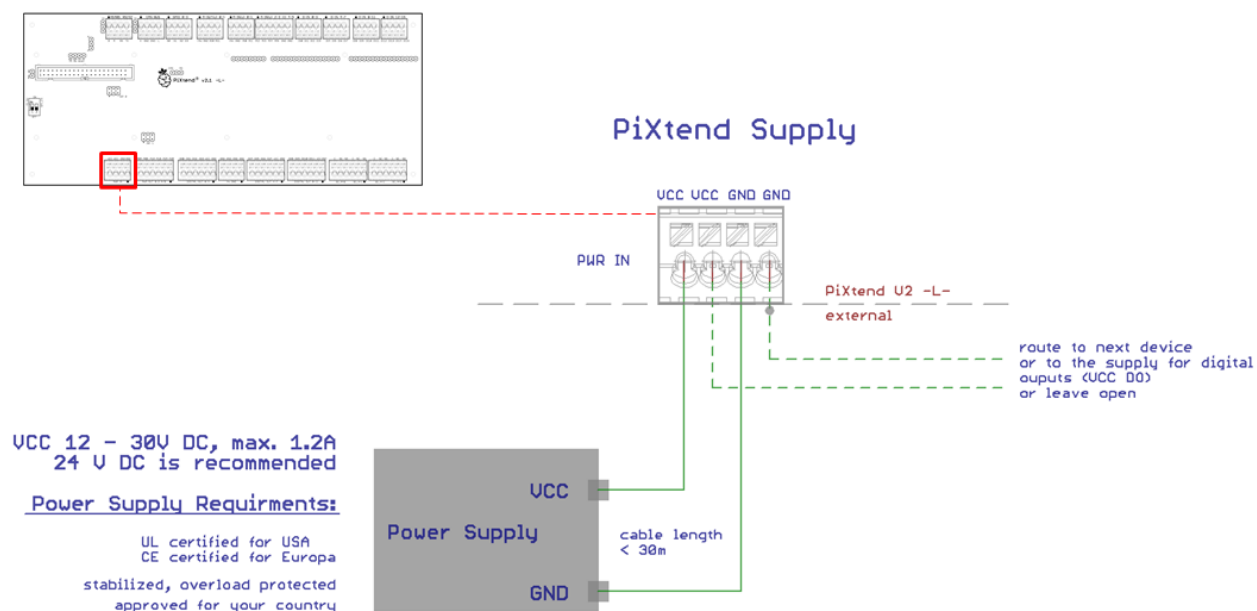
Figure 44: Simplified wiring diagram: power supply connection

The PiXtend V2 -L- uses a regulated and short-circuit-proof power supply with an output voltage between 12 and 24V DC. The power supply must comply with the legal requirements of the particular country in which the system is used. When purchasing a power supply, please check the corresponding approval marks.

You can also find compatible power supplies in our online shop.

The internal voltage regulator of PiXtend has an energy reserve. This ensures an uninterrupted power supply for voltage drops at the supply input of 10 milliseconds. The energy reserve is designed to ensure the backup power time throughout the life of the device.

There is a double power connection on the PiXtend V2 -L- (2x VCC, 2x GND).
Only one pair has to be connected (1x VCC, 1x GND). The second pair can be used for "looping through" the supply voltage to other devices or for supplying the digital outputs "VCC DOx-x" with power.

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PiXtend V2 -L- and Raspberry Pi Model B+ / 2 B / 3 B / 3 B+ / 4 B can be supplied with power in two different ways:

1. "PI_5V" switched to the "ON" position

   Operation via a shared power supply - recommended standard.
   Only the VCC and adjacent GND ports are connected to the external power supply. The Raspberry Pi is powered by the PiXtend's internal 5.1V.
   In this case, the Raspberry Pi may not be connected to another power supply!

2. "PI_5V" switched to the "OFF" position

   Operation via two power supplies.
   The PiXtend is connected to the external power supply via the VCC and adjacent GND ports.
   The Raspberry Pi connects to a second power supply (5.1V, 2.5 A minimum) via the micro USB or USB-C connector.

⚠CAUTION	If the "PI_5V" switch is in the "ON" position, the Raspberry Pi must not be connected to another power supply. **Possible compensating currents between the power supply units can result in malfunctions, overheating of components or their defect!**

USB devices on Raspberry Pi (B+, 2 B, 3 B, 3 B+, 4 B):

If the Raspberry Pi and PiXtend are supplied via the PiXtend voltage regulator (with the "PI_5V" switch in the "ON" position), the total load on the USB ports is 1 A (2x 500 mA).

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6.2.3. Connecting to the Raspberry Pi

The Raspberry Pi and PiXtend V2 -L- are connected via a 40-pin flat-ribbon cable. The cable with pre-assembled connectors is included in the package of each PiXtend V2 -L- system. In the case of the ePLC variants, the cable is already installed at the time of delivery.

6.2.3.1   Raspberry Pi pin headers

Figure 45: Connection between the PiXtend V2 -L- and Raspberry Pi

A wide range of voltages and signals from the Raspberry Pi are connected via the flat ribbon cable connection.

The following connections of the Raspberry Pi B + / 2 B / 3 B / 3 B+ / 4 B are not used on PiXtend V2 -L- and are therefore available for other applications:

GPIO27, GPIO25, GPIO5, GPIO6, GPIO12, GPIO13, GPIO19, GPIO16, GPIO26, GPIO20, GPIO21
→ They are routed over the flat ribbon cable to PiXtend, but are not used.

Raspberry Pi expansions from other manufacturers must be checked for compatibility before use. No general statement can be made as to whether the RPi expansion of a third manufacturer can be used in combination with PiXtend V2 -L-.

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Connection instructions
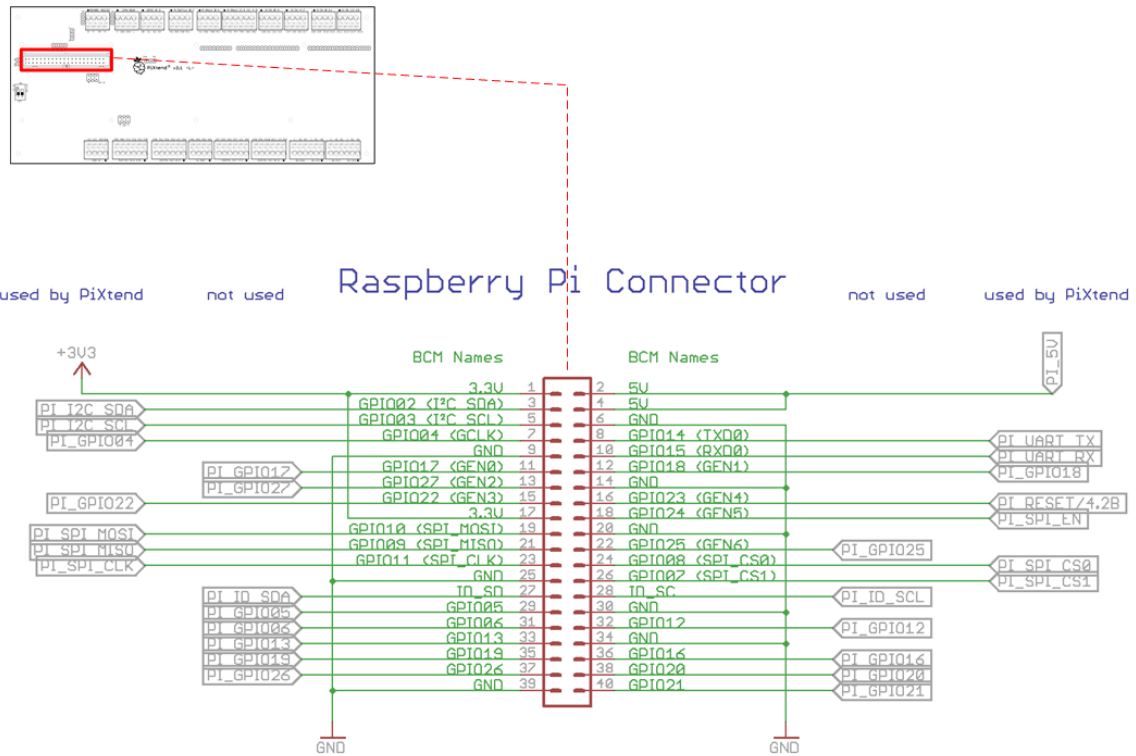
Figure 46: Simplified wiring diagram: connection between the Raspberry Pi and PiXtend V2 -L-

The pin header, labeled "Raspberry Pi Connector" in figure 46, shows all of the RPi's 40 pins. It is also possible to identify which signals are used by PiXtend and which are not.

There are different names for the pins of the Raspberry Pi. The "BCM Names" of the GPIOs are always used in this manual and in other documents of Kontron Electronics.

⚠CAUTION The flat ribbon cable connection between Raspberry Pi and PiXtend V2 -L- must never be inserted or removed during operation.

How to connect the Raspberry Pi and PiXtend V2 -L- correctly to each other is explained in chapter 4 Assembly.

6.2.3.2 I²C on 5V level
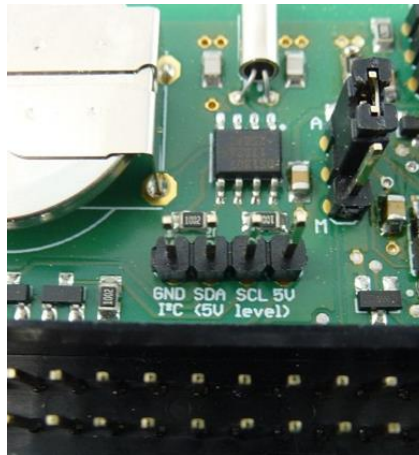
Figure 47: Pin header - I²C on 5V level

PiXtend uses only the address 0x68 (hex) on the I²C bus of the Raspberry Pi through the integrated real time clock (RTC).

An additional 127 devices* can therefore be connected to the bus system. The bus has a 5V voltage level on the PiXtend (pin header, see figure 47).

Application examples

- EEPROM, flash (memory)

- Sensors (ultrasound, temperature, air pressure, CO2 etc.)

- Data connection to integrated circuits such as micro-controllers, FPGAs, ASICs, port expanders, LED drivers, PWM chips, etc.

- Touch screen controller

- Analog/digital or digital-to-analog converters

* With 7-bit addressing – with 10-bit addressing, in principle 1136 devices are possible.

Connection instructions
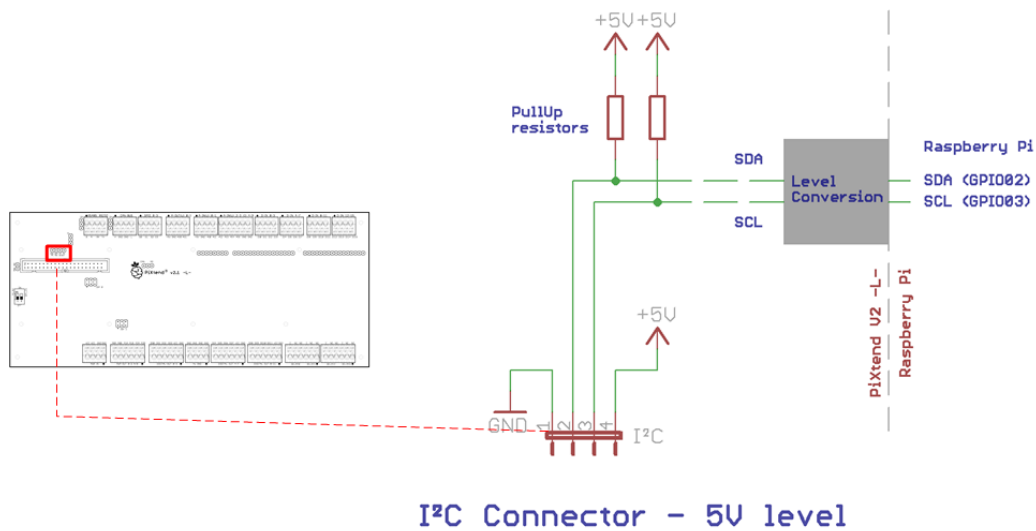
Figure 48: Simplified wiring diagram: I²C at 5V level

The I²C bus has been designed for data transfers on the circuit board. If external devices are to be connected, the cable lengths should be kept as short as possible (maximum 3 meters).

GND: General ground/Ground of PiXtend
SDA: I²C – date line (data)
SCL: I²C – clock line (clock)
+5V: Supply voltage 5.1V (±5%)

The GND and 5V connector, which is also located on the four-pin connector, must be connected to external devices on the I²C bus.

| ⚠ CAUTION | The I²C lines and the 5V supply port are unprotected and do not withstand short circuits and overloads. Branches, spikes, and lines that are too long on the I²C lines can cause malfunctions on the entire I²C bus. |

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6.2.4. Power supply - Raspberry Pi 7" touch display

The Raspberry Pi 7" touch display (original accessories from the Raspberry Pi Foundation) requires a supply voltage of 5V DC and receives a current of approximately 400 mA.

On the PiXtend V2 -L-, there is a supply connection for this purpose directly next to the 40-pin connector (see figure 49). With this, there is no need for a separate power supply for the display.
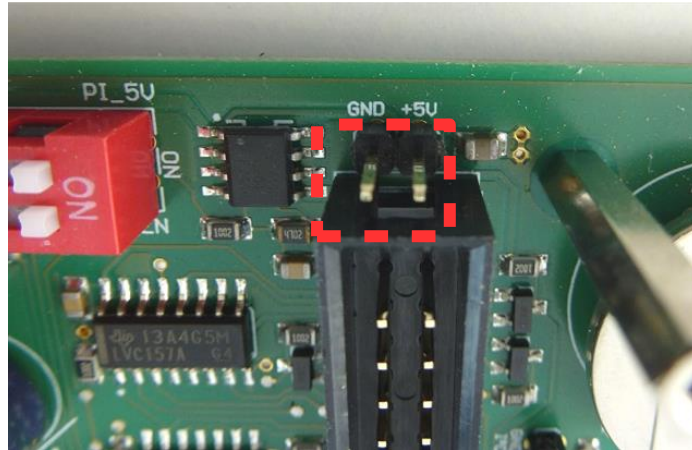
Figure 49: Power supply connection - Raspberry Pi 7" touch display

If the connection for the indicated display is used, the permissible load on the RPi USB ports is reduced to 1x 500 mA (without the display 2x 500 mA).

⚠CAUTION	The connection has no fuse protection - overloads and short circuits can lead to the breakdown of the entire 5V supply of the PiXtend and Raspberry Pi. Do not connect any cables longer than 3 meters and no load greater than 500 mA.

The connection is sufficient for test setups and non-commercial use. In the industrial environment, the display should be connected via a separate power supply with suitable connectors to ensure mechanical durability.

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6.2.5. Retain System

The PiXtend V2 -L- has a retain/persistent memory[4]. In the event of a voltage drop (fluctuations in the supply network, power failure, etc.), important data can be saved.

The Retain system is independent of the software used (CODESYS, C programs, Python programs...) and the Linux operating system. Retain data is cyclically transferred to the micro-controller by any user software running (which is depicted by the PiXtend communication protocol) on the Raspberry Pi.

The PiXtend micro-controller monitors the voltage at the supply input ("VCC"). If the Retain system is activated and the supply voltage falls below 19V DC, the controller changes to the safe state and stores the Retain data. In the time between the detection of the undervoltage and the complete storage of the data, the PiXtend V2 -L- and Raspberry Pi receive power from an internal capacitor.

After the power supply has been restored and the PiXtend system is restarted, the previously backed-up data is provided by the micro-controller and can be retrieved in the user program.

The Retain system can only be activated and used if a nominal supply voltage of 24V DC is used. If, for example, PiXtend is operated with 12V DC, the Retain memory cannot be used and is disabled.

Property	Value	Comment
Type of memory	Flash EEPROM	in the PiXtend micro-controller
Number of storage cycles	min. 10,000	
Memory size	64 bytes	
Voltage threshold	19V DC (±0.6 V)	between VCC and GND
Rated supply voltage	24V DC	to be able to use Retain
Max. input power via VCC	10W	for the guaranteed storage of all data

Table 10: Technical data – Retain system

Retain functionality should be disabled when it is not required.

Refer to the PiXtend V2 Software Manual for more information on using the Retain system.

---

[4]Also known as remanence memory

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6.2.6. Terminal block connectors

The terminal blocks on the PiXtend V2 -L- are industrial terminals with push-in technology (tool-free) and defined contact force, which ensure a long-term stable connection.

Cables with wire end ferrules or rigid wires can be plugged in directly (without tools or push buttons).

The lines are always released via the push button.

Connection data	Value	Comment
Cable cross-section min. - max.	0.2 mm² – 1.5 mm²	for rigid and flexible cables
Cable cross-section with ferrules min. - max.	0.25 mm² – 1 mm²	for flexible cables ferrules _without_ plastic collar
	0.25 mm² – 0.75 mm²	for flexible cables ferrules _with_ plastic collar
Cable cross-section AWG min. - max.	16 - 24	

Table 11: Technical data - Terminal block connectors

The clamps come from German production (WAGO or Phoenix Contact).

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6.2.7. Mechanics

The PiXtend V2 -L- has 12 holes for M2.5 screws (diameter 2.5 mm). Four of these are suitable for mounting the Raspberry Pi model B + / 2 B / 3 B / 3 B+ / 4 B. The required screws and spacers are included or already installed.

Further screws and spacers allow the PiXtend stainless-steel cover to be attached or allow connecting the PiXtend to a mounting plate. The external dimensions of the circuit board are designed for insertion into an aluminum DIN rail housing.

If the PiXtend V2 -L- is used without the mentioned housing parts, the spacers ensure a secure distance and prevent the circuit from being bent when inserting and loosening cables. During operation, the PiXtend must be installed in a housing (either with the original accessory or in another suitable housing).

How to connect the Raspberry Pi and PiXtend V2 -L- correctly to each other is explained in detail in chapter 4 Assembly starting on page 21.

On the following page, you will find the coordinates of the holes of the PiXtend V2 -L-, which you need to plan the position of the PiXtend into your device or machine. It is even easier with the 3D data, which can be downloaded free of charge from our website (in the STEP format).

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Property	Value	Comment
Thickness	1.55 mm	
Construction	two copper layers	top and bottom Layer
Dimensions [X x Y]	236.3 x 101.8 mm	
Electrically tested	Yes	
Printed circuit board	Yes	white, on top side
Lead free (RoHS compliant)	Yes	
Holes	X axis	Y axis
for Raspberry Pi Model B+ / 2 B / 3 B(+) & 4 B: for the assembly:	7.5 mm 7.5 mm 65.5 mm 65.5 mm 5 mm 5 mm 120.5 mm 120.5 mm 181.5 mm 190.5 mm 231 mm 231 mm	28.25 mm 77.25 mm 28.25 mm 77.25 mm 6.5 mm 95 mm 28.25 mm 77.25 mm 6.5 mm 77.25 mm 6.5 mm 95 mm

Table 12: Technical data – circuit board

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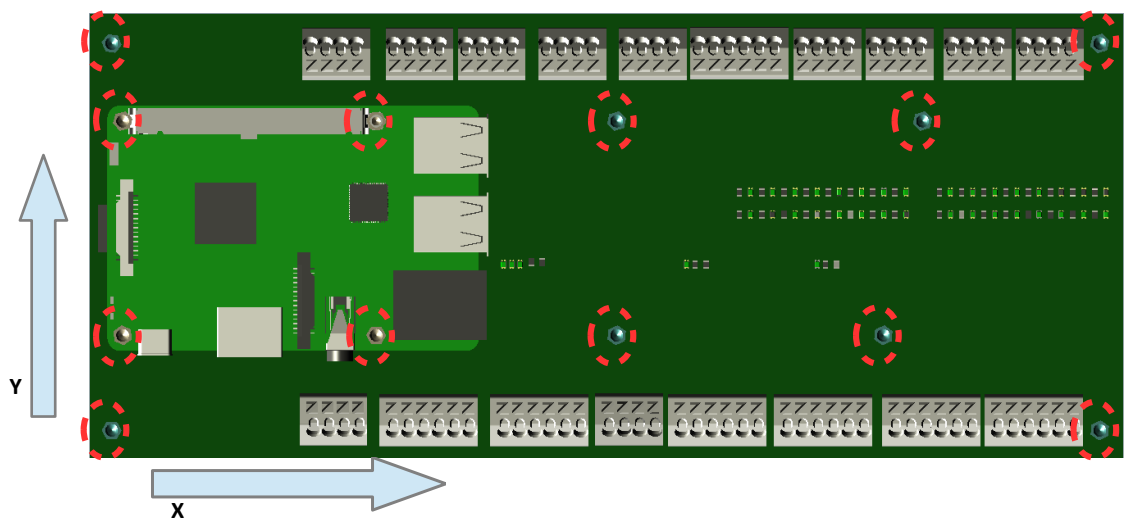
6.3. PiXtend V2 -L- micro-controller
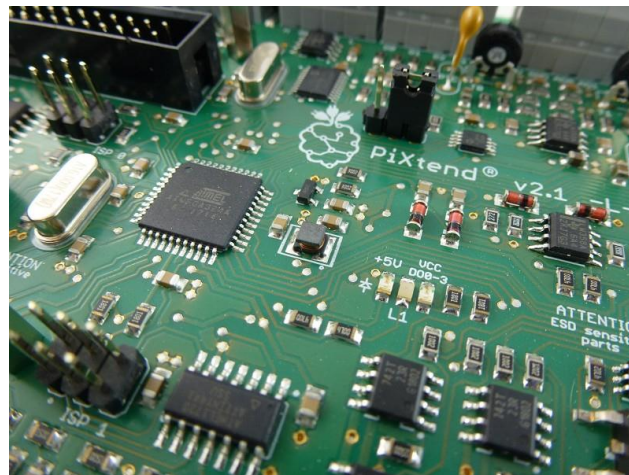
Figure 50: PiXtend V2 -L- micro-controller

The PiXtend V2 -L- uses two Atmel/Microchip 8-bit RISC processors. The ATmega/ATtiny series are extremely popular and used widespread. Similar processors can be found, for example, on Arduino boards.

The micro-controller performs a variety of tasks:

- Control of digital outputs and relays

- Generation of servo and PWM signals

- Reading of analog and digital inputs

- Operation of the four GPIOs (as input, output or for temperature and humidity sensors DHT11 / 22 / AM2302)

- Signal processing and data processing

- Watchdog functionality and voltage monitoring (brownout detection), data protection layer
- with 16-bit CRC checksum

- Monitoring of the supply voltage and holding of retain data/persistent data

Figure 51: DIP switch: SPI_EN

The Raspberry Pi and PiXtend micro-controllers (ATmega324A) are interconnected via the serial peripheral interface (SPI) bus. The Raspberry Pi is the bus master, the PiXtend micro-controller the slave. The ATtiny441 has no direct connection to the Raspberry Pi, but only to the ATmega324A.

With the "SPI_EN" switch, the SPI data connection between Raspberry Pi and PiXtend can be separated.

The micro-controllers each have a separate ISP connector:
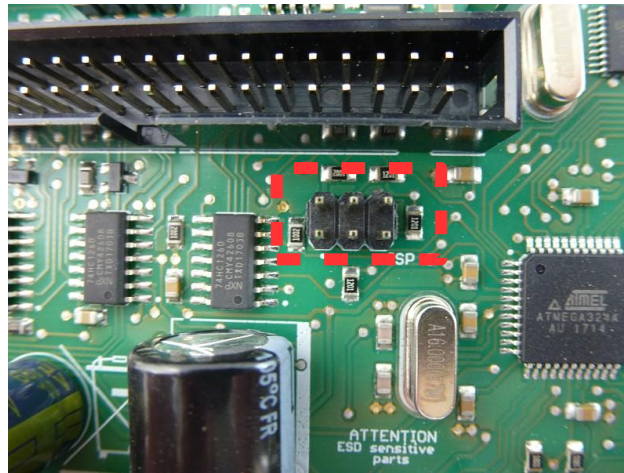
Figure 52: ISP 0 connector - In-System-Programming (ISP) - ATmega324A
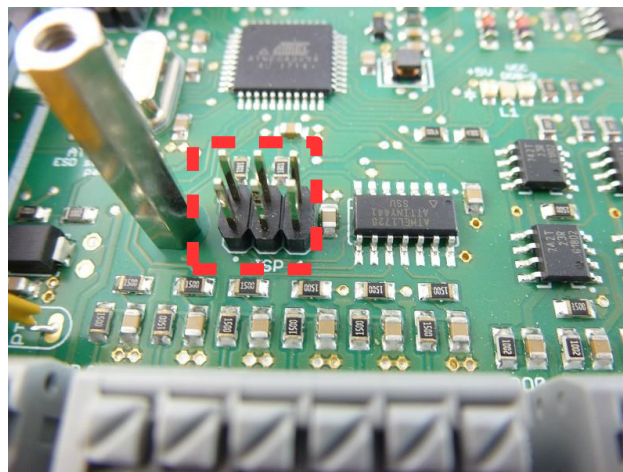
Figure 53: ISP 1 connector - In-System-Programming (ISP) - ATtiny441

The ISP connections are intended only for programming the micro-controller.

In normal operation, however, it is not necessary nor useful to reprogram the micro-controller. The controller is always up-to-date and functionally tested when the PiXtend V2 -L- devices are delivered.

The approval and guarantee of the PiXtend V2 -L- modules are lost when a custom firmware is installed!

Connection instructions

The following circuit diagrams illustrate the use of individual circuit parts which can influence the PiXtend micro-controllers.
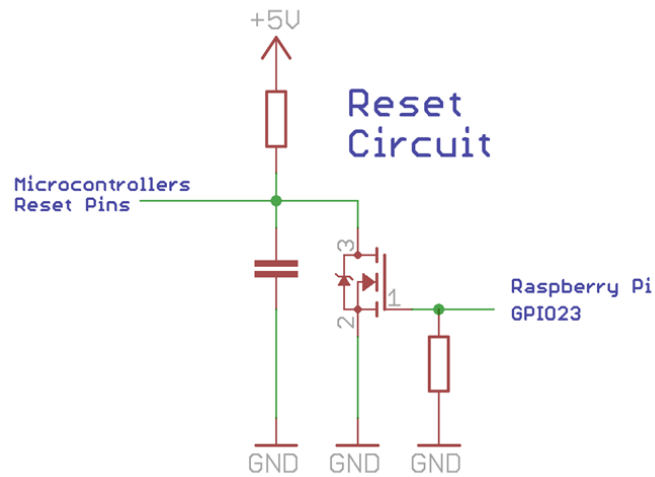
Figure 54: Simplified wiring diagram: reset circuit

The reset circuit allows both micro-controllers to be reset. The reset circuit can be operated as follows:

1. If the Raspberry Pi GPIO23 (pin 16) is configured as an input, the micro-controller is in the normal operating state.

2. If the GPIO23 is configured as an output, the state of the controller depends on the output level of the GPIO. At a low level (0V), the controller is in normal operation. At a high level (3.3V), the controller is reset and remains in the reset state until the HIGH level is cleared (set to LOW again).

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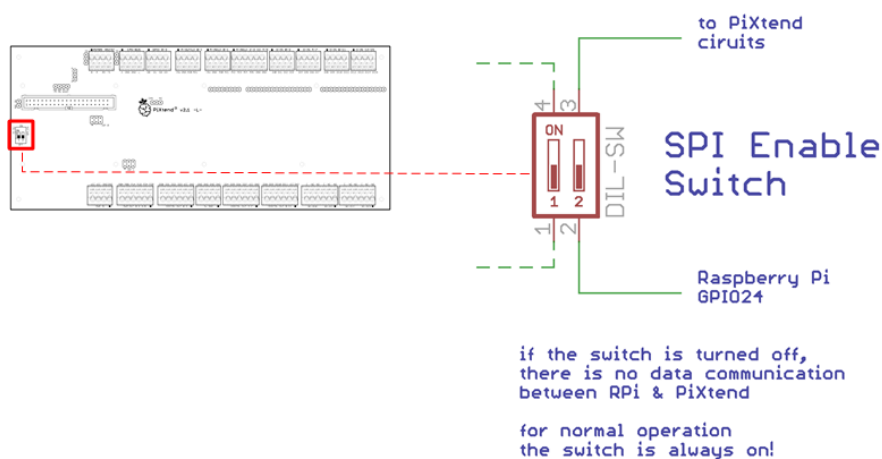
Figure 55: Simplified wiring diagram: SPI enable

The switch "SPI_EN" should always be in the "ON" position during normal operation. The data connection between the Raspberry Pi and PiXtend is only possible then.

However, the correct setting of the switch alone does not activate the data connection automatically. In addition, the GPIO24 (pin 18) must be configured as an output and switched to HIGH (3.3V).

In the PiXtend test programs, under Linux or with CODESYS, the GPIO24 is already set automatically to enable data transfer between the controllers.

NOTICE　　　　For advanced users programming your own software, remember to set the handling of the SPI to enable.
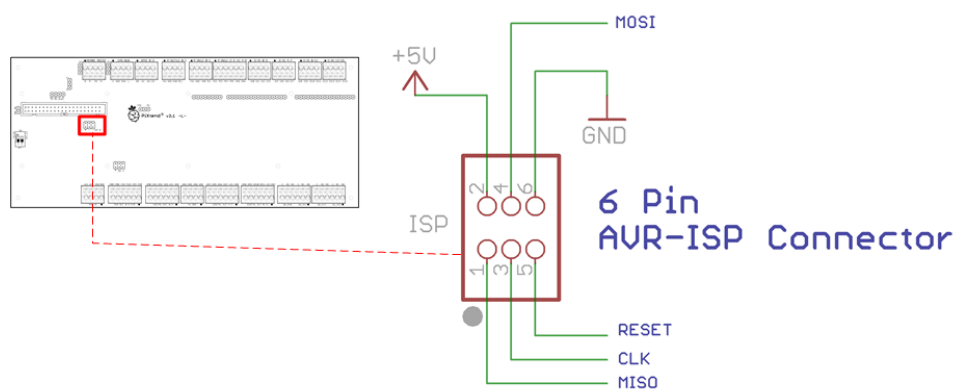
Figure 56: Simplified wiring diagram: connection of a programming adapter at
ISP 0 - ATmega324A
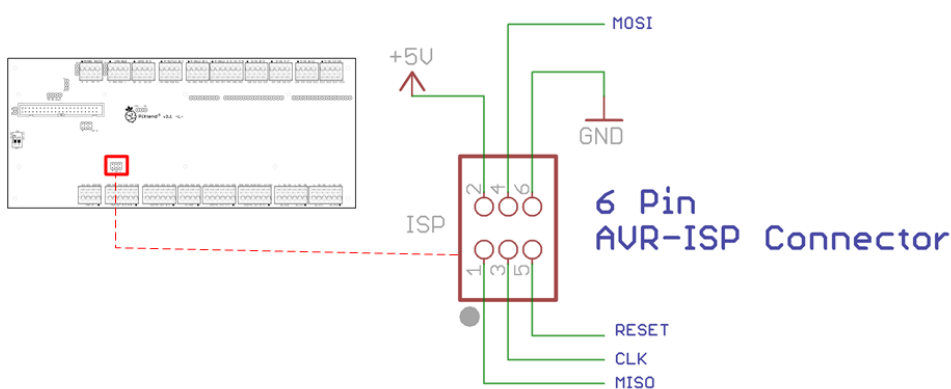
Figure 57: Simplified wiring diagram: connection of a programming adapter at
ISP 1 - ATtiny441

The PiXtend micro-controllers can be programmed via the 6-pin connector. The assignment corresponds to a standard ISP connector according to the application note "AVR042: AVR Hardware Design Considerations" by Atmel[5].

NOTICE   The approval and guarantee of the module are lost when a custom firmware is installed.

The ISP connector is not required for normal operation of the PiXtend V2 -L- and should not be connected. The ISP port is a service port on which only cables less than 3 meters can be connected.

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6.4. Digital Inputs and Outputs

The PiXtend V2 -L- has a wide range of digital inputs and outputs. This chapter contains all relevant technical data as well as connection and safety instructions. Always read the relevant sections before you begin wiring and working on inputs or outputs.

6.4.1. Digital inputs
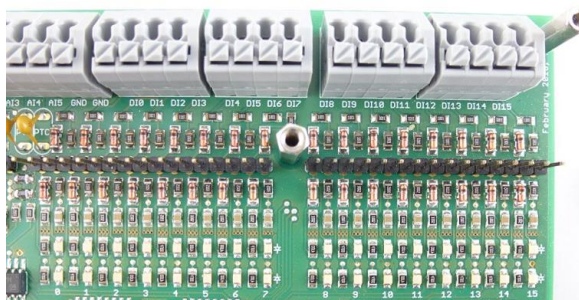
Figure 58: Terminal block - digital inputs

The 16 digital inputs (DI0 - DI15) are implemented in 1-wire connection technology and have a reference to the general ground (GND).

Application examples

- Switches, buttons, limit switches

- Sensors with switching output (proximity switches, light barriers)

- Outputs of other control units

- Outputs of integrated circuits (TTL level, CMOS level)

Two different voltage ranges can be set (one jumper per input). In the 24V range, the inputs correspond to the specifications of the PLC standard IEC 61131-2. Signals with a 12V level (for example, in the car/automotive applications) are reliably detected, over-voltages and polarity reversals up to +/- 30V cannot affect the inputs.

The 5V range is designed for 5V TTL and 3.3V CMOS levels.

Analog filter stages increase the immunity to interference and ensure the reliable signal processing by the PiXtend micro-controller. LEDs indicate the state of the inputs.

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Property	Value	Comment
Type of inputs	digital input, ohmic	for DC voltage
	type 1 according to IEC 61131-2	
	positive switching	
	1-wire connection method	with GND reference
Nominal voltage	24V	
Voltage for high level	min. 10V	logic "1", high level
Voltage for low level	max. 5V	logic "0", low level
Hysteresis	min. 0.1V	
Input current at nominal voltage	4.2 mA	
Maximum voltage	30V	Input current: 5.6 mA
Reverse polarity protection	Yes	up to -30V
Electrical isolation	No	
Status display	LED (orange)	Label "0" to "15" on the circuit board, "DI0" to "DI15" on the cover
Permissible cable length	< 30 m	

Table 13: Technical data - digital inputs - "24V range"

⚠ CAUTION   Voltages greater than 30V DC can lead to overheating and the defect of components.
The inputs are designed for DC voltages only. Do not connect alternating voltages (AC).

The LEDs indicate the high state (logic "1") of the input at nominal voltage. In the transition areas between guaranteed low and high levels, the LED is not meaningful.

Property	Value	Comment
Type of inputs	digital input, ohmic	for DC voltage
	positive switching	
	1-wire connection method	with GND reference
Nominal voltage	5V	
Voltage for high level	min. 2V	logical "1"
Voltage for low level	max. 0.8V	logical "0"
Input current at nominal voltage	6.6 mA	
Maximum voltage	9 V	Input current: 17 mA
Reverse polarity protection	Yes	up to -9V
Electrical isolation	No	
Status display	LED (orange)	Label "0" to "15" on the circuit board, "DI0" to "DI15" on the cover
Permissible cable length	< 30 m	

Table 14: Technical data - digital inputs - "5V range"

⚠CAUTION   Voltages greater than 9V DC can lead to overheating and the defect of components.
The inputs are designed for DC voltages only. Do not connect alternating voltages (AC).

The LEDs indicate the high state (logic "1") of the input at nominal voltage. In the transition areas between guaranteed low and high levels, the LED is not meaningful.

Connection instructions

The following circuit diagram illustrates the connection of different signal sources to one digital input.
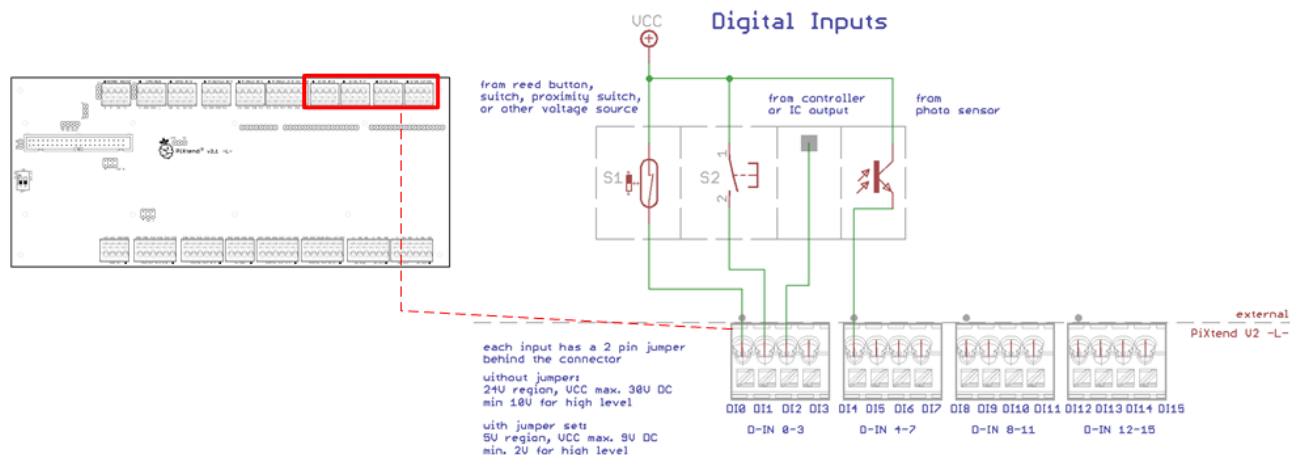
Figure 59: Simplified wiring diagram: connection of the digital inputs

The digital inputs are always logic "0" / "low" levels when idle (e.g., no voltage applied - no connection). The inputs have a ground reference (pull-down), which prevents an undefined state ("floating input").

The digital inputs can be used to read a wide range of sensors, switches and buttons. The input voltage to the inputs can be in the range from 3.3V to 30V. In order to be able to cover this large range, a jumper is provided for each input, which allows the selection between two voltage ranges (adaptation of the switching level).

The pin headers on which the jumpers can be inserted are located behind the connection terminals of the digital inputs on the PiXtend V2 -L-. Two pins of the pin strip header are assigned to one input. The first two pins (from left to right) belong to DI0, the two subsequent pins DI1, etc. With the jumper, the two pins are short-circuited, thus adapting the input circuit to the other input voltage range.

By default, thePiXtend V2 -L- V2 -L- is supplied in the 24V range (12/24V) - no jumper plugged in. With the jumper is plugged in, the input is set to the 5V range (3.3/5V). The different specifications of the voltage ranges must be observed.

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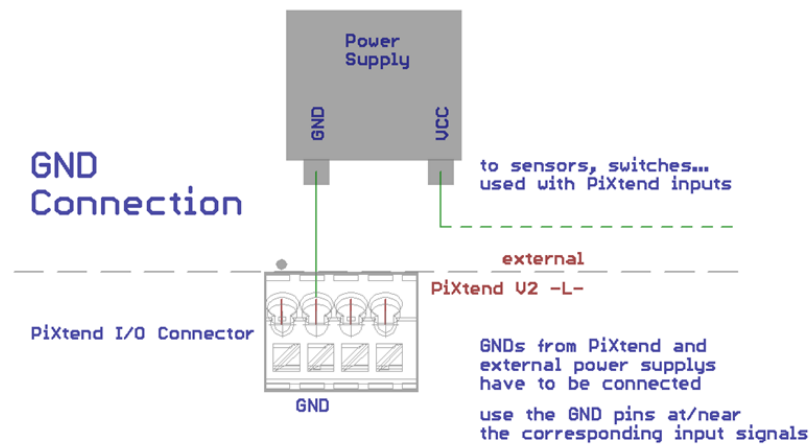
Figure 60: Simplified wiring diagram: GND connection

When using external power supplies (for sensors, switches, etc.), the GND of the PiXtend V2 -L- must be connected to the GNDs of the other power supply units. We recommend connecting the ground potentials of all power supplies used at a central point (bridged terminal block) to avoid ground loops.

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6.4.2. Digital Outputs
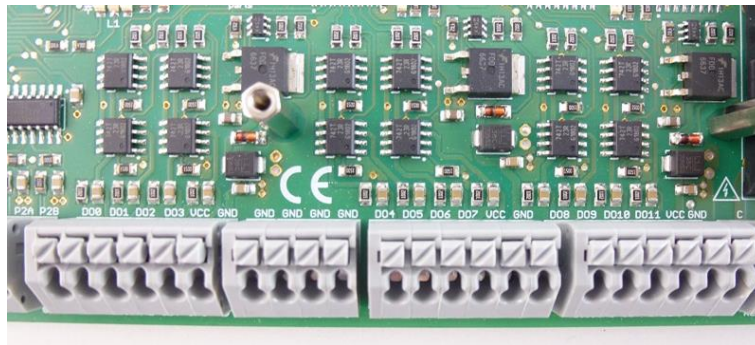
Figure 61: Terminal block - digital outputs

Twelve digital outputs (DO0 - DO11) enable the switching of DC devices with voltages up to 30V and currents up to 0.5 A.

Application examples

- Switching external power relays

- Operation of small DC motors and RC model servos

- Connection to the inputs of other control units

- Heating and Peltier elements

- Fans and blowers

- Lamps for DC and power LEDs

All twelve digital outputs are short-circuiting and overload-proof. The outputs correspond to "protected and short-circuit proof outputs" as in the PLC standard (IEC 61131-2).

These are high-side switches which are supplied with energy via a separate feed-in (four outputs per feed-in).

Each feed-in has an LED which informs about the presence of the supply voltage. The digital outputs and their supply are each located on a shared 6x terminal block.

Further LEDs signal the states of the outputs.

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Property	Value	Comment
Type	supply connection	auxiliary supply
Rated current	2.0A	Four outputs on rated load
Short-circuit current	< 10A	Short-circuit on all four outputs
Rated input voltage	24V	
Min. input voltage	5V	
Max. input voltage	30V	
Reverse polarity protection	Yes	electronically
Backpowering protection	Yes	electronically
Short circuit and overload protection	No	a 4 A (slow) fuse must be provided externally
EMC surge/burst protection	Yes	transil diode, bidirectional
Electrical isolation	No	
Status display	LED (green)	Label "VCC DOx-x"
Permissible cable length	< 30 m	

Table 15: Technical data – DO feed-ins ("VCC DOx-x")

⚠ **CAUTION** — Voltages greater than 30V DC can lead to the defect of components.
The outputs and the circuitry of the feed-in is designed exclusively for DC voltages (DC). Do not connect alternating voltages (AC).

Depending on the load and ambient temperature, the components of the feed-in can have temperatures of up to 65° C. Avoid direct contact.

Property	Value	Comment
Type of outputs	digital output, semiconductor according to IEC 61131-2	for DC voltage
	Normally open contact for each DO, positive switching (high side switch)	SPST
Rated current	0.5A	
Short circuit current	max. 2.5A	
Rated output voltage	24V	
Min. output voltage	5V	Depending on the feed-in "VCC DO"
Max. output voltage	30V	
Max. switching power	2.5W 6W 12W	at 5V DC at 12V DC at 24V DC
"ON" resistor	ca. 350 mΩ	with logic "1" and rated load
Short-circuit protection Current limiter Overload protection	Yes Yes Yes	thermal
Electrical isolation	No	
Status display	LED (orange)	Name: "0" to "11" on the circuit board, "DI0" to "DI15" on the cover
Permissible cable length	< 30 m	

Table 16: Technical data - digital outputs

⚠**CAUTION** Voltages greater than 30V DC can lead to the defect of components.
The outputs are designed for DC voltages only. Do not connect alternating voltages (AC).

Depending on the load and ambient temperature, the power transistors can have temperatures of up to 75° C. Avoid direct contact. Output currents greater than 0.5 A are not permitted in normal operation.

Connection instructions

The following circuit diagram illustrates the connection of different loads to the digital outputs.
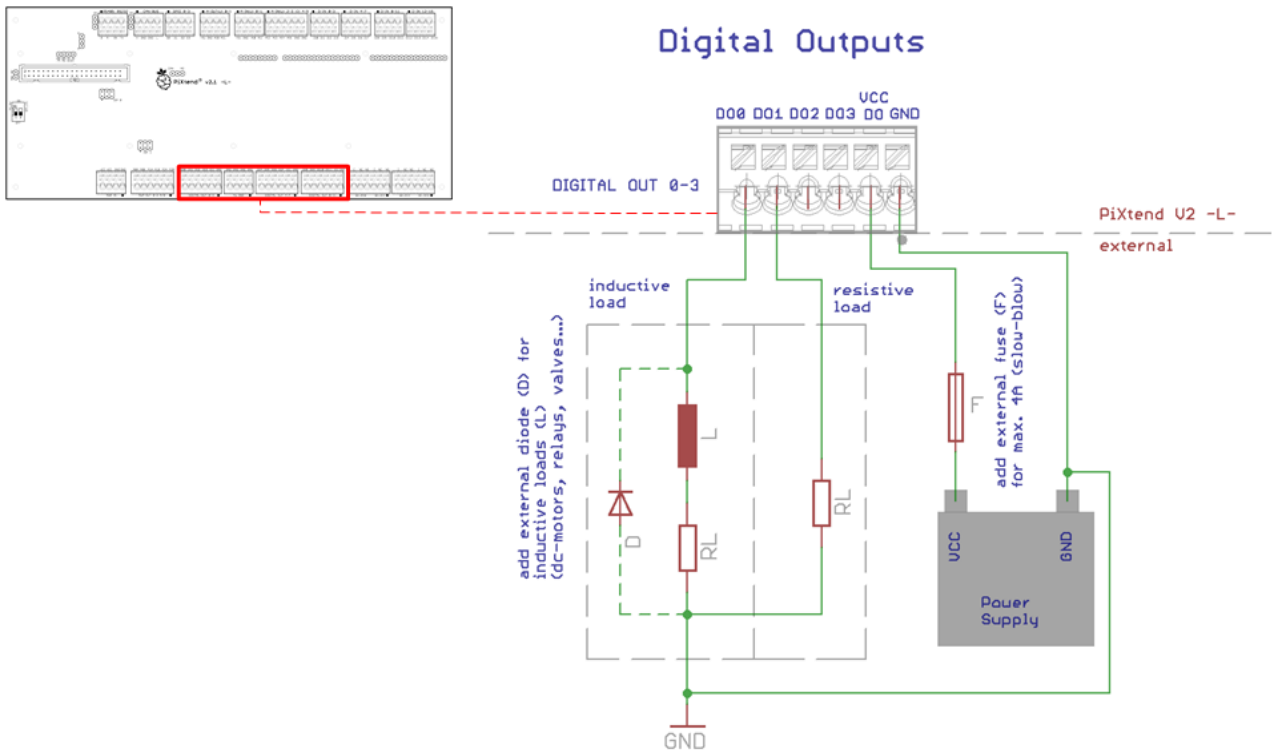
Figure 62: Simplified wiring diagram: connection of the digital outputs

For inductive loads, it must be ensured externally that the voltage at the output is never higher than 40V. This can be achieved, for example, with a free-running diode (1N4004) as shown in figure 62.

Inductive loads are DC motors, relays, magnetic coils, etc.

The ground connections (GND) of external power supply units must be connected directly to the GND connections on the connection strip of the digital outputs or the PWM outputs.

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6.4.3. Relay outputs

Figure 63: Terminal connection block – relay

The four relays (RELAY0 - RELAY3) enable the potential-free switching of direct current (DC) and alternating current devices (AC). Each relay has three connections (change-over contact - SPDT).

Application examples

- Switching 115V/230V AC devices

- Switch alternating voltages of different voltages and frequencies

- Speed selection of blowers with two speeds

- Direct operation of DC or AC motors

- Fans, blowers, heaters and lighting

- Large loads with less frequent switching cycles

The universal relay can be used to switch anything which requires a maximum of 230V and 6 A. All switching contacts are potential-free and do not have any conductive contact with the rest of the PiXtend V2 -L- controller.

LEDs indicate the state of the relays.

NOTICE   Observe the following safety instructions when working with dangerous voltages (greater than 50V)!

Property	Value	Comment
Type of outputs	relays electromechanical	for direct voltage (DC) and alternating voltage (AC)
	per changeover	SPDT
Rated current	6A	
Max. inrush current	10A	
Maximum voltage (DC)	60V	Follow the safety instructions!
Maximum voltage (AC)	250V	Follow the safety instructions!
Max. switching power	30W 72W 144W 690W 1380W	at 5V DC at 12V DC at 24V DC at 115V AC (grid USA) at 230V AC (grid Europe)
Load types	ohmic, inductive, lamp load	A free-wheeling diode must be provided externally for inductive loads
Contact resistance	ca. 100 mΩ	
Response time	ca. 10 ms	excluding bounce time
Fall time	ca. 5 ms	excluding bounce time
Power consumption	0.25W	per active relay
Mechanical lifetime (theoretically)	> 20 x 10^6 switching cycles	actual number depends on the type of load or switching power
Short circuit and overload protection	No	a 6A fuse must be provided externally
Electrical isolation	Yes	all switching contacts are isolated to the GND and all other signals on the PiXtend V2 -L-/RPi
Status display	LED (orange)	Name: "12" to "15" on the circuit board, RELAY0 ... RELAY 3 on the cover
Permissible cable length	< 30 m	

Table 17: Technical data – relay outputs

⚠CAUTION   Voltages greater than 250V AC or 60V DC must not be applied!
Spacings between interconnects and components are designed for a maximum of 250V AC.

Work on 115/230V mains voltage may only be carried out by trained and legally qualified specialists! Never work on energized parts. Do not disconnect or connect energized cables. If you do not pay attention to this warning, it can result in injury or death due to electric shock!

If the relays are to be operated with a mains voltage of 115V (USA)/230V (Europe), an insulating plastic housing or a metallic housing with a grounding connector (PE) must be provided. The housing must prevent direct contact with energized components, cables and metal parts.

We offer suitable housing parts for mounting on a DIN rail.
The PiXtend stainless-steel cover must be securely connected to the grounding connector (PE - green/yellow cable) at the intended location (PE label). Further information is available in the section about the stainless-steel cover.

Alternatively, the PiXtend V2 -L- module can also be installed in another plastic housing or grounded metal housing, which must be closed during operation of the module. Observe the legal requirements regarding the electrical safety of the country in which the module is used.

Depending on the supply voltage, load and ambient temperature, the relay can have temperatures as high as 60° C. Avoid direct contact.

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Connection instructions

The following diagram illustrates the connection of ohmic and inductive DC loads to the relay outputs.
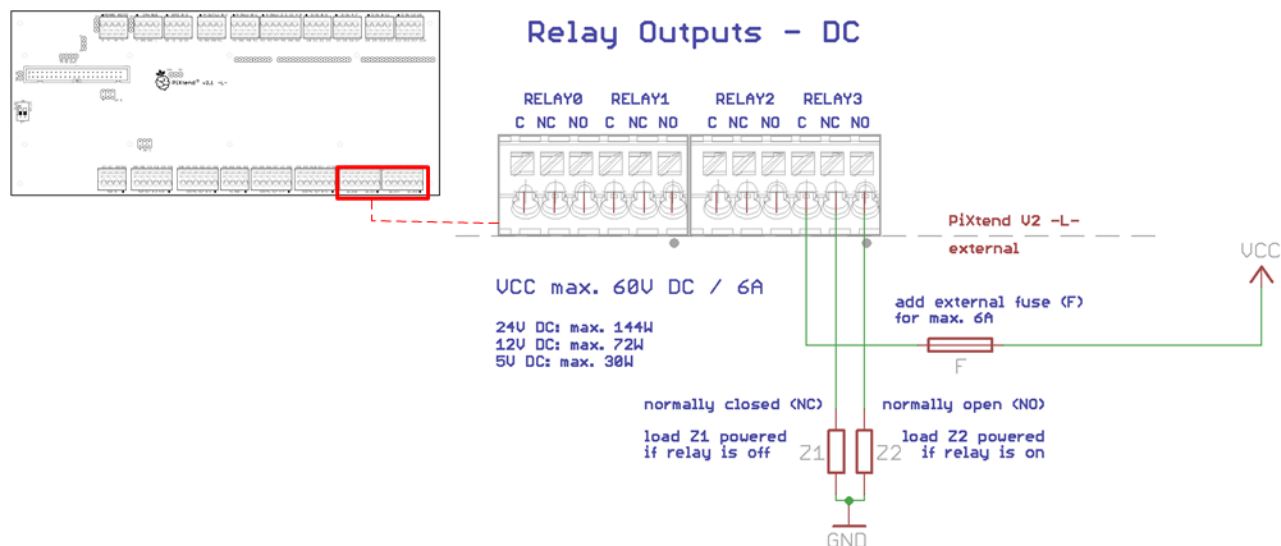
Figure 64: Simplified wiring diagram: connection of the relay (DC voltage)

The four relay outputs do not have an integrated fuse or other overload protection. It is necessary to provide for external fuses which trigger at 6A.

For inductive loads, a free-wheeling diode or a suitable snubber network must be installed externally. Otherwise, sparking may occur when the load is switched off, which could interfere with other devices and damage the relay contacts.

Inductive loads are motors, relays, magnetic coils, power supplies with transformers, etc.

The ground connections (GND) of external power supplies used in conjunction with relays do not have to be connected to the general PiXtend GND. The relays have a potential separation and therefore no conductive connection to other components or potentials of the PiXtend or Raspberry Pi.

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The following diagram illustrates the connection of ohmic and inductive AC loads to the relay outputs:
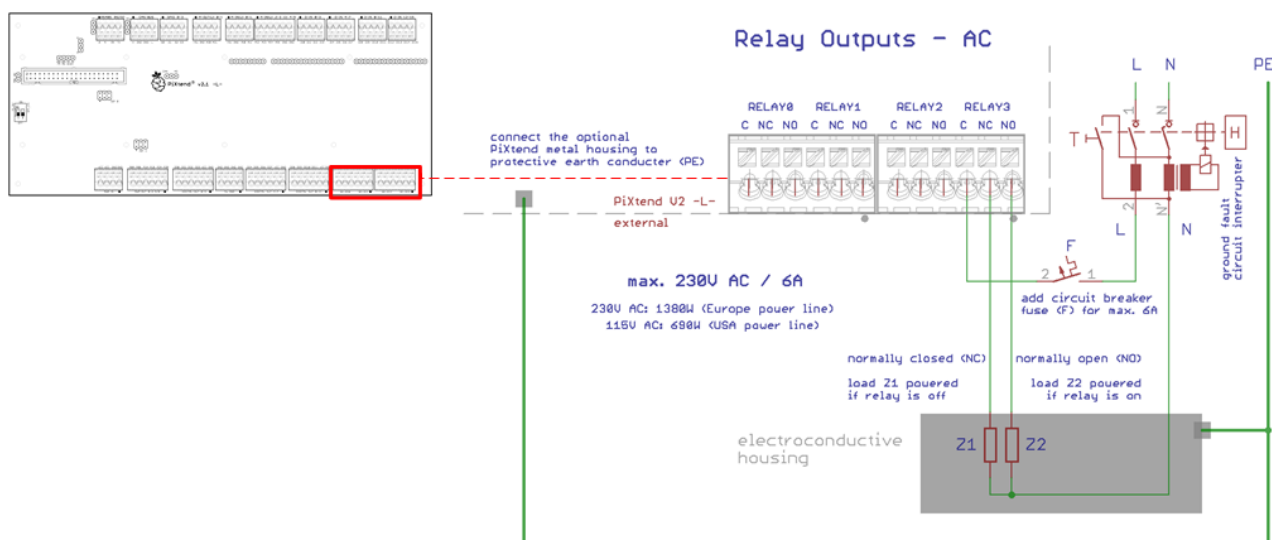
Figure 65: Simplified wiring diagram: connection of the relays (AC voltage)

Before 115V/230V or other dangerous voltages are connected to the relays, please read all safety and connection instructions.

⚠DANGER When handling 115V/230V mains voltage, a residual current circuit breaker/fault-current circuit breaker (personal protection) must always be used!

In the case of inductive loads, a snubber network (RC element) is to be used externally, which intercepts and dampens voltage peaks during switch-off.

Inductive loads are motors, relays, magnetic coils, power supplies with transformers, etc.

Alternating voltages may only be connected to the four relays. All other connections of the PiXtend V2 -L- are not designed for alternating voltages and never for mains voltage.

6.4.4. GPIOs as digital inputs and outputs
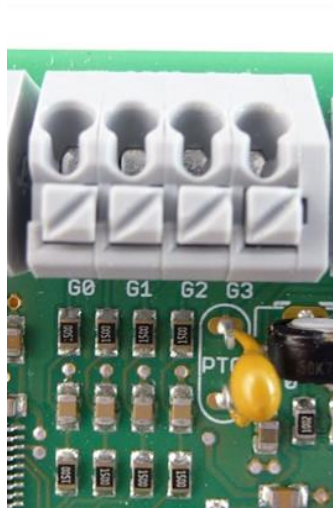
Figure 66: Terminal block connection - GPIOs

The four GPIOs[i] (GPIO0 - GPIO3) of the PiXtend V2 -L- can be configured and used for different tasks depending on the requirements. In general, the PiXtend GPIOs are designed for the range between 0V to 5V DC.

Application examples

- Connection of sensors, push buttons and limit switches (as input)

- Direct connection small electrical loads such as LEDs (as output)

- Connection to digital inputs or outputs of other control units or micro-processors

- Connection of temperature and humidity sensors (DHT11 / DHT22 / AM2302)

Unlike other inputs and outputs on the PiXtend V2 -L-, the GPIOs only have basic protection devices. Therefore, only short cables (less than 3 meters) are allowed. As output the GPIOs are short-circuit proof (against GND).

The GPIOs described here are connected to the PiXtend micro-controller (5Vlogic) and have nothing to do with the 3.3V GPIOs of the Raspberry Pi.

The GPIOs are configured by software (PiXtend Linux tools (pxdev) / CODESYS / Python / Node-RED, others).

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Property	Value	Comment
Type of inputs	Digital input	for DC voltage
	positive switching	CMOS input
Nominal voltage	5V	
Voltage for high level	min. 3V	logical "1"
Voltage for low level	max. 1V	logical "0"
Input current	max. 1 uA	in the range of 0 to 5V DC
Maximum input voltage	5.5V	minimum -0.5 V
Pull-up resistor	Yes	can be activated by software per channel, ~ 35 kΩ
Reverse polarity protection	No	
Electrical isolation	No	
Status display	No	
Permissible cable length	< 3 m	

Table 18: Technical data - GPIO as input

NOTICE Applying voltages greater than 5.5V or less than -0.5V DC can lead to a defect of the GPIOs or the entire micro-controller. Alternating voltages on the GPIO inputs are not permissible.

Connection instructions

The following diagram illustrates the connection of signal generators to the PiXtend GPIOs during operation as inputs.
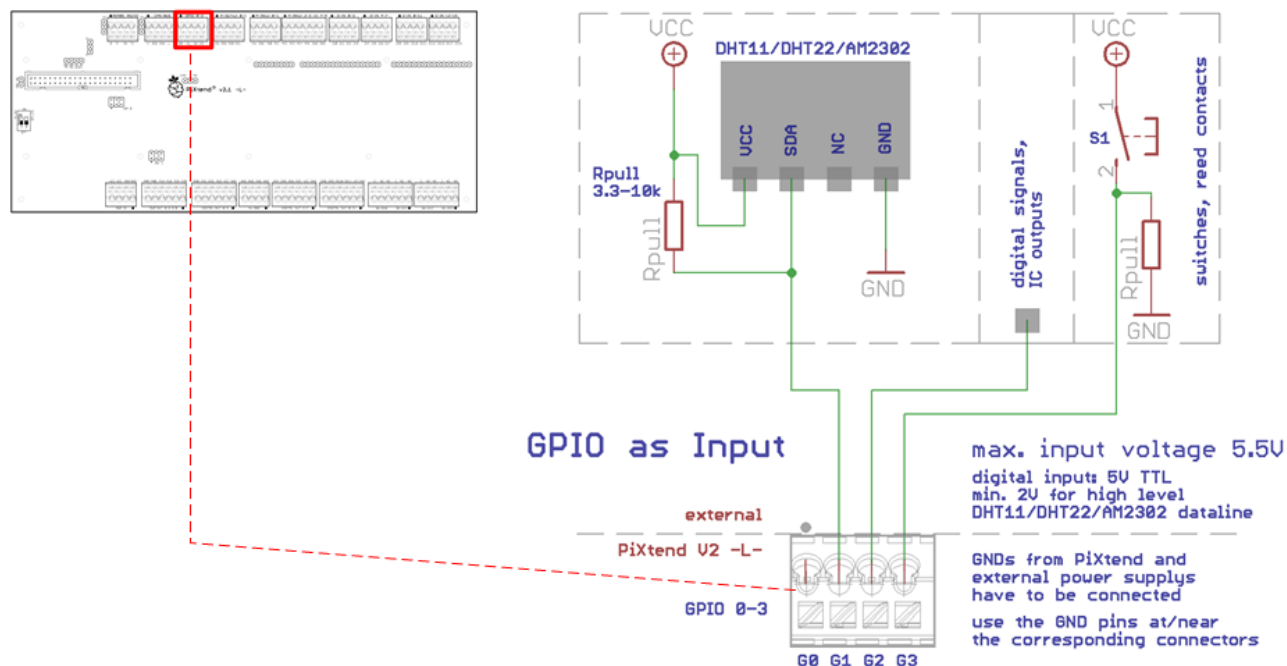
Figure 67: Simplified wiring diagram: connection of the PiXtend V2 -L- GPIOs (as inputs)

For the supply of sensors, switches and other signal transmitters, one of the +5V supply connections can be used, which are located on the terminals of the analog inputs and outputs. Care must be taken to ensure that a maximum of 100 mA current can be taken from the supply connection. In case of doubt, a self-resetting fuse (polyfuse) protects the supply connection from overload and short-circuit.

If a temperature and humidity sensor (DHT11 / DHT22 / AM2302) is to be connected to the GPIOs, a pull-up resistor must be connected to the data line (SDA) of the sensor, as shown in figure 67. For cable lengths greater than 2 m, we recommend the use of pull-ups in the range 1 kΩ - 3.3 kΩ. Since the sensors are subject to certain fluctuations (different manufacturers/batches/variants), no general value can be specified.

Four of the aforementioned sensors can be connected without difficulty to the supply connection. Each sensor receives approximately 1.5 mA of current. For cable lengths greater than 2 m, we recommend a capacitor with min. 100 nF at the sensor between VCC and GND.

The DHT11/22 sensors offered in our online shop already have a pull-up and buffer capacitor. No external circuit of the sensors is required. According to our measurements under laboratory conditions, these DHT sensors can be operated up to approximate 25 m cable length.

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Property	Value	Comment
Type of outputs	digital output, semiconductor	for DC voltage
	Push-pull	CMOS input
Output voltage	5V DC	
Rated current	2 mA*	
Rated load	≥ 3 kΩ*	for min. 4.5 V Output voltage
	≥ 1 kΩ*	for 5V TTL high level
Load types	ohmic	
Short circuit current	ca. 15 mA*	
Rated switching capacity	10 mW	
Short-circuit protection	Yes	Short circuit against GND
Electrical isolation	No	
Status display	No	
Permissible cable length	< 3 m	

Table 19: Technical data - GPIO as output

NOTICE Under no circumstances may inductive loads be connected, as the resulting voltages can damage the micro-controller when the loads are switched off.

* This is a 5V TTL output with 300 Ω resistor in series (as a series resistor for standard LEDs or as short circuit protection/current limitation).

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Connection instructions

The following diagram illustrates the connection of small electrical loads to the PiXtend GPIOs during operation as outputs.
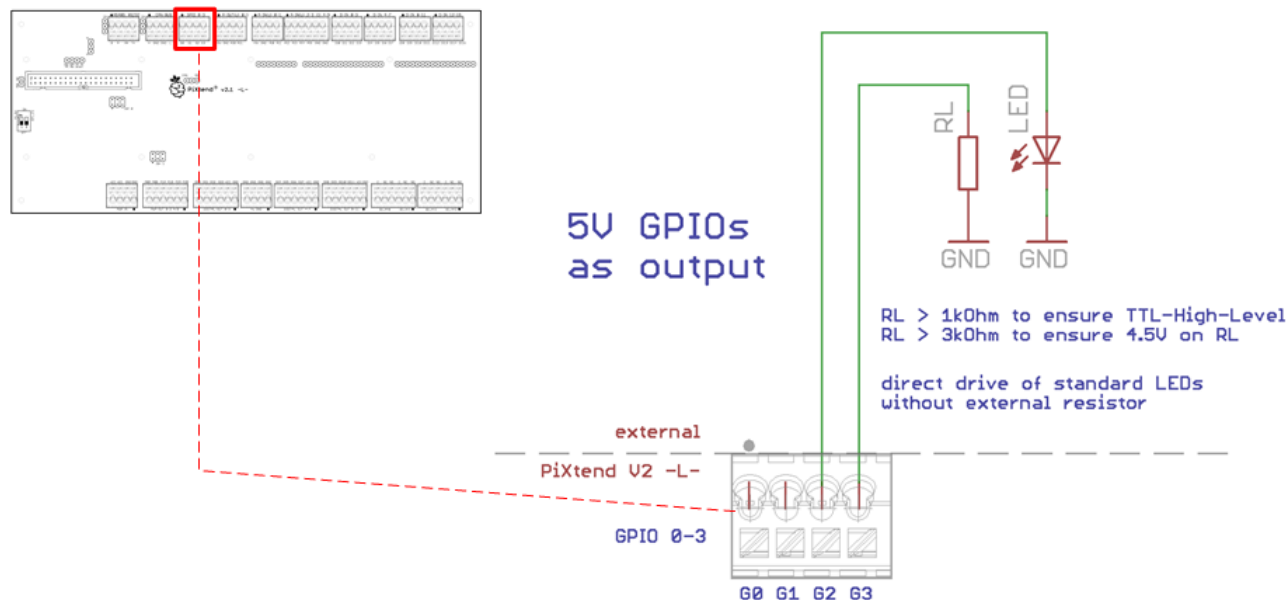
Figure 68: Simplified wiring diagram: connection of the GPIOs (as outputs)

Standard light-emitting diodes (LED) can be connected directly to the GPIOs. However, it is first necessary to calculate whether the current is suitable for the respective LED.

Example calculation:

Green standard LED: forward voltage 2.1 V

(Output voltage - forward voltage) / internal series resistor = current

(5V – 2.1V) / 300 Ω = 9.67 mA

Standard LEDs usually light up from approximately 2 mA and tolerate at least 20 mA. It is therefore possible to connect a green LED directly between a GPIO output and GND.

If the outputs are to be connected to TTL inputs of other devices, make sure that the input resistance is not less than 1 kΩ. Otherwise, the voltage at HIGH level may not be sufficient to be recognized by the input of the other device (voltage divider between internal 300 Ω - PiXtend internal and the resistance of the remote).

The GND connections shown externally in figure 68 must be connected to the PiXtend GND at least to one point in order to close the circuit.

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6.5. Analog Inputs and Outputs

Figure 69: Terminal blocks - analog inputs and outputs

The PiXtend V2 -L- has the following analog inputs and outputs:

- Four voltage inputs (AI0 – AI3)

- Two current inputs (AI4 – AI5)

- Two voltage outputs (AO0 - AO1)

Further information and details about these analog I/Os can be found on the following pages.

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6.5.1. Analog inputs

Figure 70: Terminal block - analog inputs

The PiXtend V2 -L- has four analog inputs for voltage measurements (AI0 - AI3) in the ranges 0 – 5V / 0 – 10V and another two for current measurements (AI4 - AI5) in the range 0(4) – 20 mA.

Application examples

- Read industrial sensors with analog outputs

- Detecting potentiometer positions (rotary control)

- Current and voltage measurements in the laboratory and in experimental setups

- Voltage monitoring of batteries (for example, in a robot)

- Current measurement with an external shunt (voltage at the resistor)

- Read PT100/1000 sensors (with external pre-amplifier)

- Connection to the analog outputs of other control units

The inputs are robust and can withstand overvoltages of up to 30V DC. The voltage ranges can be easily modified and adapted to the conditions by means of jumpers.

The analog channels correspond to the standard for programmable logic controllers (IEC 61131-2) and are therefore suitable for a large number of professional sensors and measuring devices.

Analog filter stages ensure low-noise measurements with the 10-bit analog-to-digital converter.

6.5.1.1   Voltage inputs

Before use, check the jumper position and adjust if necessary. Of course, you can always stay in the 10V range (no jumper) and thus enjoy the greater flexibility and robustness of the inputs. In the 5V range (jumper plugged in), however, the same resolution is available for a smaller measuring range. When it comes to accuracy, that can be very helpful.

Property	Value	Comment
Type of inputs	analog input according to IEC 61131-2	for DC voltage
	single-ended	with GND reference
Operating mode	voltage input (AI-U)	
Measuring range	0 – 10V DC	
Input resistance	20 kΩ	
Analog filtering	Cut-off frequency 275 Hz	low-pass 2nd order
RF attenuation:	52 dB 95 dB 151 dB	at 10 kHz at 100 kHz at 1 MHz
Conversion method	successive approximation	one converter with multiplexer
Conversion time	2 µs	averaging 10 values (20 µs)
Digital resolution	10 Bit	
Smallest digital step (LSB)	9.77 mV	
Max. measurement error at 25° C **	±1% (±0.1 V)	of the value range at default config
Temperature coefficient	±0.025% per °C	in the range 0 – 50° C ambient temperature
Data format	16-bit integer 32-bit float values	raw value (right-justified) calculated voltage value in V
Maximum input voltage	30V	
Reverse polarity protection	Yes	up to -30V
Electrical isolation	No	
Status display	No	
Permissible cable length	< 3 m < 30 m	unshielded cables shielded cables

Table 20: Technical data - digital inputs - "10V range"

Property	Value	Comment
Type of inputs	analog input	for DC voltage
	single-ended	with GND reference
Operating mode	voltage input (AI-U)	
Measuring range	0 – 5V DC	
Input resistance	10 kΩ	
Analog filtering	Cut-off frequency 500 Hz	low-pass 1st order
RF attenuation	26 dB 49 dB 85 dB	at 10 kHz at 100 kHz at 1 MHz
Conversion method	successive approximation	one converter with multiplexer
Conversion time	2 µs	averaging 10 values (20 µs)
Digital resolution	10 Bit	
Smallest digital step (LSB)	4.88 mV	
Max. measurement error at 25° C **	±1% (±0.05V)	of the value range at default config
Temperature Coefficient	±0.025% per °C	in the range 0 – 50° C ambient temperature
Data format	16-bit integer 32-bit float values	raw value calculated value in V
Maximum input voltage	30V	
Reverse polarity protection	Yes	up to -30V
Electrical isolation	No	
Status display	No	
Permissible cable length	< 3 m < 30 m	unshielded cables shielded cables

Table 21: Technical data - digital inputs - "5V range"

The analog voltage inputs can measure DC and AC voltages. When using alternating voltages, the input filters must be observed. Only measurements in the positive range are possible. Negative voltages can be applied within the specified maximum values but cannot be measured.

The PiXtend V2 -L- <u>cannot automatically</u> evaluate the <u>jumper state</u> (plugged/unplugged) of the analog voltage inputs. If you insert the jumper, the software must react accordingly (adjust the conversion factor).

In CODESYS, for example, the jumper position can be conveniently set via "PiXtend V2_L" --> "SPI devices Parameters". The PiXtend Linux tools (pxdev) and our Python Library also handle the switching between the 5V and 10V measuring range.

NOTICE   Voltages greater than 30V DC can lead to overheating and the defect of components.

** Deviations up to 2% (relative to the scale end value) are possible under EMC exposure.

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Connection instructions

The following diagram illustrates the connection of analog voltage sensors and analog outputs to the analog inputs of the PiXtend V2 -L-.
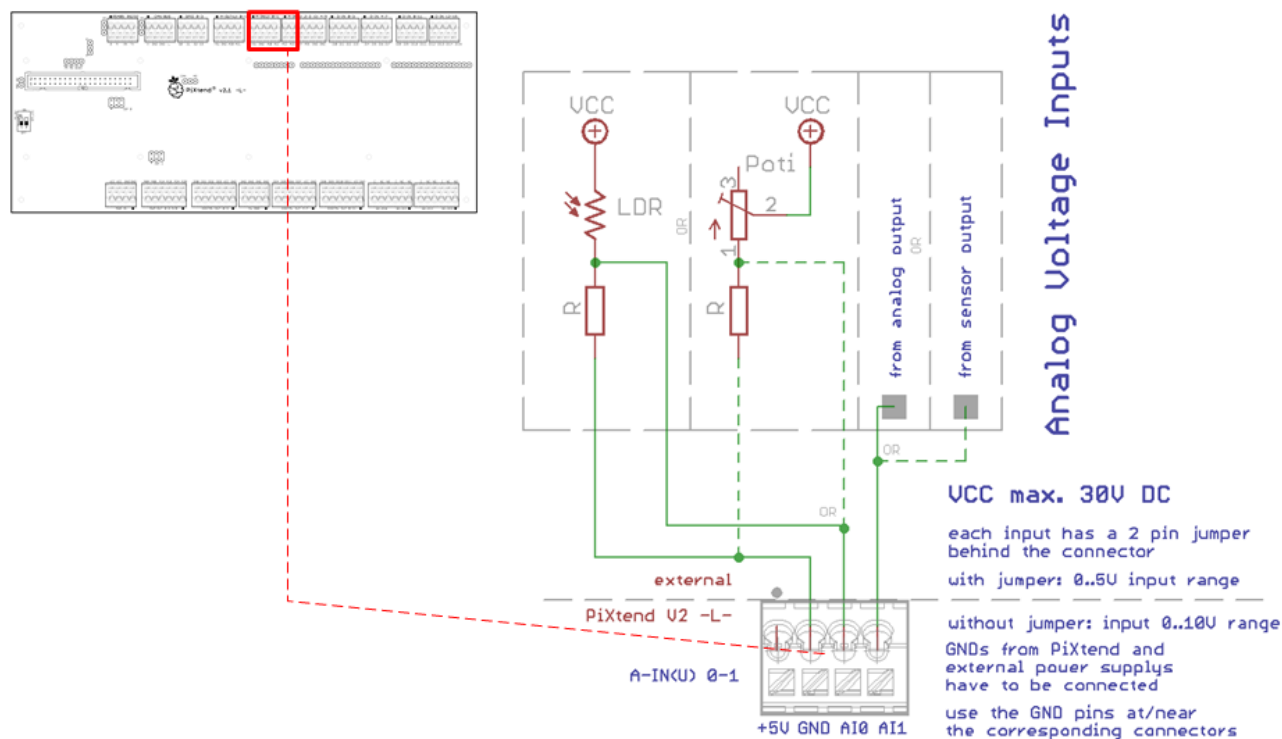
Figure 71: Simplified wiring diagram: connection of the analog voltage inputs

The voltage inputs can be used for various tasks which require measuring a voltage. Figure 71 shows a simple circuit with a light-sensitive resistor (LDR) or the evaluation of a rotary potentiometer.

If the 5V range is used, one of the two +5V power supplies of the PiXtend V2 -L- can be used for the supply of sensors or voltage dividers. Currents greater than 100 mA should not be drawn permanently. In the case of a short-circuit or a permanent overload, however, the supply output is protected by a self-resetting fuse.
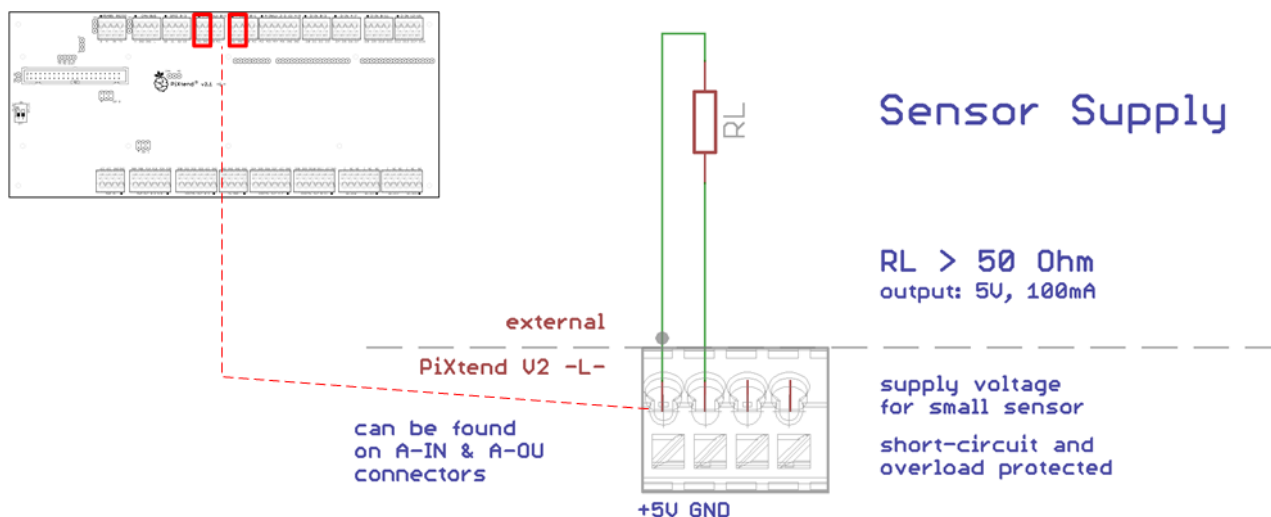
Figure 72: Simplified wiring diagram: connection of the sensor supply

The ground connections (GND) of external power supply units must be connected directly to the GND terminals of the terminal block of the analog inputs.
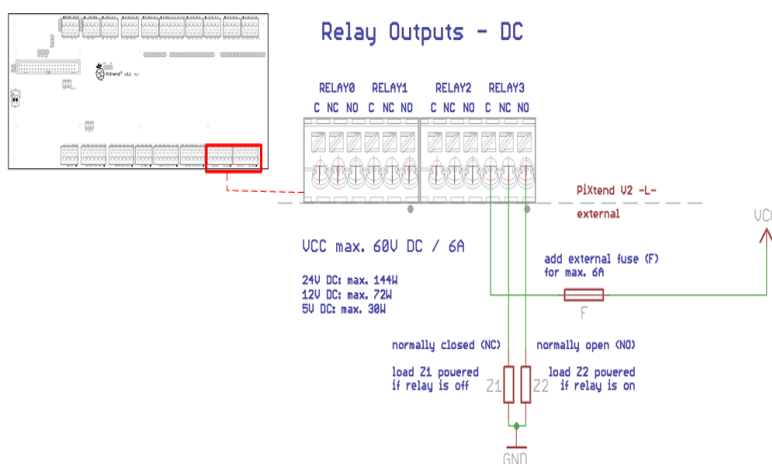
Figure 73: Simplified wiring diagram: GND connection

In the case of analog signals, we strongly advise using shielded connection cables. This is particularly important when the cables are routed in the direct vicinity of large pulsed currents (e.g., motors or transformers) or other sources of interferences.

If PiXtend is used in a metal housing or cabinet, the shield must be placed on a grounded and bare metal surface (earthing clamps and screw connections from a hardware store or electronics dealer). An electrically conductive connection between the GND and the housing/cabinet (usually PE shielded) must be available or established.

Otherwise, the wire-shield should be separated, twisted and connected to the GND of the PiXtend. For cables less than three meters, unshielded cables can also be used.

6.5.1.2 Current Inputs

Property	Value	Comment
Type of inputs	analog input according to IEC 61131-2	for DC voltage in the range 0 – 20 mA
	single-ended	with GND reference
Operating mode	current input (AI-I)	
Measuring range	0-20 mA DC	also usable for 4 – 20 mA sensor outputs measurement possible up to 20.65 mA
Input resistance	< 25 Ω	
Analog filtering	Cut-off frequency 500 Hz	low-pass 1st order
RF attenuation:	26 dB 49 dB 85 dB	at 10 kHz at 100 kHz at 1 MHz
Conversion method	successive approximation	one converter with multiplexer
Conversion time	2 μs	averaging 10 values (20 μs)
Digital resolution	10 bit	
Smallest digital step (LSB)	20.17 uA	
Max. measurement error at 25° C **	±1% (±0.2 mA)	of the value range at default config
Temperature Coefficient	±0.025 % per °C	in the range 0 –50° C ambient temperature
Data format	16-bit integer 32-bit float values	raw value (right-justified) calculated value in mA
Max. Input current	100 mA	in case of error - should not occur in normal operation
Maximum input voltage	30V	in case of error - should not occur in normal operation
Reverse polarity protection	Yes	up to -30V
Overload protection	Yes	thermal, self-resetting fuse (Polyfuse)
Electrical isolation	No	
Status display	No	
Permissible cable length	< 3 m < 30 m	unshielded cables shielded cables

The analog current inputs can measure DC and AC currents. When using alternating currents, the input filters must be observed. Only measurements in the positive range are possible. Although negative currents can be created, they cannot be evaluated.

NOTICE   Voltages greater than 30V DC can lead to the defect of components.

** Deviations up to 2% (relative to the scale end value) are possible under EMC exposure.

Connection instructions

The following circuit diagram illustrates the connection of analog current sensors to the analog current inputs of the PiXtend V2 -L-.
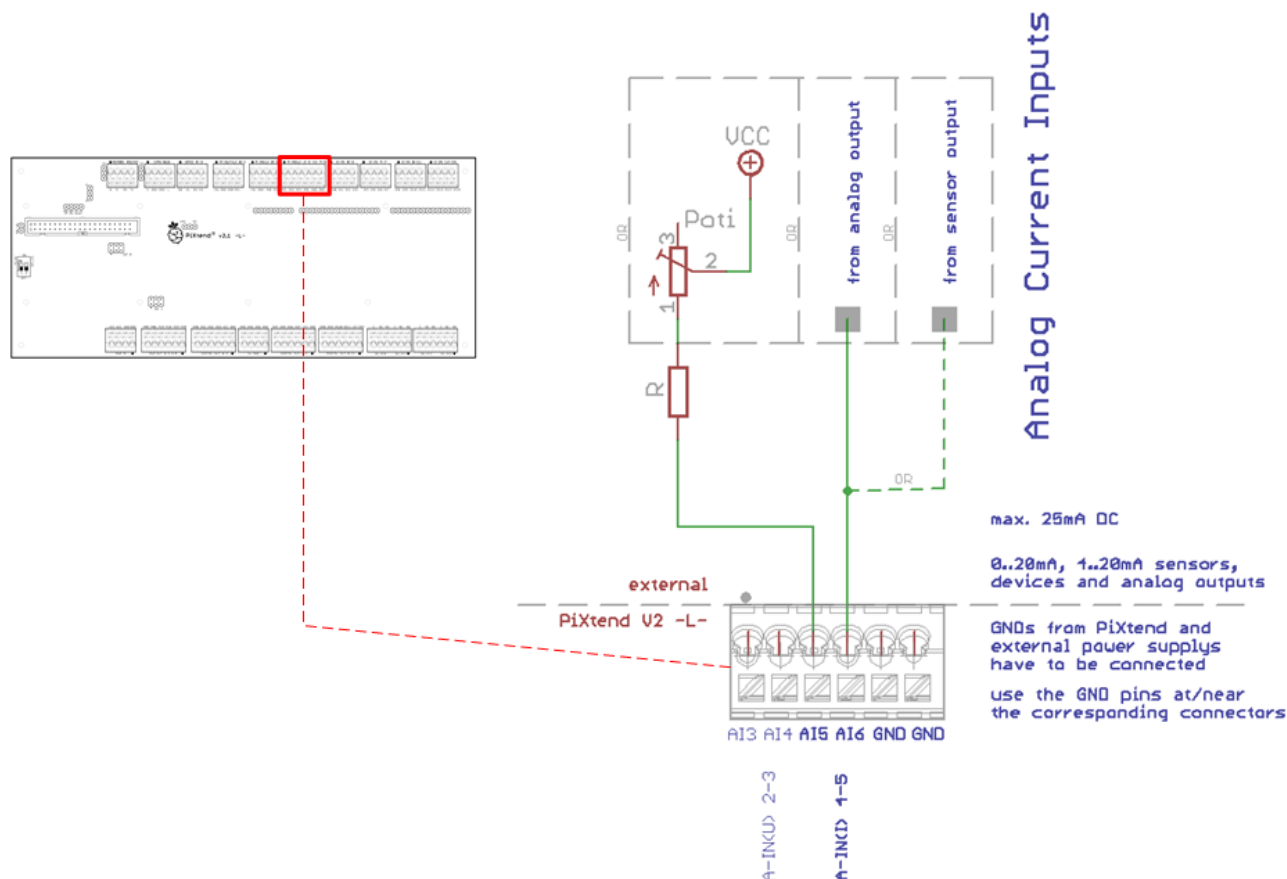
Figure 74: Simplified wiring diagram: connection of the analog current inputs

The measuring current flows through a shunt resistor with a value of 20 Ω. So if a voltage sensor is connected to the output, the maximum permissible measuring current of 20 mA flows even at very low voltages:

Umax = 20 Ω * 20 mA = 0.4 V

If larger voltages are applied to the input, the current flow increases rapidly over the permitted range and is limited at approximately 100 - 150 mA by a self-resetting fuse.
Even if such defects are avoided, it is not recommended to let the input currents rise permanently or in normal operation above 20 mA.
Currents greater than ~20.5 mA cannot be evaluated in the software.

The ground connections (GND) of external power supplies must be connected directly to the GND terminals on the terminal strips of the analog inputs.

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6.5.2. Analog outputs

Figure 75: Terminal block - analog outputs

The PiXtend V2 -L- has two analog voltage outputs. The independent channels can be used to generate output voltages in the range of 0 – 10V in 10 mV steps.

Application examples

- Supply and control of small loads: mini-DC motor, LED(s)

- Function generator (output of sine, rectangle and triangle voltages, etc.)

- Connection to analog inputs of other control units and power amplifiers

- Control analog displays

The two outputs are short-circuit-proof and can drive a current of 10 mA in normal operation. The analog outputs are supplied by the PiXtend's central voltage regulator.

The fine tuning of the output voltage range is possible via the two potentiometers T0 and T1 on the PiXtend V2 -L-.

Property	Value	Comment
Type of outputs	analog output according to IEC 61131-2	for DC voltage (DC) in the positive range
Operating mode	Voltage output (AO-U)	
Conversion method	String DAC	one converter per channel
Nominal voltage range	0-10V	
Load impedance range	≥ 1 kΩ	
Rated output current	10 mA	at 1 kΩ load, 10V min. 13.5V VCC
Digital resolution	10 bit	
Smallest digital step (LSB)	9.77 mV	depending on the potentiometer setting
Max. measurement error at 25° C **	±1% (±0.1V)	the value range, depending on the potentiometer setting
Temperature Coefficient	±0.025% per °C	in the range 0 –50° C ambient temperature
Data format	16-bit integer 32-bit float values	raw value (right-justified) output value in V
Short-circuit protection	Yes	Short circuit against GND
Permissible cable length	< 3 m < 30 m	unshielded cables shielded cables

Table 22: Technical data- analog outputs

NOTICE Since the analog outputs are fed from the central PiXtend V2 -L- supply voltage (12 - 24V), the following must be observed: The rated output current of 10 mA per channel can only be drawn when the PiXtend module has at least 13.5V supplied.

** Deviations up to 2% (relative to the scale end value) are possible under EMC exposure.

Connection instructions

The following circuit diagram illustrates the connection of loads and devices to the analog outputs of the PiXtend.
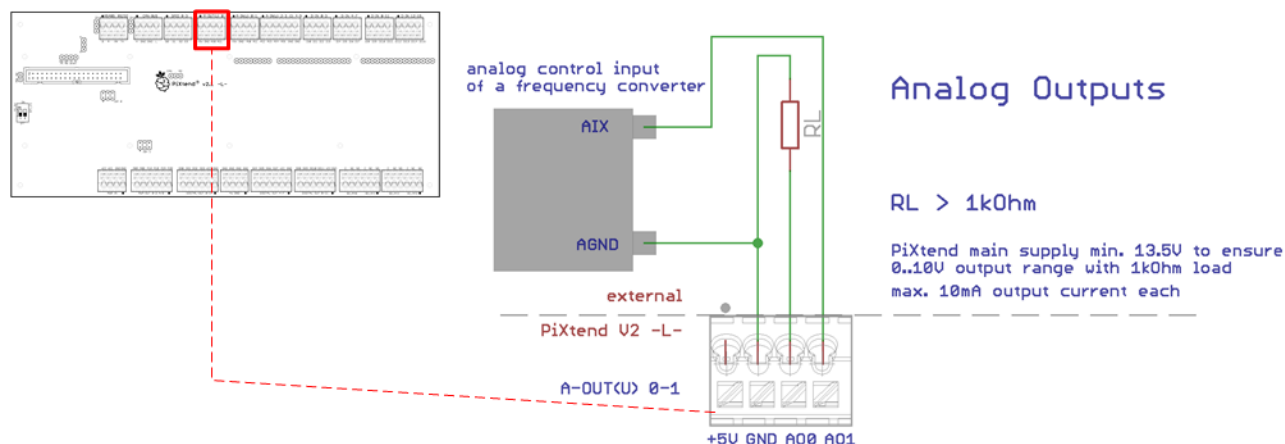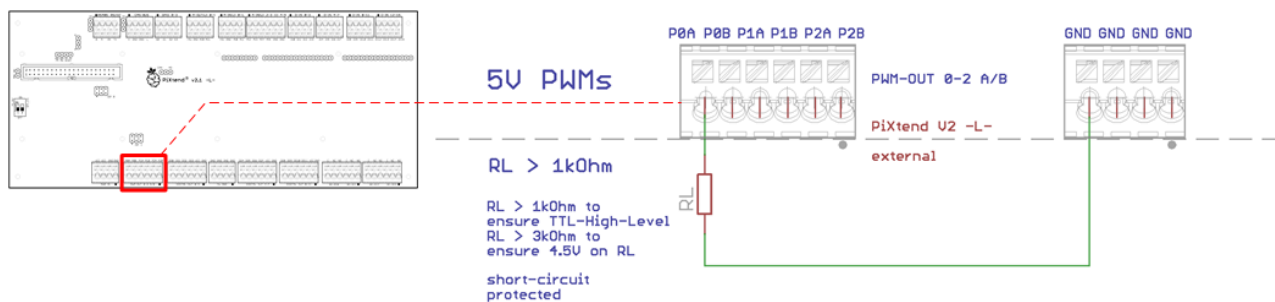

Figure 76: Simplified wiring diagram: connection of the analog voltage outputs

If the outputs are connected to analog inputs of other control units, power amplifiers (also frequency converters) or similar, the ground connections (GNDs) of the devices and PiXtend must be connected. A GND connector can be found directly on the terminal block of the analog outputs.

As with the analog inputs, shielded cables should be used for analog outputs. The fine-tuning of the analog outputs is carried out by Kontron Electronics during the production. However, after a certain time, it may be useful to repeat this trimming:

Each channel has its own potentiometer: AO0 → potentiometer "T0", AO1 → potentiometer "T1"

Procedure for trimming:

- the value "10V" or "1023" (raw value) can be set by software.

- Use a voltage/multimeter to measure the voltage at the analog output.

- Rotate the potentiometer until the exact voltage of 10.0V is displayed on the meter.

- The same procedure is also for the second channel.

Subsequently, any voltage can be preset by software and output correctly.
A 5V supply output/sensor supply is located on the terminal block of the analog outputs as well as on the terminal block of the analog inputs. This can, for example, be used to supply small sensors (DHT11/22, AM2302 on the PiXtend GPIOs) or switches that lead to the digital inputs. Currents greater than 100 mA should not be drawn permanently. In the case of a short-circuit or a permanent overload, the supply output is protected by a self-resetting fuse.

Further information and a connection diagram can be found in the analog inputs section in this document.

The digital to analog converter (DAC) for the AOs is connected to the Raspberry Pi via the SPI. Since the analog outputs (AO) and the CAN controller share an SPI-chip-select (CS1), a prefix must be made. To do this, the jumper (figure 77) is set to the "AO" position (default setting).

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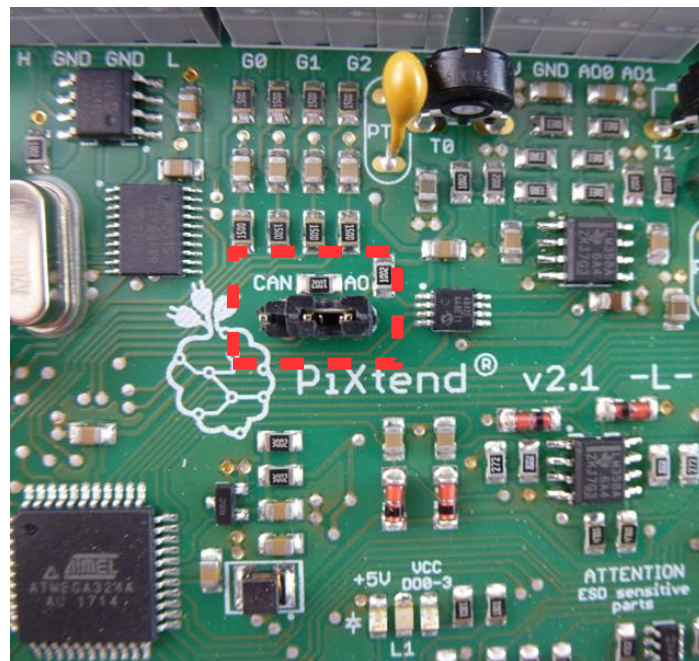
Figure 77: Jumper for switching between AO and CAN

As a result, a decision must be made between AO and CAN. Only one of the two devices can be operated at one time. Parallel operation of both functions is not possible. The jumper may only be moved when the module is turned off.

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6.6. Special Inputs and Outputs

Some inputs and outputs of the PiXtend V2 -L- have special functions.
The functions and the associated possibilities are described in detail below. See the PiXtend V2 -L- Software Manual for software configuration and usage information.

6.6.1. PWM/servo outputs
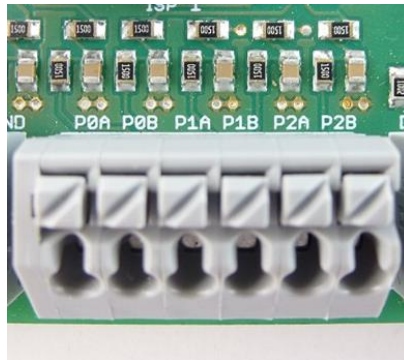
Figure 78: PWM / servo outputs

The six PWM outputs are located on the 6-pin connector between the digital outputs and the PiXtend power supply. Pulse-width-modulated (PWM) signals with adjustable frequency and duty cycle can be connected to these special outputs or connected directly to RC servos.

Application examples

- Position of up to six RC servos

- Speed control of fans and other DC motors

- Clock for stepping motor driver

- Dimming of DC lamps and light-emitting diodes (also high-power LEDs)

- Temperature control of heating elements

- Precisely adjustable clock source for a variety of electronic applications

The PiXtend V2 -L- has the following PWM outputs:

6x PWM with 16-bit digital resolution – PWM0A (P0A), PWM0B (P0B), PWM1A (P1A), PWM1B (P1B), PWM2A (P2A), PWM2B (P2B)

All PWM outputs have identical electrical characteristics.

Property	Value	Comment
Type of outputs	digital output, semiconductor	for DC voltage
	Push-pull	CMOS input
Output voltage	5V DC	
Rated current	2 mA	
Rated load	≥ 3 kΩ	For min. 4.5 output voltage
Analog filtering*	Cut-off frequency: 830 kHz	low-pass 1st order
Load types	ohmic	
Short circuit current	ca. 15 mA	
Rated switching capacity	10 mW	
Short-circuit protection	Yes	Short circuit against GND
Electrical isolation	No	
Status display	No	
Data format	16-bit integer	raw value (right-justified)
Permissible cable length	< 3 m < 30 m	unshielded cable shielded cable

Table 23: Technical data – PWM outputs

* to limit the edge steepness of the PWM signals, the cut-off frequency is at -3 dB

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The following circuit diagram illustrates the connection of loads and devices to the PWM/digital outputs of the PiXtend.

Figure 79: Simplified wiring diagram: connection of the PWM/servo outputs

In the software (PiXtend Linux Tools (pxdev) and CODESYS Demo project), you can choose between Servo, Duty-Cycle-Universal and Frequency Mode.

Here is a brief description of the characteristics/operating behavior:

- Outputs switched off (default setting - after power-up/reset)

- In Servo mode: Frequency 50 Hz (20 ms), 1-2 ms "ON" time
  1 ms: minimum swing of the servo
  2 ms: maximum swing of the servo

- In the Duty cycle mode, the duty cycle can be freely configured for each channel. The frequency is configured together for both channels - 16-bit PWMs.

- In the Universal mode, the frequency and the duty cycle can be freely configured for the A channel. The corresponding B channel is not configurable and runs at half the frequency of the A channel and with 50% duty cycle.

- The Frequency mode allows freely adjustable frequencies up to 20 kHz on all four PWM channels. The duty cycle is always 50%.

All further information on the software control of the PWM outputs can be found in the PiXtend V2 -L- Software Manual.

Connection of RC model servos:

RC servos usually have three connections.

1. Supply - positive pole

2. Supply - negative pole

3. PWM/pulse

The PWM or pulse input of the servo is connected with PWMxx to the PiXtend V2 -L-.

The supply (positive and negative poles) of the servo should be released completely externally. Servos are usually designed for battery operation in RC models and use several amps current for a short time. These peak currents can lead, for example, to short-term overload for digital outputs and trigger the safety mechanisms, which leads to unwanted behavior here.

The arrangement and color coding of the cables depends on the manufacturer and cannot be specified generally. The data sheets and/or connection instructions of the servo manufacturer must be observed.

NOTICE An external power supply or a rechargeable battery (usually 4 - 7 V DC) is required to operate RC model servos. The "+ 5V" of the PiXtend V2 -L-/Raspberry Pi must not be used since the servos receive very high currents (several amperes) at start-up, which can lead to a break of the 5V voltage for the PiXtend and Raspberry Pi.

The break in the voltage supply, in turn, results in unpredictable behavior of the overall system and therefore also of the I/Os and interfaces. The Raspberry Pi can crash and has to reboot.

The ground cable of external batteries, battery packs and power supplies used to power the servo must be connected to PiXtend. GND pins can be found on the terminal block of the digital outputs and PWM connectors.

Always make sure that the legal requirements of the country in which they are to be used are observed for accessories such as RC model servos.

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6.6.2. DHT11/22, AM2302 sensors

Figure 80: Temperature and humidity sensor DHT11

It is also possible to connect up to four temperature and humidity sensors externally to the PiXtend V2 -L-. The four PiXtend GPIOs are used for this purpose.

The sensors with the names "DHT11", "DHT22" or "AM2302" are common and popular inexpensive sensors, which can be obtained from electronics dealers or directly from sales platforms such as Ebay or Amazon from Asia. The price range is 3 to 15 € per sensor.

The sensors are designed for indoor use.
The measurement and electrotechnical details can be found in the data sheets of the respective sensor.

The connection instructions for the sensors are in the chapter GPIOs as digital inputs and outputs.

6.7. Serial interface
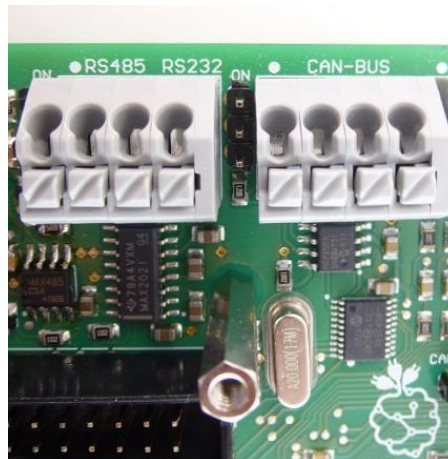
Figure 81: Terminal block connectors - serial interfaces

The PiXtend V2 -L- has one serial interface:

- RS232 classic serial computer interface - point-to-point connection

- RS485 differential serial interface - bus system (fieldbus) as used with Profibus, Modbus RTU, DMX and many more

- **CAN** differential serial interface - bus system (fieldbus) known from the automotive sector and from CANopen, J1939 (in the automation field)

RS232 and RS485 share the UART interface of the Raspberry Pi. It can be switched between the interfaces via GPIO.

Further information and details about the individual interfaces can be found below.

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6.7.1. RS232

The RS232 interface allows simple data transfer between two devices (point-to-point connection). The PiXtend V2 -L- converts the UART signals of the Raspberry Pi to the rugged RS/EIA232 standards.

Application examples

- Connection to computer (data transfer or Linux terminal)

- Data exchange with other control devices, measuring instruments, scales and micro-controllers

- Service access for telephone systems

- Connection to analog modems and other electronics classics

- RS232 can be easily converted to USB (external adapter)

The transceiver installed on the PiXtend has proven short-circuit-proof in extensive testing and can withstand overvoltages of up to +/- 30V at its inputs.

Property	Value	Comment
Type of interface	serial interface, asymmetrical (single-ended)	wired, with GND reference
Type of connection	point-to-point	between two devices
Norm/Standard	RS232/EIA232	
Maximum transmission rate	115,200 baud	depending on the kind and length of the cable used and the software used
Nominal voltage	±9V	
Maximum voltage	±30V ±20V	RX to GND TX to GND
Short-circuit current	±18 mA	
Short-circuit protection	Yes	Short circuit against GND
Electrical isolation	No	
Input resistance	ca. 5 kΩ	RX to GND
Status display	No	
Permissible cable length	< 3 m < 30 m	unshielded cables shielded cables

Table 24: Technical data – RS232

NOTICE   If the specified maximum values are exceeded, transmission errors, functional errors and component defects can occur.

Switching between RS232 and RS485 transceivers is possible via the Raspberry Pi GPIO18. If the GPIO18 is configured as an input or set to LOW level as an output, then RS232 is active. If a HIGH level is set on the GPIO, RS485 is active. RS232 is the default setting for the PiXtend system.

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Connection instructions
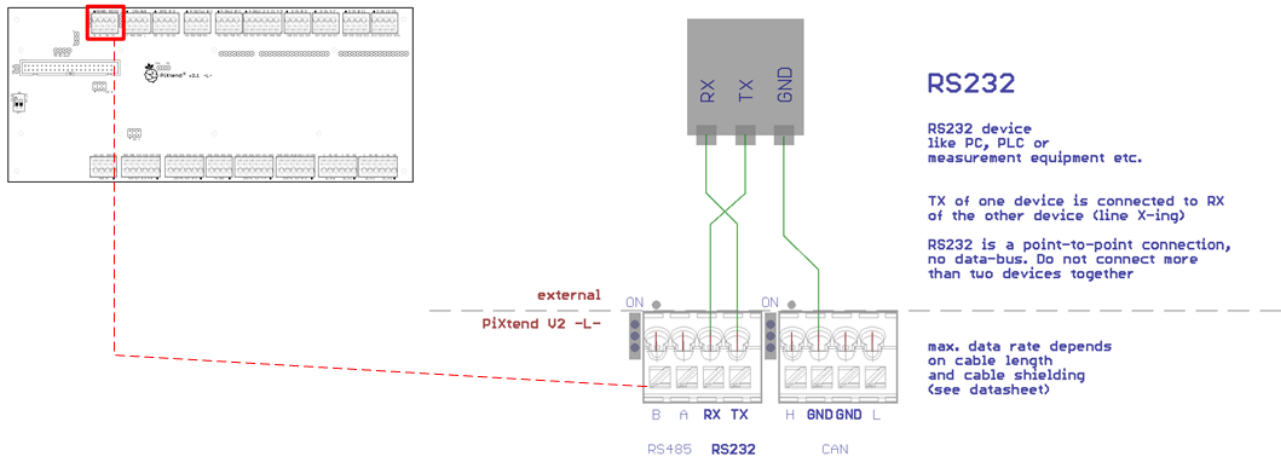
Figure 82: Simplified wiring diagram: connection of the RS232 interface

RS232 is a point-to-point connection between two devices and not a bus system.

The TX line from PiXtend is wired to the RX line of the opposite. Similarly, RX and PiXtend are connected to the TX line of the external device (crossing/X-ing).

For cables longer than three meters, shielded cables should be used. Information and tips on the connection or the application of shielding can be found in the section Voltage inputs in this document.

With standard settings for the UART interface under Raspbian Linux, the RS232 interface serves as a console. With a terminal program, the Linux console can be directly accessed from a PC. The following settings must be made in the PC program for the correct transmission:

Baud rate:	115,200 baud	Parity bit:	none
Data bits:	8	Flow Control:	none

6.7.2. RS485

The RS485 interface enables data transfer between several devices in a bus system. The PiXtend converts the UART signals of the Raspberry Pi to the differential levels of the noise-insensitive RS/EIA485 standard.

Application examples

- Participation in an RS485-based bus system (Profibus, DMX, Modbus RTU ...)

- Construction of a bus system with other control devices, micro-controllers, measuring devices, frequency converters and much more

The RS485 transceiver on the PiXtend is short-circuit proof and robust against interference. By means of a jumper directly next to the terminal strip, a 120 Ω terminating resistor can be optionally switched on or off.

An integrated bias network keeps the bus levels stable, improving immunity to interference. The interface complies with the "MODBUS over Serial Line" specification.

The RS485 interface has a manual (labeled "M") and an automatic (labeled "A") mode. These two modes affect the behavior of switching between sending and receiving on the bus. Further information can be found below.

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Property	Value	Comment
Type of interface	serial interface, symmetric (differential)	wired half-duplex
Type of connection	Data bus/fieldbus	several participants possible
Norm / Standard	RS485/EIA485 MODBUS	meets the requirements and specifications of the "MODBUS over Serial Line" specification V1.02
Maximum transmission rate (theoretically)	1 MBaud	depending on: the nature, environment and length of the cables used the software used the circuit technology of other participants on the bus
Maximum number of participants on the bus (theoretically)	32	
Differential output voltage	min. 1.5V max. 8V	with maximum load (27 Ω) without load
Minimum differential input voltage	0.2V	input threshold
Maximum voltages	-7V – +12V	A or B to GND
Short-circuit protection	Yes	Short circuit against GND
Short circuit current	max. 250 mA	
Overload protection	Yes	thermal
EMC surge/burst/ESD protection	Yes	TVS diode - bidirectional
Electrical isolation	No	
Status display	No	
Bias network	Yes	with 560 Ω resistors
Terminating resistor	Yes	120 Ω, per Jumper
Permissible cable length	< 3 m < 30 m	unshielded cables shielded cables

Table 26: Technical data – RS485

NOTICE	If the specified maximum values are exceeded, transmission errors, functional errors and component defects can occur.

Switching between RS232 and RS485 transceivers is possible via the Raspberry Pi GPIO18. If the GPIO18 is configured as an input or set to LOW level as an output, then RS232 is active. If a HIGH level is set, RS485 is active.

RS232 is the default setting for the PiXtend system.

Connection instructions
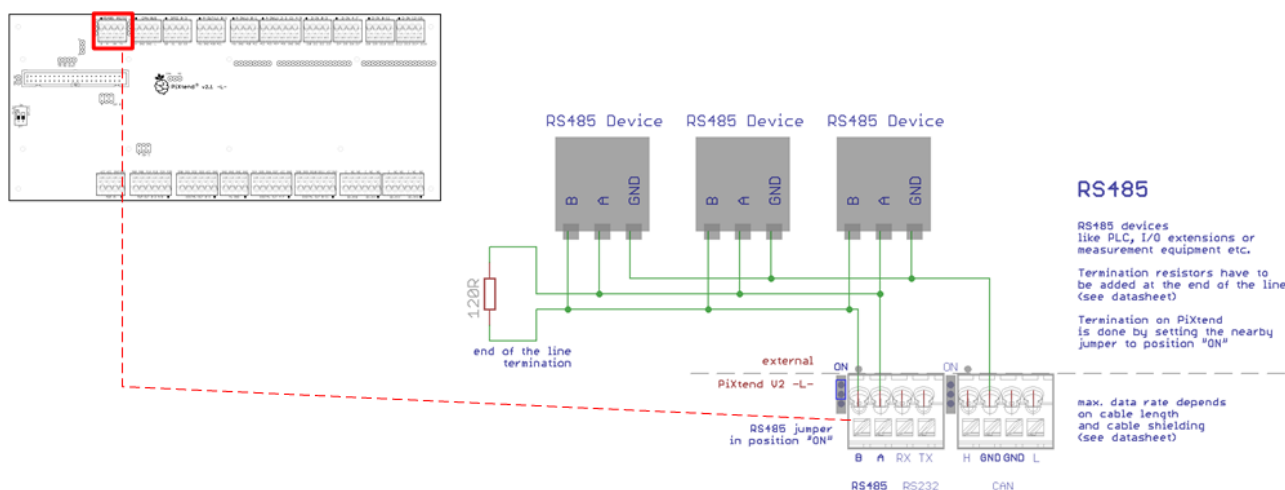
Figure 83: Simplified wiring diagram: connection of the RS485 interface

In the RS485 bus, a terminating resistor of 120 Ω must be connected at the ends of the line structure (first and last bus node). If the PiXtend is one of these bus ends, the jumper must be set to "ON". In series with the 120 Ω resistor is a 1 nF capacitor. This prevents unnecessary current flow (power dissipation) at the idle level.

The "bias network" built into PiXtend stabilizes the levels on the bus when it is "un-driven" or "floating". Without such a network, "phantom characters" can be received by the bus subscribers, which can result from disturbances/vibrations on the bus lines (unwanted change of the logic level).

Due to the ohmic load of the bus or the bus driver through the bias network, no more than two devices in a bus should have such a bias network.

For serial devices/machines, PiXtend V2 -L- modules can also be ordered without the 560 Ω biasing resistors. Contact us in this regard by e-mail at info@pixtend.de.

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6.7.2.1   Manual and automatic mode of the RS485 interface
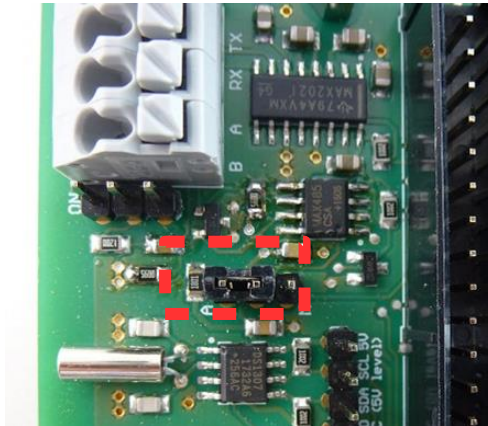
Figure 84: Jumper for send/receive switching of the RS485 interface

The RS485 interface can be operated in two operating modes:

- Automatic send/receive switching

  ◦ Jumper in position "A" (default setting - figure 84)

  ◦ Sending/receiving is automatically switched over without having to pay any attention to the software or the bus driver

  ◦ Particularly suitable for Modbus RTU

  ◦ Recommended mode for the RS485 interface on the PiXtend

- Manual send/receive switching

  ◦ Jumper in position "M" (figure 84)

  ◦ Switching between send/receive must be done by software

  ◦ Switching via the Raspberry Pi GPIO22 (configured as an output)

    ▪ High level ("1") send

    ▪ Low level ("0") or GPIO22 as an input: received

  ◦ In some applications, it may make sense to send and receive data on the bus via software

  ◦ This is only recommended for advanced users with special requirements

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6.7.3. CAN

The CAN interface enables differential data transfer between several devices in a bus system. The Raspberry Pi manages the CAN controller via the SPI interface and additional GPIOs of the Raspberry Pi. The differential signals make the CAN bus tolerant to electromagnetic interference.

Application examples

- Participation in a CAN based bus system (CANopen, DeviceNet, J1939 ...)

- Construction of a bus system with other control devices, micro-controllers, measuring devices and much more

- Data connection to control units/micro-controllers in the automotive sector

The CAN transceiver on the PiXtend is short-circuit proof and robust against interference. It supports the "extended frame format" with 29-bit identifier (CAN 2.0B). The interface can be activated via jumper. If CAN is active, the two analog outputs (AO) cannot be used. CAN and AO share the data bus and cannot be used simultaneously.

A jumper directly next to the terminal strip can be used to selectively connect or disconnect a 120 Ω terminating resistor (bus termination).

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Property	Value	Comment
Type of interface	serial interface, symmetric (differential)	wired
Type of connection	Data bus / fieldbus	several participants possible
Norm / Standard	CAN 2.0B	29-bit identifier
Maximum transmission rate (theoretically)	1 MBaud	depending on: the nature, environment and length of the cable used the software used the circuit technology of other participants on the bus
Maximum number of participants on the bus (theoretically)	112	
Differential output voltage	min. 1.5V max. 3V	with 50 Ω load without load
Minimum differential input voltage	1V	input threshold
Maximum voltages	±42V	CANH or CANL to GND
Short-circuit current	max. ±200 mA	to max. +/- 42 V
Short-circuit protection	Yes	Short circuit against GND
Overload protection	Yes	thermal
Electrical isolation	No	
Status display	No	
Terminating resistor	Yes	120 Ω, per Jumper
Permissible cable length	< 3 m < 30 m	unshielded cables shielded cables

Table 27:   Technical data - CAN

NOTICE   If the specified maximum values are exceeded, transmission errors, functional errors and component defects can occur.

Connection instructions
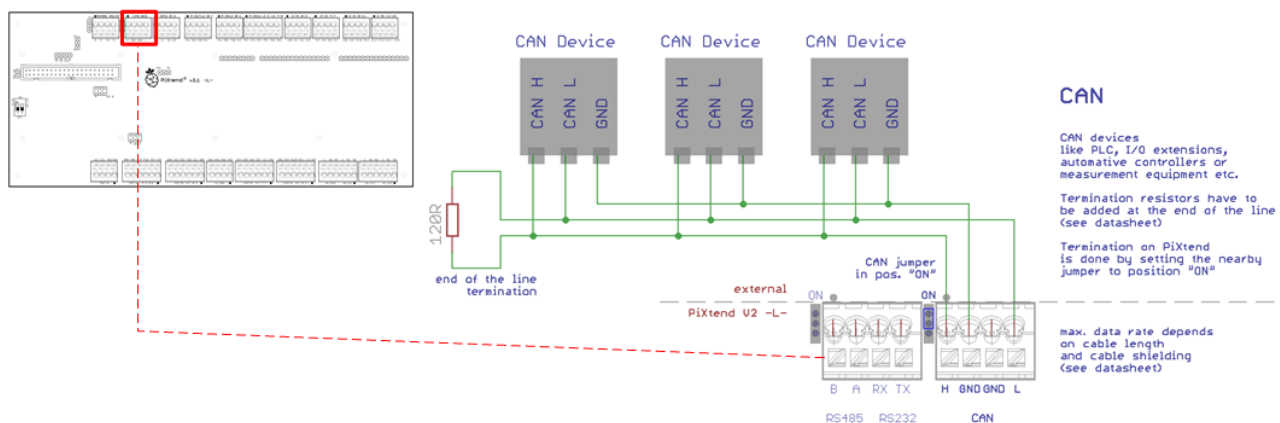
Figure 85: Simplified wiring diagram: connection of the CAN interface

In the CAN bus, a terminating resistor of 120 Ω must be connected at the ends of the line structure (first and last bus node). If the PiXtend is one of these bus ends, the jumper must be set to "ON".

The CAN controller is connected to the Raspberry Pi via SPI. Since the analog outputs (AO) and the CAN controller share an SPI-chip-select (CS1), you must first switch to the CAN controller. To do this, the jumper (figure 86) is set to the "CAN" position.

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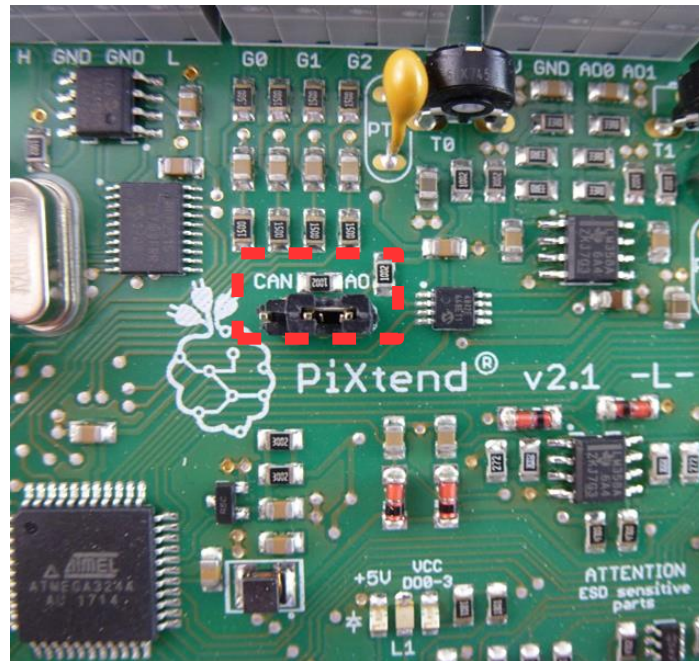
Figure 86: Jumper for switching between AO and CAN

As a result, a decision must be made between DAC and CAN. Only one of the two devices can be operated at one time, parallel operation of both functions is not possible. The jumper may only be moved when the module is turned off.

For the use of the CAN controller, another GPIO of the Raspberry Pi is important. The interrupt line is connected to the GPIO4. If the GPIO is configured as an input, it can be queried in the software or by the kernel module used. The interrupt line is "active low".

One of the two ground connections of the PiXtend, which are located directly between the data cables on the terminal strip, must be further looped to the other bus participants.

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6.8. Real Time Clock

The real-time clock (RTC) always provides the current time and date to the Raspberry Pi. A lithium battery ensures that the clock continues to run when the PiXtend or the Raspberry Pi are switched off and do not have any power.

The Raspberry Pi (with Raspbian Linux as the operating system) automatically obtains the current time from a server on the internet when connected to a network with internet access. If, however, no internet connection is available ("isolated operation"), the Raspberry Pi and thus also the operating system will forget the time after each shutdown. Here the RTC on the PiXtend comes into play.

The data exchange between Raspberry Pi and the RTC runs over the I²C bus.

Property	Value	Comment
Type of RTC	time and date	seconds, minutes, hours, day of month, month, day of week, year and leap year; 12- and 24-hour format
Data connection	I²C bus	max. 100 kHz clock speed Address 0x68 (104 decimal)
Buffering time	10 years	

Table 25: Technical data - Real Time Clock

The battery used does not need to be charged. The indicated buffer time is reached without charging.

With regard to the UL/CSA approval of devices with the PiXtend in the USA/Canada, the solution on PiXtend is not critical. It could lead to problems if the battery charge circuit is not designed according to the specifications of UL/CSA or the chip manufacturer.

Because the battery is not charged on PiXtend and is exclusively connected to the UL certified DS1307 (Maxim Integrated/Dallas Inc.) RTC chip, there is no problem with acceptance.

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7.   List of Figures

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8. List of Tables