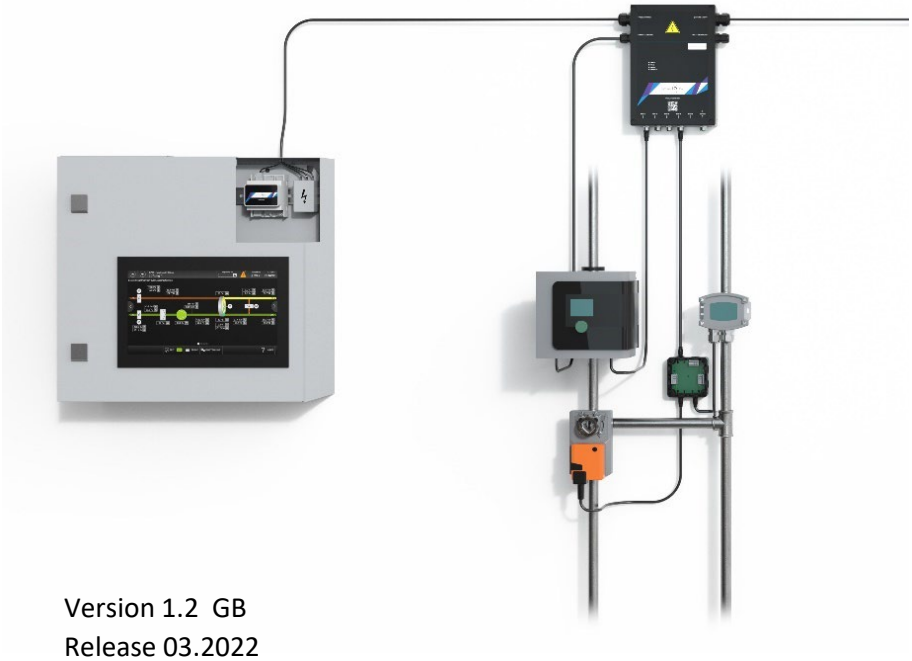
power IO
BUILDING AUTOMATION

power IO

The System for Distributed Facility Automation 4.0

Planning Guide for Technical Building Service and Measuring & Control System Designers, Programmers and Electrical Engineers



Version 1.2 GB
Release 03.2022

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1 Abbreviations

BMS	Building Management System
CCS	Central Control System
DDC	Direct Digital Control
HC	Heating Circuit
DHCP	Dynamic Host Configuration Protocol
PLC	Programmable Logic Controller
UPS	Uninterrupted Power Supply

2 Preface

"powerIO® saves installation time, coordination and cost –
while providing enhanced control and more information.
In this way, we interconnect people and technology,
environment and energy as well as living and comfort.
Creating a successful future, for each of your projects."

Dear User,

you have rightly chosen to read this planning guide.

Why?

For more than 50 years, nothing much has changed in facility automation.

Central cabinets, star-shaped wiring, and more and more cables.
Classical I/O boards, pluggable, wired, mixed I/Os, and much more.

This makes it difficult to adopt 'something new' and think differently. However, there is not so much new about powerIO®. We have simply combined the best available in the market and have optimised it to meet the needs of facility automation. For faster project management, installation savings and increased data by means of communicative sensor technology.

This planning guide has been designed to help you understand powerIO® better and to support you in the planning of specific projects.

Here you will find all relevant technical parameters, topologies and limitations as well as valuable hints for planning and installation.

Still, if you have any questions, please do not hesitate to contact us by email to support@powerio.com.

We wish you every success with your projects!

3 The powerIO® Principle in a Nutshell

powerIO®-System is a distributed installation system. Combining power and data, it builds particularly on conventional communicative sensors and actuators with standardised protocols. By automatically converting serial protocols to Ethernet TCP/IP protocols, the system is designed for large and fast applications. Ethernet based communication makes it suitable for all common facility automation, DDC/PLC and BMS/CCS technologies.
Protocols used include, e.g.:

- Modbus RTU and Modbus TCP
- BACnet MS/TP and BACnet IP
- M-Bus
- Dali
- KNX TP and KNX IP

powerIO®-System consists of 3 essential components:

- **powerIO®-Box**
  Distributed automation box

- **powerIO®-Line**
  Hybrid cable for 230V power supply and Ethernet TCP/IP

- **powerIO®-App**
  Replaces the classical ‘measuring device’ and facilitates the commissioning of communicative sensors

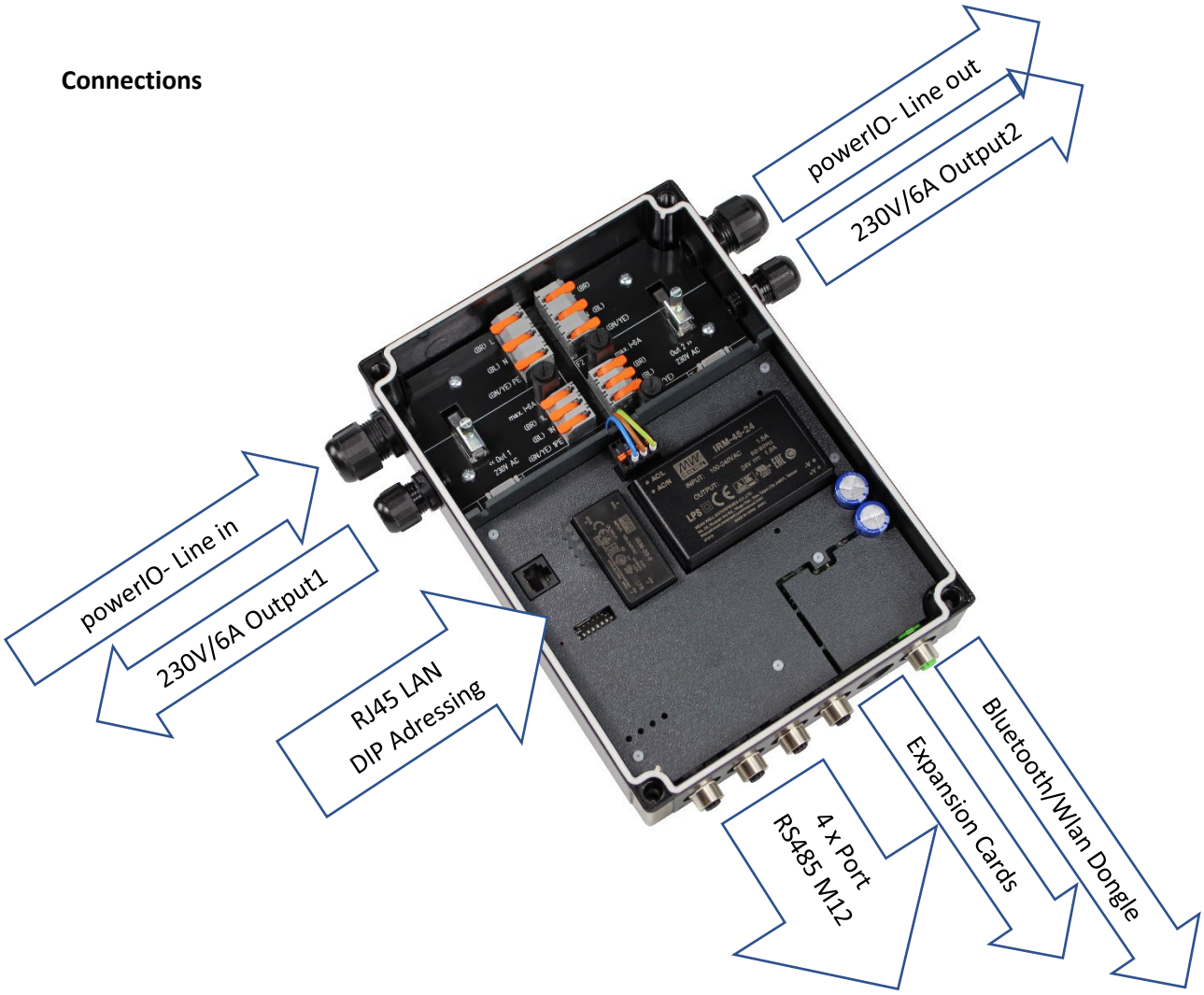
4 Overview of Hardware Components

4.1 powerIO®-Box

powerIO®-Box is a distributed automation box.
It is positioned near sensor and actuator clusters.

Dimensions: 255 x 266 x 64 mm (W x H x D)
Weight: 1,360 g

Connections



No. 3PIO-1101-0000-000 (T1.B100)

Product data online: https://www.powerio.com/en/products/t1.b100-powerio-box

4.2 powerIO®-Line (Hybrid Cable)

powerIO®-Line is a hybrid cable and connects powerIO®-Boxes with each other.
It transmits power (230V) and data (Ethernet TCP/IP).

Data wires: 2x 2x0.34mm²
Power wires: 3x 4mm²
Item No. 3PIO-1201-0000-000 (T1.L100)

or version with 3x 2.5mm²
Item No. TBD (T1.L200)

Product data online: https://www.powerio.com/de/produkte/t1.l100-powerio-line

Note: Individual bores require no firewall – a significant advantage of the combined powerIO®-Line! In addition, the connection of the 100Mbit Ethernet wires is 50% faster than that of classical LAN cables.

4.3 powerIO®-StartUnit

The powerIO®-StartUnit enables the connection of up to three powerIO®-Lines.
It serves as a switch and can be installed on top hat rails in cabinets or junction boxes.
From there it connects with PLC/DDC controllers or other network systems.

Connections:

- 3x powerIO®-Line (4-pin pierce and plug connectors)
- 2x RJ45 LAN
- Voltage supply 24VDC

Maximum transfer rate: 100Mbit/s

Item No. 3PIO-1102-0000-000 (T1.S110)

Product data online: https://www.powerio.com/en/products/t1.s110powerio-start-unit

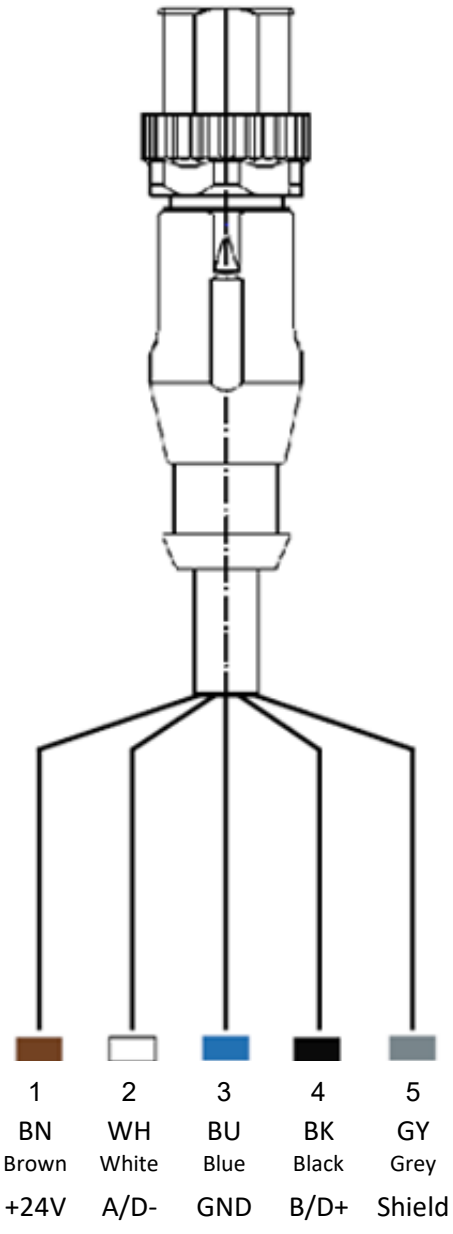
4.4 M12 Ready-Made Cables

The M12 open-end cables can easily be laid e.g. through pipes and cable glands, and shortened as needed.

Essentially, it must be determined whether or not field devices, such as sensors and actuators, are equipped with M12 female connectors. This will depend on the company's installation philosophy.

Most device manufacturers prefer ready-made connections. Open-end cables are more recommended for individual measuring and control installations.

The M12 standard is based on A-coding and 5 pins.
The wire assignment always follows the same principle:



The following M12 cable types are available:

- **M12 ready-made connection cables**
  with male and female connectors (2m / 5m / 10m, PVC, shielded)

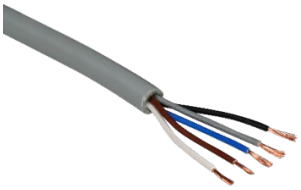
  Item No. 2000-9111-0000-031 (VLG) 2m
  Item No. 2000-9111-0000-041 (VLG) 5m
  Item No. 2000-9111-0000-051 (VLG) 10m

- **M12 open-end connection cables**
  with connector and one end open (2m / 5m / 10m, PVC, shielded)

  Item No. 2000-9121-0000-031 (ALG) 2m
  Item No. 2000-9121-0000-041 (ALG) 5m
  Item No. 2000-9121-0000-051 (ALG) 10m

- **M12 installation cable**
  with open ends (available by the metre, min. 10m, PVC, shielded)

  Item No. 3PIO-1202-0000-000 (T1.Z109)



Product data online: https://www.powerio.com/en/products/t1.z10x-m12-connection-cable

4.5 Y-Distributor

The Y-distributor splits the M12 line and permits the connection of two M12 cables.

Item No. 3PIO-1602-0000-000 (T1.Z122)

4.6 Accessory

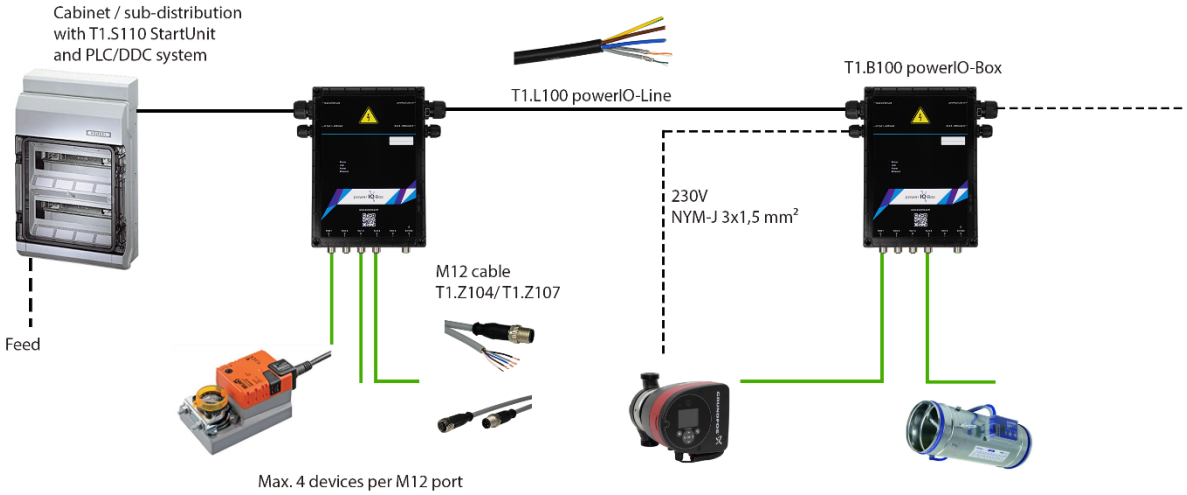
There are also M12 connectors available for custom-assembly of long cables, such as for meteorological stations.

Item No. 3PIO-1605-0000-000 (T1.Z112), M12, 5-pin, A-coded

5 Structural Topology

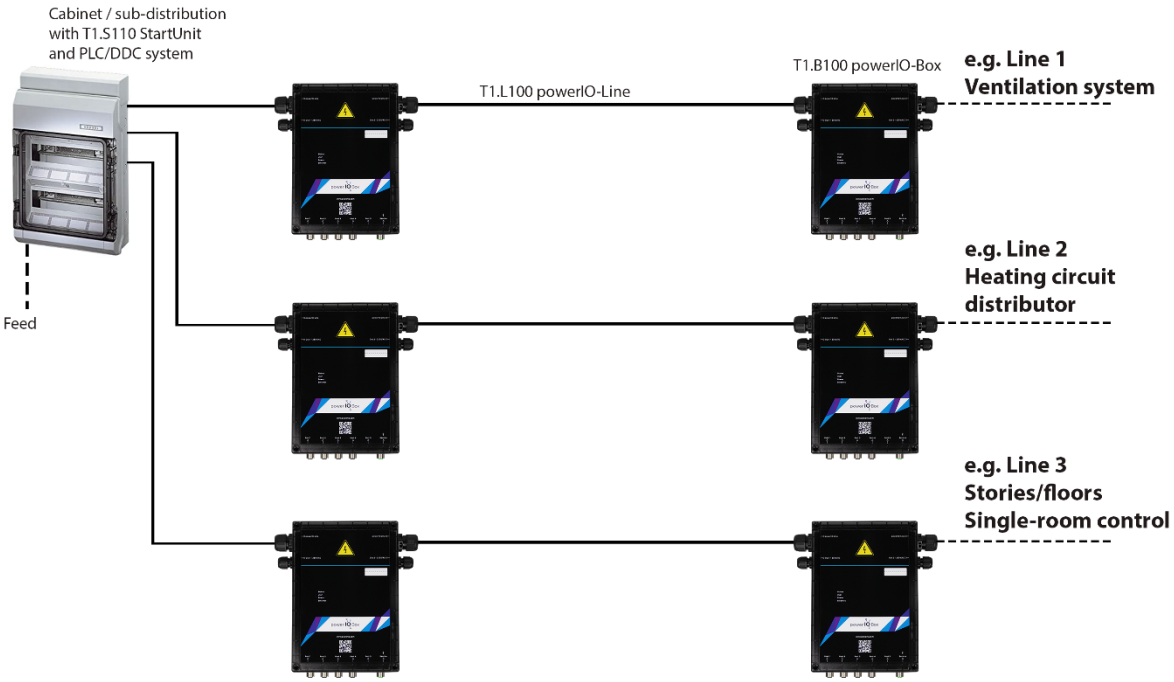
This sections illustrates various topological installation solutions for powerIO® projects.

5.1 Example 1: Small System with One powerIO®-Line

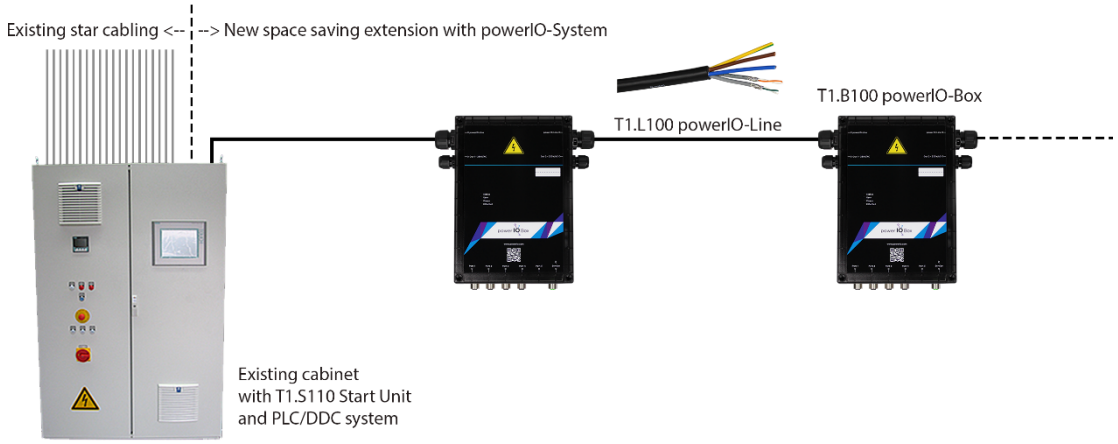


4 devices maximum can be connected to one M12 port.
This means 4 x 4 = 16 participants are possible per powerIO®-Box without an extension board.

5.2 Example 2: Large System with Several powerIO®-Lines

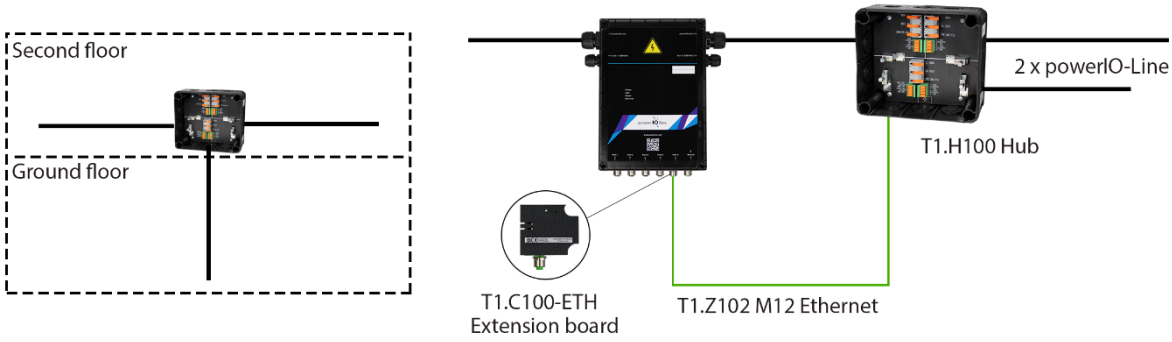


5.3 Example 3: Hybrid System – Classical Installation in Combination with powerIO®



5.4 powerIO®-Line Distribution with powerIO®-Hub

If there is a need for splitting the powerIO®-Line, this can be done using a powerIO®-Hub. An example of this is when routing the powerIO®-Line from the middle of the building through a riser duct into upper stories, or when distributing the powerIO®-Line to 'north' and 'south'. Importantly, the powerIO®-Hub must be positioned approx. 1m next to a powerIO®-Box. Reason: The hub needs to be supplied by an Ethernet T1.C100-ETH extension board.



Note: The length of the powerIO®-Line can easily be doubled without the risk of any short circuit current problems. The decisive factor of the short current release time is the length of the two lines after the powerIO-Hub. The shortest distance to the fuse is considered the short circuit event.

5.5 Limitations of Topology

powerlineIO®-Line limitations by Ethernet/communication

- The maximum distance between two powerIO®-Boxes can be 100m.
- The maximum number of powerIO®-Boxes per line is 32.

powerlineIO®-Line limitations by power/current

The maximum length of a powerIO®-Line depends on the short circuit current release time. The installation must adhere to the standards and legal regulations for electrical installations.

Basic rules:

- The longer the powerIO®-Line, the smaller the back-up fuse to be selected and the lower the corresponding nominal current. (Example: single-room control, long lines – low currents)
- The shorter the powerIO®-Line, the higher the back-up fuse that can be selected and the higher the corresponding nominal current. (Example: heating circuit distributors, short lines – high currents, e.g. for pumps)

Note:
These rules are given only as a guideline! It is imperative that each line design be individually reviewed according to the way of routing and further criteria.

M12 cable limitations by power/voltage/communication

Theoretically, the maximum cable length per RS485 port is 1,200m.

In practice, however, this length is not required thanks to the distributed design. Since the number of participants per port is limited, strict adherence to theoretical RS485 cabling requirements is not mandatory (terminating resistors, topology, stub lines).

Due to the relatively short RS485 line distances (2m to 20m), stubs of 15m each can easily branch off directly from the powerIO®-Box. In most cases there will hardly be a need for setting terminators.

The 0.22m² size of the M12 cable results in constraints with regard to length/power.

Due to the maximum limit of 2A/24VDC per powerIO®-Box, a short circuit event in longer M12 lines does not present a fire hazard, since the voltage of the power supply unit of the powerIO®-Box will collapse, preventing the further supply of power.

Calculation example:

Length 10m, cross-section 0.25 mm²

Current I = 1A voltage

U = 24VDC

Voltage drop = 1.4V

Large damper actuators / valve drives range from 1.5VA to 7VA

2x 7VA = 14VA ≙ ~ 0.6A at 24VDC

No problems should be expected, therefore, with a 0.22mm² M12 cable of up to 17m in length.

Short circuit consideration:

At 2A, the 1.9A power supply unit of the powerIO®-Box will shut down!

2A at 10m length at a voltage drop of <3Vm.

6 Field Mounting Examples

6.1 powerIO®-Box Installation Alternatives

By using the **powerIO®-MountingPlate**, the powerIO®-Box can be installed in most diverse places.

Item No. 3PIO-1403-0000-000 (T1.Z119)

Mounting on pipes with cable ties or pipe clamps:

The powerIO®-MountingPlate is also available in a version with pre-assembled **magnets**.

Item No. 3PIO-1404-0000-000 (T1.Z125)

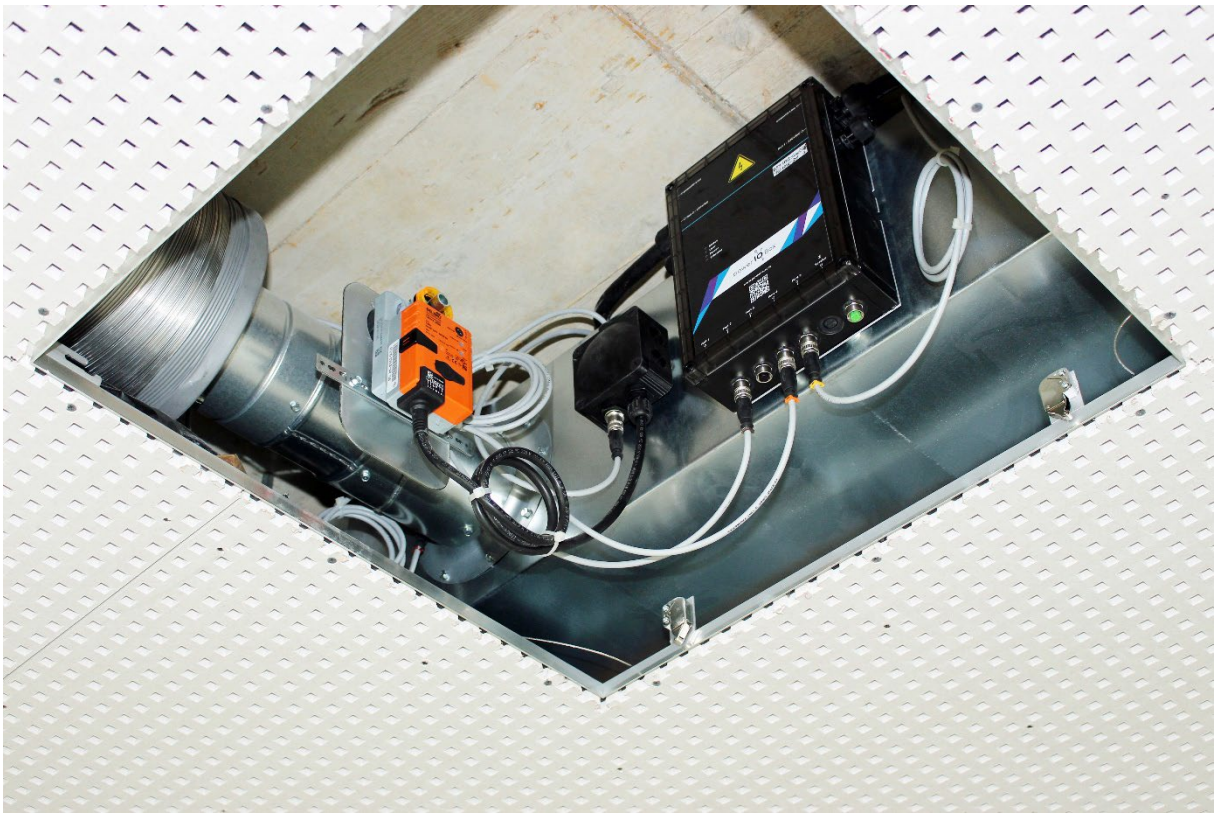
Mounting with magnets e.g. on ventilation ducts:

Mounting examples video: https://youtu.be/889MUM-zTQ4

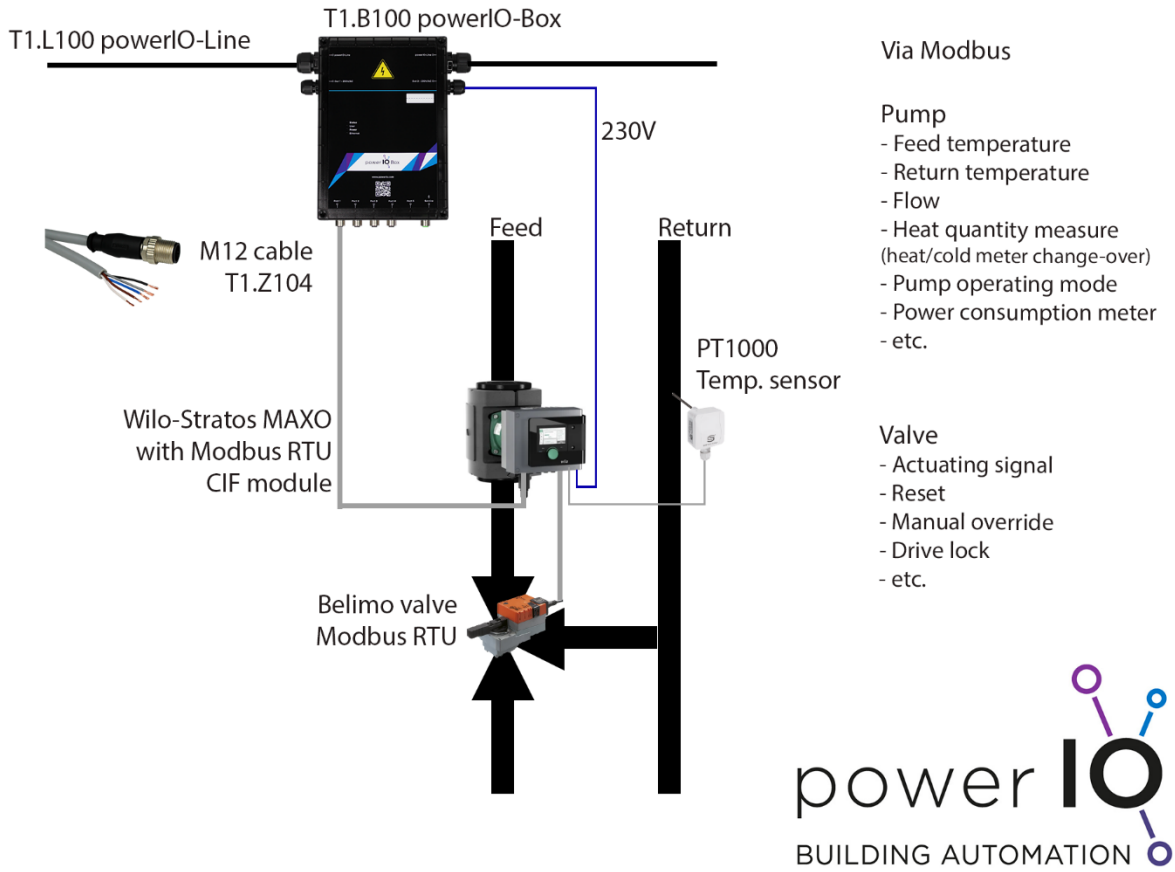
6.2 Installation on Heating Circuit Distributor

6.3 Installation on Ventilation Unit

6.4 Installation in Rooms

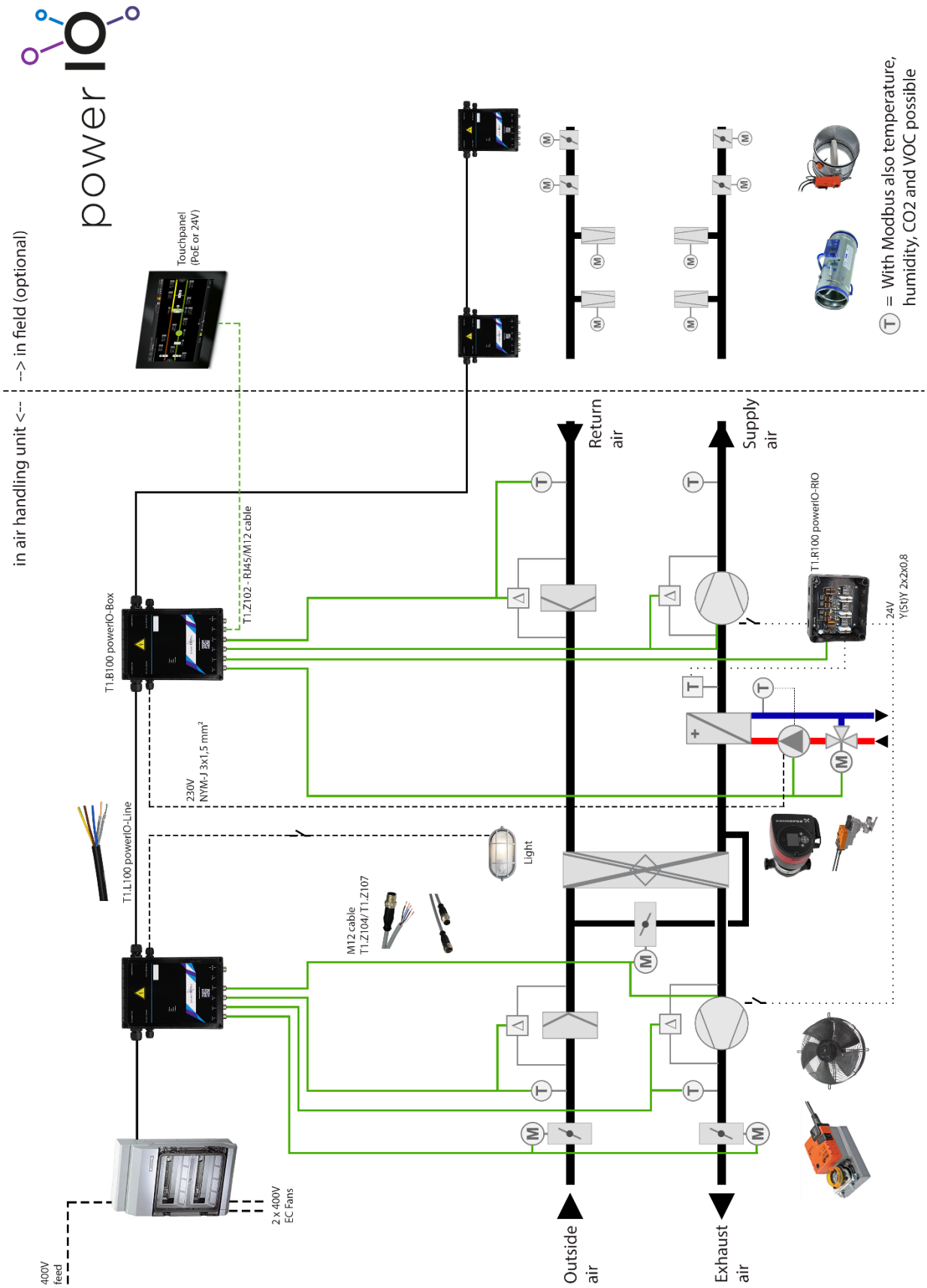


6.5 System Version with Wilo-Stratos MAXO Pump



In this example, the Wilo-Stratos MAXO pump is controlled and read over Modbus RTU. The built-in feed temperature sensor and the optional return temperature sensor can save one sensor and provide for calculating the heat quantity by way of the pump.
Only two Modbus participants are required for one heat circuit.

6.6 System Version of Complete Room Air-Conditioning Unit with powerIO®



7 Commissioning: Different Ways

The commissioning procedure can be different from site to site.
Various established solutions are described in the following.

7.1 powerIO®-Box Addressing

There are three ways to configure the IP address of a powerIO®-Box:

1. Addressing by means of dip switches
   Dip switches provide the easiest way of configuring the IP address of a powerIO®-Box. The first three parts of the IP address remain fixed (192.168.60.xxx), and the fourth part can be freely assigned from 1 to 254. Advantage: This can be done right during commissioning/ installation without power supply.

2. Addressing over web/app
   If all dip switches are set 'down', the IP address can be freely configured using the powerIO®-App (Bluetooth dongle) or the web interface.

3. Addressing via DHCP
   If all dip switches are set 'up', the powerIO®-Box is in DHCP mode. The assigned IP address can be determined using the Bluetooth dongle and the powerIO®-App.

Addressing video: https://youtu.be/M9WfinYbEY8

7.2 Communication Device Addressing

Sensors and actuators must be configured in line with the instructions of their manufacturers. This is not just important with regard to their bus addresses, but also for communication parameters such as baud rate, parity and stop bits. The communication parameters can be set by using the web interface or the powerIO®-App.

Important: Each serial address may only occur once per powerIO®-Box. Moreover, addresses must not exceed 250, as higher numbers are reserved for internal registers.

Tip: As a recommendation, sensors can be addressed as follows:

- Port 1: Addresses 1 to 4
- Port 2: Addresses 5 to 8
- Port 3: Addresses 9 to 12
- Port 4: Addresses 13 to 16

This kind of addressing immediately shows which device and ports are connected to each other.

The maximum allowed number of devices per M12 port is 4. This means, that a powerIO®-Box without expansion board can support 4 x 4 = 16 communicative devices. Since the powerIO®-Box has been purpose-designed for sensors and actuators within a maximum range of 10m to 15m, the limitation to 16 participants is fully adequate.

Advantages:

- Simple documentation / consistent 'topology'
- Structured commissioning
- Failsafe performance: problems that may occur in one M12 line branch will have no impact on the rest of the installation
- Structured troubleshooting: failures need to be identified only on a maximum of 4 devices

Reasons: Simplified commissioning, troubleshooting, enhanced operational safety as well as better documentation

7.3 Variant 1: Installation Fully Completed

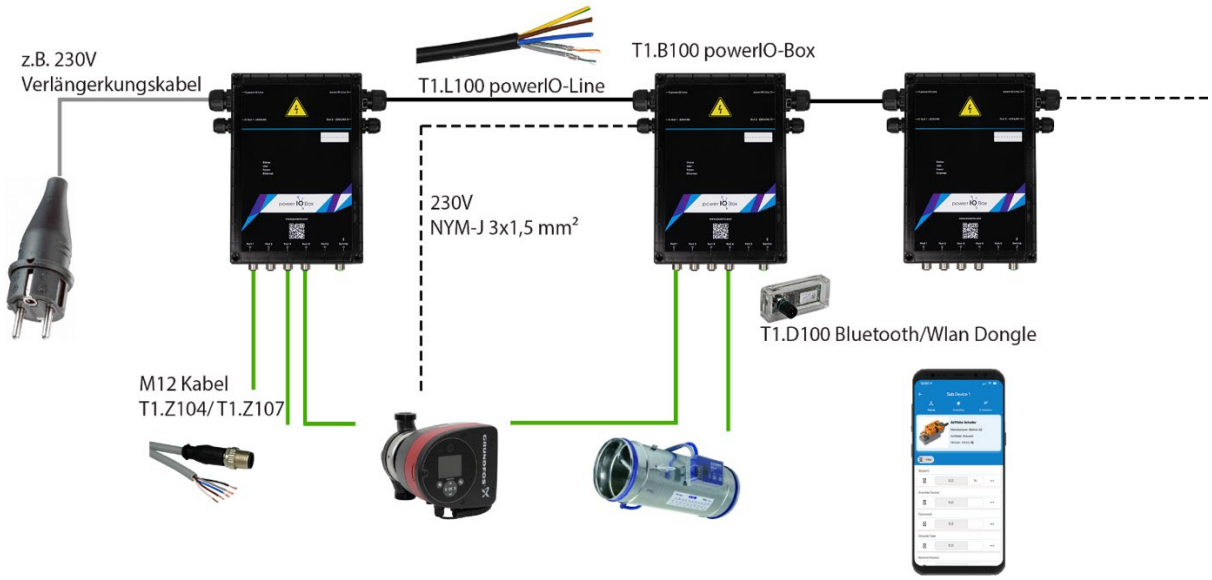
Once all boxes have been connected to the powerIO®-Line, the free end can also be energised directly, without the cabinet, e.g. by means of a separate mains cable with a 'Schuko' plug.

If a cabinet already exists, the line can be simply connected and fused. With all boxes energised, commissioning can then be started one by one. In addition, all sensors and actuators can be tested with the powerIO®-App over the Bluetooth or WLAN dongle.

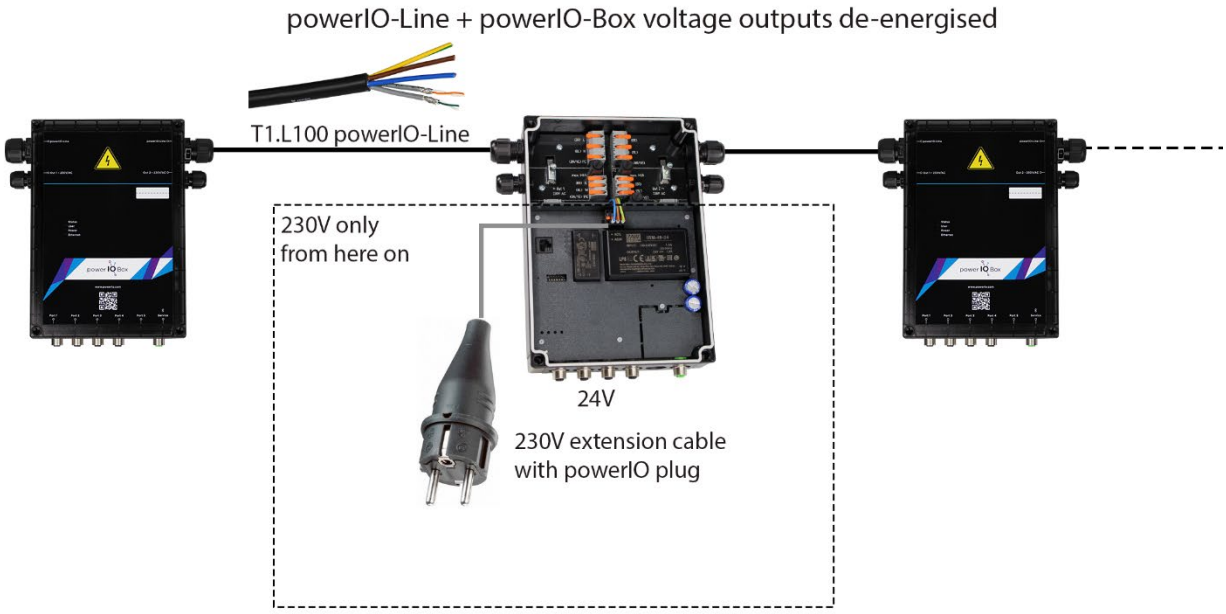
7.4 Variant 2: powerIO®-Box Commissioning w/o or Partially with powerIO®-Line

If an individual powerIO®-Box has been configured completely with all sensors and actuators while not yet or only partly connected to the powerIO®-Line, it can be energised with a 230V cable plugged into mains for commissioning by means of the powerIO®-App.

Smartphone/Laptop Inbetriebnahme ohne SPS Steuerung oder Schaltschrank möglich!



If parts of the powerIO®-Line have already been laid and voltage shall be applied only to one individual box, as in the schematic above, the 230V power supply to the upper board can be disconnected and re-directed to the lower board.



Tip: The box can be energised and commissioned also by using a **small 230V USP** instead of the separate mains cable.

This provides for a quite independent and efficient working on site, since finished sections can already be fully commissioned even if the entire site will still take longer to complete. This can relieve the workflow scheduling – a significant benefit.

The powerIO®-App can be used to test the connected devices. In case of a missing device template, please report the affected device to the appropriate product support for a prompt update.

Note: Sensors/actuators do not have to be set up by means of the powerIO®-App!
They can also be directly addressed by a PLC. The powerIO®-App serves only as a commissioning aid.

Commissioning video: https://youtu.be/XAVUAZkZE80

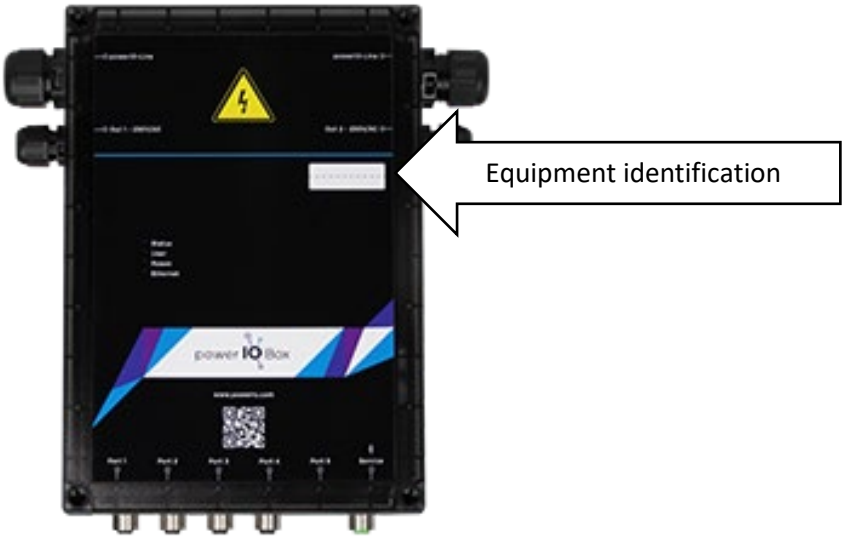
8 Documentation: Recommendations and Templates

8.1 Important Documentation Parameters

The following explains important equipment identifications for a structured hierarchy:

- ISP01
- ISP02
  - Line 1
  - Line 2
    - Box 1
      - Port 1 and/or addresses 1 to 4
      - Port 2 and/or addresses 5 to 8
      - Port 3 and/or addresses 9 to 12
      - Port 4 and/or addresses 13 to16
    - Box 2
    - …
  - …
  - …

Components such as powerIO®-Boxes can be marked with a pen or by applying a label:



Suitable self-adhesive printing labels include e.g. EML-HA 30x20R device markers from Phoenix Contact.

Example:

++ISP01=Line1-Box1
IP: 192.168.60.10

Further important parameters that should be documented:

Per each powerIO®-Box

- Box number
- IP address
- Specific port communication parameters, such as '38400 8N1' for
    - Baud rate
    - Parity
    - Stop bits

Per each field device

- Address (as set on the device)
- Manufacturer and device type (programmers also require the Modbus register)
- Function name, e.g. ++ISP01=HCK01-TF01 (temperature sensor, heating circuit 1, feed temperature)
- On-site location (optional)

There is no need for documenting the communication parameters such as baud rate etc. per each device. Since all devices on one specific port are using the same communication parameters, it is sufficient to document those parameters for the port of the powerIO®-Box.

Another possibility is to create an equipment identification hierarchy only by numbers:

Example: 1.1.5

= Line 1

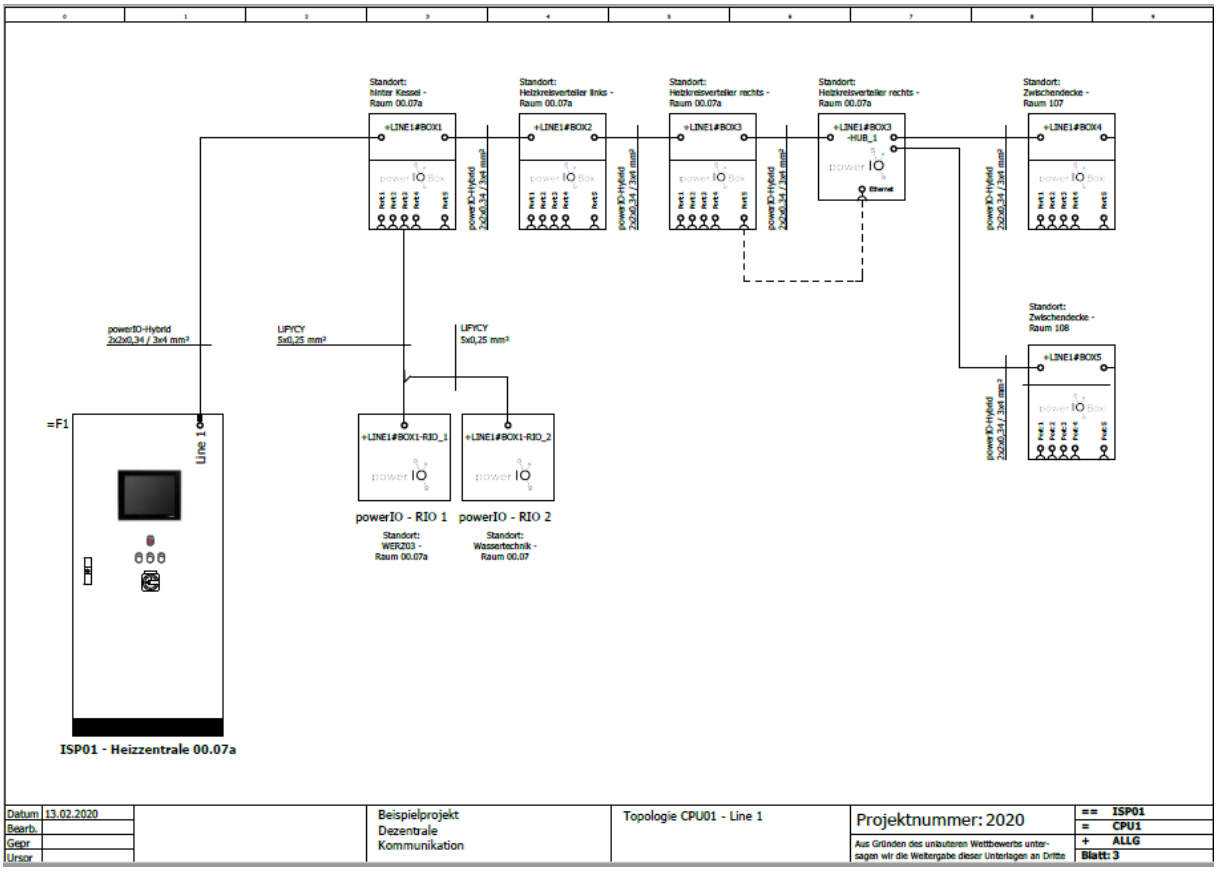
= Box 1

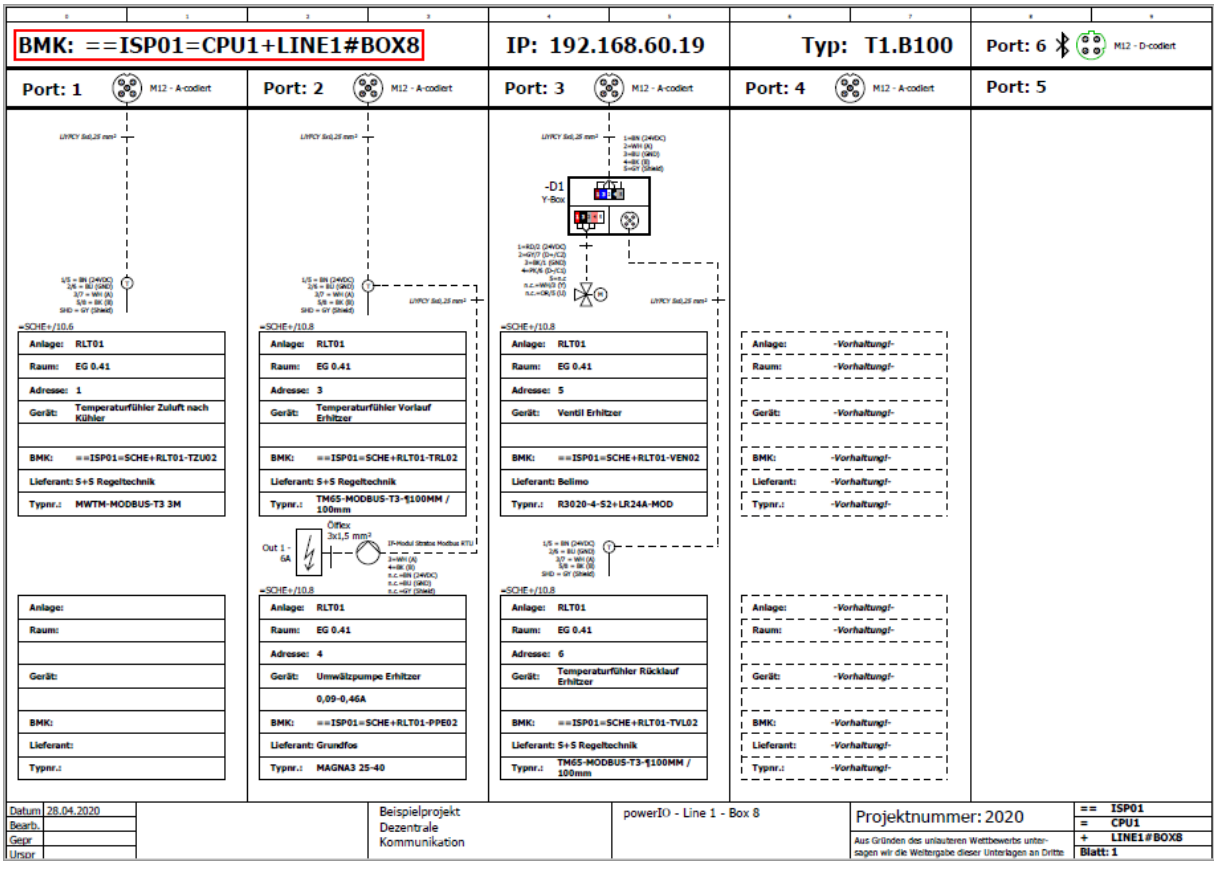
=Address 5 (or possible also include the port)

8.2 Implementation Example with EPLAN Electric P8

The following schematics illustrate some possibilities of documenting a powerIO®-System.

8.2.1 Variant 1: Separate Wiring Schematic Pages





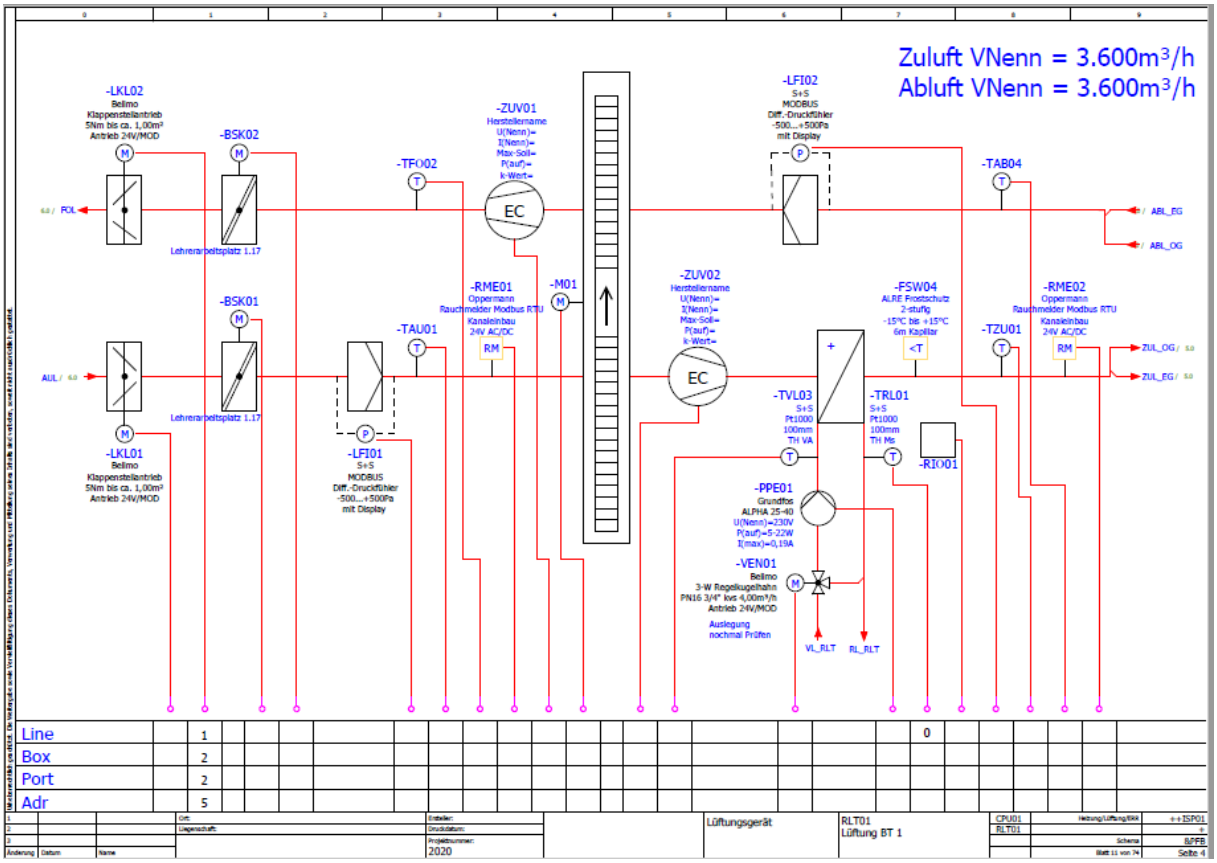
8.2.2 Variant 2: Documentation Included Directly in Wiring Schematic

In the below example, the assignments of the communicative devices are documented directly within the schematic.

Advantages:

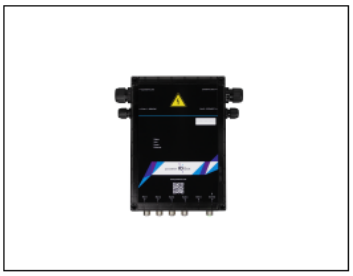
- The wiring schematic doubles as planning page – the overview per powerIO®-Box is automatically created with PLC assignment boxes.

- Work at the construction site can be optimised to the needs of the installation.
  The actual assignment text is entered by the installer.



The addressing defines the order in which the devices are looped through.
Address 1-4 on Port 1 means that beginning with Port 1 the device with Address 1 is connected. This is then followed by the next device with Address 2-4, etc.

-BOX1



Querverweis		Kanal	BMK	Adresse	Beschreibung	Einbauort	Artikel
	-O1	Port1					
	-O2	Port1					
	-O3	Port1					
	-O4	Port1					
	-O1	Port2					
	-O2	Port2					
	-O3	Port2					
	-O4	Port2					
	-O1	Port3					
	-O2	Port3					
	-O3	Port3					
	-O4	Port3					
	-O1	Port4					
	-O2	Port4					
	-O3	Port4					
	-O4	Port4					

Box 1
Lüftung

LINE1 ++ISP01
+F1
&EP5
Seite 17

9 Communication and Programming

9.1 Benefits of powerIO®-System

The following is a summary of the most important benefits provided by the powerIO®-System vs. purely serial communication:

- Parallel polling of boxes by means of TCP protocols
- Multi-master capability, i.e. simultaneous queries from different masters are possible (not with serial networks)
- Much faster communication thanks to very small serial networks
- A bus short of one device means that only this port cannot be reached (max. 4 devices affected), whereas all other ports and powerIO®-Boxes continue functioning properly
- If one participant cannot be reached, the bus master will not receive a timeout but an Error Code 11 (Gateway Target Device Failed to Respond) from the powerIO®-Box, which prevents waiting times and bus instabilities

9.2 Polling Parameters for Control (PLC)

Die register addresses of the devices correspond to those in the manufacturers' documentations. Therefore, no mapping is required on the powerIO®-Box. The documentation for each device must be requested from the specific manufacturer.

The serial bus participants are queried/polled over Modbus TCP by:

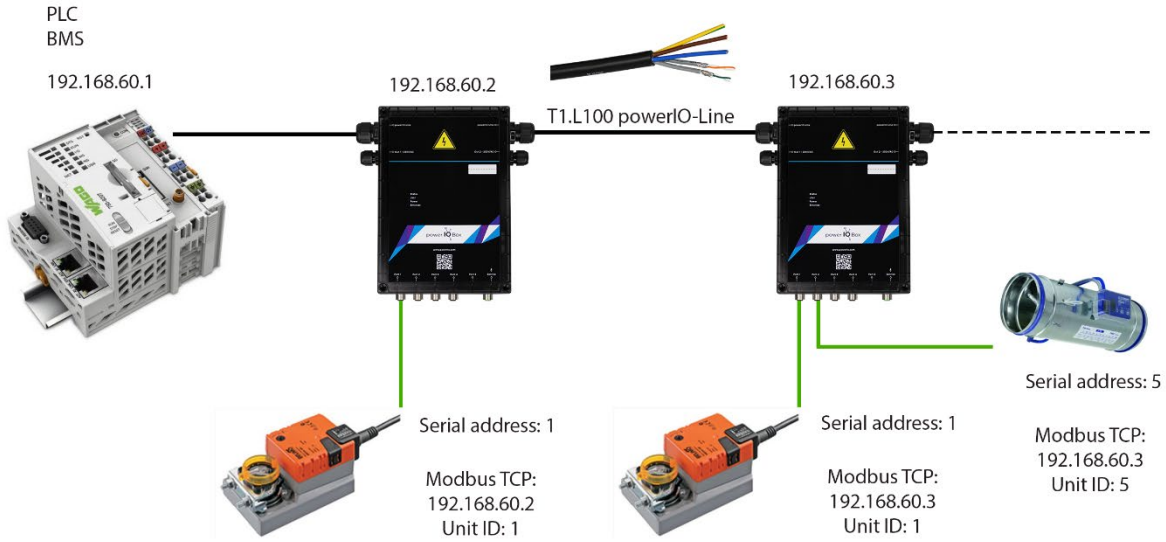
- IP address of powerIO®-Box and
- Node ID

The **node ID** of a serial participant is always the **serial device address**. Per each powerIO®-Box, therefore, the same serial address must never be assigned to M12 ports 1 to 5. The node IDs of the specific powerIO®-Box Modbus registers are 240 to 247. A serial Modbus RTU device with an address between 240 and 247, therefore, must never be connected to an M12 port.

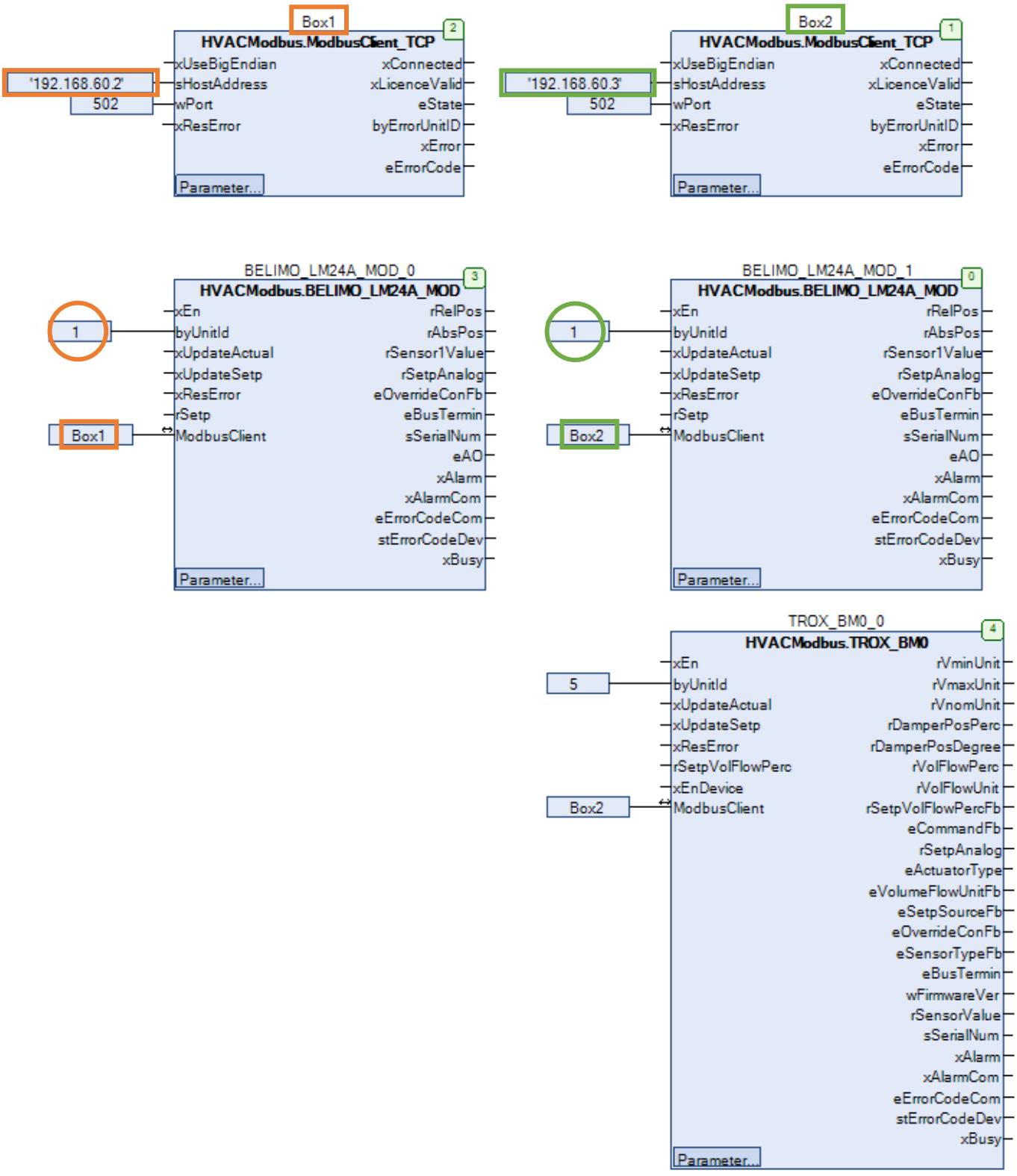
Attention: Risk of communication conflicts!

The powerIO®-App allows users to add devices for communication testing purposes.
However, this is not mandatory. The devices can also be polled by using other systems. The App only helps by enabling a one-to-one check on site when other means, such as a laptop, are not available.

Graphical overview of polling/addressing:



The following shows the implementation of the above graphical overview in CODESYS by means of the CODESYS HVAC Automation Modbus Library (www.hvac-automation.com).



9.3 PLC/DDC – Notes on Polling

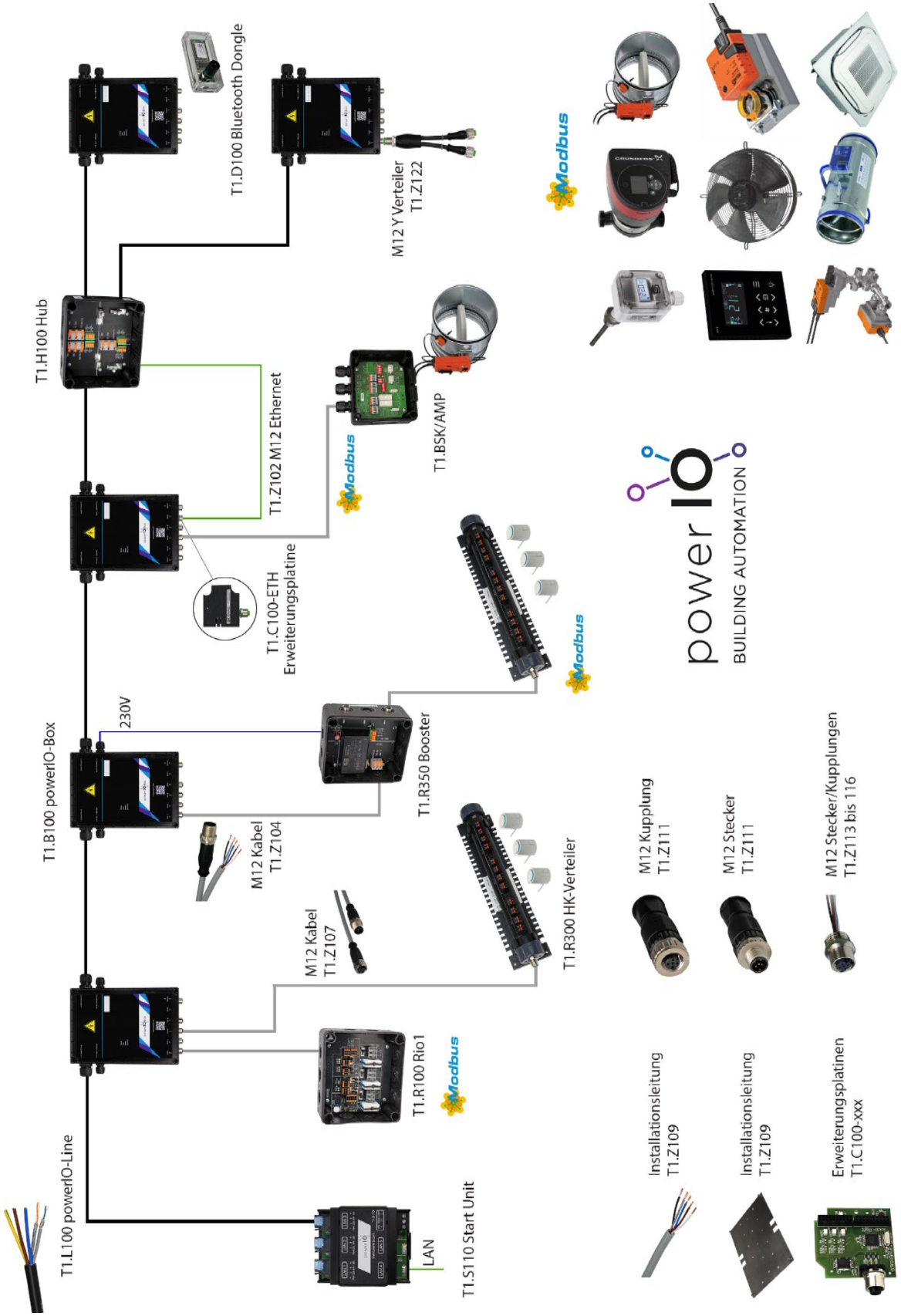
9.3.1 Modbus TCP

Serial Modbus RTU sensors/actuators are polled by the PLC/DDC over Modbus TCP. The Unit ID corresponds to the serial slave address. In order to prevent communication overloads, we recommend individual poll cycling per each participant slave. In this way, for instance, it will be possible to query less important values only every 10 seconds, whereas important values can be queried at frequencies below 1 second. In any case, polling as fast as the PLC cycle should be avoided. The same applies to the writing of values, which should only occur when values change and/or according to an adjustable time frequency.

If you encounter any problems or have any further questions, please contact our Support Team at support@powerio.com

10 Appendix

Overview of all powerIO® components:



11 Copyright

Support

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