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Industrial communication

bürkert

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A large number of field devices are installed in factory and process automation systems. In the process of digitalisation as part of Industry 4.0, the number of intelligent network participants is ever-increasing and Ethernet-based technologies such as PROFINET or EtherNet/IP are being added to the traditional fieldbuses like PROFIBUS.

Existing plants with evolved structures need to be adapted accordingly to meet the changed market or legal requirements as well as the current demands for efficiency and availability. Traditional analogue sensors and actuators often no longer meet the increased requirements because they can only deliver a limited range of process data. Simple remote access, at best even automatic integration into modern networks, or complete self-diagnosis "on demand" are thus not possible. Sensor, actuator and network technology must therefore be adapted accordingly.

When it comes to network technology there are different options depending on the technology being used. This way, devices with their own Ethernet connection can be integrated directly into the process technology network. A second variant is to use

gateways that establish the connection between the PLC and the field devices using a subnet. A third option is the use of IO-Link field devices.

1. Field devices with direct Ethernet connections

Field devices with a direct Ethernet connection offer numerous advantages for different user groups. The integrator has direct access to the unit and can specify all necessary parameters directly. These field devices also frequently offer simplified integration into higher-level systems, making easy access to the device's web server an option for the plant operator. This allows diagnostics information to be read directly from the field device without the need for special programmes or other devices. This reduces maintenance and contributes to efficient troubleshooting.

Integration

One of the most important features of an Ethernet field device is the simple and efficient project planning in the higher-level system. For example, some field devices can be quickly integrated into the Rockwell Engineering environment using an Add-On Profile (AOP). Alternatively, integration into a Siemens environment using a Hardware Support Package (HSP) is also conceivable. Such integration methods save the integrator a lot of time because he can select all important parameters directly in a graphical interface. Any device parameters configured in this way can then be copied directly into the engineering environment for further use.

Web server

Most Ethernet-capable devices have an integrated web server. This can often be used to configure devices, read out diagnostics data or display process data. As the devices are already connected and addressed via Ethernet, no additional effort is required to enable access to the web server. Password-protected access prevents unauthorised changes to device settings. The assignment of user rights also enables a high level of security when approving the various functions.

Transmission media

Ethernet-capable field devices can be wired easily and quickly, even over longer distances. The maximum distance between two devices is up to 100 metres with copper cables. If this distance is not sufficient, a fibre optic cable can be used that bridges distances of up to 14 km. However, additional infrastructure components are necessary for this. In the near future, topics such as Single Pair Ethernet (SPE) and Advanced Physical Layer (APL) will allow new possibilities in terms of wiring, line lengths and communication speeds. Wiring concepts in industrial plants will change as a result.

Redundancy functions

These days the redundancy of systems is becoming increasingly important. In the event of errors or peripheral failures, the system should continue to operate and machine downtime should be reduced to a minimum. To do this, there are different protocols with different redundancy functions that enable different safety standards.

Setting up the network as a ring topology allows the system to establish alternative communication channels when a communication line is interrupted. This ensures that the field device does not lose communication with the higher-level system. In a PROFINET network, for example, this function is called "Media Redundancy Protocol" (MRP); in EtherNet/IP, it is called a "Device Level Ring" (DLR).
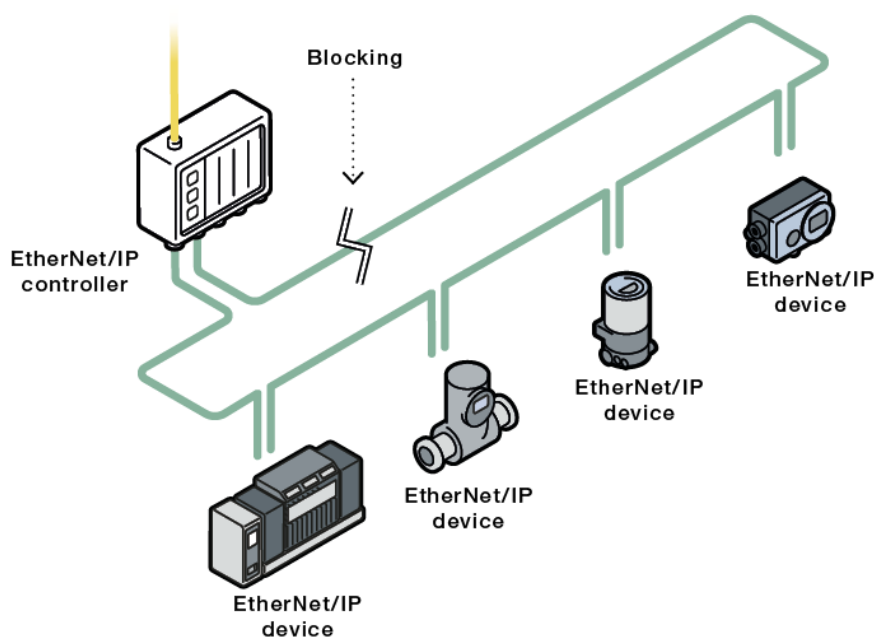

Figure: EtherNet/IP network with Device Level Ring (DLR) function.

A variety of redundancy systems exist for PROFINET. They are called S1, S2, R1 and R2. Depending on the variant, the requirements for controllers and field devices are correspondingly high. If field devices and controllers use multiple PROFINET interfaces, so-called Network Access Points (NAPs), they can maintain the connection even in the event of hardware errors. S1 and S2 are so-called singular systems. This means that the PROFINET device can only connect to a single NAP. For R1 and R2, the R stands for Redundant. The PROFINET field device can connect to several NAPs. The number after the S or R stands for the number of possible communication relations (Application Relation – AR).

S2 redundancy is becoming increasingly important for PROFINET networks in field devices and is already widespread on the market. The integration and wiring are very simple. For S2 redundancy, the IO-unit interface is connected to two redundant controllers. The controllers communicate with each other via a backbone bus. In doing so, the PROFINET device establishes a communication relationship with each controller. However, only one connection is active and the reserve connection only intervenes when the primary connection is interrupted.
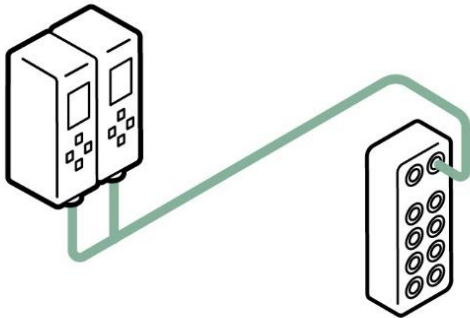

Figure: Setup of a network with S2 redundancy.

Such redundancy systems are not limited to PROFINET. Such redundancy systems also exist for other protocols such as EtherNet/IP.

2. Gateway systems

Another interesting option for device integration in an industrial environment is the use of gateways. Gateways then become the only device with a direct Ethernet connection and is itself the connection to the higher-level controller. The other field devices on the sensor-actuator level communicate with each other through a lower-level subsystem. A variety of solutions are possible for communicating in the subsystem, such as AS-Interface or CANopen. This approach enables the creation of a cost-efficient solution that is perfectly tailored to the customer's application, e.g. via Bürkert's own EDIP platform (Efficient Device Integration Platform).

Efficient Device Integration Platform (EDIP)

Figure: Mass Flow Controller (MFC) on the field level connected to a gateway with three I/O modules.

EDIP allows fast, prepared and simple networking as well as the installation of Bürkert devices that have CANopen-based büS interfaces (büS stands for Bürkert system bus). The heart of an EDIP network is the gateway. It manages the data exchange between the field devices and the higher-level controller. Bürkert gateways are available with

different Industrial Ethernet protocols such as PROFINET, EtherNet/IP, Modbus TCP, EtherCAT and CC-Link IE Field Basic. Conventional fieldbuses such as PROFIBUS and CC-Link are also supported.

The PC software Bürkert Communicator is also part of the platform. The program is used to configure or parameterise all new Bürkert products with electrical components. In addition, the software also includes data loggers, an oscilloscope, a graphical programming interface and licence management, among other things. Settings created using the software can be saved, modified, printed and copied to other devices. Access to the network is possible during operation and even several devices can be connected simultaneously. The field device firmware updates can be carried out via the software. Optionally, individual devices can be updated as well as several devices consecutively.

Gateway configuration

The focus of a gateway solution is to create the appropriate configuration. There are many different ways to do this, depending on the manufacturer. This often involves simply keeping input or output memory space free. The variables are then assigned via an external representation. The focus is not on the customer-specific solution, but on the general use of a uniform description file on the control side. It is different with EDIP. Here, a customer-specific configuration is created via the Bürkert Communicator. The process data of the individual field devices are thus quickly and easily created in the wizard. There is no unnecessary consumption of storage capacity. After it has been created, the respective configuration can be output for all supported protocols. This is of great interest to OEMs in particular, as they often build the same or similar plant components. It is also easy to adjust the configuration. After a successful change, the configuration files are output in a new version. This makes all changes trackable at any time.

Central configuration management

The central configuration management feature makes it possible to quickly replace Bürkert devices with no extra configuration effort. After parameterisation and activation, no additional software is required. Instead, there is a configuration provider in the network that reads out the configurations of all devices and stores them centrally on the gateway. Replacement of a managed device is recognised by the configuration provider, as is the replacement device, which is automatically parameterised with the stored configuration of the predecessor device since it has the same identification number. The process takes about one minute. After a restart, all necessary parameters are stored in the device.

3. Field devices with IO-Link

IO-Link is a standardised I/O (Input/Output) technology (IEC 61131-9) that enables communication between sensors and actuators. With IO-Link, field devices can be connected to and controlled at Control Level via a cost-effective point-to-point connection. IO-Link is therefore not a fieldbus but a communication protocol that builds on the traditional connection sensor and actuator technology and offers integrated communication right down to field device level. The data exchange between the higher-level controller and the IO-Link devices is bidirectional, i.e. takes place in both directions. Both cyclic (e.g. process values) and acyclic (e.g. diagnostic messages) data can thus be transmitted separately.
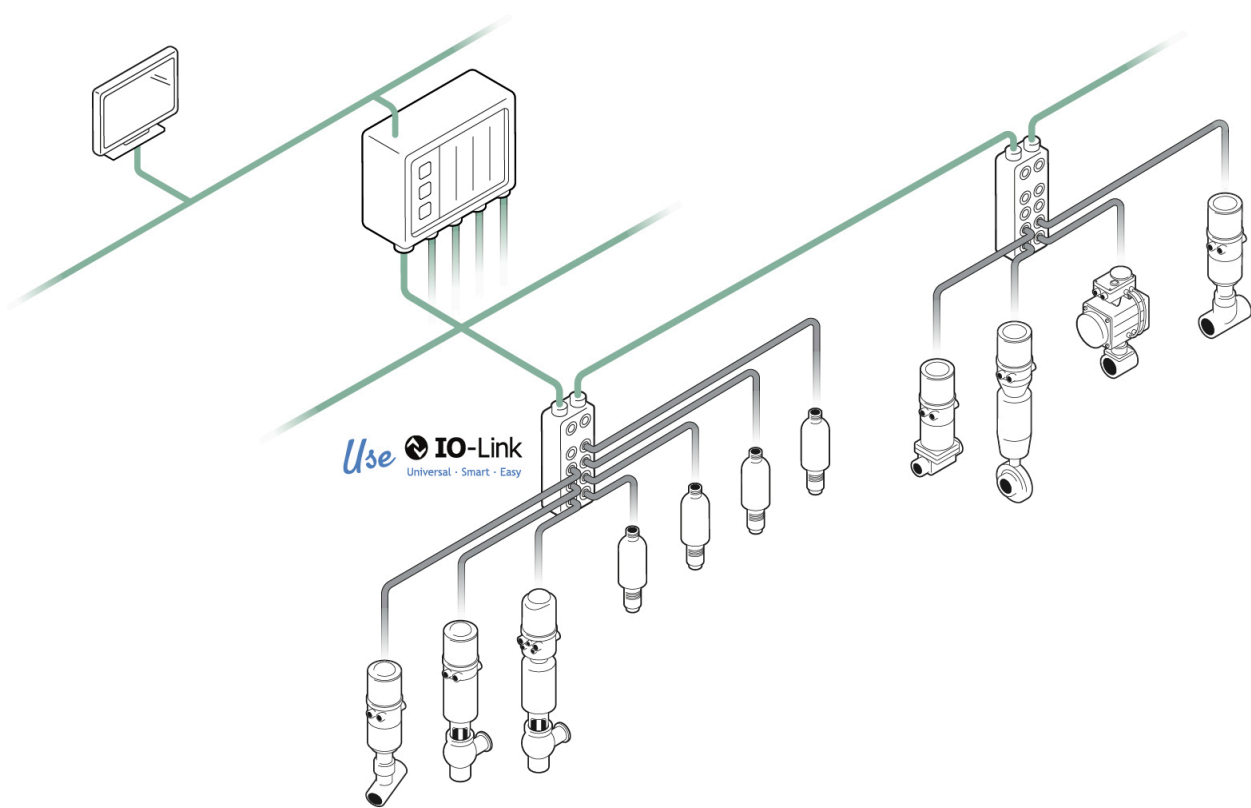

Figure: Field devices connected to a controller via IO-Link master.

Push-in connectors and port classes

There is a variety of IO-Link plug-in connections for use in the control cabinet or in the field. Various push-in connectors with screw-type terminals or spring contacts can be used in the control cabinet. In the field, however, protection against foreign bodies and

moisture is essential. The most common push-in connector used for IO-Link is an A-coded M12 plug (according to DIN EN 61076-2-101), whereby a four-pole push-in connector is usually used for sensors and a five-pole push-in connector for actuators. M12-A coded connections are available for port class A and B. Additionally, M5 and M8 push-in connectors are specified for port class A.
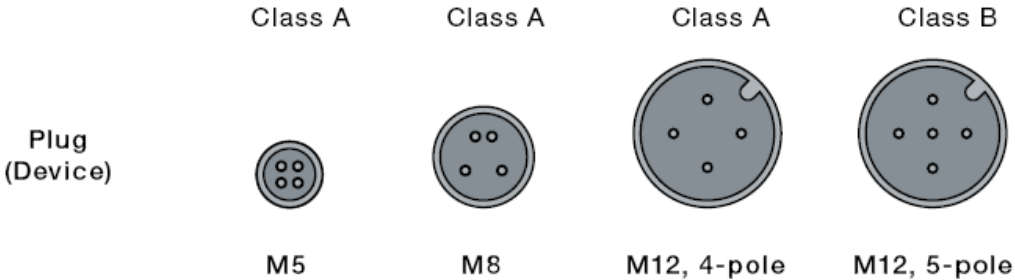

Figure: IO-Link push-in connectors for field devices.

For port class A devices, a current consumption of up to 200 mA is permissible. The device's supply voltage is on pins 1 and 3 here. This is sufficient for sensors and smaller actuators. If a device requires current consumption of more than 200 mA, port class B must be selected. A second supply voltage is available there on pins 2 and 5. Currents of up to approx. 4 A are possible; this is the limit for M12 A-coded connectors. The additional supply voltage should be operated separately from the first supply voltage and should have a separate fuse. One advantage is that the second supply voltage can be switched using a safety relay. In the event of a fault, for example from an emergency stop, all actuators can be deactivated.
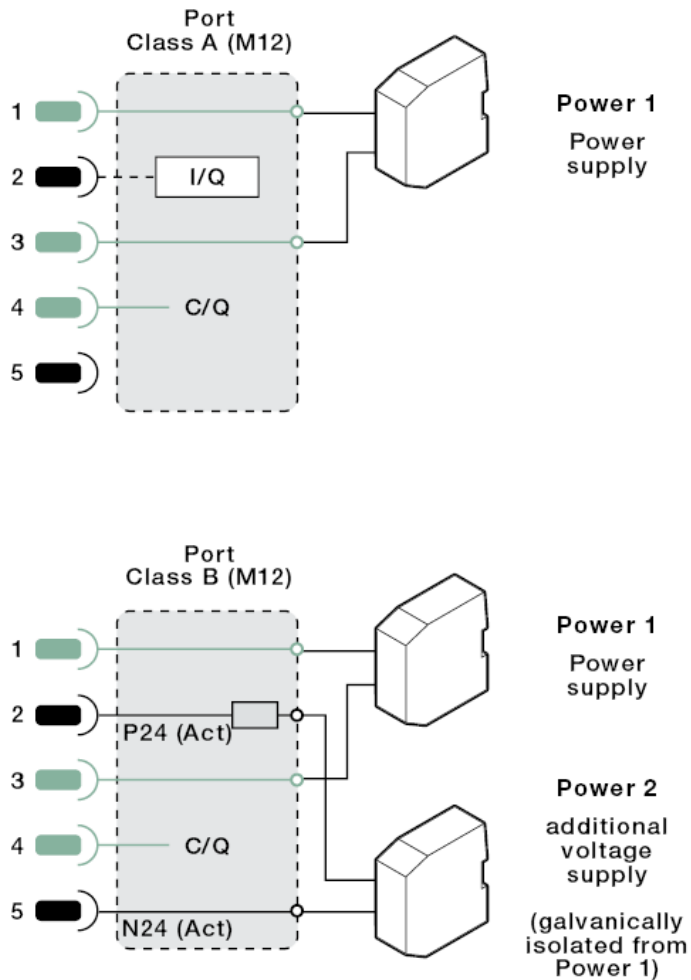
Figure: Pin assignment of push-in connector ports class A and B.

Cabling

Simple rules apply to the cabling for IO-Link. The most important one states that the total length from a port of the master to an IO-Link device must not exceed 20 metres. Since IO-Link is a point-to-point connection, no further dependencies on other devices need to be taken into account, such as baud rate, number of participants or amount of process data. Attention should also be paid to the type of cable. It is permitted to use unshielded cables here. For a port class A device, at least a three-wire cable is required, optionally also a four-wire cable if the device supports a digital input or output on pin 2. A 5-pin cable is always used for a port class B device.

Diagnostics

IO-Link offers the user good diagnostics options as well as troubleshooting support. An IO-Link device can generate events and exchange them directly with the master. These events are then forwarded to the PLC or to an HMI (Human Machine Interface). This makes it possible to transmit errors and warnings, but also maintenance requests. This sets IO-Link apart from proven, older technologies. A unit can transmit both a lot of parameterisation data and diagnostics data at the same time. Compared to a 4-20 mA interface, the advantages of an IO-Link connection are therefore obvious.

Device replacement

IO-Link greatly simplifies and accelerates device replacement. This reduces the maintenance costs and the downtime of a plant. This mechanism is called "Backup & Restore". For this purpose, specified parameterisation data in IO-Link devices is saved directly on the master. In the event of a replacement, the new device is automatically parameterised with the settings of the replaced device. This function can be optionally deactivated or also restricted. Entering the authorised vendor and device IDs at each individual port prevents exchanges with non-matching devices.

Integration

IO-Link devices are configured via the engineering tools of the controller. Often just a sufficiently large memory space is selected. This can contain input and output values, depending on the unit functions; in the case of sensors, only input values can be present. The exact arrangement of the bytes can be seen in the IODD (IO Device Description). Some manufacturers offer direct integration of the configuration tool into the engineering tool. Others integrate the IO-Link device description files as part of the master's description file. With PROFINET, this information would be contained in the GSDML device description of the master. However, it is also possible to load the IODD using another (external) tool and use it to parameterise the units. Another variant is the integration of a web server in the master, which completely takes over administration. The advantage here is that no further tool is needed and the connection to the device via Ethernet is available anyway. This avoids additional work and costs. In the meantime, many of these solutions offer a direct connection to the IODD Finder, which provides a manufacturer-independent database. From there, the IODDs can be loaded directly into the configuration tool. This eliminates the tedious work on the customer side searching for the IODDs of different manufacturers on their websites.

Another possible solution for the integration of IO-Link devices using modules that allow parameterisation. Bürkert follows this approach for some field devices and offers, for

example, add-on instructions for Rockwell and faceplates for Siemens PCS7. This supports the customer efficiently in both integration and diagnostics.

4. Summary

Ethernet devices offer an enormous number of wiring advantages in terms of line lengths and added values such as web servers, redundancy functions or the high communication speed. In addition, there is a diverse selection of protocols. The higher price of the Ethernet devices is offset by the reduced effort in wiring and planning the plant section. This usually compensates for part of the additional costs.

A gateway offers a customised solution for the customer. The gateway as the core of the subnet also has web servers and redundancy functions, like other Ethernet devices. Yet, the devices in the subsystem are not directly accessible via Ethernet and thus not connected via the redundancy function. Still, solutions like this offer an enormous cost advantage. All device data in the subnet are digitally available and a diagnostics status is available for all participants. At the lowest field level, IO-Link is a very effective and efficient way to automate plant components. There are now many manufacturers who offer both sensors and actuators with IO-Link. This means that classic technologies such as existing 4...20 mA devices can simply be replaced by IO-Link. Further advantages such as simple parameterisation and diagnostics data evaluation are virtually free of charge.

Key finding: There is no one-size-fits-all solution. The choice of technology always depends on the customer's requirements and the area of application. The number and distribution of devices in the system as well as the costs and communication speed requirements also come into play. Each of the individual technologies has strengths, but also weaknesses. No matter which of the approaches is chosen, they all offer solutions for transmitting more useful device data to higher control levels than would be possible with analogue technologies.

5. Further information and contact:

You can also find out more about this topic on our website:

https://www.burkert.com/en/more-about/EDIP-Efficient-Device-Integration-Platform

https://www.burkert.com/en/Media/plm/MAN/MA/MAME43-Software-EU-EN.pdf?id=MAN000000000000001000353712ENB

https://www.burkert.com/en/Service-Support/Support/Glossary/IO-Link-The-open-communication-standard-for-sensors-and-actuators

https://www.burkert.com/en/Landingpage/Automating-and-controlling-hygienic-production-processes

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