

# Introduction to *ETHERNET Powerlink (EPL 2.0)*

## Real-time capable Ethernet with CANopen compatible application interface

Ethernet has already established itself in the industrial field due to its high data rates and the available infrastructure. Fast Ethernet, with its data rate of 100 Mbits/s is certainly helpful in improving the fulfillment of requirements such as real-time-capability and predictable time behavior. Due to the access mechanism used with Ethernet (CSMA/CD), however, it is not possible to offer guarantees for these requirements.

Today, *ETHERNET Powerlink* provides a protocol that on the one hand is based on standard Ethernet but on the other also meets the high requirements of determinism and cycle time. In addition it has a flexible, fully developed application interface and can thus rely on a wide range of available device and application profiles.

Version V1 of the *ETHERNET Powerlink* was already developed in November 2001 by the Austrian control manufacturer Bernecker & Rainer Industrie-Elektronik. The specification was published and made available to other companies in April 2002. The EPSG (*ETHERNET Powerlink Standardization Group*) was finally founded in November 2002 by the companies B&R, Lenze, Hirschmann, KUKA and the Institute for Embedded Systems at the Zurich University of Applied Sciences in Winterthur. At the end of 2003, B&R already had more than 7000 *Powerlink* devices successfully running in systems ready for production at their customers' sites. In November 2003 the specification *ETHERNET Powerlink V2* was adopted, which contains the most important extension of V1, an application layer, i. e. a standardized application interface based on the mechanisms defined in CANopen. IXXAT was heavily involved in the standardization work for this, particularly with regard to the CANopen mechanisms.

The main objectives pursued in the development of *ETHERNET Powerlink (EPL)* are listed in the box opposite. To avoid collisions and to make maximum use of the bandwidth, data exchange between the devices is time-based. A device in the *EPL* network takes on the function of the "manager", which controls the communication, defines the time pulse for synchronization of all nodes and assigns the right of transmission to the individual devices. The devices ("controllers") only transmit when requested to by the manager.

### The objectives of the development of *ETHERNET Powerlink*

- Use of IEEE802.3u (Fast Ethernet) as transmission medium
- Use of standard hubs and standard cables
- Transmission of cyclic, deterministic data with minimum cycle times up to 200 $\mu$ s
- Synchronicity jitter of all stations less than 1 $\mu$ s
- Transmission of time-deterministic and non-deterministic data
- Parallel transmission of IP-based protocols
- Use of conventional hardware is possible

An *EPL* cycle is divided into four time periods (Fig. 1):

- **Start Period:** here the manager transmits a "Start of Cyclic Frame" (SoC) as a broadcast message to all controllers. The SoC is followed by synchronization of all devices in the *EPL* network.
- **Cyclic Period:** cyclic isochronous data exchange takes place in this state. According to a preset (configurable) plan, the manager transmits a "Poll Request Frame" (PollReq) sequentially to each

controller as a unicast message, to which the addressed controller responds with a "Poll Response Frame" (PollRes), which is transmitted as a multicast message. In this way all nodes interested in these data can receive them, whereby cross-traffic between the stations similar to CAN is achieved.

- Asynchronous Period: time interval for the asynchronous, non-time-critical data exchange. A controller is granted the right to transmit by the manager with an "Invite Frame", which is transmitted as a unicast message, and can then transmit an IP-Frame, for example.
- Idle Period: Rest period until the new EPL cycle begins.

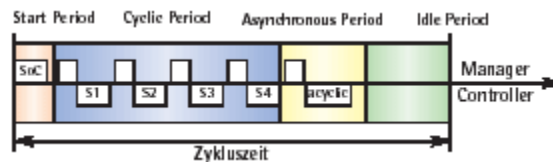


Fig 1: EPL cycle

Any topologies can be implemented by using hubs. Due to the fact that always only one device transmits at a time and thus no collisions occur, the number of hubs is no longer restricted to 2 as with Fast Ethernet. It is advantageous if EPL devices already have an integrated 2-port hub, as then line structures can be implemented very easily. The use of switches in an EPL segment is not generally prohibited, but it is not recommended as they have considerably higher latency times and jitters when passing on messages than hubs and thus adversely affects the performance and synchronicity jitter of an EPL system.

Figure 2 shows the system structure of an EPL system. There must only be EPL devices in an EPL system, as otherwise collisions cannot be excluded. By using an EPL-capable router, it is possible to access EPL devices directly from an external Ethernet-based system (e.g.. Intranet) with IP-based protocols.

The application interface of ETHERNET Powerlink V2 is based on the mechanisms defined in the CANopen communication profile DS301 of CAN in Automation (or EN50325-4). This opens up a wide range of already available and usable device and application profiles for ETHERNET Powerlink, enables universality communication services between CANopen and EPL systems and facilitates migration from CANopen to ETHERNET Powerlink at software level.

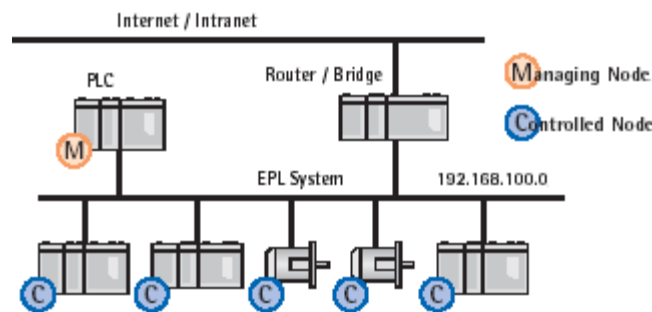


Fig 2: System architecture of an EPL systems

The reference module in Figure 3 shows the communication mechanisms and elements familiar from CANopen, such as PDO, SDO, object dictionary and network management. As can also be seen, the SDO protocol is also implemented via UDP/IP and thus via standard IP messages. This also enables

direct access to the object dictionaries of EPL devices by devices and applications outside the EPL system via EPL routers. The main features of ETHERNET Powerlink V2 are listed in the box below.

### Features of the ETHERNET Powerlink V2 Application Layers

- Up to 240 devices per EPL system
- Manager: 240 TX-PDOs, 240 RX-PDOs
- Controller: 1 TX-PDO, 240 RX-PDOs
- PDO mapping with up to 254 objects
- Maximum PDO length 1490 bytes
- Every device can communicate with every other device simultaneously via SDO
- Emergency mechanism with detailed error information
- Standardized bootup procedure and configuration manager

Due to its properties, ETHERNET Powerlink is suitable for implementing applications with severe real time conditions. However, it is also just as suitable for implementing applications which do not have such severe real time conditions but which must guarantee transmission of larger quantities of data within a defined period of time and at the same time also require the flexibility familiar from CANopen.

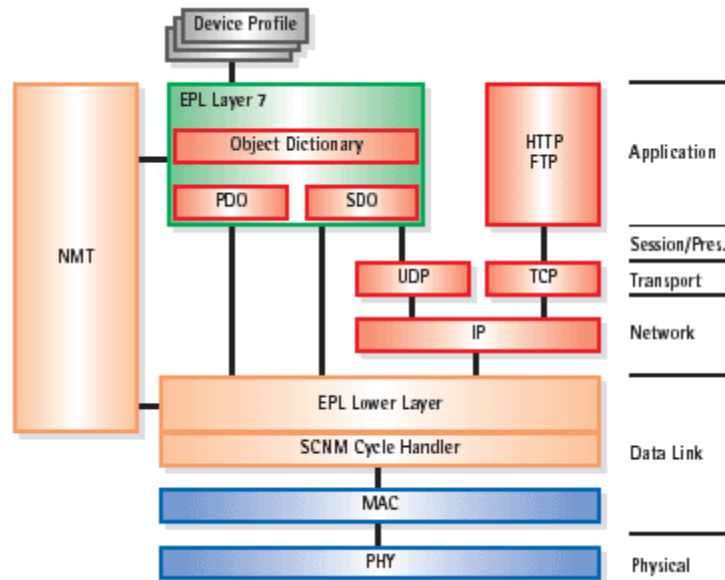


Fig 3: Reference model

## ***EPL 2.0 protocol software***

The EPL 2.0 software for the implementation of "controlled nodes" and combined "managing/controlled nodes" is available in a generic version, which can easily be ported to various target systems and operating systems. IXXAT also offers the software in a version specially adapted to an IXXAT reference platform. To supplement the protocol software, IXXAT offers training seminars and consulting services as well as the customized development of hardware and software. EPL interface cards for PCs are in preparation.

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