COMPARISON OF DIFFERENT INTERFACES AND PROFILES FOR POWER DRIVE SYTEMS

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Abstract
This document shows possible interfaces to a Power Drive System (PDS) for information exchange. It compares the profiles CANopen, CIP, DRIVECOM, PROFIdrive and SERCOS and outlines some of the common principles and differences. The approach to a generic PDS interface of IEC is introduced.

1 MOTIVATION

The IEC 61800 standard series is intended to provide a common set of specifications for adjustable speed electrical power drive systems. IEC 61800-7 is intended to describe a generic interface between control systems and power drive systems. This interface can be embedded in the control system. The control system itself can also be located in the drive (sometimes known as "smart drive" or "intelligent drive").

A variety of physical interfaces are available (analogue and digital inputs and outputs, serial and parallel interfaces, fieldbuses and networks). Profiles based on specific physical interfaces are already defined for some application areas (e.g. motion control) and some device classes (e.g. standard drives, positioner). The implementations of the associated drivers and application program interfaces are proprietary and vary widely.

The IEC 61800-7 standard is intended to define a set of common drive control functions, parameters, and state machines or description of sequences of operation to be mapped to the profiles. This is called the generic PDS interface.

There are several reasons to define a generic PDS interface:

for a drive device manufacturer

- less effort to support system integrators
- less effort to describe drive functions because of common terminology
- The selection of drives do not depend on availability of specific support

for a control device manufacturer

- No influence of bus technology
- Easy device integration.
- Independent of a drive supplier

for a system integrator (who builds modules, machines, plants etc.)

- Less integration effort for devices
- Only one understandable way of modelling
- Independent of bus technology

Much effort is needed to design a motion control application with several different drives and a specific control system. The tasks to implement the system software and to understand the functional description of the individual components may exhaust the project resources. In some cases the drives do not share the same physical interface. Some control devices support only a single interface which will not be supported by a specific drive. On the other hand the functions and data structures are specified with incompatibilities. It is up to the systems integrator to write interfaces to the application software to handle that which should not be his responsibility.

Some applications need device exchangeability or integration of new devices in an existing configuration. They are faced with different incompatible solutions. The efforts to adopt a solution to a drive profile and to manufacturer specific extensions may be unacceptable. This will reduce the degree of freedom to select a device best suited for this application to the selection of the unit which will be available for a specific physical interface and supported by the controller.

Drive manufacturer can reduce the need for adaptation if they have to exchange only the mapping instead of implementing the whole communication together with drivers in the operating systems and support for the configuration tools.

2 SYSTEM STRUCTURE

Adjustable speed electrical power drive systems are accessed more and more with industrial networks and field busses. The information exchange over these networks is defined in different profiles, defined for every network interface in a different document. The general structure of a system is given more or less in [2].

If we adapt this structure for the purpose of power drive systems we see a structure as shown in Figure 1.

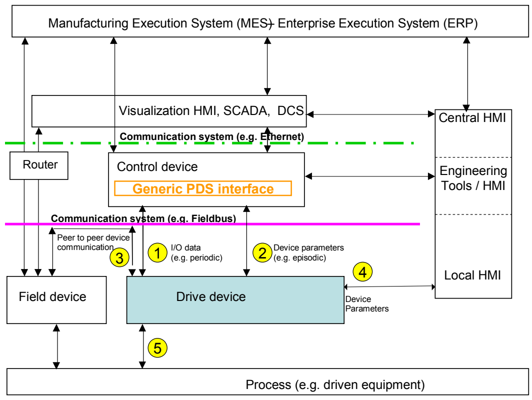

Figure 1- System structure (adapted from [1])

The drive device has different logical interfaces to the outside world numbered 1 to 5.

1. I/O data
2. Device Parameters
3. Peer to peer communication
4. Device Parameters (local or other interface)
5. Process interface

2.1 I/O data

The I/O data are available for transfer through the PDS interface typically on a regular or scheduled time base. This includes the set points and the commands from the control device to the drive device and the status and monitor values from the drive device to the control device. In a typical application this means a cyclic I/O data exchange. In some applications modes it is also possible to transmit this I/O data in a synchronous mode, meaning that the cycles of the control device, the cycles of the network and the cycle of the drive device are in a fixed relation.

2.2 Device parameters

The device parameters are available for transfer through the PDS interface typically on an unscheduled time base. This acyclic or aperiodic communication is used for engineering, configuration and diagnostics of the drive device. This interface is typically used by an engineering tool, but the control device is also able and allowed to access the drive device over the network with this interface.

2.3 Peer to peer device communication

The peer to peer device communication allows one drive device to exchange I/O data with other drive devices. This feature is specific to some of the communication profiles and is not further studied in this document.

2.4 Device Parameters

The access and interface of an engineering tool or HMI to the drive device is always possible through a local interface. These local interfaces are manufacturer specific and not covered by the communication profiles. HMI or engineering tools may use the fieldbus communication services which support the PDS interface.

2.5 Process Interface

The process interface to the driven equipment, e.g. the motor, is technology dependent and not part of this document.

3 APPLICATION MODES

Already the generic terminology is a problem. Most drive profiles define different modes of operation. But the term “mode of operation” is already defined in IEC with a clear meaning: [3] “351-31-01 operating mode: Characterization of the way and the extent to which the human operator intervenes in the control equipment.” So we call here the mode of operation of a drive device an application mode: type of application that can be requested from a drive device. The different application modes reflect the control loop for torque control, velocity control, position control or other applications like homing.

Depending on the application mode, the generic PDS interface uses different commands, set-points, actual and status values. This structure of the generic PDS interface is shown in Figure 2.

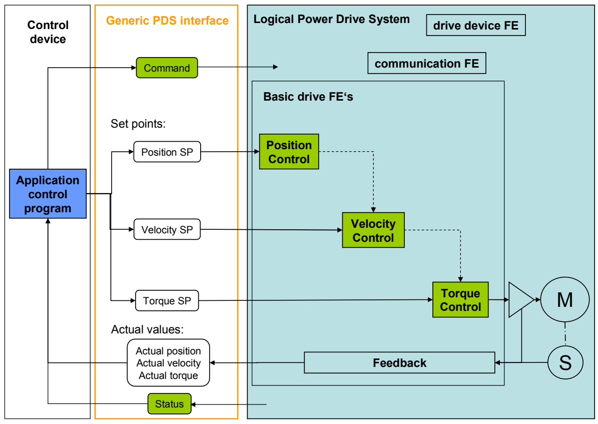

Figure 2 - Structure of the generic PDS interface

4 DRIVE INTERFACE PROFILES

There exists on the market different profiles for network drive interfaces. To define a generic interface, the different profiles have to be compared. The CANopen, CIP, DRIVECOM, PROFIdrive and SERCOS profiles are compared in this document.

4.1 CANopen

The organisation CAN in Automation (CiA) defined different Versions of profiles for Drives and Motion Control. For this study, the latest version was considered [4]. The CANopen profile is very similar to the DRIVECOM Profile. Several sections and drawings are even identical. The intention of this profile was to be used over a CAN network. But in recent publications it is also proposed for Fire-Wire and Power-Link communication networks.

The CANopen profile differentiates between Process Data Object (PDO) and Service Data Objects (SDO). PDOs are transmitted fast and efficient in real-time. They are not confirmed. SDOs are transmitted with confirmed services and are used to access parameters.

The different Qualities of Service (QoS) for PDOs are synchronous and asynchronous transmission with event or timer driven triggering modes.

4.2 CIP

The Open DeviceNet Vendor Association and ControlNet International defined a common application layer protocol the Control and Information Protocol (CIP). Of all the possible device profiles defined in chapter 6 of the document [5], only a subset is considered here in this report. The selected profiles build, in fact, a "Hierarchy of Motor Control Devices" and are designed to be downwards compatible from more complex servo drives to simpler devices. The CIP protocol is used also over Ethernet/IP.

In CIP the periodic I/O data is mapped to the assembly I/O object. All parameters of all objects can be accessed over an acyclic communication.

4.3 DRIVECOM

The DRIVECOM profile is used for INTERBUS communication networks. The profile of DRIVECOM is in fact the oldest document available of all the different profiles. An I/O data channel for the cyclic data and a communication channel for device parameter data are defined.

4.4 PROFIdrive

The PROFIBUS Organisation defined several versions of profiles for variable speed drives. The last version 3.1 [7] is called PROFIdrive and includes new features grouped in classes of applications: Application Class 1: Standard Drive; Application Class 2: Standard drive with distributed technology controller; Application Class 3: Positioning drive, single axis with distributed position control and interpolation; Application Class 4: Positioning with central interpolation and position control; Application Class 5: Positioning with central interpolation and distributed closed-loop position control; Application Class 6: Motion control for clocked processes, or distributed angular synchronism.

With the definitions of standard telegrams the I/O data for the different application modes are defined. Cyclic communication can be free running or synchronised with special telegram Global Control (GC). Peer to peer communication with broadcast messages is supported. A special communication channel to read and write parameter data is included. The definition of the parameters however is considered as technology dependant and therefore not defined in the PROFIdrive profile.

4.5 SERCOS

In 1995 the SERCOS Interface was standardised in IEC [8]. The actual version 2 was released in 1999. At the moment a version 3 based on Ethernet technology is under development.

The SERCOS Specification is very much oriented to the communication technology used to synchronise the drives. In this report the different Interface Compliance Classes are used to differentiate the different modes of operation. This is the only possibility to get a structure in the hundreds of defined parameters in the profile.

The SERCOS interface contains hundreds of identification numbers (IDNs). These IDNs are located in Annex A of [8]. The profile's parameters provide access to all signals in the drive system, including internal controller signals. The SERCOS Profile is split in 3 Classes A, B and C. Class A devices support only general parameters where the parameters specific to a mode of operation are grouped in Class B. Class C contains extensions in the functionality.

The SERCOS Profile has a cyclic data exchange (CP4). A Master Synchronisation Telegram (MST) defines the cycle limit. The Master Data Telegramm (MDT) allows the master to send data to all the drives (broadcast). The Drive Telegram (AT) is used by a drive to send data to the master.

The non-cyclic data exchange in the service channel time slot is used to modify parameters. A special Master Data Telegram (MDT) and the AT are used for this purpose. With CP5, file up- and downloading is also supported.

5 COMPARISON OF THE PROFILES

Here is an example of the differences and common features of the different profiles. We use for this comparison the command word (or byte) used by the control device inside the I/O data to control the drive

	DRIVECOM	SERCOS	CANopen	PROFIdrive	CIP
Bit 0	Switch-on	Master Handshake	Switch on	ON/OFF	Run1 (Fwd)
Bit 1	Disable voltage	Read/Write	Enable voltage	Coast Stop	Run2 (Rev) 3)
Bit 2	Quick stop	Progress	Quick stop	Quick Stop	Fault Reset
Bit 3	Enable operation	Datablock	Enable operation	Enable Operation	Reserved
Bit 4	1)	Datablock	1)	1)	Reserved
Bit 5	1)	Datablock	1)	1)	NetCtrl 3)
Bit 6	1)	Real-time	1)	1)	NetRef 3)
Bit 7	Reset-malfunction	Real-time	Fault reset	Fault Acknowledge	NetProc 3)
Bit 8	Reserved	Operation mode 3	HALT	Jog 1	---
Bit 9	Reserved	Operation mode 2	Reserved	Jog 2	---
Bit 10	Reserved	Synchronisation	Reserved	Control by PLC	---
Bit 11	2)	Operation mode1	2)	2)	---
Bit 12	2)	Reserved	2)	2)	---
Bit 13	2)	Halt/restart Drive	2)	2)	---
Bit 14	2)	Enable Drive	2)	2)	---
Bit 15	2)	Drive ON/OFF	2)	2)	---

1) Meaning depends on mode of operation
2) Manufacturer or device specific
3) Only available in extended mode

Table 1 - Name of bits in the command word (byte)

device (refer to Figure 2). The different names of the bits used in the different profiles are listed in Table 1. The meaning is almost identical with except with SERCOS, where the numbering is upside down.

The mechanism to reset a fault condition in the drive is the same in all profiles.

The switch-on and quick-stop features of the drive in the different profiles are very similar. The most important difference is with the CIP profile: There only one byte of commands is defined and most bits are optional. With this definition the CIP interface is very simple to handle by the user: just switch the drive on and off. The other models of drives include a more or less complex state-machine which is different depending the application mode. The user has to give the command in a well defined order to get the drive running.

6 CONCLUSIONS

Based on this simple example we see, that there are a lot of common things in the different profiles for communication interfaces to power drive systems. But there are a lot of differences in the interpretation and implementation of the different profiles. The manufacturers do not have the intention to redesign their successful products, if a new generic PDS interface standard will be published.

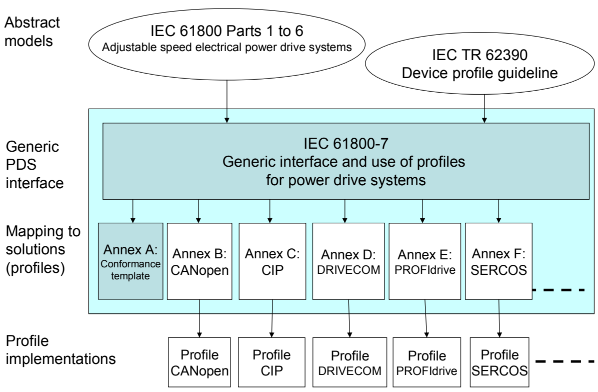

Figure 3 - Structure of IEC CD 61800-7

So the new generic PDS interface will not define an interface which can be implemented, it will only provide a guideline how to structure the description of the profiles, that the different versions of the interface implementations become comparable. The structure of the new IEC CD 61800-7 document is given in Figure 3.

I wish to thank Trevor Bagnall, who made the first comparison of the profiles and critically read though this document.

[1] IEC CD 61800-7, Adjustable speed electrical power drive systems, Part 7: Generic interface and use of profiles for power drive systems, International Electrotechnical Commission, CD available in June 2004

[2] IEC TR 62390, Common Automation Device Profile Guideline, International Electrotechnical Commission

[3] IEV 60050-351 Ed.3, Control Technology, Industrial Process Measurement and Control, International Electrotechnical Commission

[4] CANopen Device Profile Drives and Motion Control, Draft Standard Proposal DSP 402 Version 2.0, July 2002, Published by CAN in Automation e.V. CiA, Erlangen

[5] CIP Common Specification, Chapter 6: Device profiles, Release 1.0, June 5, 2001, Open DeviceNet Vendor Association & ControlNet International

[6] PROFILE Drive Engineering / Servo, Draft 22, September 1994, published by DRIVECOM Nutzergruppe e.V., Blomberg, Order No.: 22

[7] PROFIBUS Profile: PROFIdrive – Profile Drive Technology, Version 3.1, November 2002, Published by PROFIBUS Nutzerorganisation e.V. Karlsruhe, Order No.: 3.172

[8] Specification SERCOS interface, Draft Version 2.2 (November 2001), Published by Interest Group SERCOS interface e.V., Stuttgart (Sercos Interface standard IEC 61491, Electrical equipment of industrial machines)