PROFINET IO
Conformance Classes

Guideline
für PROFINET IO

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Prepared by the PROFIBUS Working Group 2 “PROFINET Marketing” in the Committee 1 “Marketing”.

In this specification the following key words (in bold text) will be used:

may: indicates flexibility of choice with no implied preference.

should: indicates flexibility of choice with a strongly preferred implementation.

shall: indicates a mandatory requirement. Designers shall implement such mandatory requirements to ensure interoperability and to claim conformance with this specification.

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Revision Log

Version	Originator	Date	Change Note / History / Reason
0.9	TC5WG4	Nov 2007	internal version
1.0	TC5WG4	Dec 2007	first public version
1.1	C1WG2	Mar 2011	second public version

Content

1 Content and objective

The objective of this document is to support plant owners in device selection and cabling. This requires evaluation of the range of functions needed for the specific application and device (product view).

Another objective is to provide product managers with a catalog of functions for the targeted field of application of a new PROFINET device. The product manager specifies the basic class and all requirements according to the market in which the product is to be used (market view).

1.1 Why are there conformance classes?

The range of functions of PROFINET IO is divided into well-organized ´*conformance classes*´ (“CC” for short). These conformance classes provide a practical summary of the various minimum properties.

The certification of a device according to a CC is done to ensure that selected devices will have the defined minimum properties with respect to functionality and interoperability.

Optional functions in PROFINET extend the conformance classes to include user functionalities such as fast start-up (FSU), media redundancy (MRP), multiple access (SharedDevice), and many more.

1.2 Additional documentation

For detailed information, see:
- PROFINET System Description (“PROFINET Technology and Application - System Description”)
- Specification (“Profiles for decentralized periphery”)

2 Overview

There are three Conformance Classes that build upon one another and are oriented to typical applications.

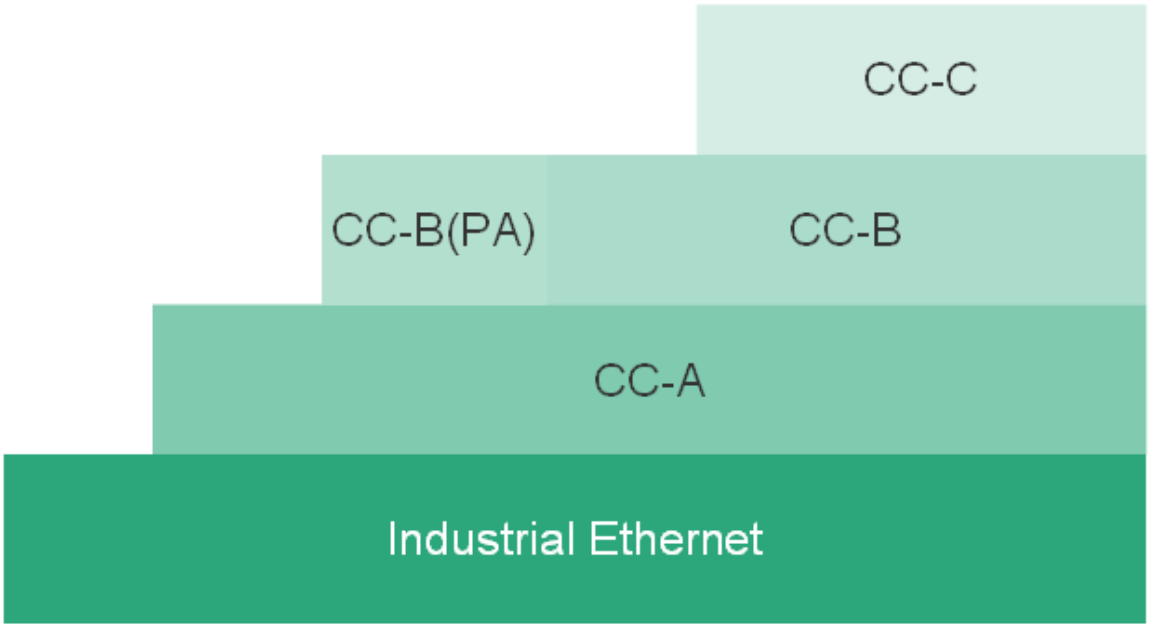

Figure 1: Conformance Classes (CC) are built on one another

CC-A provides basic functions for PROFINET IO with RT communication.

CC-B extends the concept to include network diagnostics via IT mechanisms as well as topology information. The system redundancy function important for process automation is contained in an extended version of CC-B named CC-B(PA).

CC-C describes the basic functions for devices with hardware-supported bandwidth reservation and synchronization (IRT communication) and is thus the basis for isochronous applications.

The Conformance Classes also serve as the basis for the certification and the cabling guidelines.

	CC-A	CC-B	CC-C
Basic function	PROFINET IO with RT communication • Cyclic I/O • Parameters • Alarms • Topology information (LLDP)	PROFINET IO with RT communication • Cyclic I/O • Parameters • Alarms • Network diagnostics via IP (SNMP) • Topology information (LLDP) with LLDP-MIB • System redundancy (only for CC-B(PA))	PROFINET IO with IRT communication • Cyclic I/O • Parameters • Alarms • Network diagnostics via IP (SNMP) • Topology information (LLDP) with LLDP-MIB • Hardware-supported bandwidth reservation • Synchronization
Certification	• Controller/devices with certificate • Infrastructure via manufacturer declaration	• Controller/devices with certificate • Infrastructure with certificate	• Controller/devices with certificate • Infrastructure with certificate
Cabling	• IEC 61784-5-3 and ISO/IEC 24702 (CC-A Cabling Guide) • Copper, fiber-optic • Wireless	• IEC 61784-5-3 • Copper, fiber-optic	• IEC 61784-5-3 • Copper, fiber-optic
Typical application	• Infrastructure • Building Automation	• Factory Automation • Process Automation	• Motion Control

Figure 2: Contents of Conformance Classes

3 Description of Conformance Classes

3.1 Description of Conformance Class A

Conformance Class A contains comprehensive basic functions. These are:

- Cyclic exchange of I/O data with real time properties (1 to 512 ms)
- Acyclic data communication for reading and writing of demand-oriented data (parameters, diagnostics)
- Parallel TCP/IP communication
- Flexible alarm model for signaling device and network errors with three alarm levels (maintenance requirement, urgent maintenance requirement, and diagnostics)

Based on these standardized communication mechanisms, every device has the following:

- A modular, slot- and subslot-based addressing scheme
- A GSD file for integration into the engineering system
- An Identification & Maintenance Function for reading out device information

PROFINET is based on a 100 Mbps, full-duplex Ethernet network. Faster communication is also possible on all transmission sections (e.g., between switches, PC systems or camera systems).

PROFINET defines not only the functionality but also the passive infrastructure components (cabling, connectors). Communication may take place via copper or fiber-optic cables. In a Conformance Class A network, communication is also allowed over wireless transmission systems (Bluetooth, WLAN).

The cabling guideline defines 2-pair cabling according to IEC 61784-5-3 for all Conformance Classes. For transmission systems with Gigabit cabling requirements, 4-pair cabling may also be used. In addition, a CC-A network allows complete networking with active and passive components according to ISO/IEC-24702 while taking into consideration the Conformance Class A Cabling Guide.

Active infrastructure components (e.g., switches) according to IEEE 801.x may be used in Conformance Class A, provided they support the VLAN tag with prioritization.

3.2 Application areas of Conformance Class A

Conformance Class A is adequate for all (sub-)applications in which the network topology and functions relying on it (see Conformance Class B) are not needed. Examples of these include locally separated I/O stations and (sub-)networks linked via wireless technologies. In addition, a Conformance Class A network is used to connect various automation islands using the company network, for example.

3.3 Description of Conformance Class B

Conformance Class B expands devices to include functions for additional network diagnostics and for topology detection. PROFINET uses the Simple Network Management Protocol (SNMP) for this. Portions of the Management Information Base 2 (MIB2) and the Lower Link Discovery Protocol-MIB (LLDP-EXT MIB) are integrated in the devices. In parallel to SNMP, all diagnostic and topology information can also be queried from the Physical Device Object (PDEV) using acyclic PROFINET services.

Starting with CC-B, infrastructure components (switches) are actively integrated in the automation system as a PROFINET IO-Device in order to make use of comprehensive network diagnostics from the controller via PROFINET mechanisms.

Passive network components (cables, connectors) are specified in IEC 61784-5-3 and, based on the PROFINET component approach, provide maximum safety as well as very easy planning and installation of cabling. Compliance with the PROFINET specification is confirmed by a simple manufacturer's declaration.

For devices in the process industry, Conformance Class B has been expanded to include the system redundancy function. As a result, this Conformance Class B (PA) provides the option of a cross-vendor application solution with redundant controllers for the purpose of achieving increased availability.

3.4 Application of Conformance Class B

CC-B covers the typical requirements of process and factory automation. As a result, tasks of modern automation islands (complete machines or individual plant units) can be implemented efficiently. The PROFINET network is also integrated perfectly into higher-level network management systems via the SNMP mechanisms.

3.5 Description of Conformance Class C

CC-C includes all necessary network-wide synchronization functions for applications with the most stringent requirements for deterministic behavior. Networks based on Conformance Class C enable applications having a jitter of less than 1 microsecond. Cyclic data packets are transferred as synchronized packets on a reserved bandwidth. All other packets, such as packets for diagnostics or TCP/IP, share the rest of the Ethernet bandwidth.

By default, the minimum update rate is defined at 250 µs in Conformance Class C. For maximum control performance, this can be reduced to as low as 31.25 µs, depending on the hardware used. In order to expand data volumes when cycle times are set at less than 250 µs, a message frame optimization method (Dynamic Fame Packing, DFP) is incorporated. With this method, nodes that are wired together in a line structure are addressed with one message frame. In addition, for cycle times less than 250 µs, the TCP/IP communication is fragmented and transmitted in smaller packets.

Starting with CC-C, this requires specific hardware on the part of the PROFINET Controller, in the switches, and in the PROFINET Devices.

3.6 Application areas of Conformance Class C

In Conformance Class C applications, it is ensured that input and output data are transmitted as fast as possible within the cycle. Delays caused by other communication or by storing data temporarily in devices are excluded. Measured values or even control loops can depend on these functions and be recorded or controlled with much greater precision.

CC-C is the basis for isochronous tasks such as motion control applications found in the printing and machine building industries. Data are exchanged between the controllers and the drives of a machine as synchronized data, which is a basic requirement within a drive train, for example.

4 Combination of Conformance Classes

A major advantage of PROFINET lies in the possible combination of Conformance Classes. All 3 classes can be integrated in a meaningful way within one system. A machine may just as well be designed according to CC-B or CC-C only.

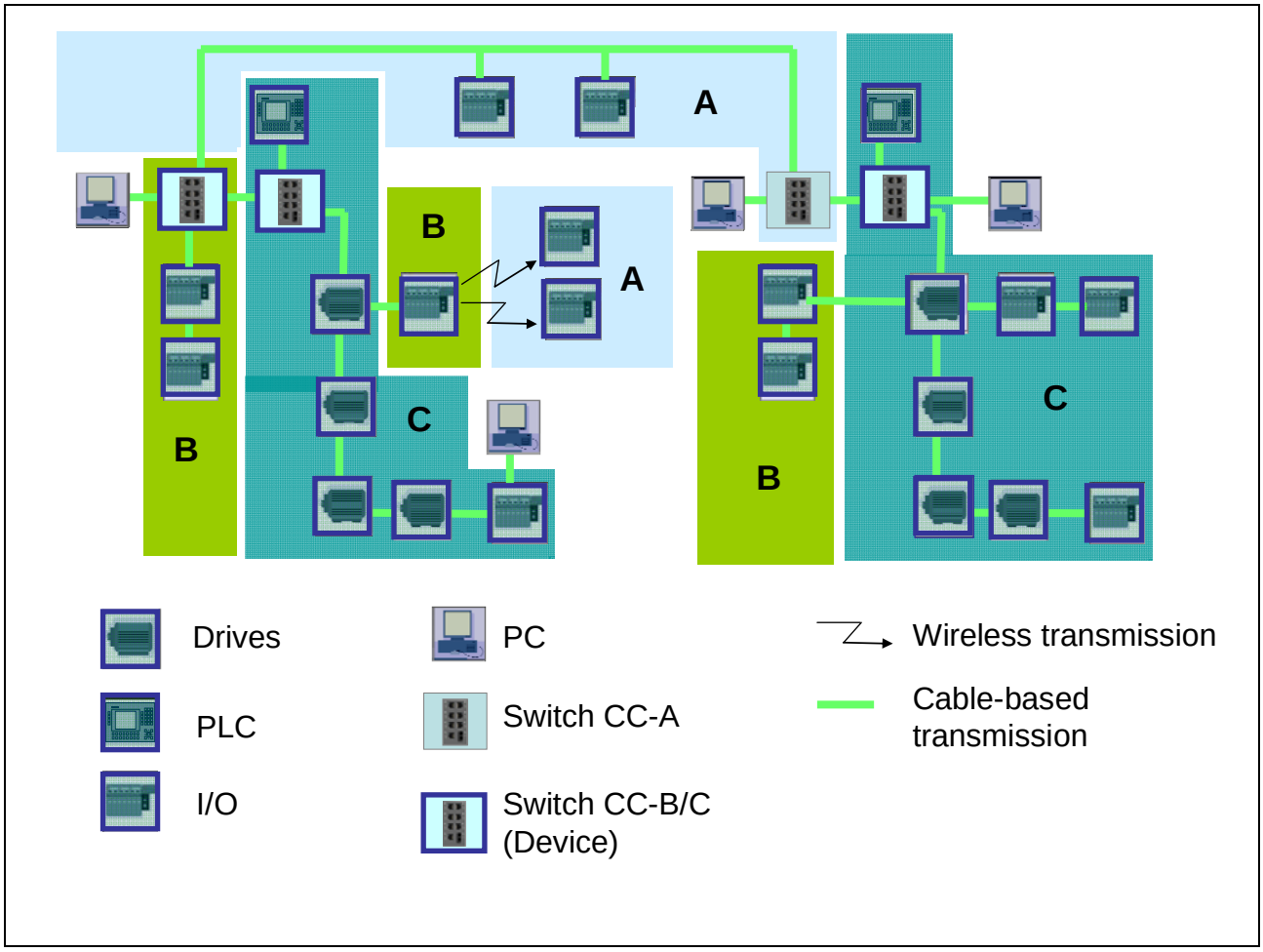

Figure 3: System and machine scenarios with CC-A, CC-B, and CC-C

5 Optional functions

Additionally, PROFINET provides a large number of optional functions that are not included as standard functions in devices by way of Conformance Classes. These optional functions are also tested during certification tests.

If additional functions are to be used in the project, this must be checked on a case-by-case basis using the device properties (data sheet, manuals, GSD file). This pertains to optional functions as well as to the profiles that are built on the PROFINET basic technology, such as PROFIdrive, PROFIsafe, or PROFIenergy.

Refer to the system description for details on the functions.

6 Complete overview of functions

The following table provides an overview of customer requirements and the implementation of standard and optional functions in the various Conformance Classes.

Requirement	*Technical function/solution*	*Standard/Optional*	*Conformance class*
Device functions			
Cyclic data exchange	PROFINET with RT	Standard	A, B, C
Acyclic parameter data	ReadRecord/ WriteRecord	Standard	A, B, C
Device diagnostics (alarms)	Diag./ Maint.Alarm	Standard	A, B, C
Device identification (HW/FW)	I&M 0	Standard	A, B, C
Neighborhood detection	LLDP	Standard	A, B, C
Port-related network statuses via PROFINET	PDEV	Standard	A, B, C
Multiple access to inputs by various controllers	Shared Input	Optional	A, B, C
Distribution of device functions to various controllers	Shared device	Optional	A, B, C
Extended device identification (location designation, installation date, etc.)	I&M 1-4	Optional	A, B, C
Direct communication between IO-Devices	Slave-to-slave communication	Optional	A, B, C
Network diagnostics via IT mechanisms	SNMP	Standard	B, C
System redundancy with two IO-Controllers	System redundancy	Standard	B (PA)
Automatic addressing of devices after device replacement	Name assignment via DCP, PDEV	Optional	B, C
Configuration changes during operation	Configuration in Run (CiR)	Optional	B, C
Time stamping of I/O data	Time sync	Optional	B, C
Fiber-optic cable diagnostics for POF/HCS	Fiber-optic cable maintenance alarms, PDEV	Optional	B, C
Fast start-up after voltage recovery for switching operations	FSU	Optional	B
Higher availability through ring redundancy	MRP	Optional	B
Bandwidth reservation with update rates of 250 µs and higher	PROFINET with IRT	Standard	C
Isochronous operation	PROFINET with IRT	Optional	C
Update rates less than 250 µs	PROFINET with IRT	Optional	C
Optimized IRT mode for line topologies	DFP	Optional	C
Higher availability through harmonious redundancy switchover	Two-way transmission, MRPD	Optional	C

Network cabling and infrastructure components			
Passive network components (connectors, cables)	IEC 61784-5-3 and ISO/IEC 24702 (CC-A Cabeling Guide)	Standard	A
Passive network components (connectors, cables)	IEC 61784-5-3	Standard	A, B, C
Copper and fiber-optic transmission systems	TX, FX, LX according to IEEE 802.x	Standard	A, B, C
Wireless connections	IEEE 802.11 WLAN, IEEE 802.15.1 Bluetooth	Standard	A
IT-compatible switches	With VLAN tag according to IEEE 802.x and LLDP 802.1ab	Standard	A
Switches with device function	PROFINET with RT	Standard	B
Switches with device function and bandwidth reservation	PROFINET with IRT	Standard	C

Engineering			
Integration of devices via GSD	GSDML	Standard	A, B, C
Topology display	SNMP, LLDP, PDEV	Standard	B, C
Call of a device-specific engineering tool	TCI	Optional	A, B, C
Individual Parameter Server for automatic parameter assignment of devices	iPAR server	Optional	A, B, C

Device profiles			
Profile for energy-saving modes	PROFIenergy	Optional	A, B, C
Profile for functional safety	PROFIsafe	Optional	A, B, C
Profiles for drive functions	PROFIdrive	Optional	A, B, C

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