

SEMI E54.8-0309

SPECIFICATION FOR SENSOR/ACTUATOR NETWORK COMMUNICATIONS FOR PROFIBUS-DP

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NOTICE: This Document is no longer published with the SEMI E54 suite of Standards. It is published and sold separately.

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1 Purpose

1.1 This Specification is part of the SEMI Sensor/Actuator Network (SAN) suite of Standards and defines a specific communications protocol based on the PROFIBUS standard. This Network Communication Standard (NCS) taken together with the SEMI Sensor/Actuator Network Standard suite and the PROFIBUS standard completely and unambiguously defines an open standard providing an industry specific solution to off-the-shelf interoperability of networked devices in semiconductor manufacturing equipment.

1.2 PROFIBUS is a vendor independent, open fieldbus standard for a wide range of applications in manufacturing, process and building automation. Vendor independence and openness are guaranteed by the IEC standards for PROFIBUS, IEC 61158 part 2, part 3-3 to part 6-3 and IEC 61784-1. PROFIBUS is optimized for high speed and inexpensive connectivity between automation control systems and distributed I/O at the device level.

2 Scope

2.1 This Document specifies a SAN Communications Standard based on the PROFIBUS specification that is in compliance with SEMI E54.1. As such, it specifies the protocol, services, and behavior that compliant intelligent devices must support in order to interchange information over this SAN in a method compatible with SEMI E39.

2.2 In conjunction with a SEMI Standard SAN Common Device Model (CDM) Specification and one or more SEMI Standard Specific Device Model (SDM) Specifications (e.g., for a Mass Flow Controller, In-Situ Particle Monitor Devices or Endpoint Devices), this Network Communication Standard (NCS) with the related PROFIBUS standard describe the data structures, interactions, and behavior that are characteristic of the various devices on the network. This composite model forms a complete interoperability standard for communications among intelligent sensors, actuators, and controllers in semiconductor manufacturing equipment.

NOTICE: SEMI Standards and Safety Guidelines do not purport to address all safety issues associated with their use. It is the responsibility of the users of the Documents to establish appropriate safety and health practices, and determine the applicability of regulatory or other limitations prior to use.

3 Limitations

3.1 This Document specifies a semiconductor equipment SAN based solely on PROFIBUS and is a companion document to the PROFIBUS specification; thus, a complete specification of this standard necessarily includes the PROFIBUS specifications. There are other semiconductor equipment SAN communications options. The specifications for these options are not included here.

3.2 The specifications within are strictly enhancements that provide additional capabilities over and above those currently required by PROFIBUS. Included throughout this document, primarily in § 6, is information paraphrased from the PROFIBUS specifications such as: protocol structure, capabilities, options, and limitations. This information is provided here for reference only and is not intended to provide specification definitions. In all such areas, refer to the PROFIBUS specification documents for information. This Document is limited to describing enhancements or limitations to the PROFIBUS specification that are imposed by this Standard.

- 3.3 A complete specification of the conformance testing procedure shall include the PROFIBUS protocol conformance testing specification. Conformance testing shall also include enhancements and limitations to the PROFIBUS specification required by this standard.

4 Referenced Standards and Documents

4.1 SEMI Standards and Safety Guidelines

SEMI E39 — Object Services Standard: Concepts, Behavior, and Services

SEMI E54.1 — Standard for Sensor/Actuator Network Common Device Model

SEMI E54.3 — Specification for Sensor/Actuator Network Specific Device Model for Mass Flow Device

SEMI E54.10 — Specification for Sensor/Actuator Network Specific Device Model for an In-Situ Particle Monitor Device

SEMI E54.11 — Specific Device Model for Endpoint Devices

SEMI E54.18 — Specification for Sensor/Actuator Network Specific Device Model for an In-Situ Particle Monitor Device

4.2 IEC Standards¹

IEC 61158-2 — Digital Data Communication for Measurement and Control – Fieldbus for Use in Industrial Control Systems – Physical Layer Specification

IEC 61158-3-3 — Digital Data Communication for Measurement and Control – Fieldbus for Use in Industrial Control Systems – Data Link Layer Service Definition – Type 3 Elements

IEC 61158-4-3 — Digital Data Communication for Measurement and Control – Fieldbus for Use in Industrial Control Systems – Data Link Layer Protocol Specification – Type 3 Elements

IEC 61158-5-3 — Digital Data Communication for Measurement and Control – Fieldbus for Use in Industrial Control Systems – Application Layer Service Definition – Type 3 Elements

IEC 61158-6-3 — Digital Data Communication for Measurement and Control – Fieldbus for Use in Industrial Control Systems – Application Layer Protocol Specification – Type 3 Elements

IEC 61784-1 — Digital Data Communication for Measurement and Control – Profile Sets for Continuous and Discrete Manufacturing Relative to Fieldbus Use in Industrial Control Systems

4.3 ISO Standard²

ISO 7498 — Basic Reference Model for Open Systems Interconnection (OSI)

4.4 PROFIBUS Standard³

PROFIBUS Profile Guidelines — Part 1: Identification and Maintenance Functions – order number 3.502

Specification for PROFIBUS Device Description and Device Integration, Volume 1: GSD – order number 2.122

NOTICE: Unless otherwise indicated, all documents cited shall be the latest published versions.

5 Terminology

5.1 Abbreviations and Acronyms

5.1.1 APDU — Application Protocol Data Unit

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² International Organization for Standardization, ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland; Telephone: +41.22.749.01.11, <http://www.iso.org>

³ Profibus International, Haid-und-Neu-Str. 7, 76131 Karlsruhe, Germany. Telephone: +49.721.9658.590; Fax: +49.721.9658.589; <http://www.profibus.com>

- 5.1.2 *AREP* — Application Reference Endpoint
- 5.1.3 *ASE* — Application Service Element
- 5.1.4 *CDM* — Common Device Model
- 5.1.5 *DMPM* — data link mapping protocol machine
- 5.1.6 *DP* — decentralized periphery
- 5.1.7 *DPM1* — DP-Master Class 1
- 5.1.8 *DPM2* — DP-Master Class 2
- 5.1.9 *DPV1* — DP Extensions Version 1
- 5.1.10 *DSAP* — Destination SAP
- 5.1.11 *FDL* — Fieldbus Data Link
- 5.1.12 *FSPM* — Fieldbus Service Protocol Machine
- 5.1.13 *GSD* — Generic Data Description
- 5.1.14 *IM* — Identification and Maintenance
- 5.1.15 *NCS* — Network Communication Standard
- 5.1.16 *NIL* — not in list
- 5.1.17 *OSI* — Basic Reference Model for Open Systems Interconnection [ISO 7498]
- 5.1.18 *PDU* — Protocol Data Unit
- 5.1.19 *PHY* — Physical Layer
- 5.1.20 *SAN* — Sensor/Actuator Network
- 5.1.21 *SAP* — Service Access Point
- 5.1.22 *SDA* — Send Data with Acknowledge
- 5.1.23 *SDM* — Specific Device Model
- 5.1.24 *SDN* — Send Data with No acknowledge
- 5.1.25 *SRD* — Send and Request Data with reply
- 5.1.26 *SRV* — service
- 5.1.27 *SSAP* — source SAP
- 5.2 Terminology Defined in Sensor/Actuator Network Common Device Model [SEMI E54.1]
 - 5.2.1 *attribute*
 - 5.2.2 *behavior*
 - 5.2.3 *byte*
 - 5.2.4 *common device model*
 - 5.2.5 *device*
 - 5.2.6 *device manager (DM) object*
 - 5.2.7 *device model*
 - 5.2.8 *instance*
 - 5.2.9 *Network Communication Standard*
 - 5.2.10 *object*

5.2.11 *sensor, actuator and controller (SAC) object*

5.2.12 *service*

5.2.13 *specific device model*

5.2.14 *state diagram*

5.3 Terminology Mapping

5.3.1 As this Standard defines the mapping of CDM data structure and behavior over a network, it makes use of many of the terms in SEMI E54.1. Table 1 provides a mapping of fundamental terminology of the CDM Document into this Document which uses the terminology of PROFIBUS.

Table 1 Mapping of CDM to NCS Terminology

<i>CDM Term</i>	<i>NCS Equivalent</i>
Device	DP Slave
Object	= (with ASE as class specification)
Instance	=
Attribute	=
Behavior	=
Service	=
State Diagram	Protocol Machine, State Machine
Byte	=, Unsigned8
Nibble	Specific field coding
Character String	Visible String

5.4 Terminology Defined in PROFIBUS

5.4.1 *Device Data Base* — an electronic file that provides a clear and comprehensive description of the characteristics of a device type in a precisely defined format. Also called a GSD File.

5.4.2 *Device Profile* — a Device Data Base Sheet, which specifies the characteristic features of a device, and a GSD File.

5.4.3 *Data Link Mapping Protocol Machine* — a protocol layer that provides an interface to the Application Layer Protocol Machines by translating service requests and responses between the Application Layer and the Fieldbus Data Link.

5.4.4 *DP-Master Class 1 (DPM1)* — a device that polls its assigned DP-Slave devices and handles user data exchange.

5.4.5 *DP-Master Class 2 (DPM2)* — a device that interacts as a configuration or diagnostic tool; usually a programming device.

5.4.6 *DP-Slave* — a device that is configured, managed, and polled by Master devices; a DP-Slave initiates no unsolicited communications.

5.4.7 *Fieldbus Data Link* — the PROFIBUS model for the OSI Layer 2 definition.

5.4.8 *GSD File* — see Device Data Base.

5.4.9 *Service Access Point* — an addressable location in a device for the directing of service requests.

5.4.10 *Send Data with No acknowledge* — a service request that sends data with no reply.

5.4.11 *Send and Request Data with reply* — a service request that sends data followed by a reply by the receiving device.

5.4.12 *Slave Diagnostics* — a method of retrieving a specifically formatted Data Structure that represents the diagnostic status of a DP-Slave.

6 Communication Protocol High Level Structure

6.1 In a typical remote I/O configuration, single master architectures are used to optimize response times. In lower speed applications, multi-master architectures are also possible. PROFIBUS uses the polling principle for communication (Master-Slave method).

6.1.1 Message transfer is organized in cycles. A message cycle mainly consists of a request-frame followed by a corresponding acknowledge/response-frame of the addressed station. An exception to this is the global-control function for synchronization and coordination of several remote I/O stations.

6.1.2 A brief description of the PROFIBUS protocol as it relates to the ISO 7498 OSI model follows in the sections below. For protocol efficiency, PROFIBUS does not define layers 3 to 6. Layer 7 is the interface between the Application Process and the communication stack.

NOTE 1: The information contained in this section is for reference only. It does in no way represent the full specification for PROFIBUS. See related documentation for these specifications.

6.2 Physical Layer — Layer 1

6.2.1 There are three options specified for the Physical Layer (PHY): Manchester Coded Interface for Bus Powered Systems, RS-485 and Optical. See the PROFIBUS standard for more information about these options.

6.3 Data Link Layer — Layer 2

6.3.1 Data Transfer

6.3.1.1 The Data Link Layer or Fieldbus Data Link (FDL) provides the functions for sending and receiving data over the network. Protocol Data Units (PDU) are packaged, delivered, and checked. Acknowledgements, responses, retries, and timeouts are used to guard against Line Protocol Errors (e.g., frame, overrun, and parity) and Transmission Protocol Errors (e.g., start and end delimiters, frame check, frame length, and response times).

6.3.1.2 A PDU is restricted to 246 bytes. In addition to the PDU, a transmission frame of variable length will contain 8 bytes of overhead; one of fixed length (8 bytes) will contain 6 bytes of overhead. Various acknowledgement and response frames are also defined.

6.3.1.3 To better understand the FDL, a summary of FDL data transfer services is given by the following list:

- Send Data with Acknowledge (SDA),
- Send Data with No Acknowledge (SDN), and
- Send and Request Data with Reply (SRD).

6.4 Application Layer — Layer 7

6.4.1 The PROFIBUS application layer is structured in a so-called service definition and protocol specification. The service definition uses an object orientated approach and specifies the services for remote access and local functions together with their objects (the ASE is a class definition of these objects). The protocol specification includes both coding and state machines.

6.4.2 Service Definition

6.4.2.1 Application layer services are structured to reflect the needs of flexible configurable automation devices. A Device consists of a set of modules that are placed in slots (see Figure 2). Modules are addressed uniquely by the slot number. The module view can be a hardware oriented or reflects the software structure of the DP-Slave.

6.4.3 Slot 0 is used to address the DP Slave itself. Subslot 0 represents the module and contains no IO Data. The other object classes can have instances scattered over the modules addressed by slot number. Each module can contain IO Data, Context parameter, Diagnosis information, Process Data and Alarms. Process Data is a generic class which can contain different application specific parameters accessible by read and write services. There is a set of identification and maintenance parameters defined in a PROFIBUS Guideline.

6.4.3.1 Object classes are defined for:

- IO Data for periodic reporting,
- Context for configuration,
- Diagnosis for event collection,
- Process Data for polled access, and
- Alarms for asynchronous event reporting.

6.4.3.1.1 A set of services are defined for these object classes.

6.4.3.2 IO Data is handled mainly by buffered services which allow decoupling between application and communication. Client/Server service structure (request/response) is used for Record Data, Context and Diagnosis.

6.4.4 Protocol Specification

6.4.4.1 A DP-Slave shall get an FDL address before using it in the target configuration.

6.4.4.2 To access a DP-Slave the DP-Master has to check the availability with a Slave-Diag service. To establish the context a SetPrm service is issued first. A check is done to ensure that the appropriate device type with the required resources is accessed. The following ChkCfg service. Another Slave Diag service has been used to check the establishment of the application relationship.

6.4.4.3 After this start up procedure the data exchange of IO data can be done, and alarms can be signaled from the DP Slave to the DP Master. The DP Master can invoke services to read and write process data that contain all kind of information (e.g., produced units, calibration information, and batch information).

6.4.4.4 A context is monitored by the Data Exchange Service at the DP-Slave. The DP-Master monitors the communication by the receipt of the responses to the FDL services.

6.4.5 Data Link Mapping Protocol Machine (DMPM)

6.4.5.1 The DMPM performs the interpretation of service requests from, and responses to, the Application Protocol Machines. Table 2 is included to demonstrate the basic structure of the PROFIBUS DMPM. For speed and efficiency, the PROFIBUS protocol defines the Service Access Point (SAP). These are included in the transmission protocol to direct messages within the device for fast dedicated processing. Defined are Destination SAP (DSAP) and Source SAP (SSAP).

6.4.6 I&M Functions

6.4.6.1 “Identification & Maintenance Functions” (I&M functions) define general parameters and protocols. The main purpose of the I&M functions is to support the end user during various scenarios of a device’s life cycle be it configuration, commissioning, parameterization, diagnosis, repair, firmware update, asset management, audit trailing, and alike. Well-defined uniform parameters and rules should enable the manufacturers to offer devices that behave in a uniform manner. These profile guidelines take into account requirements from FDA (Food & Drug Administration) and others. The basic information offered can be characterized as “Type Plate” or “Boiler Plate.” It consists of Manufacturer ID, Order ID, Serial Number, Hardware Revision, Software Revision, Revision Counter, and Profile ID.

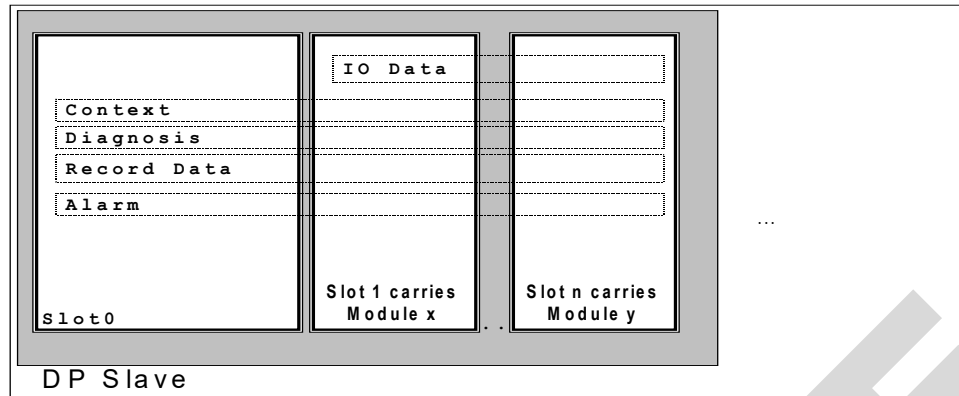


Figure 1
Device Model

Table 2 DMPM Primitive Functions

<i>DMPM Function</i>	<i>Description</i>	<i>SSAP</i>	<i>DSAP</i>	<i>FDL SRV</i>
Master-Slave				
Data_Exchange	Exchanges I/O Data	NIL	NIL	SRD
Check_Cfg	Sends Configuration to DP-Slave for verification.	62	62	SRD
Set_Prm	Sends Parametric Data to DP-Slave.	62	61	SRD
Slave_Diag	Retrieves the Diagnostic Data Structure from a DP-Slave.	62	60	SRD
Get_Cfg	Retrieves the Configuration Data Structure from a DP-Slave.	62	59	SRD
Global_Control	Controls the Operational and Synchronization of DP-Slaves.	62	58	SDN
DPM2-Slave				
RD_Outp	Retrieves the Status of the Outputs of the DP-Slave.	62	57	SRD
RD_Inp	Retrieves the Values of the Inputs of the DP-Slave.	62	56	SRD
Set_Slave_Add	Sets the Node Address of a DP-Slave.	62	55	SRD
Master-Master				
	Various Services for Master-Master Communications.	54	54	SRD/SDN
Master-Slave — Extended Communications				
Read/Write	Acyclic Read/Write of DP-Slave Data.	51	51	SRD
DPM2-Slave — Connection Configuration				
Initiate/Read/Write ...	Services for Control and Management of the MS2 Connection.	50	x..49	SRD

6.4.7 Service Access Point (SAP)

6.4.7.1 The Service Access Point provides standard access addressing for messages. The FDL message frame includes fields for Source and Destination SAP. By directing a message to a particular Destination SAP, its context is immediately known. This provides a fast and interoperable environment for device messaging.

6.4.8 Device Profile/Device Data Base

6.4.8.1 PROFIBUS devices have different performance characteristics. Features differ in regard to available functionality (i.e., number of I/O signals and diagnostic messages) or possible bus parameters such as baud rate and time monitoring. These parameters vary individually for each device type and vendor. These parameters are usually documented in the technical manual. To achieve simple plug-and-play configuration of PROFIBUS, the characteristic features are specified in an electronic data sheet called a Device Data Base file or GSD file.

6.4.8.2 The GSD Files provide a clear and comprehensive description of the characteristics of a device type in a precisely defined format. These are prepared individually by the vendor for each type of device and made available to the user in the form of a Device Data Base Sheet and a GSD File. The device data base file is divided into three parts: General Specifications, Master Related Specifications, and Slave Related Specifications.

6.4.8.3 These GSD Files are maintained and managed by the PROFIBUS Trade Organization.

6.5 Network Management

6.5.1 The PROFIBUS system is managed through several phases of operation. A Master device must have knowledge of the Device Profile for each of the Slave devices it will connect. The Device Data Base Files serve this purpose. Upon initialization, a Master will control a DP-Slave through three operational modes: Parameterization, Configuration, and I/O Data Exchange. In any operational mode, a Master may interrogate a DP-Slave for its Diagnostic information.

6.5.2 In the sections that follow, these operation modes are mapped to related SAN CDM behavior states.

7 Required Object Types

7.1 This section describes a general mapping of the SEMI SAN Object Model to the PROFIBUS environment. Component definitions are clarified, and the mapping of Attributes, Services, and Behaviors are specified.

7.2 Object Model

7.2.1 The Object Model defined in the CDM is represented in the PROFIBUS NCS. Specifically, the DM and SAC objects are mapped.

7.2.2 The CDM Objects are mapped to slots. These slots have a unique address space within the device. The Application Objects associated with the SDM Standards are mapped in PROFIBUS Device Data Base documents as defined above in the Device Profile/Device Data Base section. § 9 specifies the mapping of SDM Objects in PROFIBUS.

7.3 Component Mapping Summary

7.3.1 Figure 2 provides a summary of the components of the CDM object model as they relate to the components of PROFIBUS.