

SEMI E54.4-0422

SPECIFICATION FOR SENSOR/ACTUATOR NETWORK COMMUNICATIONS FOR DEVICENET®

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NOTICE: The section symbol (§) is used to reference a numbered section, paragraph, or header and all subordinate paragraphs, headers, and embedded material (i.e., EXCEPTIONs, lists) therein. The paragraph symbol (§) is used to reference a particular numbered paragraph and embedded material therein. When duplicated (i.e., §§ and §§) the symbols are used to reference more than one section or paragraph, respectively.

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

1 Purpose

1.1 This Standard defines a Communication Specification based on the DeviceNet®¹ protocol to enable communications between intelligent devices on a Sensor/Actuator Network (SAN) that operate according to SEMI-specified device models (common and device specific) in a semiconductor manufacturing tool.

1.2 *Background and Motivation* — DeviceNet provides for networking between simple industrial devices (e.g., sensors and actuators) and higher level devices such as controllers. DeviceNet provides:

- A solution to low-level device networking.
- Access to intelligence present in low-level devices.
- Master/Slave and Peer-to-Peer capabilities.

1.2.1 DeviceNet is based on the Controller Area Network (CAN) technology. CAN defines a media access control (MAC) methodology and physical signaling characteristics. DeviceNet wraps a communication model and protocol as well as a complete Physical Layer definition around CAN to provide a complete network definition.

1.3 This Specification enables communications between intelligent devices on a SEMI-compliant SAN by providing a presentation mapping of common and specific device network visible structure and behavior to a DeviceNet network.

2 Scope

2.1 This Standard specifies the protocol and services that compliant intelligent devices must support to interchange information over this semiconductor equipment SAN.

2.2 This Standard specifies the utilization of the DeviceNet protocol to present externally visible device structure and behavior, specified in the Common Device Model (CDM) and appropriate Specific Device Models (SDM's), on a DeviceNet network.

2.3 This Specification is used in conjunction with SEMI E54.1, Specification for Sensor/Actuator Network Common Device Model, and one or more SEMI Standard-specific device model specifications (e.g., for a mass flow controller [MFC]). Together, they describe the externally visible data structure and behavior of devices using the DeviceNet networking capability in a SEMI-compliant SAN system.

2.4 This Standard, together with a SAN interoperability guideline, the SAN CDM, one or more SAN specific device model documents, and the DeviceNet specifications, form a complete interoperability Standard. The general SAN Document architecture is shown in the Sensor/Actuator Network Common Device Model Standard in Figure 1.

¹ Trademark is owned by ODVA, Inc.

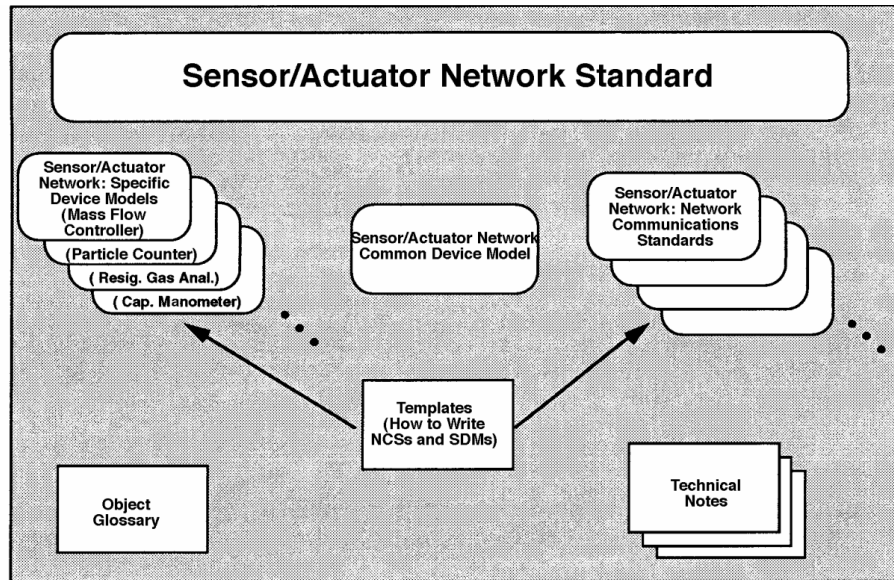


Figure 1
Sensor/Actuator Network Related Documents

2.5 Document Structure — The DeviceNet Network Communication Standard complies with the SEMI SAN NCS template Document structure; this structure is shown in Figure 2. The Standard is composed of two main parts. The first part (§§ 1 through 8) specifies the SAN enabling protocol as well as the presentation (i.e., mapping) of CDM object structure and behavior onto the network (referred to as the ‘CDM mapping’). The second part (§ 9) specifies the presentation (i.e., mapping) of SDM object structure and behavior onto the network for each SEMI-specified SDM (referred to as the ‘SDM mapping’).

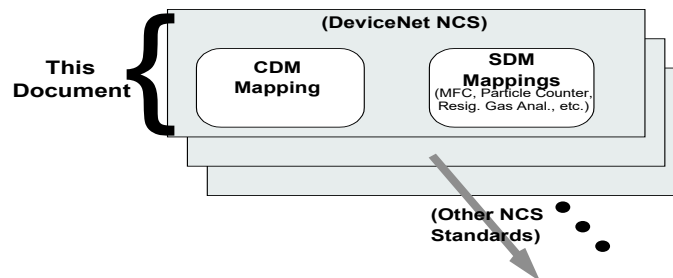


Figure 2
DeviceNet NCS Document Structure

2.6 Adding SDM Mappings — SDM mappings added to part two of this Specification are considered additions and are balloted as such. An SDM mapping may only be balloted for addition to this Specification if the corresponding SEMI SDM has been standardized or is in the process of being balloted for standardization.

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 Standard specifies a semiconductor equipment SAN based solely on DeviceNet and is a companion Specification to the DeviceNet specification; thus, a complete specification of this Standard necessarily includes the

DeviceNet specifications. There are other semiconductor equipment SAN communications options. The specifications for these options are not included here.

3.2 This Standard specifies enhancements that provide additional capabilities over and above those currently required by DeviceNet. In order to avoid Specification consistency problems, information in the DeviceNet specification that relates to this Standard is not repeated in this Specification. This Specification is limited to describing enhancements or limitations to the DeviceNet specification that are imposed by this Standard.

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

4 Referenced Standards and Documents

4.1 SEMI Standards and Safety Guidelines

SEMI E30 — Specification for the Generic Model for Communications and Control of SEMI Equipment (GEM)

SEMI E39 — Specification for Object Services: Concepts, Behavior, and Services

SEMI E54.1 — Specification 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 — Specification for Sensor/Actuator Network Specific Device Model for Endpoint Devices

SEMI E54.18 — Specification for Sensor/Actuator Network Specific Device Model for Vacuum Pump Device

SEMI E54.22 — Specification for Sensor/Actuator Network Specific Device Model for Vacuum Pressure Gauges

SEMI E54.24 — Specification for Sensor/Actuator Network Specific Device Model of a Generic Equipment Networked Sensor (GENSen)

4.2 ISO[®] Standards²

ISO/IEC 7498-1 — Information Technology – Open Systems Interconnection – Basic Reference Model: The Basic Model

ISO 11898-2 — Road Vehicles – Controller Area Network (CAN) – High-Speed Medium Access Unit

4.3 Other Documents

ODVA[®] — Volume 3: DeviceNet Adaptation of CIP³

Controller Area Network Specification, Version 2.0⁴

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

5 Terminology

5.1 Terminology that is common to all of the documents in this Specification may also be defined in the SAN Standard. Terminology may be reproduced here which is defined in other SEMI Standards.

5.2 Abbreviations and Acronyms

5.2.1 CAN — Controller Area Network

5.2.2 CDM — Common Device Model

² International Organization for Standardization, ISO Central Secretariat, 1, ch. de la Voie-Creuse, CP 56, CH-1211 Geneva 20, Switzerland; Telephone: +41.22.749.01.11, Fax: +41.22.733.34.30, <http://www.iso.org>. ISO trademark is owned by International Organization for Standardization.

³ Open DeviceNet Vendor Association; <http://www.odva.org>. Trademark is owned by ODVA, Inc.

⁴ Robert Bosch GmbH, Postfach 50 D-7000, Stuttgart, Germany, <http://www.bosch.com>

5.2.3 *DM* — device manager (object)

5.2.4 *DN* — DeviceNet

5.2.5 *GENSen* — Generic Equipment Networked Sensor

5.2.6 *MAC* — media access control

5.2.7 *NCS* — Network Communication Standard

5.2.8 *OSI* — open systems interconnect

5.2.9 *SAC* — sensor, actuator, controller (object)

5.2.10 *SAN* — Sensor/Actuator Network

5.2.11 *SDM* — Specific Device Model

5.3 *Device Component Definitions* — As this Standard defines the presentation or mapping of CDM data structure and behavior over a network, it makes use of many of the terms in the CDM Specification. Table 1 provides a mapping of fundamental terminology of the CDM Specification into this Specification and the DeviceNet specification. Note that column 2 contains an equal sign (=) if the definition is used exactly as specified in the CDM Specification.

Table 1 Mapping of CDM to NCS Terminology

<i>CDM Term</i>	<i>NCS Equivalent</i>	<i>DeviceNet Equivalent</i>
Device	=	=
Device Model	=	=
Object	=, Class	=, Class
Instance	=	=
Attribute	=	=
Behavior	=	=
Service	=	=
State Diagram	=	=
Byte	=	=
Nibble	=	=
Character String	=	=

5.4 *DeviceNet Specific Definitions*

5.4.1 *class* — a set of objects that all represent the same kind of system component. A class is a generalization of an object. All objects in a class are identical in form and behavior, but may contain different attribute values.

5.4.2 *Controller Area Network (CAN)* — a protocol developed by the Bosch corporation for automotive in-vehicle networking. ISO 11898-2 specifies OSI reference model layers 1 and 2, specifically the physical signaling and media access/data link protocols.

5.4.3 *device profile* — a DeviceNet specification for a device that contains an object model for the device type, the I/O data format for the device type, and the configuration data and the public interface(s) to that data.

5.4.4 *explicit message connections* — connections over a DeviceNet network that provide generic, multi-purpose communication paths between two devices. These connections often are referred to as just messaging connections. Explicit messages provide the typical request/response—oriented network communications.

5.4.5 *input/output connections* — connections over a DeviceNet network that provide dedicated, special-purpose communication paths between a producing application and one or more consuming applications. Application-specific I/O data moves through these ports.

6 Communication Protocol High Level Structure

6.1 The DeviceNet protocol is loosely based on a three-layer architecture. These layers constitute a collapsed form of the open systems interconnect (OSI) seven-layer architecture, mapping into the physical, data link, and application layers of the Reference Model; however, DeviceNet provides additional functionality (such as connection support) commonly attributed to other OSI layers. The high level protocol architecture is shown in Figure 3.

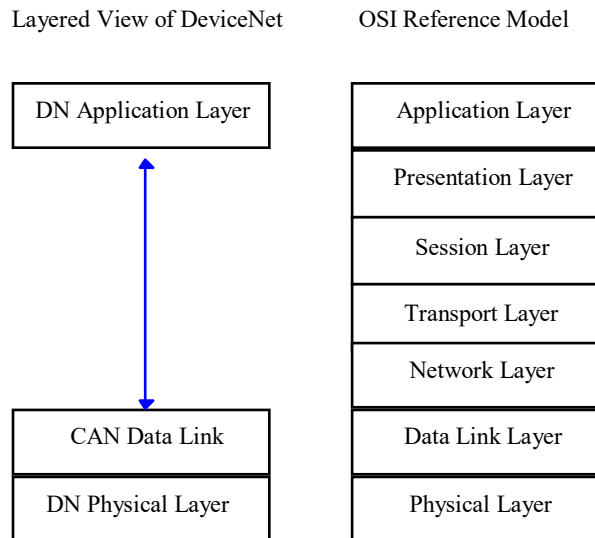


Figure 3
Layered View of DeviceNet

6.1.1 Note that Figure 3 represents a conceptual view of the device architecture. Conforming implementations must implement the services defined in this Specification at each layer and must appear (from the network) to have implemented this architecture; however, an internal modular partitioning is not required. Implementations may sacrifice modularity in order to achieve high performance.

6.2 The DeviceNet physical layer is fully specified in Volume 1 of the DeviceNet specification. Features of this layer include trunkline-dropline configuration, simultaneous support for both network-powered and self-powered devices, and selectable data rates including at least 125k, 250k, and 500k baud. At the data link layer, ISO 11898-2 defines a carrier sense multiple access mechanism for media access control that avoids collisions and sends frames reliably. The application layer is specified in Volumes 1 and 2 of the DeviceNet specification and provides for the definition of DeviceNet applications as a collection of addressable objects. Two basic categories of objects exist: communication objects and application objects. Communication objects manage and provide for the runtime exchange of messages across DeviceNet. Application objects implement product-specific features and/or provide a logical interface to product-specific information of devices on a DeviceNet network.

6.3 In the remainder of this section, the protocol structure is described in more detail in terms of the OSI seven layer reference model, the object model environment, and network management specifications.

6.4 *Physical Layer* — The device shall comply with the DeviceNet physical layer specification as well as the “Interface Guidelines for DeviceNet Devices on Semiconductor Manufacturing Tools” which is published as part of the DeviceNet specification. This includes physical signaling (levels and baud rates—detailed in ISO 11898-2), transceivers, node isolation, media topology, cable specifications, network connectors and taps, and power considerations (load limits, system tolerances, and power supply options).

6.4.1 *Physical Layer Enhancements* — This Standard supports the following physical layer enhancement to the DeviceNet specifications:

- The transmission media, including both trunk cable and drop cable, shall be DeviceNet thin cable. specifications on this cable and its utilization in DeviceNet systems (e.g., maximum trunk and drop lengths) are included in the DeviceNet specification.

6.5 *Data Link Layer* — The device shall comply with the DeviceNet data link layer specifications (i.e., Controller Area Network Specification: Version 2). This includes the media access control mechanism and the logical link control mechanism. Addressing is currently limited to 11 bits.

6.6 *Network Layer* — There is no distinct network layer.

6.7 *Transport Layer* — There is no distinct transport layer. Some of the functionality of this layer is implemented in the Application Layer. Specific functions include: segmentation/reassembly for full message delivery and the establishment of node-to-node connections.

6.8 *Session Layer* — There is no distinct session layer.

6.9 *Presentation Layer* — There is no distinct presentation layer. Data types and data presentation in DeviceNet messages are specified as part of the DeviceNet object definitions and object attribute and service communication protocol.

6.10 *Application Layer* — The device shall comply with the DeviceNet application layer specification for defining and addressing objects, including their attributes and services, and enabling specified network behavior. The device shall comply with the object model specifications provided in the DeviceNet specification as well as the “Interface Guidelines for DeviceNet Devices on Semiconductor Manufacturing Tools” component of the DeviceNet specification. In addition, the device shall comply with the object specifications defined in § 7 of this Document.

6.10.1 *Object Models* — The DeviceNet protocol provides an object-oriented specification for creating, defining, and addressing objects explicitly, including their attributes and services (i.e., explicit messaging), and creating, defining, and communicating object attribute assemblies in an application-dependent format (i.e., input/output messaging). The device shall comply with the object model specifications provided in the DeviceNet documentation. In addition, the device shall comply with the object specifications defined in § 7 of this Document.

6.11 *Network Management* — The device shall comply with the DeviceNet network management specifications (e.g., physical layer bit rate, duplicate MAC ID detection, master-slave, and peer-to-peer network management). No (additional) network management functions are specified in this Document.

7 Required Object Types

7.1 The DeviceNet specification identifies and describes objects (i.e., classes) that must exist in all DeviceNet-compliant devices. The CDM Specification additionally identifies two objects (namely the device manager [DM] and sensor actuator controller [SAC] objects) that must exist in all SEMI-compliant SAN devices. The required object types for a SEMI-compliant SAN device, using the Network Communication Specification described herein, necessarily comprise the union of the above to requirements.

7.2 A list of required and optional object types is given in Table 2. Note that the sensor, actuator, and controller object types are not required and are indicated as optional in the CDM Specification. These objects are aggregated together to form a SEMI- and DeviceNet-compliant device, as shown in Figure 4.

7.3 The mapping of the DM and SAC objects are combined into a single object in DeviceNet called the s-device supervisor (S-DS) object.

Table 2 Required Object Types

<i>Object</i>	<i>DN Class Number^{#1}</i>	<i>CDM Tag^{#2}</i>	<i>Required by DN^{#1}</i>	<i>Required by CDM^{#2}</i>	<i>Required by NCS</i>
Identity	01	N/A ^{#3}	Yes	No	Yes
MR	02	N/A	Yes	No	Yes
DN	03	N/A	Yes	No	Yes
CNX	05	N/A	Yes	No	Yes
DM(DS)	48	Dml0	No	Yes	Yes

Object	DN Class Number ^{#1}	CDM Tag ^{#2}	Required by DN ^{#1}	Required by CDM ^{#2}	Required by NCS
SAC(DS)	48	SACI0	No	Yes	Yes
Sensor	#4	SenIn	No	No	No
Actuator	#4	ActIn	No	No	No
Controller	#4	CntIn	No	No	No
(Other)	#4	N/A	No	No	No

#1 Refer to DeviceNet specification for further information; values are hexadecimal.

#2 Refer to CDM Specification for further information.

#3 Not applicable.

#4 Application-dependent.

7.4 An embodiment of a specific device type represented as an aggregation of the object types listed in Table 2, that is compliant with both the CDM Specification and the DeviceNet specification, is a candidate for a SEMI SDM as well as a DeviceNet device profile. Conversely, all SEMI SDMs and DeviceNet device profiles specified for operation over a SEMI-compliant DeviceNet network must be an aggregation of the object types listed in Table 2 and be compliant with both the CDM Specification and the DeviceNet specification.

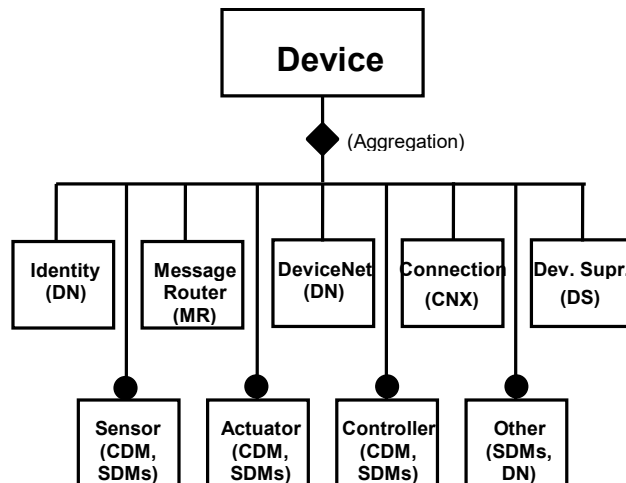


Figure 4
Aggregation of a Compliant Device

7.5 In the following sections, the presentation to the network of object addressing, object attributes, and object services for each of the object types listed in Table 2 and Figure 4 is described in detail.

7.6 Identity Object — This object provides identification of, and general information about, the device. The identity object must be present in all DeviceNet products. As specified by DeviceNet, each DeviceNet product shall support one (and only one) identity object per physical connection to the DeviceNet communication link. Presentation of object identity, attributes, and services to the network for this object is described in the DeviceNet specification. Compliance with the DeviceNet specification shall constitute compliance with this NCS for the identity object.

7.7 Message Router (MR) Object — The MR object provides a messaging connection point through which a service of any object class or instance residing in the physical device may be addressed. The MR object must be present in all DeviceNet products. As specified by DeviceNet, each DeviceNet product shall support one (and only one) MR object per physical connection to the DeviceNet communication link. Presentation of object identity, attributes, and services to the network for this object is described in the DeviceNet specification. Compliance with the DeviceNet specification shall constitute compliance with this NCS for the MR object.