SEMI E54.23-0513
SPECIFICATION FOR SENSOR/ACTUATOR NETWORK COMMUNICATIONS FOR CC-LINK IE FIELD NETWORK

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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 CC-Link IE Field Network standard. This Network Communication Standard (NCS) taken together with the SEMI Sensor/Actuator Network Standard suite and the CC-Link IE Field Network 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 CC-Link IE Field Network is a vendor independent, open device level network standard. Vendor independence and openness are guaranteed by the CC-Link Partner Association.

2 Scope

2.1 This Document specifies a SAN communications standard based on the CC-Link IE Field Network 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), this Network Communication Standard (NCS) with the related CC-Link IE Field Network 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 CC-Link IE Field Network; thus, a complete specification of this standard necessarily includes the CC-Link IE Field Network 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 CC-Link IE Field Network. Included throughout this Document, primarily in § 6, is information paraphrased from the CC-Link IE Field Network 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 CC-Link IE Field Network specification documents for information. This Document is limited to describing enhancements or limitations to the CC-Link IE Field Network specification that are imposed by this Standard.

3.3 A complete specification of the conformance testing procedure shall include the CC-Link IE Field Network protocol conformance testing specification. Conformance testing shall also include enhancements and limitations to the CC-Link IE Field Network specification required by this Standard.

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4 Referenced Standards and Documents

4.1 *SEMI Standards and Safety Guidelines*

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

SEMI E54.1 — 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 Vacuum Pump Device

4.2 *ISO Standard*[1]

ISO 7498 — Basic Reference Model for Open Systems Interconnection

4.3 *IEEE Standards*[2]

IEEE 802.3 — IEEE Standard for Information Technology — Telecommunications and Information Exchange Between Systems—Local and Metropolitan Area Networks — Specific Requirements Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications

4.4 *CC-Link Partner Association*[3]

CC-Link IE Field Network Specification

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

5 Terminology

5.1 *Abbreviations and Acronyms*

5.1.1 *ASE* — application service element

5.1.2 *CDM* — common device model

5.1.3 *DA* — destination address

5.1.4 *IP* — Internet Protocol

5.1.5 *NCS* — Network Communication Standard

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

5.1.7 *SA* — source address

5.1.8 *SAN* — sensor/actuator network

5.1.9 *SDM* — specific device model

5.2 *Definitions from 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*

[1] 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

[2] Institute of Electrical and Electronics Engineers, 3 Park Avenue, 17th Floor, New York, NY 10016-5997, USA; Telephone: +1.212.419.7900, Fax: +1.212.752.4929, http://www.ieee.org

[3] CC-Link Partner Association; http://www.cc-link.org

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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 *Definitions*

5.3.1 *acyclic data ASE* — a service element used to communicate over the CC-Link IE Field Network on a transient basis. This ASE is used for all service request and response transactions as defined below.

5.3.2 *acyclic transmission* — transient transmission.

5.3.3 *application service element* — an encapsulation abstract similar to an object definition. CC-Link IE Field Network employs ASE definitions for managing the network (included here by reference only, see the CC-Link IE Field Network specification for more information) and definitions for Cyclic Data ASE and Acyclic Data ASE.

5.3.4 *cyclic data ASE* — a service element used to access data on a cyclic basis.

5.3.5 *cyclic transmission* — transmission performed periodically.

5.3.6 *intelligent device station* — a node capable of performing 1:n bit data and word data cyclic transmission and transient transmission with the master station, and transient transmission with slave stations, excluding remote I/O stations. Has client functions or server functions during transient transmission.

5.3.7 *link device* — a general term for RX, RY, RWr, and RWw.

5.3.8 *link scan* — the updating of RX, RY, RWr, and RWw and the transmission of transient communication and station diagnostic information that are repeated periodically.

5.3.9 *link scan time* — the time required for one link scan.

5.3.10 *local station* — a node capable of performing n:n bit data and word data cyclic transmission and transient transmission with the master station and other local stations, and transient transmission with slave stations, excluding remote I/O stations. Has server functions and client functions during transient transmission.

5.3.11 *master station* — a node that has control information (parameters) and manages cyclic transmission.

5.3.12 *network management* — refers to management of information related to the network status and settings, starting and stopping cyclic transmission, distribution of parameters required for cyclic transmission, and information notification.

5.3.13 *node* — an element that forms a network and performs data transmission, reception, and transfer.

5.3.14 *octet* — a unit expressing data of an 8-bit unit. One octet is within the range of '-128-127' in decimal format when signed, and '0-255' in decimal format and '0x00-0xFF' in hexadecimal format when unsigned.

5.3.15 *remote device station* — a node capable of performing 1:n bit data and word data cyclic transmission and transient transmission with the master station, and transient transmission with slave stations, excluding remote I/O stations. Has server functions during transient transmission.

5.3.16 *remote I/O station* — a node capable of performing 1:n bit data cyclic transmission with the master station.

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5.3.17 *RWr* — a remote register (input) as viewed from the master station. Word data that are periodically updated by cyclic transmission and held by nodes. In a slave station other than the local station, the data are word data sent to the master station. In the local station, RWr as viewed from the master station is RWw of the local station.

5.3.18 *RWw* — a remote register (output) as viewed from the master station. Word data that are periodically updated by cyclic transmission and held by nodes. In a slave station other than the local station, the data are word data received from the master station. In the local station, RWw as viewed from the master station is RWr of the local station.

5.3.19 *RX* — a remote input as viewed from the master station. Bit data that are periodically updated by cyclic transmission and held by nodes. In a slave station other than the local station, the data are bit data sent to the master station. In the local station, RX as viewed from the master station is RY of the local station.

5.3.20 *RY* — a remote output as viewed from the master station. Bit data that are periodically updated by cyclic transmission and held by nodes. In a slave station other than the local station, the data are bit data received from the master station. In the local station, RY as viewed from the master station is RX of the local station.

5.3.21 *slave station* — a general term for a node other than the master station.

5.3.22 *station* — a node.

5.3.23 *station number* — an identifier for uniquely identifying a node within the network.

5.3.24 *transmission control manager* — a node that performs token passing management. One exists per network. The master station.

5.3.25 *transient transmission* — transmission performed upon request.

5.3.26 *transient transmission client function* — a function that issues a transient request to a node having a server function.

5.3.27 *transient transmission server function* — a function that receives a transient request from a node having a client function, and issues a response to the request.

6 Communication Protocol High Level Structure

6.1 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.

6.2 A brief description of the CC-Link IE Field Network protocol as it relates to the ISO 7498 OSI model follows in the sections below. For protocol efficiency, CC-Link IE Field Network does not define layers 3–6.

NOTE 1: The information contained in this section is for reference only. It in no way represents specifications for CC-Link IE Field Network. See related documentation for these specifications.

6.3 *Physical Layer – Layer 1* — The Physical Layer conforms to the IEEE 802.3 1000 Base-T standard ANSI/ITA/EIA-568-B (Category 5e) compatible 4-pair balanced shielded cable. See the CC-Link IE Field Network standard for more information.

6.4 *Data Link Layer – Layer 2* — The Data Link Layer conforms to the IEEE 802.3 standard. See the CC-Link IE Field Network standard for more information.

6.5 *Application Layer – Layer 7* — The services and protocols of the Application Layer are defined in terms of Application Service Elements. These ASE define the attributes, services and behaviors for Network Management, Cyclic Transmission and Acyclic Transmission (or Transient Transmission). Application Object Models are specified as CC-Link IE Field Network Profiles. See the CC-Link IE Field Network standard for more information.

7 Required Object Types

7.1 This section describes a general mapping of the SEMI SAN Object Model to the CC-Link IE Field Network environment. Component definitions are clarified and the mapping of Attributes, Services and Behaviors are specified.

7.2 *Object Model* — The CDM and SDM objects are mapped to memory areas in CC-Link IE Field Network abstracts called Modules and Memory blocks. The service request and response communications are transacted via the Acyclic Data ASE. The mapping of CDM objects is specified in § 7. The mapping of SDM objects is specified in § 9.

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7.3 *Objects* — The required objects of the CDM are identified here. CDM object identifiers are mapped in terms of CC-Link IE Field Network Module Number offsets. The manufacturer of a station compliant with this NCS specifies the Base Module Number. Objects are addressed by adding this Base value to the mapping values specified in this NCS. Additional objects that are contained in the SDM are given identifiers in the Device Profile. § 9 specifies additional mapping information for each SDM.

7.3.1 Table 1 lists the Object Identifiers specified for use in protocol messages.

Table 1 Object Identifiers

Object ID	*Object*
0	DM Object
1	SAC Object
2	Assembly Object
3	Local Link Object
4	Sensor-AI Object
5	Actuator-AO Object
6	Controller Object
7	Sensor-BI-TH
16–n	Application Objects as specified in § 9

7.4 *Attributes* — All attributes are accessible via Random Read Memory and Random Write Memory services with Octet Access via the Acyclic Data ASE. The identifiers for attribute access are defined in the sections below.

7.4.1 *Attribute Identifiers* — The required attributes for each object of the CDM are identified here. CDM object attribute identifiers are mapped in terms of CC-Link IE Field Network Memory Address offsets. The manufacturer of a station compliant with this NCS specifies the Base Memory Address. Attributes are addressed within an object by adding this Base value to the mapping values specified in this NCS.

7.5 *DM Object*

7.5.1 *DM Object Attributes* — See Table 2 for a list of DM attributes.

Table 2 DM Object Attribute Identifiers

SEMI DM Attribute ID	*CC-Link IE Field Network Attribute ID*	*Attribute*
DmA1	0	Device Type
DmA2	8	Standard Revision Level
DmA3	18	Device Manufacturer Identifier
DmA4	38	Manufacturer Model Number
DmA5	58	Software or Firmware Revision Level
DmA6	66	Hardware Revision Level
DmA7	N/A	Serial Number
DmA8	N/A	Device Configuration
DmA9	74	Device Status
DmA10	N/A[#1]	Reporting Mode
DmA11	N/A	Exception Status Report Interval
DmA12	76	Exception Status
DmA13	N/A	Exception Detail Alarm
DmA14	N/A	Exception Detail Warning

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SEMI DM Attribute ID	*CC-Link IE Field Network Attribute ID*	*Attribute*
DmA15	77	Visual Indicator
DmA16	78	Alarm Enable
DmA17	79	Warning Enable
DmA18	80	Exception Detail Type
DmA19	N/A	Exception Detail Alarm Queue
DmA20	N/A	Exception Detail Warning Queue
DmA21	81	Date and Time
DmA22	N/A	Date and Time Type

#1 Reporting is controlled in CC-Link IE Field Network by connection configuration parameters. See the CC-Link IE Field Network specification for more information.

7.5.2 *DM Object Services* — The required services of the DM are identified here. Table 3 specifies the required services and ID numbers. These services are mapped to the Acyclic Data ASE, Service Type ID = 12, with the subtype value as shown in the table and argument parameters as specified in SEMI E54.1. For usage rules, behaviors and encoding details, see the CC-Link IE Field Network specifications.

Table 3 Network Presentation of DM Object Services

CDM Tag	*DM Object Service*	*CC-Link IE Field Network Service ID*
DmS1	Reset	1
DmS2	Abort	2
DmS3	Recover	3
DmS4	Get Attribute	4
DmS5	Set Attribute	5
DmS6	Execute	6
DmS7	Perform Diagnostics	7
DmS8	Publish Attribute	N/A[#1]
DmS9	Lock	9
DmS10	Unlock	10
DmS11	Get Exception Queue	11
DmS12	Clear Exception Queue	12

#1 Reporting is controlled in CC-Link IE Field Network by connection configuration parameters. See the CC-Link IE Field Network specification for more information.

7.6 *SAC Object*

7.6.1 *SAC Object Attributes* — See Table 4 for a list of SAC attributes.

Table 4 SAC Object Attribute Identifiers

SEMI SAC Attribute ID	*CC-Link IE Field Network Attribute ID*	*Attribute*
SacA1	0	Last Calibration Date
SacA2	4	Next Calibration Date
SacA3	8	Expiration Timer
SacA4	10	Expiration Warning Enable

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