

SEMI E54.17-1018

SPECIFICATION OF SENSOR/ACTUATOR NETWORK FOR A-LINK

This Standard was technically approved by the Information & Control Global Technical Committee. This edition was approved for publication by the global Audits and Reviews Subcommittee on May 22, 2018. Available at www.semiviews.org and www.semi.org in October 2018; originally published July 2005; previously published August 2012.

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 Document defines a communication specification based on the A-LINK protocol to enable communications between intelligent devices on a sensor/actuator network (SAN) that operate according to SEMI E54 device models on semiconductor manufacturing equipment.

1.2 This Document gives interoperability with SEMI E54 common/specific device model based sensor/actuator devices.

2 Scope

2.1 This Document specifies how sensor/actuator/controller (SAC) devices interoperate on the network specific for the A-LINK public specification referenced in the § 4, as a part of equipment's control system.

2.2 This Document defines relation with main part of SEMI E54 including common device model (CDM) and existing specific device models (SDMs). This Document is to be used with the CDM and one or more SDMs, as well as the A-LINK Public Specification.

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 only A-LINK and is a companion document to the A-LINK specification; therefore, a complete specification of this Standard includes the A-LINK specifications. There are other semiconductor SAN communication options. The specifications for these options are not included here.

3.2 This Standard specifies enhancements that provide additional capability over and above those currently required by A-LINK. In order to avoid document inconsistency problem, information in the A-LINK specification that relates to this Standard is not repeated in this Document. This Document is limited to describing enhancements or limitations to the A-LINK specification that are imposed by this Standard.

3.3 A complete specification of the conformance testing procedure shall include the A-LINK protocol conformance testing specification. Conformance testing shall also include enhancements and limitations to the A-LINK 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 — 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 Gauge

SEMI E54.24 — Specification for Sensor/Actuator Network Specific Device Model of Generic Equipment Network Sensor

4.2 *ISO Standard*¹

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

4.3 *Other Documents*

A-LINK Public Specification Version 1.2 — Basic Reference Model for Open Systems Interconnection¹

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

5 Terminology

5.1 *Abbreviations and Acronyms*

5.1.1 *AUF* — A-LINK user forum

5.1.2 *CDM* — common device model

5.1.3 *NCS* — Network Communication Standard

5.1.4 *OSI* — Open System Interconnection [ISO 7498]

5.1.5 *PHY* — physical layer

5.1.6 *SAN* — sensor/actuator network

5.1.7 *SDM* — specific device model

5.1.8 *UI* — user interface

5.2 This section includes the terms defined in SEMI E54.1, Specification for Sensor/Actuator Network Common Device Model.

5.2.1 *attribute*

5.2.2 *behavior*

5.2.3 *byte*

5.2.4 *class*

5.2.5 *common device model (CDM)*

5.2.6 *device*

5.2.7 *device model (DM)*

5.2.8 *device manager (DM) object*

5.2.9 *instance*

5.2.10 *Network Communication Standard*

5.2.11 *object*

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

5.2.13 *service*

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>

5.2.14 *specific device model (SDM)*

5.2.15 *state diagram*

5.3 *Terminology Defined in A-LINK*

5.3.1 *A-LINK user forum (AUF)*² — a kind of consortium for A-LINK users to recommend improvement to A-LINK trade organization,³ share A-LINK applications, provide A-LINK compliance test, etc.

5.3.2 *AN MS* — a station that accesses and exchanges data by polling its assigned networked-slave stations. Even if this may be physically located on the network, this may not be seen logically on the network.

5.3.3 *AN SS* — a station that is managed and accessed by AN MS. Often a device is a kind of AN SS on A-LINK network.

5.3.4 *data exchange* — a capability to communicate such data for a device as raw/processed sensed data and variable settings.

5.3.5 *device profile* — a kind of electric table to provide the characteristic features of a device including configuration and capabilities.

5.3.6 *directive* — a capability to instruct such basic functions to a device as reset or abort.

5.3.7 *DP facility* — a capability to manage diagnostic matters of the device.

5.3.8 *service access element* — an addressable location in a device for the directing of service requests. Even if this may be physically located on the network, this may not be seen logically on the network.

5.3.9 *unite inventory* — a capability to realize and communicate the device profile. This provides property and configuration information of devices on the network.

5.3.10 *unite states* — a capability to communicate state of a device.

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 complicated applications, multi-master architectures are also possible. A-LINK uses the polling principle for communication.

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 A-LINK protocol as it relates to the ISO/IEC 7498 OSI model follows in the sections below. For protocol efficiency, A-LINK does not define layers 3–7. However, since the OSI model specifies Layer 7 as the interface between the application process and the communication stack, it is appropriate to discuss several aspects of the A-LINK standard at this level.

NOTE 1: The information contained in this section is for reference only. It in no way represents specifications for A-LINK. See related documentation for these specifications.

6.2 *Physical Layer — Layer 1*

6.2.1 The bottom physical layer is established by RS-485. See the A-LINK standard for more information for detail.

6.3 *Data Link Layer — Layer 2*

6.3.1 *Data Transfer*

6.3.1.1 The data link layer provides the functions for sending and receiving data over the network. Data elements 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).

² <http://www.a-linkuf.com>

³ <http://www.algosystem.co.jp>

6.4 Network Layer — Layer 3

6.4.1 There is no distinct network layer.

6.5 Transport Layer — Layer 4

6.5.1 There is no distinct transport layer. Such functions as disassembling of message into transport unit and reassembling for transportation are implemented in the application layer.

6.6 Session Layer — Layer 5

6.6.1 There is no distinct session layer.

6.7 Presentation Layer — Layer 6

6.7.1 There is no distinct presentation layer. Such functions as data representation conformance are implemented in the application layer.

6.8 Application Layer — Layer 7

6.8.1 The device shall comply with A-LINK application layer specification for defining and addressing objects including functions deferred in lower layers as described above.

6.8.2 User Interface (UI)

6.8.2.1 The UI provides the user with access to functionality of the A-LINK protocol as a part of application layer.

7 Required Object Types

7.1 This section describes a general mapping of the SEMI SAN object model to the A-LINK 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 A-LINK NCS. Especially the DM, SAC, and abstract or fundamental application objects are mapped.

7.2.2 The application objects associated with the SDM Standards are mapped in A-LINK user forum public specification documents. § 9 specifies the mapping of SDM Objects in A-LINK.

7.3 Component Mapping Summary

7.3.1 Table 1 provides a summary of the components of the CDM object model as they relate to the components of A-LINK.

7.4 Objects

7.4.1 The required objects of the CDM are identified here. Additional objects that are contained in the SDM are given identifiers in the device profile. § 9 specifies additional mapping information.

7.4.2 Table 1 lists the object identifiers specified for use in protocol messages.

Table 1 Object Identifiers

<i>Object Name</i>	<i>A-LINK Class/Object ID</i>	<i>CDM Object ID Tag</i>	<i>CDM Attribute/Service ID Tag Prefix</i>
DM	1	DmI0	Dm
SAC	2	SacI0	Sac
Assembly	3	AsmIn	Asm
Local Link	4	LnkIn	Lnk
Sensor-AI	9	SenIn	Sai
Sensor-EI	10	SenIn	Sei
Sensor-BI	11	SenIn	Sbi
Sensor-BI-TH	12	SenIn	Sbith

<i>Object Name</i>	<i>A-LINK Class/Object ID</i>	<i>CDM Object ID Tag</i>	<i>CDM Attribute/Service ID Tag Prefix</i>
Actuator-AO	17	ActIn	Aao
Actuator-EO	18	ActIn	Aeo
Actuator-BO	19	ActIn	Abo
Controller	24	CntIn	C
Application Objects	>31	-	-

7.5 Attributes

7.5.1 All attributes are accessible via *Get_Attribute* and *Set_Attribute* services defined in the sections below. Attributes are also accessible via different A-LINK peculiar instructions which are additionally mapped in this document based on attribute type.

7.5.1.1 The attributes of the DM object consists of distinctive information, states, and setups. Distinctive information attributes are retrieved with the unite inventory. Inquiring state attributes are provided by getting status data. Setup attributes are written by setting configuration data.

7.5.1.2 The attributes of application objects are divided into two types: input/output (I/O), settings, status and configuration. I/O attributes are acquired from or given through data exchange capability of A-LINK. Configurable attributes can be retrieved with unite inventory capability.

7.5.1.3 See Table 2 for a list of DM attributes and their related alternative access instructions.

7.5.1.4 A-LINK Settings

7.5.1.4.1 Attributes related to general settings are accessed through unite inventory communication.

7.5.1.4.2 Structure of the unite inventory for a given SDM is beyond the scope of this Document. The A-LINK trade organization is responsible for the management of this information.

7.5.1.5 A-LINK States and Diagnostics

7.5.1.5.1 Attributes related to device state are categorized and handled as unite state information. For example, two attributes of the DM object listed in Table 2 that are identified with an alternative access instruction of unite states are mapped into the A-LINK unite states as specified in this section. See the A-LINK standard for a description of the unite states.

7.5.1.5.2 These two attributes are mapped into the unite state data structure. Additional diagnostic data may be included with DP facility as specified by A-LINK.

7.5.2 A-LINK I/O Data Exchange

7.5.2.1 I/O attributes of the application objects are communicated using the I/O data exchange instruction of A-LINK. This instruction is described in the A-LINK standard. A list of which attributes are accessible with this instruction is included in the A-LINK device profile for a given device type.

7.5.3 A-LINK Device Configuration

7.5.3.1 Configuration attributes of the DM object and application objects are communicated using the unite inventory service of A-LINK. This service is described in the A-LINK standard. A list of which application object attributes are accessible with this instruction is included in the A-LINK device profile for a given device type.

7.5.3.2 Attribute Identifiers

7.5.3.2.1 Every class object specified in the CDM uses attribute identifier tags to identify its attributes. The tags are formed with alphabetic part of its object identifier tag, a character 'A' for impressing attribute and a numerical identifier of the attribute. The numerical identifier is assigned to the attribute ID used in the A-LINK NCS for classes DM, SAC, Assembly, Local Link, AE, S, A and C, as described in following tables (i.e., from Tables 2 through 8).

7.5.3.2.2 Except sensor-binary input threshold (SBITH) class, the attribute ID used in the A-LINK for derived classes of sensor and actuator classes is assigned with the same manner as above.

7.5.3.2.3 For SBITH class, the attribute ID used in the A-LINK starts from 128 to prevent duplication with the numerical identifiers in CDM assigned and reserved to its parent class, SBI.

7.5.3.2.4 The A-LINK attribute ID is used to identify attributes for access via A-LINK message requests, which are explained in later sections.

7.5.4 A-LINK Attribute Mappings for CDM

7.5.4.1 *DM Object* — The DM object is the device component responsible for managing and consolidating the device operation as defined in the CDM Standard. Attribute values including DM state are also as same as defined in the CDM Standard. The presentation of object instance attributes to the A-LINK network shall be as indicated in Table 2.

Table 2 DM Object Attribute Identifiers for A-LINK

<i>Attribute ID</i>		<i>Attribute Name</i>	<i>Alternative Access</i>
<i>CDM</i>	<i>A-LINK</i>		
DmA1	1	Device Type	Unite Inventory
DmA2	2	Standard Revision Level	Unite Inventory
DmA3	3	Device Manufacturer Identifier	Unite Inventory
DmA4	4	Manufacturer Model Number	Unite Inventory
DmA5	5	Software or Firmware Revision Level	Unite Inventory
DmA6	6	Hardware Revision Level	Unite Inventory
DmA7	7	Serial Number	Unite Inventory
DmA8	8	Device Configuration	Unite Inventory
DmA9	9	Device Status	Unite States
DmA10	10	Reporting Mode	Unite Inventory
DmA11	11	Exception Status Report Interval	Unite Inventory
DmA12	12	Exception Status	Unite States
DmA13	13	Exception Detail Alarm	Unite Inventory
DmA14	14	Exception Detail Warning	Unite Inventory
DmA15	15	Visual Indicator	Unite Inventory
DmA16	16	Alarm Enable	Unite Inventory
DmA17	17	Warning Enable	Unite Inventory
DmA18	18	Exception Detail Type	Unite Inventory
DmA19	19	Exception Detail Alarm Queue	Unite Inventory
DmA20	20	Exception Detail Warning Queue	Unite Inventory
DmA21	21	Date and Time	Unite Inventory
DmA22	22	Date and Time Type	Unite Inventory

7.5.4.2 *SAC Object* — The SAC object is the device component responsible for coordinating the interaction of the device with the sensory/actuation/control environment as defined in the CDM Standard. Attribute values including SAC state are also as same as defined in the CDM Standard. The presentation of object instance attributes to the A-LINK network shall be as indicated in Table 3.

Table 3 SAC Object Attribute Identifiers for A-LINK

<i>Attribute ID</i>		<i>Attribute Name</i>	<i>Alternative Access</i>
<i>CDM</i>	<i>A-LINK</i>		
SacA1	1	Last Calibration Date	DP Facility

Attribute ID		Attribute Name	Alternative Access
CDM	A-LINK		
SacA2	2	Next Calibration Date	DP Facility
SacA3	3	Expiration Timer	DP Facility
SacA4	4	Expiration Warning Enable	DP Facility
SacA5	5	Run Hours	DP Facility

7.5.4.3 *Assembly (Asm) Object* — The Asm object instances may be used to provide for grouping more than one attribute from one or more object instances as defined in the CDM Standard. Attribute values are also as same as defined in the CDM Standard. The presentation of object instance attributes to the A-LINK network shall be as indicated in Table 4.

Table 4 Asm Object Attribute Identifiers for A-LINK

Attribute ID		Attribute Name	Alternative Access
CDM	A-LINK		
AsmA1	1	Data	Data Exchange

7.5.4.4 *Local Link (Lnk) Object* — The Lnk object instances may be used to ‘link’ an attribute of one object instance to an attribute of another object instance as defined in the CDM Standard. Attribute values are also as same as defined in the CDM Standard. The presentation of object instance attributes to the A-LINK network shall be as indicated in Table 4.

Table 5 Lnk Object Attribute Identifiers for A-LINK

Attribute ID		Attribute Name	Alternative Access
CDM	A-LINK		
LnkA1	1	Source Object Class	Unite Inventory
LnkA2	2	Source Object Instance	Unite Inventory
LnkA3	3	Source Object Attribute	Unite Inventory
LnkA4	4	Destination Object Class	Unite Inventory
LnkA5	5	Destination Object Instance	Unite Inventory
LnkA6	6	Destination Object Attribute	Unite Inventory
LnkA7	7	Commit	Unite Inventory

7.5.4.5 *Active Element (AE) Class* — The AE class is an abstract class generic to any device component as defined in the CDM Standard. Attribute values including AE state are also as same as defined in the CDM Standard. The presentation of object instance attributes to the A-LINK network shall be as indicated in Table 6.

7.5.4.6 These attributes are inherited by any sensor, actuator and controller objects, and such further derived objects as Sensor-AI and Actuator-BO objects.

Table 6 AE Class Attribute Identifiers for A-LINK

<i>Attribute ID</i>		<i>Attribute Name</i>	<i>Alternative Access</i>
<i>CDM</i>	<i>A-LINK</i>		
nA1	1	Name	Unite Inventory
nA2	2	Status	Unite States
nA3	3	AlarmEnable	Unite Inventory
nA4	4	WarningEnable	Unite Inventory

#1 Prefix n in CDM attribute ID represents one of Sai, Sei, Sbi, Sbith, Aao, Aeo, Abo and C.

7.5.4.7 Sensor (S) Class — The S class is an abstract class generic to any sensors on device component as defined in the CDM Standard. Attribute values are also as same as defined in the CDM Standard. The presentation of object instance attributes to the A-LINK network shall be as indicated in Table 7. These attributes are inherited by any sensor objects as Sensor-AI object. They also inherit AE class attributes. Attribute identifiers on A-LINK for such direct and indirect inheritor classes of S class as Sensor-AI are assigned as ¶ 7.5.3.2 and data exchange communication could give alternative access for the attributes.

Table 7 S Class Attribute Identifiers for A-LINK

<i>Attribute ID</i>		<i>Attribute Name</i>	<i>Alternative Access</i>
<i>CDM</i>	<i>A-LINK</i>		
nA16	16	Value	Data Exchange
nA17	17	ReportInhibitTimer	Data Exchange
nA18	18	EnableReportRate	Data Exchange
nA19	19	ReportRate	Data Exchange

#1 Prefix n in CDM attribute ID represents one of Sai, Sei, Sbi or Sbith.

7.5.4.8 Actuator (A) Class — The A class is an abstract class generic to any actuators on device component as defined in the CDM Standard. Attribute values are also as same as defined in the CDM Standard. The presentation of object instance attributes to the A-LINK network shall be as indicated in Table 8. These attributes are inherited by any sensor objects as Actuator-AO object. They also inherit AE class attributes. Attribute identifiers on A-LINK for inheritor classes Sensor-AO are assigned as ¶ 7.5.3.2 and data exchange communication could give alternative access for the attributes.

Table 8 A Class Attribute Identifiers for A-LINK

<i>Attribute ID</i>		<i>Attribute Name</i>	<i>Alternative Access</i>
<i>CDM</i>	<i>A-LINK</i>		
nA16	16	Setting	Data Exchange
nA17	17	SafeState	Data Exchange
nA18	18	WatchRate	Data Exchange
nA19	19	WatchDog	Data Exchange

#1 Prefix n in CDM attribute ID represents one of Aao, Aeo or Abo.

7.5.4.9 Controller (C) Object — The C object contains structure and behavior common to all controller element instances on device component as defined in the CDM Standard. Attribute values are also as same as defined in the CDM Standard. The presentation of object instance attributes to the A-LINK network shall be as indicated in Table 9. It inherits AE class attributes.

Table 9 C Class Attribute Identifiers for A-LINK

<i>Attribute ID</i>		<i>Attribute Name</i>	<i>Alternative Access</i>
<i>CDM</i>	<i>A-LINK</i>		
CA16	16	Setpoint	Data Exchange
CA17	17	ProcessVariable	Data Exchange
CA18	18	ControlVariable	Data Exchange
CA19	19	DataType	Data Exchange
CA20	20	DataUnits	Data Exchange
CA21	21	AlarmSettleTime	Data Exchange
CA22	22	AlarmErrorBand	Data Exchange
CA24	24	WarningSettleTime	Data Exchange
CA25	25	WarningErrorBand	Data Exchange

7.6 Services

7.6.1 A-LINK specifies standard mechanisms for the communication of data over the network. These mechanisms are used to communicate attributes specified in the device on the A-LINK. Also, they are used to request instructions specific for component in the device on the A-LINK.

7.6.2 Service Requests and Response

7.6.2.1 The A-LINK attribute communications and instructions require specific definitions. They are described in the following sections.

7.6.2.1.1 Service Request and Response Protocol

7.6.2.1.1.1 All service request messages, except Get_Attribute and Set_Attribute, are sent to a device using directive service functions of A-LINK. The responses to these message requests are specified by A-LINK.

7.6.2.1.1.2 The Service Request message is formatted, as defined by A-LINK, with the following information:

Location: = Object ID

7.6.2.1.1.3 This service request message has no other information requested with the message. Response of the request has following information:

Location: = Object ID

Status: = Response Information

NOTE 2: The Location information for the response message is optional (conditional) information. Representation of the status information is implementation specific. The response information is dependent on class and/or device. However, if the first item of the response information (i.e., response code) is zero, it always means successful. Additional data may follow.

7.6.2.1.2 Set_Attribute Protocol

7.6.2.1.2.1 The service request message for the Set_Attribute is sent to a device using writing capability for following service functions of A-LINK: unite inventory service, data exchange service or DP facility service. Using service function is dependent on attribute and object class as well. The dependency is given by object service identifier tables in following subsections of ¶ 7.6.

7.6.2.1.2.2 The service request message with unite inventory service function of A-LINK has a couple of information items. Information items for the request and its response are given below respectively:

(Request)

Location: = Object ID : optional

Data Name ID: = Attribute ID

Data Value: = Attribute Value