SEMI E54.3-0698 (Reapproved 0721)
SPECIFICATION FOR SENSOR/ACTUATOR NETWORK SPECIFIC DEVICE MODEL FOR MASS FLOW DEVICE

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

NOTICE: This Document was reapproved with minor editorial changes.

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.

1 Purpose

1.1 This Specification is part of a suite of Standards which specify the implementation of SEMI Standards for the Sensor/Actuator Network. The specific purpose of this Specification is to describe a network-independent application model comprised of device objects which are common to all mass flow devices (MFDs) on a semiconductor equipment Sensor/Actuator communications network.

2 Scope

2.1 This Specification specifically addresses the minimum attributes, services, and behavior a mass flow controller (MFC) and mass flow meter (MFM) device must support to be interoperable on the Sensor/Actuator Network.

2.2 This Specification is intended to ensure a high-degree of device interoperability on the Sensor/Actuator Network, while still allowing flexibility for product differentiation and technology evolution.

2.3 The model specified in this Specification is used in conjunction with the Sensor/Actuator Network Common Device Model (CDM) to completely describe the MFC or MFM as it appears from the network interface.

2.4 This Specification, together with the Sensor/Actuator Network Standard, the Sensor/Actuator Network Common Device Model, and a Sensor/Actuator Network Communication Specification, form a complete interoperability specification for the MFC and MFM.

2.5 To comply with this Specification, a device must implement and support, at a minimum, the required attributes, services, and behavior identified in these documents. Support for optional attributes, services, and behavior are not required to be compliant to this Specification. Optional attributes, services, and behavior are specified in these documents to promote further device interoperability as features evolve and are adopted by more manufacturers. If optional attributes, services, and behavior are implemented for this device, they must be implemented as identified in this Document.

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 Specification is a companion to a suite of Specifications which together make up the Sensor/Actuator Network Communication standard. Therefore, using portions of this Specification that relate to network communications necessarily requires an understanding of the associated network specification.

3.2 As this Document is a specification for the MFD Model, it does not contain any definition of objects, attributes, services, or behavioral descriptions that are already defined in the Sensor/Actuator Network CDM. Additional

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attributes, attribute assignments, services, and/or service parameters that are MFD-specific and/or implementation-specific are contained in this Specification.

3.3 While this Specification is sufficient to completely describe the MFC or MFM as it appears from the network, it does not fully describe behavior of the MFC or MFM which is not visible from the network. This allows flexibility in implementation techniques and product differentiation between manufacturers. Manufacturer-specific objects may be defined by the manufacturer, but are, by definition, outside the scope of this Standard.

3.4 This Specification is compatible, but not compliant, with SEMI E39. This means that although this Specification does not require compliance with SEMI E39, it is extensible such that implementations may be developed that are fully compliant with both Standards. Note that the concepts and terminology of this Specification are compatible with those of SEMI E39. However, SEMI E39 has specific requirements that are intended for higher level applications and, thus, are not applied to the MFD Model.

3.5 Operation over the entire range specified for an attribute within a specific object instance is not a requisite for compliance with this Specification.

4 Referenced Standards and Documents

4.1 *SEMI Standards and Safety Guidelines*

SEMI E12 — Guide for Standardized Pressure, Temperature, Density, and Flow Units Used in Mass Flow Meters and Mass Flow Controllers

SEMI E18 — Guide for Temperature Specifications of the Mass Flow Controller

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

SEMI E52 — Practice for Referencing Gases and Gas Mixtures Used in Digital Mass Flow Controllers (Replaced by SEMI AUX030)

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

4.2 *IEEE Standard*[1]

IEEE 754 — Floating Point Definition

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

5 Terminology

5.1 This Standard uses terminology that is defined in SEMI E54.1. Refer to the Compilation of Terms for the latest Abbreviations and Acronyms, Definitions, and Symbols.

5.2 *Definitions*

5.2.1 *Boolean (BOOL)* — a binary bit representing 0 and 1 corresponding to FALSE and TRUE or DISABLE and ENABLE respectively.

5.2.2 *common device model (CDM)* — refers to Sensor/Actuator Network Common Device Model. [SEMI E54.1]

5.2.3 *data type* — an unsigned short integer formatted as an enumerated byte to specify attribute data format. The intended use of this attribute type is in cases where an attribute, or set of attributes, may be defined, allowing for more than one level of support (e.g., INT or REAL). The following values are defined:

- 0 = INT
- 1 = REAL
- 2 = USINT
- 3 = SINT

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- 4 = DINT
- 5 = LINT
- 6 = UINT
- 7 = UDINT
- 8 = ULINT
- 9 = LREAL
- 10–99 = Reserved for CDM
- 100–199 = Reserved for SDMs
- 200–255 = Manufacturer-Specified

5.2.4 *data units* — an unsigned integer formatted as an enumerated byte to specify attribute data units. The intended use of this attribute type is in cases where an attribute, or set of attributes, may be defined, allowing for more than one unit's context. The values are defined in an appendix of this Document.

5.2.5 *date* — a data structure of four bytes used to represent a calendar date. Table 1 defines the format of the date data type.

Table 1 Date Format

Data #	*Description*	*Range*
0–1	Year	Unsigned Integer
2	Month	Unsigned Short Integer (range of 1–12)
3	Day	Unsigned Short Integer (range of 1–31)

5.2.6 *double integer (DINT)* — an integer, four bytes long, in the range -2^{31} to $2^{31}-1$.

5.2.7 *enumerated byte* — a byte with assigned meaning to the values 0 through 255. May take on one of a limited set of possible values.

5.2.8 *full scale*— the defined 100% value of an attribute in its assigned units. This value is not necessarily the maximum value for the attribute. As an example, the *indicated flow* attribute value may attain 120% of the full scale range.

5.2.9 *gas calibration* — a reference to a set of parameters or methods which are used to calibrate or correct the device for a particular gas type, range, and units.

5.2.10 *gas standard number* — a number that references a gas type. The number and its referenced gas type are defined in SEMI E52.

5.2.11 *gas standard symbol* — a text symbol that references a gas type. The symbol and its referenced gas type are defined in SEMI E52.

5.2.12 *last valid value (LVV)* — the most recent value successfully assigned to an attribute.

5.2.13 *long integer (LINT)* — an integer, eight bytes long, in the range -2^{63} to $2^{63}-1$.

5.2.14 *long real (LREAL)* — a double floating point number, eight bytes long, as defined in IEEE 754.

5.2.15 *manufacturer* — in the context of this Document, this refers to the manufacturer of the device.

5.2.16 *mass flow controller (MFC)* — a self-contained device, consisting of a mass flow transducer, control valve, and control and signal-processing electronics, commonly used in the semiconductor industry to measure and regulate the mass flow of gas.

5.2.17 *mass flow device (MFD)* — a device which is either a mass flow controller or mass flow meter.

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5.2.18 *mass flow meter (MFM)* — a self-contained device, consisting of a mass flow transducer and signal-processing electronics, commonly used in the semiconductor industry to measure the mass flow of gas.

5.2.19 *null character* — a byte with a value of zero.

5.2.20 *programmed gas calibration* — a reference to a particular gas type, range, and units for which the device is currently calibrated.

5.2.21 *real (REAL)* — a floating point number, four bytes long, as defined by IEEE 754.

5.2.22 *short integer (SINT)* — an integer, one byte long, in the range −128 to 127.

5.2.23 *signed integer (INT)* — an integer, two bytes long, in the range −32768 to 32767.

5.2.24 *text string* — a string of one-byte characters. See ¶ 5.1 for a definition of a character.

5.2.25 *unsigned integer (UINT)* — an integer, two bytes long, in the range 0 to 65535.

5.2.26 *unsigned short integer (USINT)* — an integer, one byte long, in the range 0 to 255.

6 Requirements

6.1 In order to implement this Standard in a MFD, it is necessary to also implement SEMI E54.1 and one of the Sensor/Actuator Network Communication Standards. See § 2 for more information on a complete interoperability standard.

7 Conventions

7.1 This Document embraces the Harel State Chart notation, the transition table definition format, the object attribute representation formats, service message definition formats, and behavior definition formats as specified in SEMI E54.1.

7.2 Figure 1 describes the convention for object representation used throughout this Specification.

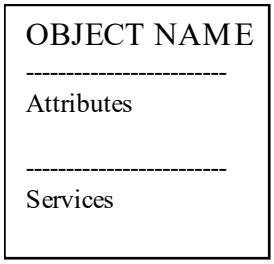

Figure 1
Object Representation

8 Device High Level Structure

8.1 *General Description* — The high level object view of a MFM device and a MFC Device is shown in Figure 2.

8.1.1 Note that the 'MFM' and the 'MFC' objects are depicted in Figure 2 only for the purposes of illustrating a high level view of the device and its component objects. In the context of this Document, these objects are not addressable, do not have addressable attributes, do not have accessible services, nor do they exhibit any defined behavior. These objects are only included in the figures to aid in the visualization of the device.

8.1.2 This Document defines in detail all of the component objects unique to the MFC and the MFM devices. References, rather than definitions, are included for the DM, the SAC, and other objects defined in SEMI E54.1.

8.1.3 Many of the objects defined in this Document inherit properties from other objects. The properties inherited include attribute, service, and behavior definitions. These other objects are specified here or in SEMI E54.1.

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8.1.4 This Document provides for future extensions, as well as manufacturer-specific enhancements, by reserving object attribute identifiers and object service identifiers. Specifically, all object definitions in this Document specify or reserve the first 64 attribute identifiers (A1–A64) and the first 64 service identifiers (S1–S64), allowing manufacturers to specify identifiers beyond these ranges. Additionally, byte-enumerated attributes are specified or reserved from 0 to 63, allowing manufacturers to specify enumerations beyond this range (64–255).

8.1.5 *MFM Device Description* — A MFM device profile is composed of the component objects and object relationships shown in Figure 2.

8.1.6 *MFC Device Description* — A MFC device profile is composed of (1) all of the component objects and object relationships of the MFM Device in addition to (2) the component objects and object relationships as shown in Figure 2.

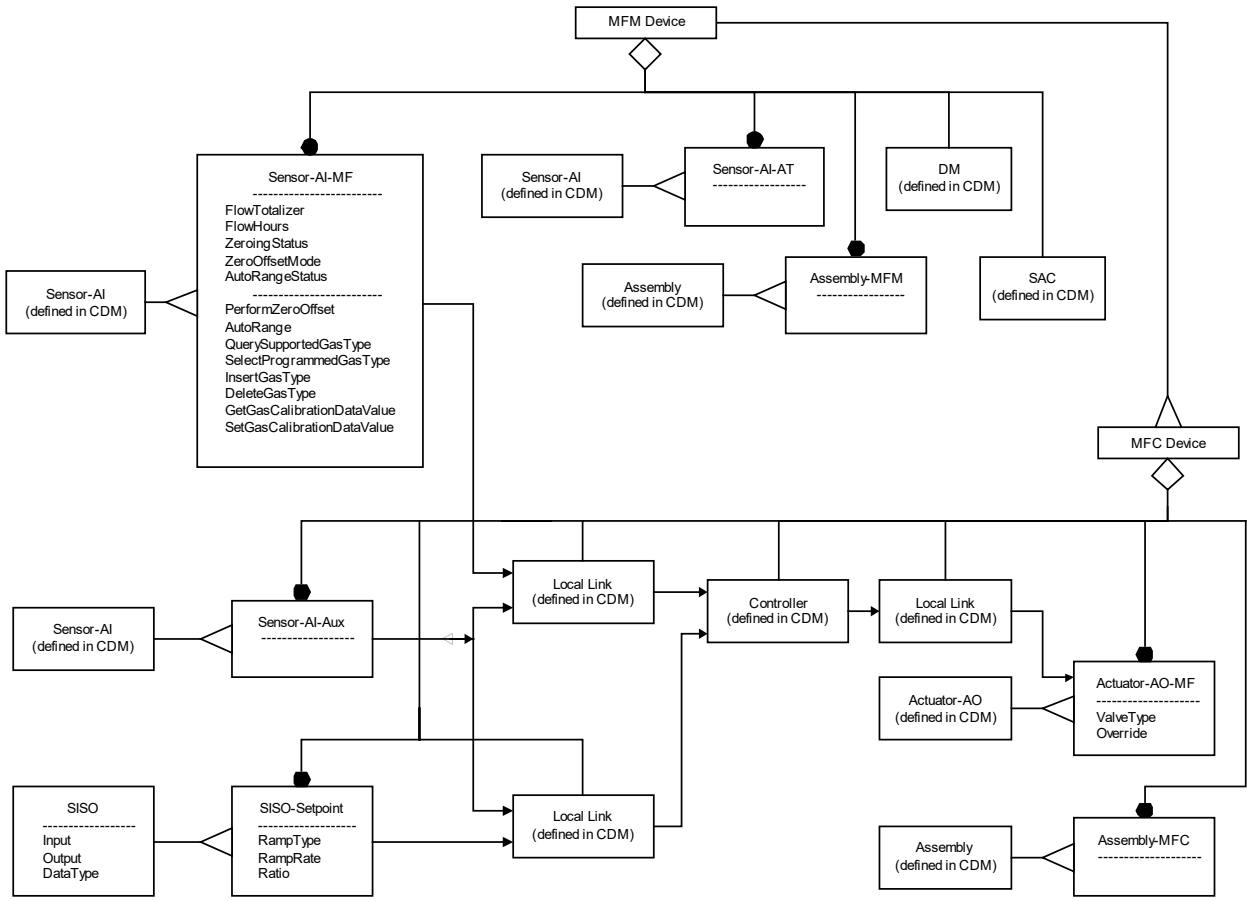

Figure 2
MFM Device and MFC Device High Level Structure

8.1.7 *General Requirements*

8.1.7.1 *Device Objects* — All objects are defined in terms of their object name and instance identifier. Identifiers for all objects described in this Specification are summarized in Table 2.

Table 2 Mass Flow Device Objects

Referenced Section	*Object Name*	*Object Identifier*	*MFC Minimum Instances*	*MFM Minimum Instances*	*Maximum Instances*
8.2	Device Manager (DM)	MFD1	1	1	1

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Referenced Section	*Object Name*	*Object Identifier*	*MFC Minimum Instances*	*MFM Minimum Instances*	*Maximum Instances*
8.3	Sensor Actuator Controller (SAC)	MFD2	1	1	1
8.4	Sensor-AI-MF	MFD3	1	1	Manufacturer-Specified
8.5	Sensor-AI-AT	MFD4	0	0	Manufacturer-Specified
8.6	Assembly-MFM	MFD5	0	0	1
8.7	Sensor-AI-Aux	MFD6	0	0	Manufacturer-Specified
8.8	Actuator-AO-MF	MFD7	1	0	Manufacturer-Specified
8.9	Controller	MFD8	1	0	1
8.10	Local Link	MFD9	2	0	Manufacturer-Specified
8.11	SISO	MFD10	0	0	Manufacturer-Specified
8.12	SISO-Setpoint	MFD11	0	0	Manufacturer-Specified
8.13	Assembly-MFC	MFD12	0	0	Manufacturer-Specified
-	Reserved	MFD13–MFD64	-	-	-
-	Manufacturer-Specified	>MFD64	-	-	-

8.1.7.2 *Object Services* — Not all object services listed in this Specification can necessarily be requested over the network. They are included in this Specification because their behavior may generate network activity.

8.1.7.3 *Object Behavior* — For all service requests received over the network that are unsupported by the object, or contain a parameter value which is beyond the supported range, or which is otherwise invalid, a network-specific service error response is generated as specified in SEMI E54.1.

8.2 *Device Manager (DM) Object*

8.2.1 The DM object instance is the device component responsible for managing and consolidating the device operation as specified in SEMI E54.1. The following sections specify the components of the DM object that are not specified in the CDM.

8.2.2 *DM Object Attributes* — Required and optional DM object instance attributes are listed in Table 3.

Table 3 DM Object Attributes

Attribute Name	*Attribute Identifier*	*Access Network*	*Required*	*Form*
Device Type	A1	R	Yes	Refer to CDM. (SEMI E54.1)
Exception Detail Alarm	A13	R	No	Refer to CDM. (SEMI E54.1)
Exception Detail Warning	A14	R	No	Refer to CDM. (SEMI E54.1)
Reserved	A33–A64	-	-	Reserved for SDM future expansion.
Manufacturer-Specified	>A64	-	-	Manufacturer-Specific attributes

8.2.2.1 *Device Type* — An attribute which uniquely identifies the type of the device on the network. The device type attribute is assigned as follows:

- MFC Device = ‘MFC’
- MFM Device = ‘MFM’

8.2.2.2 *Exception Detail Alarm (Optional)* — An attribute which identifies the detailed alarm status of the device. Table 4 defines the bit assignments associated with the alarm exception detail.

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Table 4 Exception Detail Alarm Bit Assignments

Bit	*Device-Specific Alarm [0]*
0	Reserved
1	Indicated Flow High
2	Indicated Flow Low
3	Flow Controller
4	Flow Valve Actuator
5	Reserved
6	Reserved
7	Reserved

8.2.2.3 *Exception Detail Warning (Optional)* — An attribute which identifies the detailed warning status of the device. Table 5 defines the bit assignments associated with the warning exception detail.

Table 5 Exception Detail Warning Bit Assignments

Bit	*Device-Specific Warning [0]*
0	Reserved
1	Indicated Flow High
2	Indicated Flow Low
3	Flow Controller
4	Flow Valve Actuator
5	Reserved
6	Reserved
7	Reserved

8.2.2.4 *Initial and Default Values*

Table 6 DM Object Attribute Initial and Default Values

Attribute	*Initial Value*	*Default Value*	*Comment*
Device Type	MFC, MFM	MFC, MFM	MFM = Mass Flow Meter Device MFC = Mass Flow Controller Device
Exception Detail Alarm	0	0	
Exception Detail Warning	0	0	

8.3 *Sensor Actuator Controller (SAC) Object* — The SAC object instance is the device component responsible for coordinating the interaction of the mass flow device with the sensory/actuation/control environment as specified in SEMI E54.1.

8.4 *Sensor-AI-MF Object* — The Sensor-AI-MF object inherits the attributes, services, and behavior of the Sensor-AI as defined in SEMI E54.1. The Sensor-AI-MF object instance is the device component responsible for retrieving a reading from a physical flow sensor, optionally correcting the reading with a manufacturer-specified algorithm, or algorithms, then making the value available to feed the Controller object instance via a Local Link object instance.

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