SEMI E134.2-1022
SPECIFICATION FOR PROTOCOL BUFFERS OF DATA COLLECTION MANAGEMENT

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 September 7, 2021. Available at www.semiviews.org and www.semi.org in October 2022.

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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: Paragraphs entitled 'NOTE:' are not an official part of this Standard or Safety Guideline and are not intended to modify or supersede the official Standard or Safety Guideline. These have been supplied by the global technical committee to enhance the usage of the Standard or Safety Guideline.

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1 Purpose

1.1 The purpose of this Specification is to provide an implementation mapping of the SEMI E134 to gRPC®[1] and Protocol Buffers.

2 Scope

2.1 The scope of this Specification is the faithful representation of the messages and services to support SEMI E134 with gRPC and Protocol Buffers. It will not add new concepts to the SEMI E134 model. The only additions made are those needed to render useful Protocol Buffers messages.

2.2 This Specification requires SEMI E132 authentication, and defines requirements for the application of SEMI E132 concepts to the SEMI E134 Specification using gRPC and Protocol Buffers.

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 None.

4 Referenced Standards and Documents

4.1 *SEMI Standards and Safety Guidelines*

SEMI E125 — Specification for Equipment Self Description (EqSD)

SEMI E132 — Specification for Equipment Client Authentication and Authorization

SEMI E132.2 — Specification for Protocol Buffers Implementation for Equipment Client Authentication and Authorization (ECA)

SEMI E134 — Specification for Data Collection Management

SEMI E179 — Specification for Protocol Buffers Common Components

[1] Trademark is owned by The Linux Foundation®

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4.2 *IETF® Documents*[2]

RFC 7540[3] — Hypertext Transfer Protocol Version 2 (HTTP/2)

RFC 4122[4] — A Universally Unique Identifier (UUID) URN Namespace

4.3 *NIST® Standards*[5]

Federal Information Processing Standards (FIPS) – 180-4 — Secure Hash Standard[6]

4.4 *CNCF® Documents*[7]

Wire format over HTTP2 – gRPC® over HTTP2[8]

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

5 Terminology

5.1 *Abbreviations and Acronyms*

5.1.1 *DCP* — Data Collection Plan

5.1.2 *EDA* — Equipment Data Acquisition

5.1.3 *gRPC* — gRPC Remote Procedure Call

5.1.4 *HTTP/2* — Hypertext Transfer Protocol version 2

5.1.5 *Protobuf* — Protocol Buffers

5.1.6 *protobuf3* — Protocol Buffers version 3

5.1.7 *SHA* — Secure Hash Algorithm

5.1.8 *TCP/IP* — Transmission Control Protocol/Internet Protocol

5.1.9 *UUID* — Universally Unique Identifier

5.2 *Definitions*

5.2.1 *SHA-256* — member of the SHA-2 family of hash functions that generates a 246-bit hash value.

6 Resources, Organizations, and Standards

6.1 Important resources and organizations used in the generation and definition of this Standard are found in:

- *Protocol Buffers* — https://developers.google.com/protocol-buffers/
- *gRPC* — https://grpc.io/docs/

6.2 For an overview of Protocol Buffers and gRPC, refer to:

- SEMI E179 — Related Information 1, Technology Overview
- SEMI E179 — Related Information 2, Protocol Buffers and gRPC Implementation Considerations

[2] Internet Engineering Task Force, IETF Administration LLC, 1000 N West Street, Suite 1200, Wilmington, DE 19801, USA; Telephone: +1.510.492.4080, Fax: +1.510.492.4001, http://www.ietf.org. IETF trademark is owned by the IETF Trust.

[3] https://tools.ietf.org/html/rfc7540

[4] https://tools.ietf.org/html/rfc4122

[5] National Institute of Standards and Technology, 100 Bureau Drive, Stop 3460, Gaithersburg, MD 20899-3460, USA; Telephone: +1.301.975.2000, http://www.nist.gov. NIST trademark is owned by National Fire Protection Association.

[6] https://doi.org/10.6028/NIST.FIPS.180-4

[7] Cloud Native Computing Foundation c/o The Linux Foundation, 548 Market St, PMB 57274, San Francisco, CA 94104-5401, USA; Telephone: +1.415.723.9709, https://www.cncf.io. Trademark is owned by The Linux Foundation.

[8] https://github.com/grpc/grpc/blob/master/doc/PROTOCOL-HTTP2.md

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7 Conventions

7.1 *Requirements Identification*

7.1.1 The following notation specifies the structure of requirement identifiers.

7.1.1.1 The following requirements prefix format is used at the beginning of requirement text. Refer to 0 for the format notation of the requirements prefix: [Esss.ss-RQ-nnnnn-nn]

7.1.1.2 To mark the end of the requirement text, the following suffix format is used: [/RQ]

7.1.1.3 Requirements in the body text are highlighted with a border and light green background (may appear gray in black and white printouts) as shown below.

[Esss.ss-RQ-nnnnn-nn] Requirement text. [/RQ]

Table 1 Requirement Identifiers

Format Notation	*Purpose*
Esss.ss	SEMI Standards Specification identifier. Examples: E87.00, E87.01, E134.00.
RQ	Indicates this is a requirement identifier.
Nnnnn	Unique five-digit number within this Specification. 90000–99999 are reserved for use by SEMI.
Nn	Two-digit number that indicates version level of the requirement. A value of .00 is used for the first version of a requirement.
/RQ	Indicates the end of a requirement.

7.1.1.4 Note that the requirements in Appendix 1 use the reserved requirement numbers noted in 0 because they are repeated in other SEMI Standards that use this convention.

7.1.2 Requirements in tables are delimited in one of two ways.

7.1.2.1 Where the requirement occupies an entire row in the table, the requirement identifier (RequirementID) is placed in column 1. No '[/RQ]' is used to mark the end of the requirements text in this case. The table may also contain rows that are not requirements. In this case, the column 1 cell is left blank.

7.1.2.2 Non-requirements text related to a requirement row may be included in an adjacent row. The relationship between the rows is indicated by a broken line separating the two.

7.1.2.3 Where the requirement occupies only one cell, the text in the cell includes the RequirementID prefix and suffix similar to requirements in the body text.

7.1.2.4 No cell in a table will contain both requirement and non-requirement text.

7.1.2.5 Cells that contain requirements are shaded light green.

7.1.2.6 Table 2 provides an example of requirements in a table. Note that in this example, the same requirement is presented in two alternative formats. In practice, mixing the two approaches in the same table is not typically done.

Table 2 Example Table with Requirements

RequirementID	*Statement*	*Additional Detail*
Esss.ss-RQ-nnnnn-nn	The light shall be the sole blue light.	There shall be no similar color in the light panel.
	The blue light is typically placed at the leftmost position in the light panel.	
	[Esss.ss-RQ-nnnnn-nn] The light shall be the sole blue light. There shall be no similar color in the light panel. [/RQ]	The blue light is typically placed at the leftmost position in the light panel.

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7.1.3 Only text marked with the RequirementID is a requirement of this Specification.

7.1.3.1 Clarifications, examples, and related recommendations may be provided near a requirement, but are not part of the requirement.

7.1.3.2 Note that the word 'should' is used in some non-requirements text, where it denotes a recommendation or a best practice, not a requirement.

7.1.3.3 Note that the words 'must' and 'will' are used in the Implementation Overview section to illustrate the logical result of requirements specified in the prerequisites and requirements section. Such statements should not be considered requirements.

7.1.4 Parent-child relationships of requirements are noted in Appendix 1, Table A1-1. Where a parent requirement includes conditions or selection criteria, these are passed to their children. For example, if a parent requirement is stated to apply only to photolithography equipment, any child requirements also apply only to such equipment. The condition need not be restated for each child requirement.

7.1.4.1 Compliance to a parent requirement includes compliance to all of its child requirements.

7.1.4.2 Some cells or rows in a table may contain headings that are assigned a RequirementID. These are parent requirements for other requirements in the table—typically for the rows that immediately follow that heading.

7.2 This Standard uses 'service definition' to refer to gRPC services defined in the .proto file (such as E134DataCollectionManagement) and 'interfaces' to refer to interfaces defined in SEMI E134 (such as DataCollectionManager and DCPConsumer).

8 General Requirements for Protocol Buffers

8.1 The following is the top-level parent requirement of all others in this Specification.

[E134.02-RQ-00001-00] Compliance to this Specification requires compliance to all other identified requirements in this Specification, including complementary files. [/RQ]

8.2 *Protocol Buffers File*

8.2.1 This Specification includes a .proto file, 'SEMIE134-02-1022.proto' file, that provides the normative definitions of the types and methods described here.

[E134.02-RQ-00002-00] Implementations shall use the Complementary File 'SEMIE134-02-1022.proto' file that accompanies this Specification. The Complementary File is an official part of and accompanies this Specification. The contents of the .proto file constitutes a core part of this Specification. [/RQ]

8.2.2 The .proto file can be compiled into your implementation-specific programming language, generating the appropriate classes for all specified types.

[E134.02-RQ-00003-00] Implementations shall integrate with Protocol Buffers v3.17.0 at a minimum. Implementations may use newer versions of Protocol Buffers if they are compatible with this stated version. [/RQ]

8.2.3 gRPC provides an SDK framework based on the EDA application's specific development language. Each of the development language-specific gRPC implementation have their own version number. A specific version is not required to comply with this Standard because they all support the gRPC wire format (refer to § 11).

NOTE 1: The Standard specifies a minimum version of Protocol Buffers that needs to be supported to ensure compatibility because Protocol Buffers is used as the gRPC payload.

8.2.4 This Specification also includes Various Materials. These Various Materials are not an official part, but accompany this Specification. Use of these Various Materials is optional and is not required for compliance with this Specification.

8.2.4.1 The file SEMIE134-02-1022-helper.proto is a marked up version of the .proto file for this Specification and is released as Supplementary Material. It has comments prefixed by 'INTERNAL –' that describe how the Protocol Buffers messages map to XML definitions. Most of these items were specified in complementary files for SEMI E134.1. These comments can be helpful to implementers familiar with the XML objects. They are not included in the official .proto file included with the SEMI Specification to keep that document readable.

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NOTE 2: Implementers should not use the SEMIE134-02-1022-helper.proto file as its messages are the same as the ones defined in the official .proto file that accompanies the Specification.

9 Mapping of SEMI E134 to Protocol Buffers

9.1 *Interactions with SEMI E179*

9.1.1 This Standard supports SEMI E179 for common Protocol Buffers elements that are not specific to a single standard and are available to multiple standards.

[E134.02-RQ-00004-00] SEMI E134.2 implementations shall use SEMI E179 for common Protocol Buffer components. [/RQ]

9.2 *SEMI E134 Object Definitions*

9.2.1 SEMI E134 defines several classes in a general manner because the data formats to use are protocol specific.

[E134.02-RQ-00005-00] SEMI E134.2 implementations shall use SEMI E179 objects for specific SEMI E134 objects, as described in 0. [/RQ]

Table 3 SEMI E179 Object Mappings

SEMI E134 Object	*Used in*	*SEMI E179 Object*
Parameter Value Class	• GetParameterValues() operation – parameterValues argument • AttributeData class – attributeValue attribute • EventReport class – parameterValues association • ExceptionReport class – parameterValues association • CollectedData class – parameterValues association	ParameterValueType
Operator Class	Condition class – operator attribute	OperatorType#1

#1 SEMI E179 OperatorType matches the allowed values for the operator attribute defined in SEMI E134 (Operator Definitions and Applicability).

9.3 *Interactions with SEMI E132.2*

9.3.1 SEMI E134.2 implementations use SEMI E132 for equipment client authentication and authorization. They support SEMI E132.2, which provides the gRPC and Protocol Buffers implementation details.

[E134.02-RQ-00006-00] SEMI E134.2 implementations shall use SEMI E132.2 for session management and security administration. [/RQ]

9.3.2 Connection scenarios between the Equipment Server, Client Session, and Consumer Sessions are described in SEMI E132.2. (Refer to section on gRPC Connections in SEMI E132.2.)

9.3.3 EDA Applications with Client Sessions connect to the Equipment Server to perform data collection management.

[E134.02-RQ-00007-00] The EDA Application with Client Sessions shall make gRPC method calls on the E134DataCollectionManagement service definition. [/RQ]

9.3.4 The Equipment Server sends operational messages (collected DCP data) to the Consumer Session.

[E134.02-RQ-00008-00] The Equipment Server shall send operational messages to the Consumer Session using either the E134ConsumerDataCollection or E134ConsumerReceiverDataCollection service definitions, depending on who establishes the gRPC connection. [/RQ]

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9.4 *SEMI E134 Operation Errors*

9.4.1 *Common Errors* — 0 below provides a mapping of the SEMI E134 defined errors to its common error code. The SEMI E134 mapped error codes below are in addition to any common error codes defined in SEMI E179, SEMI E132.2 and any errors defined by the equipment supplier. These error codes are reported with the SEMI E179's ErrorType structure or RPC Exceptions as outlined by SEMI E179.

[E134.02-RQ-00009-00] SEMI E134 error codes shall be denoted in the ErrorType structure by defining the 'source' name of 'urn:semi-org:E134'. [/RQ]

Table 4 SEMI E134 Error Codes

SEMI E134 Error	*Common Error Code*
InvalidPlan.	8000
NoSuchPlan.	8001
DCPIsActive.	8002
DCPNotActive.	8003

9.4.2 *Custom Errors* — Custom errors structures defined in the 'SEMIE134-02-1022.proto' file (such as InvalidPlan) do not need to specify the source information explicitly specified because they are specific to SEMI E134.

9.4.3 *Using SEMI E132.2 Errors*

9.4.3.1 This Standard rejects any SEMI E134.2 operations that are not authorized using the SEMI E132.2 error infrastructure.

[E134.02-RQ-00010-00] SEMI E134.2 implementations shall report unauthorized operations with the SEMI E132.2 UnauthorizedOperationType structure, or if it is reported through the ErrorType structure, the error is associated with SEMI E132.2 error code '6000' and source 'urn:semi-org:E132'. [/RQ]

9.4.3.2 This Standard uses the same SEMI E132.2 error codes when it rejects a SEMI E134.2 operation that do not have a valid SessionId or if the SessionId is already in use.

[E134.02-RQ-00011-00] The Equipment Server shall use SEMI E132.2 error codes for SEMI E134.2 operations for the error conditions described in 0, specifying the error source as 'urn:semi-org:E132'. [/RQ]

Table 5 SEMI E132.2 Error Conditions Used with SEMI E134.2

Error Condition	*SEMI E132.2 Error Code*
Unrecognized session	6005
SessionId already in use	6016

9.4.3.3 When working with a streaming gRPC method (e.g., E134DataCollectionManagement. DataCollectionNotificationUsageStream()), there is no message response that can indicate error conditions to the calling code (e.g., the SessionId specified in the gRPC metadata is invalid). SEMI E132.2 define specific RPC Exception to throw using trailer gRPC metadata to provide the error information. This Standard uses the same SEMI E132.2 exceptions when SEMI E134.2 streaming gRPC methods are rejected.

[E134.02-RQ-00012-00] SEMI E134.2 implementations shall use RPC Exceptions and metadata defined in SEMI E132.2 when rejecting SEMI E134.2 streaming gRPC methods for the error conditions described in Table 6, specifying the source as 'urn:semi-org:E132'. [/RQ]

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Table 6 SEMI E132.2 Exceptions Used with SEMI E134.2

Error Condition	*SEMI E132.2 Error Code*
Unrecognized session	6005
SessionId already in use	6016

9.5 *Using SEMI E179 Common Errors*

9.5.1 SEMI E179 defines common error codes. Implementations may return these error codes if they are applicable and the Primary Standard does not explicitly define the error condition. These error codes are reported with the SEMI E179's ErrorType structure and the error source is listed as SEMI E134.

9.5.2 Table 7 below provides a mapping of the SEMI E134 defined errors to specific SEMI E179 common error codes.

Table 7 SEMI E132 Error Codes Mapped to SEMI E179 Common Error Codes

SEMI E132 Error	*SEMI E179 Error Code*
System not ready	5004
System shutting down	5005
Specified configuration is invalid	5003

[E134.02-RQ-00013-00] If SEMI E179 error codes are reported by the SEMI E134.2 implementation, 'source' name of the error shall be 'urn:semi-org:E134'. [/RQ]

9.6 *Client Session Disconnect*

9.6.1 It is possible for a Client Session to disconnect from the Equipment Server. This disconnection does not close the SEMI E132 session in the Equipment Server. It is possible for the Client Session to reconnect to the Equipment Server later on and continue to do management activities.

9.7 *Session Identifier*

9.7.1 The session identifier (SessionId) is defined in SEMI E132 and is generated by the equipment during the SEMI E132 EstablishSession operation. It is an UUID that is guaranteed unique across space and time (refer to RFC 4122 for specific details on syntax and format of a UUID).

9.7.2 In Protocol Buffers messages, the SessionId is represented as a string data type, as it is more easily understood in its human-readable form.

9.7.3 The session identifier is specified in all requests to the Equipment Server over a SEMI E132 authenticated session. gRPC's metadata infrastructure is used to pass the SessionId for gRPC methods. This provides the most transparent way of sending the session identifier without affecting the input/output parameters of the individual unary methods. gRPC metadata take name-value pairs and stores them in the HTTP/2 header data.

NOTE 3: For more information about gRPC's metadata infrastructure, refer to SEMI E179, Related Information 2.

[E134.02-RQ-00014-00] SEMI E134 DataCollectionManager and DCPConsumer operations that are implemented as gRPC methods shall specify the SessionId with the gRPC metadata infrastructure. [/RQ]

9.7.4 The SessionId for methods in the E134DataCollectionManagement and E134ConsumerDataCollection service definitions can be sent in plain text because the expectation is that this will be done over a secure connection.

[E134.02-RQ-00015-00] When sending SessionId information with gRPC metadata for methods on the E134DataCollectionManagement and E134ConsumerDataCollection service definitions,
The key for the SessionId name-value pair shall be 'sessionid'
The value for the SessionId name-value pair shall be the SessionId. [/RQ]

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9.7.5 To help protect the SessionId in outgoing messages from the Equipment Server (which may be sent over a not secured connection), it is hashed with the SHA-256 hash algorithm (as specified in the Secure Hash Standard). The value of SessionId when it is hashed is based on Base64 Binary type. The SessionId is first converted to UTF-8 prior to applying the hash, and the hashed value is stored in a string data type.

[E134.02-RQ-00016-00] When sending SessionId information with gRPC metadata on the E134ConsumerReceiverDataCollection service definition,
The key for the SessionId name-value pair shall be 'sessionidhash'
The value for the SessionId name-value pair shall be the SessionId hashed with SHA-256. [/RQ]

9.8 *Client Identifier*

9.8.1 The client identifier (ClientId) is defined in SEMI E132 and is specified by the Client Session during the EstablishSession operation to identify the ACLEntry to authenticate. SEMI E134 operations sometime include the ClientId as the identity of the Client Session that triggered a DCP management activity. (For example, DefinedBy, ActivatedBy or DeletedBy attributes.) Similar to the SessionId, the Equipment Server needs to protect the ClientId identifier sent through the SEMI E134 DCPConsumer interface as it could be sent over not secure communications. The ClientId value is hashed with SHA-256 hash algorithm and stored in a string data type.

9.8.2 SEMI E134 uses the same object definitions in the DataCollectionManager interface. For those messages, the ClientId can be sent in plain text because the expectation is that they will sent with secure communications.

NOTE 4: For consistency, the ClientId value is hashed in messages corresponding to SEMI E134 DCPConsumer operations regardless if they are sent over secure communications. (For example, if the DCPActivation notification message is sent to the Client Session over secure communications.)

9.8.2.1 For example, SEMI E134 defines the DCPActivated object, which stores the ClientId value in the activatedBy attribute. This object is used in both the DataCollectionManager.ActivatePlan() operation and in the DCPConsumer.DCPActivation notification message.

- If the Protocol Buffers message DCPActivatedType is sent as part of the ActivatePlan response message (part of the DataCollectionManager interface), the ClientId is stored in plain text in the ActivatedBy.ClientId field.
- If the Protocol Buffers message DCPActivatedType is sent as part of the DCPActivation message (part of the DCPConsumer interface), the ClientId is hashed and stored in the ActivatedBy.ClientIdHash field.

[E134.02-RQ-00017-00] ClientId values specified in Protocol Buffer messages corresponding to the SEMI E134 DCPConsumer operations shall be hashed with SHA-256 and stored in the ClientIdHash field in the Protocol Buffers message. [/RQ]

9.9 *SEMI E132 Privilege Definitions*

9.9.1 An Equipment Server needs to have certain privileges defined to support SEMI E134 functionality. The privileges are of the format 'urn:semi-org:priv.<priv-name>'

[E134.02-RQ-00018-00] The Equipment Server shall define SEMI E134 privilege levels as SEMI E132 privileges as specified in Table 8. [/RQ]

Table 8 SEMI E134 to SEMI E132 Privilege Mapping

SEMI E134 Privilege Level	*SEMI E132.2 PrivilegeId Entry*
ManageOnlyAuthoredDCPs	urn:semi-org:priv.ManageOnlyAuthoredDCPs
UseAnyDCP	urn:semi-org:priv.UseAnyDCP
ManageAnyDCP	urn:semi-org:priv.ManageAnyDCP

9.10 *SEMI E132 Communication Errors*

9.10.1 SEMI E132 defines certain behavior when there is a communication error. The following Equipment Server error conditions when working with E134.2 service definitions are considered SEMI E132 communication errors.

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