

SEMI E148-0222

SPECIFICATION FOR TIME SYNCHRONIZATION AND DEFINITION OF THE TS-CLOCK OBJECT

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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.

1 Purpose

- 1.1 The purpose of this Standard is to define the requirements for any factory component computer clock that requires synchronization of time to maintain and manage date/time accurately and consistently by using a common time synchronization protocol.
- 1.2 This Standard defines the TS-Clock object for accessing factory application and equipment time value and synchronization status, describes an example of network time synchronization architecture, and specifies which protocol to use for precise time synchronization of clocks in factory environments that use network communication.
- 1.3 RFC 5905, NTPv4 protocol for time synchronization is specified in this Standard because it is applicable to systems communicating by local area networks supporting multicast messaging including but not limited to Ethernet. This protocol enables heterogeneous systems that include clocks of various inherent precision and stability to synchronize.

2 Scope

- 2.1 This Standard applies to factory components that collect, store, distribute, and process time-sensitive data. Factory components include applications used to manufacture devices, maintain equipment, provide process resources, condition the factory, control processes. In particular, it includes the equipment used in manufacturing.

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 Factory component services to be used in conjunction with the TS-Clock object are specific to the interfaces and protocols used by those factory components.
- 3.2 This Standard does not specify the mechanism for synchronization of components within the equipment.

4 Referenced Standards and Documents

4.1 SEMI Standards and Safety Guidelines

- SEMI E39 — Specification for Object Services Standard (OSS)
- SEMI E120 — Specification for the Common Equipment Model (CEM)
- SEMI E134 — Specification for Data Collection Management

4.2 ISO® Standards¹

ISO 8601:2004 — Internet Standard for Date/Time Format

4.3 IETF® Documents²

RFC 5905³ — Network Time Protocol Version 4: Protocol and Algorithm Specification

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

5 Terminology

5.1 Abbreviations and Acronyms

5.1.1 EDA — equipment data acquisition

5.1.2 SECS-II — Semiconductor Equipment Communication Standard II

5.2 Definitions

5.2.1 *clock* — a device that is used to provide real-time date/time information that generates periodic, accurately spaced signals used for timing applications.

5.2.2 *equipment* — equipment (manufacturing equipment) performs one or more manufacturing functions in the factory (e.g., material process, material analysis, material transport, or material storage). Equipment is made up of various parts: subsystems, subassemblies, and sensors/actuators. Equipment communicates directly with the factory.

5.2.3 *equipment components* — a collection of subassemblies or subsystems owned by the equipment that may provide a clock or timestamp information.

5.2.4 *factory components* — a collection of software applications, software/hardware systems, and equipment used for manufacturing.

5.2.5 *stratum* — a number assigned to a clock in a network that indicates the clock's quality and position in the time synchronization hierarchy. Lower stratum levels are assigned to time servers. The highest quality time servers assigned to stratum 1 are referenced to a high quality atomic clock source such as a GPS, radio or an atomic oscillator (refer to NTP Protocol reference).

5.2.6 *subassembly* — a component of equipment that provides some limited functionality.

5.2.7 *subsystem* — a subsystem is an intelligent aggregate of an equipment that behaves as a unit. A subsystem is made up of sensors and/or actuators and may contain mechanical assemblies.

5.2.8 *time server* — a computer or device that is assigned a stratum level and is used as reference to time synchronize other computer or devices that require synchronized date and time.

5.2.9 *time synchronization* — the process or methodology used to maintain the clock in a system such that it coincides with a date/time source within specified accuracy.

5.2.10 *timestamp* — refers to a time mark of the instant an event (data generated, document signed, process fault, etc.) that has occurred based on a specified time scale.

6 Conventions

6.1 Requirements Identification

6.1.1 The following notation specifies the structure of requirement identifiers.

6.1.1.1 The following requirements prefix format shall be used at the beginning of the requirement text.

- [Esss.ss-RQ-nnnnnn-nn]

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>. Trademark is owned by the International Organization for Standardization.

² Internet Engineering Task Force, IETF Administration LLC, 1000 N West Street, Suite 1200, Wilmington, DE 19801, USA, <http://www.ietf.org>. Trademark is owned by the IETF Trust.

³ <https://tools.ietf.org/html/rfc5905>

6.1.1.2 To mark the end of the requirement text the following suffix format must be used.

- [/RQ]

6.1.2 Requirement IDs apply across the row (left to right) of a table unless otherwise specified.

Table 1 Requirement Identifiers

<i>Format Notation</i>	<i>Purpose</i>
Esss.ss	SEMI Standards Specification identifier. Examples: E087.00, E087.01, 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 (00 is used for the first version of a requirement).
/RQ	Indicates the end of a requirement.

6.2 *Unified Modeling Language (UML)* — This Specification uses UML notation for all class diagrams and for object diagrams provided as examples.

6.3 *Class and Object Conventions* — This Specification conforms to the conventions for classes established by Unified Modeling Language (UML) and SEMI E39, including class diagrams, object diagrams, class terminology, and requirements for classes. When the terms used in the two standards conflict; the definitions and conventions defined in the OMG UML specification take precedence.

6.4 *Objects*

6.4.1 Objects defined in this Specification comply with the basic requirements of SEMI E39.

7 Implementation Overview

7.1 Traditionally, factory applications have been implemented in a centralized architecture in which the timing constraints are met by careful attention to programming combined with communication technologies having deterministic latency. In recent years an increasing number of systems utilize a more distributed architecture coupled with mainstream network technologies having less stringent timing specifications than the older technologies. Use of network time synchronization protocols allows the different systems within the factory to remain closely synchronized with a high degree of accuracy, and it relieves the factory host from explicitly setting the factory component's internal clock(s). In this environment the most widely used technique for synchronizing these clocks is RFC 5905, NTPv4 (refer to the Referenced Standards and Documents section for additional information regarding this protocol).

7.2 In manufacturing, time synchronization capability is needed to maintain an accurate date/time with respect to a reliable source, and to provide this date/time information to all factory components via network configuration. Factory components include software applications, software/hardware systems, and equipment used in manufacturing.