SEMI E148-0707
SPECIFICATION FOR TIME SYNCHRONIZATION AND DEFINITION OF THE TS-CLOCK OBJECT

This standard was technically approved by the global Information and Control Committee. This edition was approved for publication by the global Audits and Reviews Subcommittee on April 25, 2007. It was available at www.semi.org in June 2007 and on CD-ROM in July 2007.

1 Purpose

1.1 The purpose of this document 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 It 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 The Network Time Protocol (NTPv3) protocol for time synchronization is specified in this document 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 The time synchronization 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: This standard does not purport to address safety issues, if any, associated with its use. It is the responsibility of the users of this standard 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*

SEMI E5 — SEMI Equipment Communication Standard 2 Message Content (SECS-II)

SEMI E39 — Object Services Standard (OSS)

SEMI E120 — Specification for the Common Equipment Model (CEM)

SEMI E134 — Specification for Data Collection Management

4.2 *IEEE Standard*[1]

IEEE 1588/IEC 61588 — Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems.

1 Institute of Electrical and Electronics Engineers; IEEE Operations Center, 445 Hoes Lane, P.O. Box 1331, Piscataway, New Jersey 08855-1331, USA. Telephone: 732.981.0060; Fax: 732.981.1721; http://www.ieee.org

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4.3 *ISO Standards*

ISO 8601:2004 — Internet standard for date/time format[2]

ISO/IEC 11578:1996 — Information Technology [3]

4.4 *Other Documents*

UML — Unified Modeling Language Specification 2.0

NTP Version 3 (RFC 1305) — Network Time Protocol[4]

NIST — Time and Frequency Glossary[5]

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 *MES* — Manufacturing Execution System

5.1.3 *NIST* — National Institute of Standards and Technology

5.1.4 *NTP* — Network Time Protocol

5.1.5 *OMG* — Object Management Group

5.1.6 *SECS-II* — Semiconductor Equipment Communication Standard II

5.1.7 *UTC* — Coordinated Universal Time

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 (see 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.

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2 International Organization for Standardization; ISO Central Secretariat, 1, rue de Varembé, Case postale 56, CH-1211 Geneva 20, Switzerland. Telephone: 41.22.749.01.11; Fax: 41.22.733.34.30; http://www.iso.ch

3 International Electrotechnical Commission; 3, rue de Varembé, Case Postale 131, CH-1211 Geneva 20, Switzerland. Telephone: 41.22.919.02.11; Fax: 41.22.919.03.00; http://www.iec.ch

4 Network Time Protocol (NTP); http://www.ntp.org

5 National Institute of Standards and Technology; 100 Bureau Drive, Stop 3460, Gaithersburg, MD 20899-3460, USA. Telephone: 301.975.6478. http://www.nist.gov ; http://tf.nist.gov/timefreq/general/glossary.htm

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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.

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

- [Vsss.ss-RQ-nnnnn-nn]

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

Format Notation	*Purpose*
Vsss.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 document 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 document comply with the basic requirements of SEMI E39 Object Services Standard (OSS).

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 the Network Time Protocol version 3 (NTPv3) (see Referenced Standards and Documents section for additional information regarding this protocol).

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