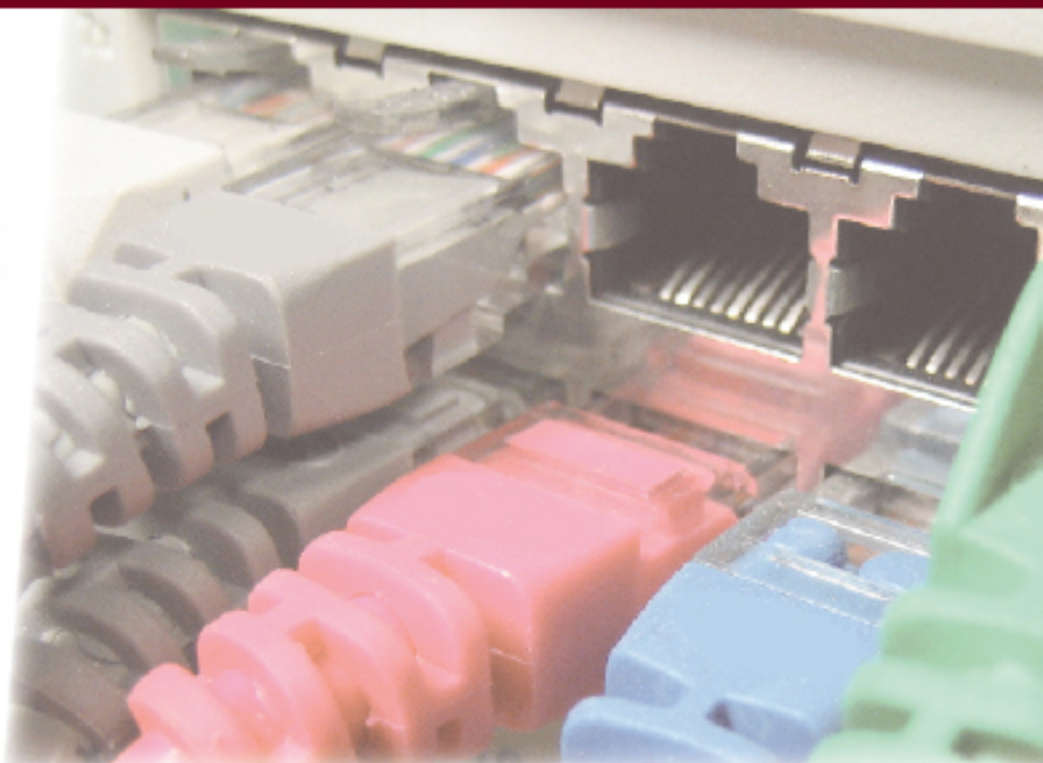


LAN eXtensions for Instrumentation



LXI IEEE-1588 Profile 1.0

December 1, 2008



LXI IEEE 1588 Profile

Version 1.0

1 December, 2008

Recipients of this draft are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

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Revision History

<i>Revision</i>	<i>Description</i>
1.0 December 1, 2008	Initial version was adopted.

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1 Overview and Class Definition

This document has been written and is controlled by the members of LXI Consortium, a not-for-profit organization created for the development and promotion of a LAN (Ethernet) based standard for instrumentation and related peripheral devices. This LXI document details the technical requirements applicable to the use of IEEE 1588 in LAN-based devices that are LXI conformant. This document is applicable to versions of IEEE 1588 starting with IEEE 1588-2008. It is not applicable to version IEEE 1588-2002.

1.1 Intended Audience

This LXI document is intended for use by designers, integrators and users of devices that are designed to be LXI conformant.

1.2 Background and Terminology

LXI is an acronym for LAN eXtensions for Instrumentation. The LXI specification details the technical requirements of LXI Devices using Ethernet as the primary communications bus between devices.

1.3 Purpose and Scope of this Document

This document defines a set of **RULES** and **RECOMMENDATIONS** for the LXI 1588 profile referenced by all versions of the LXI Standard based on IEEE 1588-2008.

1.4 Definition of Terms

Throughout this document you will see the following headings on paragraphs. These headings identify the contents of the paragraph:

RULE: Rules **SHALL** be followed to ensure compatibility for LAN-based devices. A rule is characterized by the use of the words **SHALL** and **SHALL NOT**. These words are not used for any other purpose other than stating rules.

RECOMMENDATION: Recommendations consist of advice to implementers that will affect the usability of the final device. Discussions of particular hardware to enhance throughput would fall under a recommendation. These should be followed to avoid problems and to obtain optimum performance.

SUGGESTION: A suggestion contains advice that is helpful but not vital. The reader is encouraged to consider the advice before discarding it. Suggestions are included to help the novice designer with areas of design that can be problematic.

PERMISSION: Permissions are included to clarify the areas of the specification that are not specifically prohibited. Permissions reassure the reader that a certain approach is acceptable and will cause no problems. The word **MAY** is reserved for indicating permissions.

OBSERVATION: Observations spell out implications of rules and bring attention to things that might otherwise be overlooked. They also give the rationale behind certain rules, so that the reader understands why the rule must be followed. Any text that appears without heading should be considered as description of the specification.

1.5 Other Applicable Standards

This profile builds on the following published open standards.

LXI Standard 1.0, 1.1, 1.2, 1.3	www.lxistandard.org
IEEE 1588-2008 Standard for a Precision Clock Synchronization Protocol for Networked Measurements and Control Systems	http://standards.ieee.org/

2 LXI Rules and Recommendations for Implementing IEEE 1588-2008

2.1 Identification

PTP Profile

LXI Consortium IEEE 1588 profile for LXI instrumentation and supporting infrastructure.

Version: 1.0

Profile identifier: 00-21-D6-00-01-00

This profile is specified by the LXI Consortium.

A copy may be obtained from <http://lxistandard.org>

2.2 General requirements

2.2.1 Recommendation – Non-volatile storage

LXI Devices should implement the non-volatile storage mechanism for retaining dynamic or configurable IEEE 1588 data set members as specified in IEEE 1588-2008 subclause 8.1.3.

2.3 Best Master Clock Algorithm

2.3.1 RULE – Default best master clock algorithm

LXI Devices shall determine the master-slave hierarchy using the IEEE 1588 specified default best master clock algorithm, clauses 9.3.2, 9.3.3, and 9.3.4, of IEEE 1588-2008.

2.4 Management Mechanism

2.4.1 RULE – Management messages

IEEE 1588 clocks in an LXI Device shall implement the IEEE 1588 management messages specified in clause 15.2 of IEEE 1588-2008.

2.5 Path Delay Mechanism

2.5.1 RULE – Request-response default PTP profile

Unless otherwise specified in this document, the specifications of the Delay Request-Response Default PTP profile of Annex J, clause J.3, of IEEE 1588-2008 shall apply.

2.5.2 RULE – Request-response mechanism

LXI Devices shall use the delay request-response mechanism of IEEE 1588-2008 as the default path delay measurement mechanism.

2.5.3 **Permission – Peer delay mechanism**

In addition, LXI Devices may support the peer delay mechanism of IEEE 1588-2008.

2.5.4 **RULE – Peer delay mechanism inactive by default**

If an LXI Device supports the peer delay mechanism, it shall be inactive unless specifically enabled via a management message with an IEEE 1588 managementId value of DELAY_MECHANISM.

2.5.5 **RULE – Peer-to-peer default PTP profile**

If the peer delay mechanism option is enabled, then unless otherwise specified in this document, the specifications of the Peer-to-Peer Default PTP profile of Annex J, clause J.4, of IEEE 1588-2008 shall apply to all links on which the peer delay mechanism is enabled.

2.5.6 **Recommendation – Retrofit of peer delay mechanism**

IEEE 1588 devices used in an LXI system should be designed such that the peer delay mechanism and the use of this mechanism in synchronizing clocks as specified in IEEE 1588-2008 can be retrofit at a future time.

2.6 **Transport Mechanism**

2.6.1 **RULE – UDP over IPv4**

LXI Devices shall use the UDP over IPv4 transport mapping of Annex D of IEEE 1588-2008 as the default transport mechanism.

2.6.2 **Recommendation – UDP over IPv6**

IEEE 1588 devices used in an LXI system should be designed such that a UDP over IPv6 transport (Annex E), or IEEE 1588 over IEEE 802.3 Ethernet layer 2 (Annex F), can be retrofit at a future time.

2.7 **Clock Types**

2.7.1 **RULE – Slave-only clocks**

LXI Devices shall not be designed as slave-only clocks, IEEE 1588-2008 subclause 9.2.2.

2.8 **Communication Model**

2.8.1 **RULE – Multicast communication model**

LXI Devices shall use the multicast communication model of IEEE 1588-2008 subclause 7.3.

2.8.2 **Permission – Unicast communication model**

In addition, LXI Devices may use the unicast communication model of IEEE 1588-2008 subclause 7.3.1 on links where the options of IEEE 1588-2008 subclauses 16.1 and/or 17.3 are used.

2.9 Timescale

2.9.1 RULE – PTP timescale

The timescale of an LXI system shall be the PTP timescale of IEEE 1588-2008 subclause 7.2.

2.9.2 Permission – ARB timescale

The timescale of an LXI system may be the ARB timescale of IEEE 1588-2008 subclause 7.2, for applications where only relative time is required.

2.9.3 RULE – Grandmaster clockClass

Any LXI Device specifically designed to be the grandmaster clock shall be capable of operating as a clockClass 6 clock, IEEE 1588-2008 subclause 7.6.2.4.

Observation: This means that such a device must have mechanisms to access a traceable source of UTC/TAI time such as GPS, NTP, NIST server, etc. If this mechanism fails, e.g. no network connectivity to external timeservers, then rule 2.9.4 applies.

2.9.4 RULE – Grandmaster clockClass degradation

Any LXI Device specifically designed to be the grandmaster clock shall degrade to a clockClass 7 or 187 clock when appropriate, see IEEE 1588-2008 subclause 7.6.2.4.

2.9.5 Rule – Ordinary clockClass

Any LXI Device not subject to rule 2.9.3 shall initially have a clockClass of 248. If the timescale attributes and the time are set such that the clock correctly supports the PTP timescale then the clockClass may be upgraded to 220. If these attributes become invalid for any reason then the clockClass shall revert to 248.

Observation: The timescale attributes are those that can be set using management messages with IEEE 1588 managementId values of TIME, CLOCK_ACCURACY, UTC_PROPERTIES, TRACEABILITY_PROPERTIES, and TIMESCALE_PROPERTIES. Essentially this means that the timescale of the clock is determined by an administrative procedure involving human intervention. If this is automated for example by regular internet-based access to a NIST timeserver, then the device falls under rule 2.9.3.

Observation: The timescale attributes may become invalid due to a power cycle or sufficient passage of time that the drift of the local oscillator is incompatible with the configured time accuracy. It may also become invalid if sufficient time passes that the validity of the other time properties, e.g. leap second information, may have changed.

2.9.6 RULE – Grandmaster timescale

All ordinary and boundary clocks in an LXI system shall be designed to support the PTP timescale in the event they become the grandmaster.

2.9.7 **RULE – Configuration of clocks**

All LXI Devices with clockClass values of 128 or greater shall be configurable based on the use of management messages with IEEE 1588 managementId values of TIME, CLOCK_ACCURACY, UTC_PROPERTIES, TRACEABILITY_PROPERTIES, and TIMESCALE_PROPERTIES.

2.10 **Clause 16 and 17 Annex K and L Options**

2.10.1 **Recommendation – Implementation of options**

LXI Devices should not implement the options specified in clauses 16 and 17 and in Annexes K and L of IEEE 1588-2008.

2.10.2 **Permission – Unicast negotiation option**

Ports on an LXI Device may implement the unicast negotiation option of IEEE 1588-2008 subclause 16.1.

2.10.3 **Permission – Master cluster table option**

Ports on an LXI Device may implement the master cluster table option of IEEE 1588-2008 subclause 17.3.

2.10.4 **RULE – Use unicast option with master cluster table option**

If a port on an LXI Device implements the master cluster table option, it shall also implement the unicast negotiation option of IEEE 1588-2008 subclause 16.1.

2.10.5 **RULE – Options inactive by default**

In an LXI Device, all implemented options specified in clauses 16 and 17 and in Annexes K and L of IEEE 1588-2008 shall be inactive by default.

2.11 **Synchronization Interval and the value of logSyncInterval**

2.11.1 **RULE – logSyncInterval required values**

The logSyncInterval value for all ordinary and boundary clock ports shall be as specified in the following table:

Attribute	Value	Corresponding synchronization	
		interval (seconds)	sampling rate (Hz)
Default initialization value	0	1	1
Minimum configurable value	One of the integers: -4, -3, -2, -1	0.0625, 0.125, 0.25, 0.5	16, 8, 4, 2
Maximum configurable value	1	2	0.5

2.11.2 **Recommendation – logSyncInterval recommended values**

The logSyncInterval value for all ordinary and boundary clock ports should have a configurable range as defined in the following table:

Attribute	Value	Corresponding synchronization	
		interval (seconds)	sampling rate (Hz)
Minimum configurable value	-4	0.0625	16
Maximum configurable value	1	2	0.5

Observation: For an ordinary clock port on LXI Devices that require exceptional synchronization precision, the preferred logSyncInterval default initialization value may be any integer value in the range -4 to 1 inclusive to allow greater freedom in matching the sampling rate to the characteristics of the clocks and the system and the required synchronization performance.

2.11.3 Permission – Load balancing

For boundary and transparent clocks, the designed aggregate IEEE 1588 message load on all ports may require that increasing the message rate on one or more ports requires a corresponding reduction on the remaining ports.

2.11.4 RULE – Synchronization at all values of logSyncInterval

All boundary clock ports and all ports on ordinary clocks that are in the SLAVE state shall correctly synchronize their local clock for all values of logSyncInterval that they support.

Observation: This rule does not require that the information in all received Sync messages be used in the synchronization process. For example, devices unable to process received Sync messages at a supported rate may selectively ignore Sync messages to reduce the processing load provided synchronization specifications are met. The rule does require that synchronization specifications can be met with a logSyncInterval value of 1, i.e. the minimum permitted sampling rate of 0.5 Hz. This may require that the device synchronization specifications be stated separately for each supported logSyncInterval.

2.11.5 RULE – Master message support at all values of logSyncInterval

All boundary clock ports and all ports on ordinary clocks that are in the MASTER state shall correctly issue Sync messages and respond to Delay_Req messages from a single slave for all supported values of logSyncInterval.

2.11.6 Recommendation – Minimum slave support on grandmaster clocks

All boundary clock ports and all ports on ordinary clocks specifically designed to be the grandmaster should support a minimum of 32 slaves on each port when the slaves are sending Delay_Req messages at the minimum value of the maximum rate permitted (i.e. 1 Delay_Req message every 32 Sync messages, clause 7.7.2.4 of IEEE 1588-2008) and the configured logSyncInterval on the port is -1, i.e. a sampling rate of 2 Hz. Note- this recommendation corresponds to an average rate of received Delay_Req messages of 2 Hz.

Observation: A master clock advertises the maximum permissible rate of sending Delay_Req messages by its slaves. The minimum value of this maximum permissible rate is 1 Delay_Req message every 32 Sync messages. Note that a slave can send Delay_Req messages at a slower rate, but on average cannot exceed this advertised value. A master can increase the advertised rate at its discretion from 1 every 32 to a 1 to 1 ratio of Sync to Delay_Req messages.

2.11.7 Recommendation – Minimum message support on transparent clocks

All transparent clock ports should support a minimum of 16 Delay_Req messages per second received on each downstream port and 16 Sync messages per second received on the upstream port. In addition, they should support all IEEE 1588 Follow_Up or Delay_Resp messages associated with the Sync or Delay_Req messages, respectively.

2.12 priority1

2.12.1 RULE – priority1

On LXI Devices the default initialization value of priority1, IEEE 1588-2008 subclause 7.6.2.2, shall be 128 for all ordinary clocks meeting recommendation 2.11.6.

2.12.2 Permission – priority1

On LXI Devices the default initialization value of priority1, IEEE 1588-2008 subclause 7.6.2.2, may be 255 for ordinary clocks not meeting recommendation 2.11.6. If not set to 255, the value shall be set to 128.

Observation: An ordinary clock not meeting the requirements of recommendation 2.11.6 may not be suitable for selection as grandmaster in a system if for example clocks with greater processing power are available. A value of 255 ensures that such clocks will not become grandmaster unless the system consists solely of similar clocks or if the system integrator reconfigures the values of priority1. Most LXI instrumentation will have sufficient capacity to warrant a priority1 initialization value of 128.

2.13 clockIdentity

2.13.1 RULE – EUI-64 or EUI-48 clockIdentity

LXI Devices shall construct clockIdentity values, IEEE 1588-2008 subclause 7.5.2.2, based on EUI-64 or EUI-48 as specified in IEEE 1588-2008 subclause 7.5.2.2.2.

2.14 LXI Specific TLVs

2.14.1 RULE – Support of LXI specific IEEE 1588-2008 TLVs

The following LXI specific TLV specifications shall be supported on all LXI Devices implementing IEEE 1588-2008. The implementation of these TLVs shall conform to the terms of IEEE 1588-2008 section 14.3.

2.14.2 RULE – TLV field values and interpretation

The LXI specific TLV field values shall be as defined as follows:

- tlvType (Enumeration16); ORGANIZATION_EXTENSION (value = 0003 hex)
- organizationId (Octet[3]); The OUI of the LXI Consortium. Octet[0] = 00, Octet[1] = 21, Octet[2] = D6

- lengthField (UInteger16); N+ 6 where N is the number of octets in the dataField and N is an even number.
- dataField (N octets): organizationSubType specific.
- organizationSubType (Enumeration24): The LXI specific TLV organizationSubType, lengthField, and dataField values and interpretations shall be as specified in the following table:

organizationSubType		lengthField	dataField	Interpretation
Name	Value (hex)	UInteger16 decimal	(hex)	
NOT_DEFINED	FFFFFF	Consistent with user specified dataField value	User specified	This TLV shall be ignored on receipt except for determining the length to allow locating any following TLV. This is a permanently reserved value. This TLV may be used in conformance testing for IEEE 1588-2008 section 14.1.

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