LXI Event Messaging Extended Function

Revision 1.0

8 November 2016

Reference Documents

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Revision history

Revision	***Description***
1.0 Version	Initial Release November 8, 2016

1 Overview

1.1 Introduction

With LXI Event Messaging, an LXI Event message containing triggering information is sent directly from one device to another via the LAN, without computer intervention.

LAN-based triggers provide programmatically triggered events through driver commands from the controller to the LXI device or by message exchange between LXI devices. They emulate traditional hardware triggers but can carry information that hardware triggers cannot - such as trigger slope and time stamps based on synchronized system clocks. Antenna Testing can make good use of this capability where a signal source and analyzer, separated by line-of-sight, can trigger each other over the LAN.

1.2 Purpose and Scope of this Document

1.2.1 Purpose

Each LXI Extended Function has its own document with unique section numbering that, if merged with the LXI Specification Core document, would produce a contiguous representation of the entire LXI Specification.

This document supplies the requirements for LXI conformance to the LXI Event Messaging Extended Function.

1.2.2 Scope

This document defines a common set of **RULES** and **RECOMMENDATIONS** for constructing a conformant LXI Device with one or more Extended Functions. Whenever possible these specifications use existing industry standards.

The original LXI Device Specification included both requirements for all LXI Devices and a number of Extended Functions in a single document. Common information remains in the LXI Device Specification and specific information related to the Extended Function moves to separate documents.

1.3 Definition of Terms

This document contains both normative and informative material. Unless otherwise stated the material in this document shall be considered normative.

NORMATIVE: Normative material shall be considered in determining whether an LXI Device is conformant to this standard. Any section or subsection designated as a RULE or PERMISSION is normative.

INFORMATIVE: Informative material is explanatory and is not considered in determining the conformance of an LXI Device. Any section or subsection designated as RECOMMENDATION, SUGGESTION, or OBSERVATION is informative. Unless otherwise noted examples are informative.

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.

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.

1.4 Additional LXI Conformance Requirements

1.4.1 Extended Functions

1.4.1.1 General Description

The LXI Standard consists of the LXI Device Specification, required for all LXI Devices. In addition, it includes all optional Extended Functions.

LXI Extended Functions

Extended Functions come in the form of external documents. Each Extended Function document will have sections numbered as though they were part of the LXI Device Specification, but the documents are separate to simplify maintenance of the standard and to add new Extended Functions without altering the LXI Device Specification. The ***Guide to LXI Documentation*** identifies the Extended Function documents.

1.4.1.2 Conformance Requirements

The rules in this document define the conformance requirements for this Extended Function. In addition to the requirements for all LXI Devices found in the ***LXI Device Specification***, an Extended Function may require conformance to another Extended Function. All these requirements are detailed in the following Rule.

1.4.1.2.4 RULE – Event Messaging Conformance Requirements

The rules in this document define the conformance requirements for this Extended Function. In addition to the requirements for all LXI Devices found in the LXI Device Specification, there may be cases where an Extended Function requires conformance to another Extended Function. All requirements follow below:

LXI Device Specification Document:

- All LXI Devices shall conform to the rules found in Section 1.4 and all subsections
- Sections 3.5 and 3.7, including all subsections
- Section 6.1.1, sections 6.3 through 6.6, including all subsections
- Section 9.6, including all subsections
- A Function element with the FunctionName attributes of “LXI Event Messaging” and version “1.0” in the LXIExtendedFunction element of the LXI identification document as described in Section 10.2.5

LXI Event Messaging (this document):

- Include all rules.

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3 LXI Device Synchronization and Events

Section 3 of the LXI Device Specification summarizes the various methods of synchronization and triggering available for LXI Devices.

3.3 LXI Event Messages

This section defines the mechanism for communicating LXI Event Messages between modules in an LXI system. The rules of this section make it possible for LXI Devices to communicate timestamped information about asynchronous events to one another directly over the LAN, without the need for controller intervention.

Section 4 of this document defines the data format for LXI Event Messages and the on-the-wire message format necessary to achieve overall instrument compatibility.

Section 6.4 in the ***LXI Device Specification*** defines a programmatic use model for these LXI Event Messages.

3.3.1 RULE – LXI Event Message Communication Transport Mechanism

All LXI Devices that transmit or receive LXI Event Messages shall be capable of the following:

- Using both multicast UDP and unicast TCP Stream transports for these transmissions.
- Listening for and responding to LXI Event Messages using both multicast UDP and unicast TCP Stream transports.

3.3.1.1 RULE – LXI Multicast Address and Port Numbers for LXI Event Messages

LXI Devices shall use the IANA registered multicast address 224.0.23.159 for LXI Event Message transmission using UDP multicast.

LXI Devices shall implement a UDP port listener (multicast capable) and a TCP socket listener for the purposes of receiving LXI Event Messages. The TCP listener shall be capable of at least 8 simultaneous connections. These listeners shall default to the IANA registered port number 5044 for LXI Event Messages—user configuration may override this default.

3.3.2 RULE – Require Specified Data Format for LXI Event Messages

LXI Event Message communication shall use the format specified in Section 4.

3.3.2.1 RULE – Use of LXI "Domain"

All modules receiving LXI Event Messages shall use the "domain" byte in the LXI Event Message to ensure that each received LXI Event Message is intended for receipt by the module. Each module shall be configurable as to the domain of which it is a member. Upon receipt of an LXI Event Message, the device shall ignore those whose "domain" byte does not match the locally configured value.

3.3.2.1.1 RULE – Other Uses of the "Domain" Byte Disallowed

The "domain" byte shall not be used other than as specified by Rule 3.3.2.1.

Observation – Clarification of Intent of RULE 3.3.2.1

> Rule 3.3.2.1 allows multiple test systems to coexist on the same LAN. In this scenario, every test system will receive UDP multicast packets from every other system. This rule makes it possible for the various modules to be sure that they can distinguish the LXI Event Messages properly. Every module in a test system should be configured to be a member of the same domain; other test systems should be in different domains.

3.3.3 RULE – LXI Events to be Transmitted in an LXI Event Message

LXI Devices shall be configurable as to whether or not they transmit an LXI Event Message for any given LXI Event. Such events shall be the following:

- LXI Events specified in this standard
- LXI Device-specific events specified by the vendor
- Application-specific events specified by the user.

For these LXI Event Messages:

1. The Event ID shall be the following:
    a. A value specified in this document; e.g., LAN0
    b. A vendor-specific value documented by the vendor
    c. An application-specific value specified by the user.
2. The timestamp, T1, in the transmitted LXI Event Message shall be the time at which the LXI Event occurred or will occur with respect to the local clock of the transmitting module. Please refer to Section 3.3.7 for information on timestamps of zero. Note that it is permissible for a module to schedule a local or system-wide LXI Event in the future. For example, a controller can specify that “test-A” will start at some future time, or an instrument can specify that it will go out of calibration at some future time.
3. The data fields shall be null by default, but additionally may be:
    a. Specified in this document for standard-specified Event IDs
    b. A vendor-specific value documented by the vendor
    c. Application-specific as specified by the user.

Section 6.4.4 of the ***LXI Device Specification*** document contains details on the API that may be used for configuration.

3.3.4 RULE – Response to Received LXI Event Messages

It shall be possible for the user to program the LXI Device’s response to an LXI Event as follows:

1. By default, the LXI Device shall not respond to the LXI Event Message.
2. The nature of the response shall be based on the Event ID and shall be specified or configured by the user. This does not preclude vendors from specifying a default response that can be overridden by the user.
3. The action time, T2, shall be computed as T2=T1+Dt. The time T2 may be in the past or the future and shall be interpreted in the context of the local clock of the receiver of the LXI Event Message. By default, Dt shall be zero.
4. The use of the data field shall be specified by the user. This does not preclude vendors from specifying a default interpretation for a specific Event ID.

For all events, the specified response shall occur when the action time T2 matches the local clock in the receiving LXI Device. Note that the accuracy and precision of this match depends on the implementation of IEEE 1588 and the design of the LXI Device.

When T2 is in the future, LXI Devices shall schedule an internal alarm or similar mechanism to cause the specified response to occur at the proper time.

When T2 is in the past, LXI Devices shall take immediate action by default. Additionally, vendors may provide user-selectable options for the behavior when T2 is in the past, including no response (ignore) as well as LXI Device-specific semantics (e.g., report data previously measured at time T2 and stored for future retrieval).

While many LXI Devices will likely provide a standard trigger/arm state machine model to respond to LXI Event Messages, the use LXI Event Message is not limited to such behavior models. For the trigger layer of the trigger/arm state machine (as seen in the figure accompanying Rule 6.4.4 of the ***LXI Device Specification***), T1 is the time at which the transition from “WaitingForTrigger” to “Wait: trigger delay” occurs. Dt is the time spent in the “Wait: trigger delay” state and T2 is the time at which the measure layer is entered.

Please refer to Section 6.4.4 of the ***LXI Device Specification*** document for reserved Event IDs.

Section also contains details on the API that may be used to configure these responses.

Observation – Publish/Subscribe Architecture

> Rules 3.3.1, 3.3.2, 3.3.3, and 3.3.4 implement a common publish-and-subscribe architectural design pattern for LXI Event Messages.

Observation – UDP Reliability

UDP is sometimes referred to as an “unreliable” protocol. It is possible for UDP data packets to be lost in transit. Most test systems, which are expected to be configured into small private subnets with modern LAN switches, will never experience UDP packet losses. More complicated network installations may encounter situations in which data can be lost. In these cases, TCP links may be utilized at the cost of higher latency. In addition, it is possible to enhance the reliability of UDP transmissions by any of several means, including automatic re-transmission of packets and custom handshaking protocols. The LXI specification does not mandate any of these methods. However, the LXI Event Message format specified in Section 4 includes some support for them to ensure that LXI Devices from different manufacturers can work together even if some of them attempt to enhance UDP reliability and others do not. Refer to that section for further details. Vendors may choose to implement some method of enhancing UDP reliability optionally, but such features must be carefully documented to ensure interoperability with other manufacturers’ instruments.

In addition, it is possible for UDP packets to arrive out of sequence. Although this will only be seen on rare occasions in complex networks, LXI Devices should be designed to account for the possibility. The LXI Event Message format in Section 4 includes a sequence number that can be used to detect out-of-order packets.

3.3.4.1 **RULE – Interpretation of Times Associated with LXI Event Message Communications**

The following definitions and figure shall be used to clarify the timing behavior of responses to LXI Event Messages:

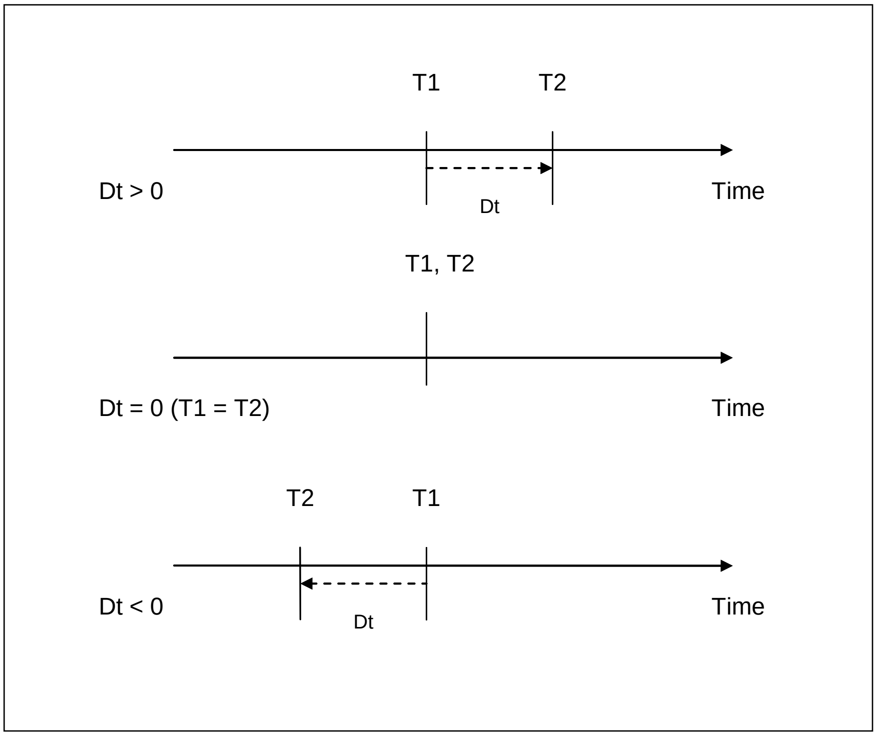
Reception Time – Time when an LXI Event Message is received by a module. This time is normally logged in the LXI Event Log.

Trigger Time – The point in time at which the response to an event begins. This is the timestamp field of the LXI Event Message. In the classic SCPI trigger state machine (see example figure in Section 6.4.4 of the ***LXI Device Specification***), the response to a trigger event causes the state machine to begin the optional offset (e.g., trigger delay or advance) and then the triggered action (e.g., take a measurement, enable source output, change switch configuration, etc.).

T1 = Trigger Time – Timestamp field of the LXI Event Message. If T1 is zero (“Now”), it is replaced with the current time of the receiving clock.

Dt = Offset – This may be zero, positive, or negative.

T2 = Action Time – Examples of this time are as follows: take a measurement, enable source output, change switch configuration, etc.



3.3.5 Recommendation – Support LXI Events with Arbitrary Event IDs

In addition to the Event IDs "LAN0" through "LAN7", LXI Devices should support LXI Events with arbitrary Event IDs.

3.3.6 RULE – Ignore LXI Event Message with Unknown Event ID

If an LXI Device receives an LXI Event Message with an Event ID not known by the LXI Device, the LXI Device shall ignore the message.

3.3.6.1 Permission – Log Unknown LXI Event Messages

If an LXI Device receives an LXI Event Message with an Event ID not known by the LXI Device, the LXI Device may log this event in an LXI Event Log.

3.3.7 RULE – Timestamp of Zero

If a module receives an LXI Event Message with a Timestamp field of zero, the time indicated by the timestamp shall be interpreted as “now” by the receiving module, i.e., the current time as it is understood by the receiving module.

A module shall transmit an LXI Event Message with a value of zero for the Timestamp field only if one or more of the following apply:

- The module does not implement IEEE 1588
- The LXI Device is overloaded and cannot capture timestamps fast enough. This condition should be considered a serious or fatal error.
- The user-specified semantics required upon receipt is “now.”

3.3.8 RULE – LXI Event Interpolation

When transmitting LXI Event Messages with a Stateless Event (Flags Bit 4) value of 0 (zero), devices shall behave as follows:

- when transmitting LXI Event Messages configured to be in Wired-OR mode the device shall transmit only a single sense of the event in Hardware Value (Flags Bit 2)
- otherwise, devices shall send both senses of the event in Hardware Value (Flags Bit 2)

When the value of Stateless Event (Flags Bit 4) is zero, recipients of events are required to compare the sense of incoming events with the current state of that event. If the received event sense (value of Hardware Value – Bit 2) is identical (true or false) to the current state of the event, recipients must interpolate an opposite sense event occurring immediately prior to the received event and behave accordingly.

Note: The Wired-OR mode of transmission for LXI Events does not implement true Wired-OR logic in the way that the LXI Wired Trigger Bus does. Wired-OR mode has no mechanism for detecting the absence of all signals (the false state) because it is impractical to keep an infinite buffer of all packets received.

Observation – Rule Replacement

This rule replaces Rule 6.7.1 (LXI Events Mimic Hardware Wired-OR Capability) in LXI Standard 1.0 and 1.1. The original rule included event interpolation capability but implied a more complex implementation that has been deprecated.

Observation – Transmission by Multiple Event Sources

This rule adds more robust behavior for the case in which multiple event sources are transmitting to one or more receivers. For example, normal operation of an LXI Event is to send an event packet on any logical signal transition (both rising and falling edges). Such operation is essential for anyone who desires to use the event system to link two hardware signals over the LAN in a point-to-point connection or who needs to take some action on both sides of the signal. However, when multiple sources actively transmit triggers to one or more receivers, it is possible for leading and trailing edges to overlap and cause triggers to be lost in the trigger logic. This happens in part because there is no guarantee that all of the packets will arrive in the same order in which they were transmitted. Therefore, when the Wired-OR mode of transmission is selected for LXI Events, only one edge (user-selectable) of the signal actually causes an LXI Event packet to be transmitted. Wired-OR mode works in conjunction with Rule 3.3.8 to provide a signal edge for each packet sent. The receivers are expected to take appropriate action each time a packet is received. This scenario is expected to be a common use model for some systems. One side benefit of this particular scenario is that the LXI Event traffic is cut in half, which may be an important throughput consideration for very large or dispersed systems.

3.4 Recommendation – Programmable LXI Devices

Introduction 3.1 of the ***LXI Device Specification*** document implies that LXI Devices can respond to and generate LXI Events based on user configuration. There are a number of ways in which this feature can be implemented, the simplest of which is to pre-define all of the possible responses that an LXI Device might execute for each LXI Event. It is recommended that LXI Devices be programmable for this purpose and capable of downloading executable code.

4 Module-to-Module Data Communication of LXI Event Messages

4.1 Introduction

This section describes the data format for direct module-to-module messages. These messages are LXI Event Messages that are either multicast on the LAN via UDP or transmitted through a point-to-point TCP connection. Each message is timestamped and signals the occurrence of some LXI Event in the system. LXI Devices in the system can be programmed to broadcast messages (or not) as needed.

4.2 RULE – LXI Event Message Size

For UDP communications, the total size of the data used for module-to-module communications of LXI Event Messages shall not be larger than a single LAN data packet.

Observation – Clarification of Intent of RULE 4.2

LXI Event Messages must be encoded into single packets on the LAN to achieve minimum latency and avoid unacceptable complications to the use of UDP multicasting.

LAN data packets will be fragmented if they are too big. However, “too big” is a user-definable parameter. A common value is 1400 bytes, but users may set this parameter to a larger or smaller value. Fortunately, LAN devices must always be able to accept packets of at least 512 bytes without fragmenting the packet. If all the devices in the system are suitably configured, packet size may be larger. It is the responsibility of the system integrator to ensure that systems are properly configured.

The available space in a packet depends on the LAN options that are being used and whether IPv6 is implemented. Overall, it is reasonable to expect that at least 450 bytes will be available for data packets. Some of this space is allocated for required data fields such as a timestamp (see the following paragraphs for details). The rest of the space is available for user-defined purposes, subject to the formatting constraints described below.

For TCP-based communications, any fragmented packets will automatically be reassembled by the receiving module’s protocol stack. In this case, module-to-module communication of LXI Events may include data of any size. However, the larger the data, the longer it takes to get to the receiver. Time-critical communications will generally use small packet sizes.

4.3 RULE – LXI Event Message Format

Module-to-module LXI Event Messages shall contain the following fields as specified. Please see ***LXI Event Message Examples*** in the *LXI Example and Reference Material* document for examples.

HW Detect	Domain	Event ID	Sequence	Timestamp	Epoch	Flags	Data Fields…	0 (two bytes)

Each field is described below. It is assumed that one byte is the standard size, i.e. 8 bits (also referred to as an octet). Furthermore, *all multi-byte numeric fields are big-endian (most significant byte comes first). Within each byte (octet) of the fields described above the least significant bit is transmitted first. For octet array fields the most significant field is transmitted first. The most significant array field is the field with index 0.*

The above fields shall be marshaled into the on-the-wire format in the following order:

HW Detect: Octet array of length 3: Used as a "magic value" to identify valid packets, and also reserved for future hardware detection of LXI Event packets. This field should be set to the value "LXI." Note that the third octet, ASCII "I" is also used as a version identifier; future revisions to this spec may change this value.

Domain: UInteger8. The default value shall be zero.

Event ID: Octet array of length 16: Contains an LXI Event identifier. This field shall contain the first 16 octets of the LXI Event name (a sequence of ASCII characters) specified in the LXI API. Event names longer than 16 ASCII characters are truncated to the first 16 characters. All LXI Event names listed in the table of strings for triggering and synchronization in Rule 6.4.4 of the LXI Device Specification document that refer to repeated capabilities are predefined by the LXI Consortium. All LXI Event names beginning with the 3 ASCII characters LXI are reserved by Rule 6.4.5, also in that document. All other names are available to users. The leading character shall be in the octet with index 0. For LXI Event names of less that 16 characters the unused octets shall be set to 0x00. This field is not NULL-terminated (0x00) but appears so if the LXI Event name happens to be less than 16 characters. All 16 octets of this field are significant.

Sequence: UInteger32: Contains a sequence number. Each transmitting instrument shall maintain the following independent sequence counter(s):

- One for each combination of UDP multicast network interface and UDP multicast destination port that the instrument supports

- One for each TCP connection.

Upon transmitting an LXI Event message, an instrument shall increment the sequence counter associated with the transport for that message by one.

The initial value of a sequence counter is not defined by this standard and is left up to the vendor.

By specifying how sequence numbers are generated, modules and applications may implement various forms of duplicate packet detection; however, discussion of duplicate packet detection is beyond the scope of this standard.

(Note: If packets are re-transmitted to enhance reliability, re-transmitted packets shall contain the same sequence number as the original.)

Timestamp: 10 octets: A timestamp that identifies the time that the LXI Event occurred or will occur. This timestamp shall use the format specified here:

```
struct TimeRepresentation
{
   UInteger32 seconds:
   UInteger32 nanoseconds:
   UInteger16 fractional_nanoseconds:
}
Where:
The seconds field is the least significant 32 bits of the seconds
field of the IEEE 1588 data type Timestamp.
The nanoseconds field is the nanoseconds field of the IEEE 1588 data
type Timestamp. The nanoseconds field is always less than 10+9.
The fractional nanoseconds field shall be any fraction of a
nanosecond provided by the timestamp mechanism of the IEEE 1588
clock. Note that in the IEEE 1588 on-the-wire communication used for
synchronizing clocks, this information will be contained in the
correctionField. The application interface to the local clock may or
may not present fractional nanosecond information. If none is
provided then this field shall be zero.



These fields shall be marshaled into their on-the-wire format in the
following order: seconds, nanoseconds, fractional_nanoseconds.



For example:
+2.0 seconds is represented by seconds = 0x00000002 and nanoseconds =
+0x00000000
-2.0 seconds is represented by seconds = 0x00000002 and nanoseconds =
0x80000000
+2.000000001 seconds       by seconds = 0x00000002 and nanoseconds =
0x00000001
```

If no event timestamp is available, for example if the event is derived from a legacy device or an LXI Device incapable of assigning a timestamp, a time value of 0 (zero) shall be assigned to the timestamp. A value of 0 for a timestamp shall be interpreted as "now," i.e., the time when the recipient handles the message.

Epoch: A UInteger16 that contains the most significant 16 bits of the seconds field of the IEEE 1588 data type Timestamp. Devices incapable of assigning a timestamp shall assign a value of zero (0) to the epoch.

Observation – Rational for Changes in the Definition of Timestamp and Epoch

In IEEE 1588-2008 two significant changes were made in the representation of timestamps: the former IEEE 1588-2002 epoch and seconds fields were combined into a single UInteger48, and negative timestamps are no longer allowed. Eliminating negative timestamps has no practical effect on LXI since negative timestamps do not occur in an LXI system. The change in datatype required the revision of the relationship between LXI and IEEE 1588-2008 timestamp datatypes.

Flags: UInteger16 that contains data about the packet. Bits within the flag byte are defined as follows:

Bit 0 – Error Message: If set to 1, shall indicate that this packet is an error message.

Bit 1 – Reserved. This bit shall be set to zero.

Bit 2 – Hardware Value: A logical value that characterizes trigger events (particularly hardware events). Refer to the programmatic interface section of the LXI spec for further explanation.

Bit 3 – Acknowledgement: If set to 1, shall indicate that this packet is an acknowledgement that a prior packet was successfully received. This allows LXI systems to implement UDP-based handshaking protocols (for increased reliability), if desired. Modules are not required to implement this feature; however, those modules shall ignore packets if this bit is set.

Bit 4 - Stateless Event. If set to 0 (required in versions of this standard prior to 1.2), shall indicate that the contents of Hardware Value (Flags Bit 2) must be monitored by receiving modules. If set to 1, indicates that the LXI Event being transmitted is stateless and thus the contents of Hardware Value (Flags Bit 2) must be ignored by receivers.

Bit 5-15 – Reserved. All bits shall be set to zero.

Data Fields: Arbitrary number of bytes, up to the capacity of the LXI Event Message. Each data field shall be formatted as follows:

Data Length (UInteger16): Length of the User Data that follows the next Identifier field. This field shall contain a zero if no further data is contained in the packet. The value of this field does not include the 1-octet Identifier in the length.

Identifier (Integer8): A user-definable identifier that specifies the type of data to follow. Numbers from zero to 127 are available for user-defined identifiers. All negative values are reserved for specification by the LXI Consortium.

The LXI Consortium has defined the following Identifier values:

Value	**Data Type**	**Length (Octets)**	**Notes**
-1 (0xFF)	ASCII Data	1	ASCII Character String; not null-terminated
-2 (0xFE)	int8	1	Two's-complement
-3 (0xFD)	uint8	1	
-4 (0XFC)	int16	2	Two's-complement; multi-octet fields are big-endian
-5 (0XFB)	uint16	2	Multi-octet fields are big-endian
-6 (0XFA)	int32	4	Two's-complement; multi-octet fields are big-endian
-7 (0xF9)	uint32	4	Multi-octet fields are big-endian
-8 (0xF8)	int64	8	Two's-complement; multi-octet fields are big-endian
-9 (0xF7)	uint64	8	Multi-octet fields are big-endian
-10 (0xF6)	float32	4	IEEE 754 Format; multi-octet fields are big-endian
-11 (0xF5)	float64	8	IEEE 754 Format; multi-octet fields are big-endian
-12 (0xF4)	float128	16	IEEE 754 Format; multi-octet fields are big-endian
-13 (0xF3)	UTF-8 Data	1	Unicode String Data encoded in UTF-8; not null-terminated
-14 (0xF2)	UTF-8 JSON	1	JSON encoded in UTF-8; not null-terminated
-15 (0xF1)	UTF-8 XML	1	XML encoded in UTF-8; not null-terminated
-16 (0xF0)	Octet	n	Uninterpreted octet

For any of the LXI Consortium-defined Identifier values, the Data Length field may be an integer multiple of the data type's length, indicating that a sequence of values of the indicated data type is stored in the User Data field. For example, for a sequence of 3 int16 values the Data Length value is 6. Note that the Data Length field is always a length in octets, regardless of the Identifier value.

User Data (succeeding bytes): Data as an octet-array whose length is given by the Data Length field.

There may be multiple data fields in an LXI Event packet. The packet ends when a zero (two bytes) is encountered as the length of the next field or when the maximum data payload limit is reached.

This variable-length data field is designed to satisfy two different needs. First, it allows the LXI Consortium to define new data fields that may become a part of the LXI specification. Second, it allows vendors to define proprietary data fields of their own. LXI Event Messages containing user data with identifiers not known by the module shall be ignored.

The specification of the data identifiers in the above table does not require implementers to be able to parse all possible values, e.g. it is not required to implement a XML parser because of this table.

4.3.1 RULE – Use of HW Detect Field

LXI Devices shall ignore any received LXI Event Message if the value of the HW Detect field does not match the value pertinent to the version of the LXI specification to which the LXI Device conforms.

Observation – LXI Event Message Version

> The ‘HW Detect’ field is currently specified as “LXI”. This value may change in the future as new versions of the LXI specification become available. Every effort will be made to ensure that later versions of the LXI Event Message format are compatible with earlier versions, but this cannot be guaranteed.

4.3.2 RULE – Use of Domain Byte

LXI Devices shall maintain an internal configuration option that allows users to specify the value of the Domain field. Upon transmitting an LXI Event Message, LXI Devices shall copy that value to the Domain field. Upon receiving an LXI Event Message, LXI Devices shall ignore all packets whose Domain field does not match the LXI Device’s own.

Observation – Clarification of the Intent of RULE 4.3.2

> The Domain value is designed to allow multiple test systems to coexist on the same subnet. The instruments in each test system should be configured to have the same ‘Domain’ setting. Each test system would then ignore any messages that were transmitted by the other. This allows identical software to run on multiple test systems that are on a single subnet.

4.3.3 RULE – NULL Events

If the Event ID field of an LXI Event Message contains only zeros, the event shall be considered a “null event.” All LXI Devices shall ignore null events, except that unless LXI Event Logs are disabled they shall be recorded in log files for debugging purposes.

4.3.4 RULE – Acknowledgements

One possible way to improve the reliability of UDP data transmissions is to program the receiving module to return an acknowledgement upon receipt of an LXI Event Message. If this is implemented, the acknowledgment packet shall have set the Acknowledgement flag (bit 3 of the Flags byte) to 1. LXI Device that do not implement this feature shall ignore received LAN Event Messages if this flag is set to 1.

Observation

> Acknowledgements have not proven necessary on typical network. Only heavily loaded networks are at risk of UDP packet loss.

4.3.4.1 RULE – Handling Acknowledgement Packets

If a module receives an LXI Event Message with the Acknowledgement flag set to 1, and the module does not implement a handshaking protocol, then the module shall ignore the packet.

Observation – Re-transmission/Acknowledgement Not Needed with TCP

> If point-to-point TCP data transmission is utilized, re-transmission or handshaking protocols need not be implemented. TCP will automatically attempt up to five re-transmission and acknowledgement cycles to increase the reliability of packet delivery. Note that if the LXI Event is time critical, latency of TCP will be much greater (about five times greater, even if the connection is already established) than for UDP.

4.4 RULE – Pre-defined Error Messages

Some LXI Event Messages may contain error messages rather than LXI Event notifications. These messages are broadcast on the same address and port as normal LXI Event Messages, but the Error bit (bit zero) of the Flags field of the LXI Event Message is set to 1. This allows the creation of an "LXI Event monitor" tool that can be used for debugging and can quickly identify errors as they occur.

Errors can be further identified by the use of the data fields in the message. This allows specific errors to be identified by an ID number, a descriptive string, or both.

Certain error messages are predefined. For these messages, the Event ID field in the LXI Event Message shall be set to "LXIError." The Data Field shall consist of an Error Identifier and possibly error specific data. Error identifiers shall be an Integer8 with negative values reserved for definition by the LXI Consortium.

The following table lists the LXI Consortium defined error message Error Identifier and error specific data definitions.

Error Identifier	Error definition	Error specific data
-1	Time reset. A time reset has occurred. The error message is broadcast once by the grandmaster clock whenever the grandmaster IEEE 1588 clock has drifted away from a traceable source of UTC and is being adjusted.	The time offset that is needed to bring the timescale into agreement with UTC. The data type shall be the TimeInterval of IEEE 1588 (Integer64 scaled nanoseconds)

For example, the contents of the Data Field of Rule 4.3 for the LXI defined error Time reset are:

Data Length (UInteger16)	Identifier (Integer8)	User Data (error identifier)	Data Length (UInteger16)	Identifier (Integer8)	User Data
Octet 0 – 1	Octet 2	Octet 3	Octet 4 – 5	Octet 6	Octets 7-14
0x0001	0xFE (Integer8)	0xFF (-1)	0x0008	0xF8 (Integer64)	IEEE 1588 TimeInterval