



AEROSPACE STANDARD	AS5643™	REV. B
	Issued 2004-12 Revised 2016-04 Reaffirmed 2025-04 Superseding AS5643A	
(R) IEEE-1394b Interface Requirements for Military and Aerospace Vehicle Applications		

RATIONALE

Update document to incorporate lessons learned from manufacturing, production, and flight test since AS5643 REV. A.

AS5643B has been reaffirmed to comply with the SAE Five-Year Review policy.

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1. SCOPE

IEEE-1394b, Interface Requirements for Military and Aerospace Vehicle Applications, establishes the requirements for the use of IEEE Std 1394™-2008 as a data bus network in military and aerospace vehicles. The portion of IEEE Std 1394™-2008 standard used by AS5643 is referred to as IEEE-1394 Beta (formerly referred to as IEEE-1394b.) It defines the concept of operations and information flow on the network. As discussed in 1.4, this specification contains extensions/restrictions to “off-the-shelf” IEEE-1394 standards and assumes the reader already has a working knowledge of IEEE-1394.

This document is referred to as the “base” specification, containing the generic requirements that specify data bus characteristics, data formats, and node operation. It is important to note that this specification is not designed to be stand-alone; several requirements leave the details to the implementations and delegate the actual implementation to be specified by the network architect/integrator for a particular vehicle application. This information is typically contained in a “network profile” slash sheet that is compliant with this base specification. In a similar manner, the electrical characteristics of the bus media, as well as connector information, is contained in a “physical layer” slash sheet that also may be unique to a particular vehicle application.

In summary, full understanding of this specification requires knowledge of IEEE Std 1394™-2008 standards and access to the physical layer slash sheets, slash sheets, and handbook for the target application.

1.1 Purpose

The purpose of this document is to standardize an approach to using IEEE-1394 in safety-critical/mission-critical applications for military and aerospace vehicles. The information herein will be used to assist the design, fabrication, and maintenance of the nodes that interface via the vehicle's network.

This document is controlled and maintained by SAE International with technical support from Remote Node vendors.

1.2 Application

The IEEE-1394 Network defined in this document provides a deterministic, rate-based communication protocol overlaid on the existing IEEE-1394 standard capabilities.

1.3 Interpretation

The following interpretations shall be placed upon these words, unless stated otherwise, where they are used in this document.

May: An allowed action.

Shall: A mandatory requirement.

Should: A recommended action.

Will: A declaration of intent.

1.4 Additions to the IEEE Std 1394™-2008 Standard

Additions include the use of asynchronous stream packets, a fixed frame rate synchronized with a Start Of Frame packet, addition of a Vertical Parity Check, static assignment of channel numbers, pre-assignment of bandwidth, and use of Anonymous Subscriber Messaging. IEEE Std 1394™-2008 was baselined using IEEE-1394-1995 and amendments: IEEE Std 1394a-2000; IEEE Std 1394b-2002, and IEEE Std 1394c-2006.

1.4.1 Use of Asynchronous Streams

Asynchronous streams are used for the majority of communication on the network. Asynchronous and isochronous packets are not required but may be utilized. Architectures and protocols discussed in the context of this document are based on asynchronous streams, unless otherwise mentioned. An example of using asynchronous packets would be to allow test equipment to read data from a Configuration ROM. An example of using isochronous packets would be for streaming video and/or audio.

1.4.2 A Fixed Frame Rate

If isochronous packets are not utilized, there is no requirement for Cycle Start packets to be sent at the normal 125-μs rate. Instead, this implementation provides a fixed frame rate for synchronization of the network. If isochronous packets are utilized, it is necessary to utilize the Cycle Master function so the 125-μs periodic cycle starts are available to isochronous sources that expect them. Figure 20 in 3.3.3.3 shows an example of interleaving isochronous packets and asynchronous stream packets.

1.4.3 Synchronization via Start of Frame Packets

A Start Of Frame (STOF) packet is transmitted by the Control Computer on each bus at a periodic (e.g., 100 Hz) frame rate. This packet informs all nodes on the bus that a new frame has started.

1.4.4 Static Assignment of Channel Numbers

Asynchronous stream packets use the same packet format as isochronous packets; therefore, the destination of the packet is identified by a channel number. Unlike commercial applications, channel numbers are not allocated through the Isochronous Resource Manager (IRM). Instead, the channel numbers for each node on the bus are pre-assigned, are application specific, and will be defined as required by the architecture.

1.4.5 Pre-Assignment of Bandwidth

Unlike commercial applications, the static nature of AS5643 implementations allow bandwidth to be pre-assigned. Transmit and receive times for each node on the bus are assigned as offsets, in increments of 1 μs, from the start of each frame (STOF packet). The offsets for each node on the bus are application specific and will be defined as required by the architecture.

1.4.6 Vertical Parity Check

Vertical Parity Checking (VPC) is performed on the data area of each packet as an adjunct to the Cyclic Redundancy Check (CRC) performed by the 1394 physical layer devices. The VPC provides additional data integrity as the messages progress through the physical and software layers.

1.4.7 Anonymous Subscriber Messaging

Anonymous Subscriber Messaging (ASM) is a protocol in which a Remote Node on the network can subscribe to each message that it requires. The ASM software in the Remote Node will forward only the messages to which the Remote Node has subscribed.

ASM is an upper level protocol tailored for the demands of highly modular embedded real-time systems operating under a “data push” paradigm. ASM is designed to be independent of lower level protocols and, as such, does not utilize the 1394 header to transport ASM-peculiar information. ASM is tailored to support deterministic, secure, low-latency communication between processors, sensors, instrumentation, and displays in mission-critical applications. It uses Message IDs to decouple the network traffic from physical addresses so application software can communicate without knowledge of network topology.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1.1 U.S. Government Publications

Copies of these documents are available online at <http://quicksearch.dla.mil>.

None Identified.

2.1.2 Non-Government Publications

The following non-government documents form a part of this document to the extent specified herein.

IEEE Std 1394™-2008 IEEE Standard for a High Performance Serial Bus

IEEE Std 1394™-2008 includes IEEE-Std 1394-1995, Amendment IEEE Std 1394a-2000 and IEEE Std 1394b-2002 plus additional information and corrections.

IEEE Std 754 IEEE Standard for Binary Floating-Point Arithmetic

IEEE Std 1212-2001 IEEE Standard for a Control and Status Register (CSR) Architecture for Microcomputer Busses

INCITS TR-41-2006 INCITS Technical Report for Information Technology - Fibre Channel - Avionics Environment - Anonymous Subscriber Messaging (FC-AE-ASM)

2.1.3 Other Publications

Firewire System Architecture, Second Edition, IEEE 1394a, Mindshare, Inc., 1999

2.2 Definitions

ASM HEADER: Anonymous Subscriber Messaging Header, the header that contains information relevant to the node transmitting the data and the communication status of that node.

ASYNCHRONOUS: (1) Pertaining to a transmission technique that does not require a common clock between the communicating devices. Timing signals are derived from special characters in the data stream itself. (2) Not synchronous, not occurring or existing at the same time or having the same period or phase.

ASYNCHRONOUS STREAM PACKET: An isochronous packet that occurs in the fairness interval or asynchronous time frame. Data transmission is carried out in accordance with asynchronous arbitration rules, however, there is no acknowledge packet or response returned by the targeted node.

ASYNCHRONOUS TRANSACTION: A transaction carried out in accordance with asynchronous arbitration rules. The transaction is always a request/response transaction and provides an acknowledgement of data delivery.

BER: Bit Error Rate is a parameter relating to the quality of a serial transmission system. BER is the percentage of bits having errors, relative to the total number of bits received in a transmission. BER is usually expressed as ten to a negative power.

BIG ENDIAN: Describes a memory-addressing architecture in which, within a given multi-byte numeric representation, the most significant byte has the lowest address (the word is stored 'big-end-first'). Big-endian byte order is also sometimes called 'network order'.

BRANCH: A node physically connected to two or more nodes (i.e., two or more ports are connected).

BUS: One of the 1394 trees connected to each CC Branch.

BUS MANAGER: One node residing on the bus may be selected to provide serial bus services for the benefit of the community of all nodes residing on the bus.

CC: Control Computer. The CC is the root node, Cycle Master (if used), and Bus Manager for its respective data bus.

CC-BRANCH: One set of redundant resources (e.g., a CC including all of its buses and Remote Node).

CHANNEL/CHANNEL NUMBER: The means by which Isochronous and Asynchronous Stream packets are addressed. Data is transmitted onto the bus with a particular channel number. Nodes on the bus wishing to receive the data are configured to accept packets addressed with that channel number.

CORBA: Common Object Request Broker Architecture, OMG's open, vendor-independent architecture and infrastructure that computer applications use to work together over networks. Using the standard protocol IIOP, a CORBA-based program from any vendor, on almost any computer, operating system, programming language, and network, can interoperate with a CORBA-based program from the same or another vendor, on almost any other computer, operating system, programming language, and network.

CRC: Cyclic Redundancy Check - a "check summing" algorithm generated and verified by the 1394 hardware.

CYCLE MASTER: The node that generates the periodic (125 μ s) cycle start packet.

DATA PUMP: Internal equipment software parameters or memory values placed on the bus to support integration and test.

FRAME: The time interval between consecutive STOF messages (e.g., 10.0 ms).

IBIT: Initiated Built-In Test.

ICD: Interface Control Document.

ISOCHRONOUS: Uniform in time (i.e., having equal duration) and recurring at regular intervals. A form of data transmission that guarantees to provide a certain minimum data rate, as required for time-dependent data such as video or audio. Isochronous transmission transmits asynchronous data over a synchronous data link so individual characters are only separated by a whole number of bit-length intervals. This is in contrast to asynchronous transmission in which the characters may be separated by arbitrary intervals, and with synchronous transmission.

ISOCHRONOUS RESOURCE MANAGER: The node that maintains the channels available, bandwidth available, and bus manager ID registers.

ISOCHRONOUS TRANSFER: A data transmission method that occurs uniformly in time and recurs at regular intervals (integer multiple of 125 μ s).

LEAF: A node physically connected to only one other node (i.e., only one port is connected).

LINK LAYER: The serial bus layer that defines the data transfer services. It also provides addressing, data checking, and data framing.

LRC: Line Replaceable Component.

LRU: Line Replaceable Unit.

MESSAGE: Unlike the classic definition of a message, this implementation limits a message to the amount of data that may encompass only one packet.

NODE: An addressable device attached to the Serial Bus with at least the minimum set of control registers. Changing the control registers on one node does not affect the state of control registers on another node. A node may have one or more ports.

NODE ID: A 16-bit number (10-bit bus address/6-bit node address) that uniquely identifies a node. The node ID can change subsequent to a bus reset.

PAYLOAD: The useful information or data contained within a message (e.g., that portion of the packet data that is exclusive of the ASM Header and the Vehicle Trailer).

PORT: A physical layer entity in a node that connects to a cable and provides one end of a physical connection with another node.

PHY LAYER: The serial bus physical layer that translates the logical symbols used by the link layer into electrical signals on serial bus media. The PHY is also responsible for performing the arbitration tasks for a node to gain access to the bus.

QUADLET: Four bytes, or 32 bits of data.

REMOTE NODE: A node, other than the CC, on a bus.

ROOT NODE: The node on the bus with the highest node ID. The root node is responsible for resolving arbitration in IEEE-1394 buses unless there are 1394 Beta (1394b) nodes present and the topology is configured to allow BOSS arbitration in which case the node currently transmitting can grant the bus (resolve arbitration). Only the root node can be Isochronous Transfer Cycle Master, if used.

STOF: STart Of Frame. A packet sent by each CC at a periodic (frame) rate.

TRANSACTION: A request and the optional, corresponding response.

VPC: Vertical Parity Check. A secondary verification of data within a packet.

XOR: Exclusive-OR.

XOR-ed: Exclusive-ORed.

3. IEEE-1394™-2008 REQUIREMENTS

The requirements are based on the IEEE Standard for a High Performance Serial Bus (IEEE Std 1394™-2008). This section delineates the options selected and interprets any ambiguities.

3.1 Data Bus Architecture and Operation

The network functions synchronously using the asynchronous stream packets of IEEE 1394 operation. Transmission occurs in a "dual simplex" manner; packets can be transmitted on the TPB pair at the same time arbitration and/or signaling is received on the TPA pair and packets can be received on the TPA pair at the same time arbitration is transmitted on the TPB pair. Control of information transmission resides with the individual nodes on the bus.

Data transmission on the bus shall be composed primarily of Asynchronous Stream Packets, as defined in 3.3.3.1. In addition, asynchronous and isochronous packets, as defined in 3.3.3.2 and 3.3.3.3 may be utilized as necessary. The representative Remote Nodes' Subsystem IDs and Channel Numbers are defined in 4.1.

The network shall implement a physical layer based on the IEEE-1394 Beta signaling standard. This standard provides automatic detection and breaking of loops. Implementing a loop enhances redundancy by providing an alternate path to a node when another node on the bus fails. For example, in Figure 2, if CC-Branch Node 4 should fail, the CC can still access CC-Branch Node 5 and CC-Branch Node 3 via its two separate ports.

The 1394 data bus may typically be configured with several independent buses connecting the nodes. The following sections illustrate different network configurations.

3.1.1 Basic Network Architecture

Figure 1 illustrates a basic network architecture with a single Control Computer (CC). Even though each of the three ports of the CC has Remote Nodes attached, it comprises a single 1394 bus.

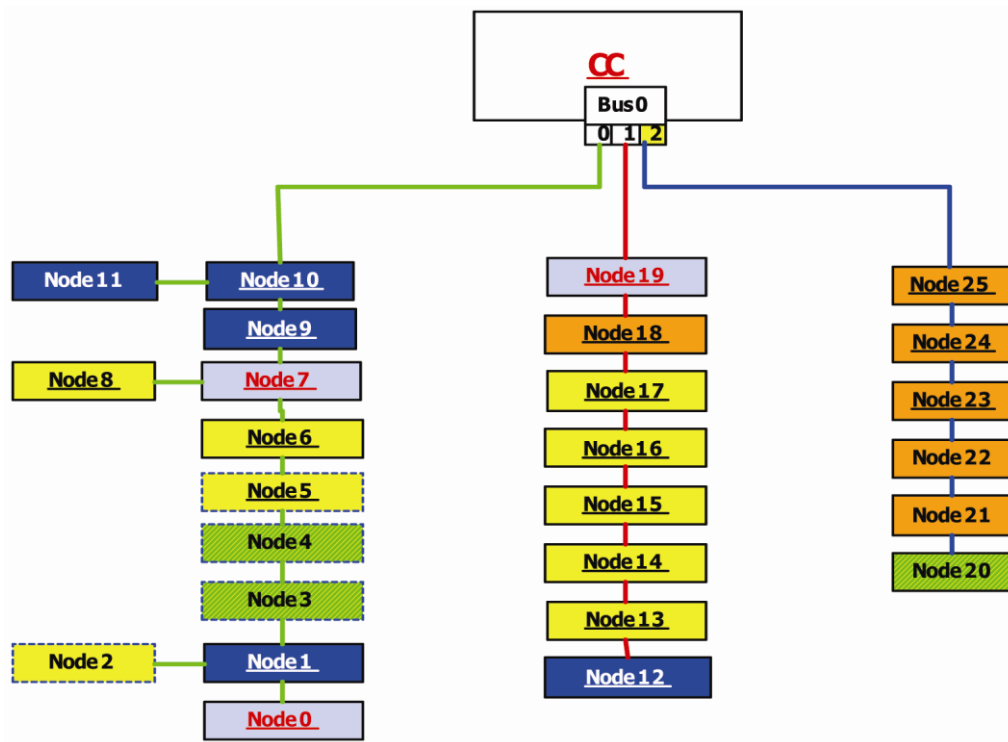


Figure 1 - Basic network with single CC
Colors, shading, and outlines could indicate different types of nodes on the busses

3.1.2 Basic Network Architecture with a Loop

Figure 2 illustrates a basic network architecture utilizing a single CC and a loop created by connecting Node 0 back to port 1 of the CC. Loops are not allowed in IEEE-1394 Alpha (1394a), however IEEE-1394 Beta (1394b) PHYs will automatically detect and break the loop. Exactly where the loop is broken is unknown until the new topology has been configured. After the PHYs break the loop there will be two main branches, one on port 0 and the other on port 1. If a node on either port should now fail, the bus will automatically reconfigure with the failed node on the “end” of one of the branches. All other nodes will still be enabled. This provides the first level of redundancy.

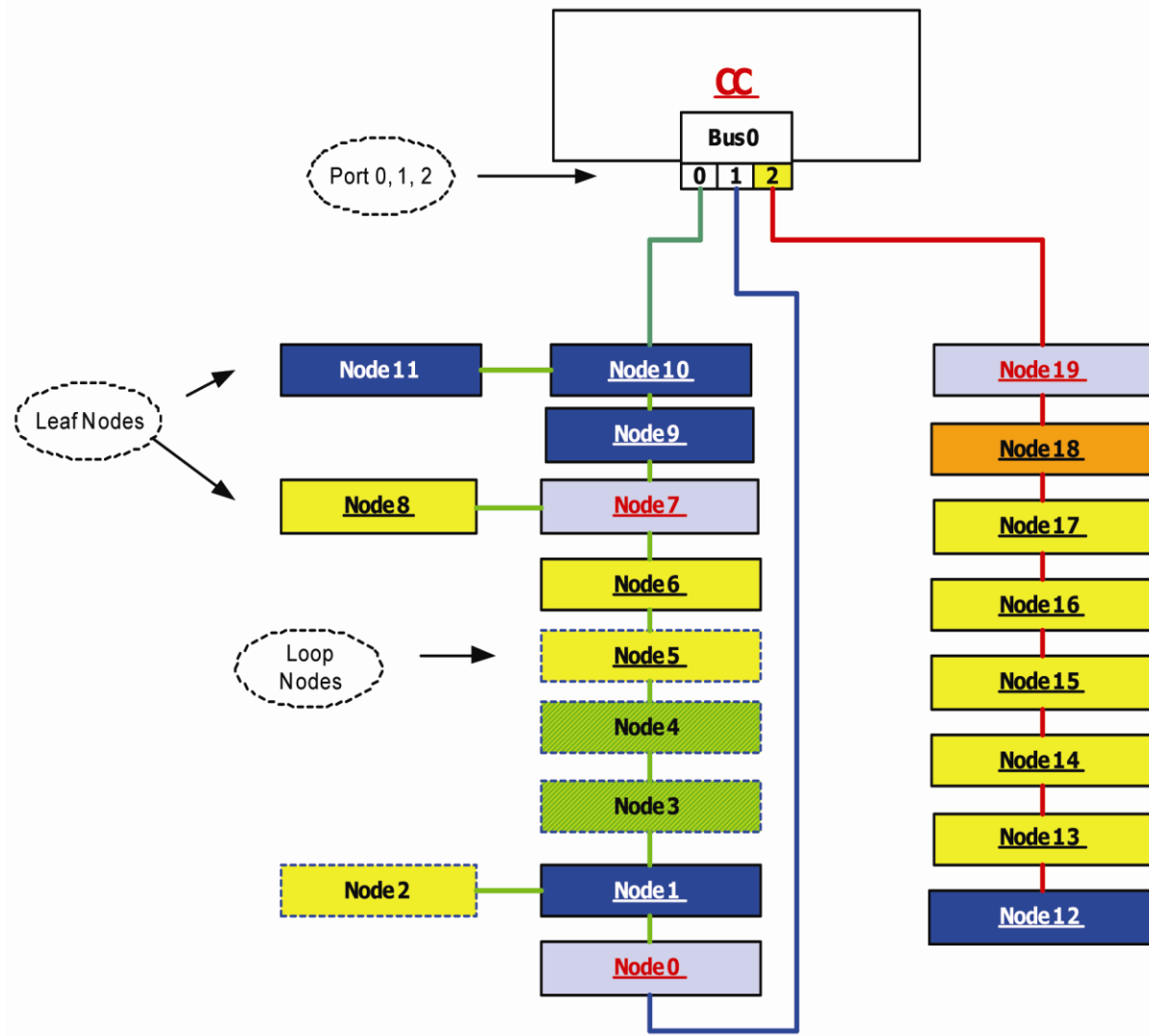


Figure 2 - Basic network with single CC and a loop
Colors, shading, and outlines could indicate different types of nodes on the busses

3.1.3 Representative Triplex Network Architecture with Loops

Figure 3 illustrates an architecture for a representative triplex 1394 vehicle network. The three CCs have been cross-channel linked, thus providing another level of redundancy.

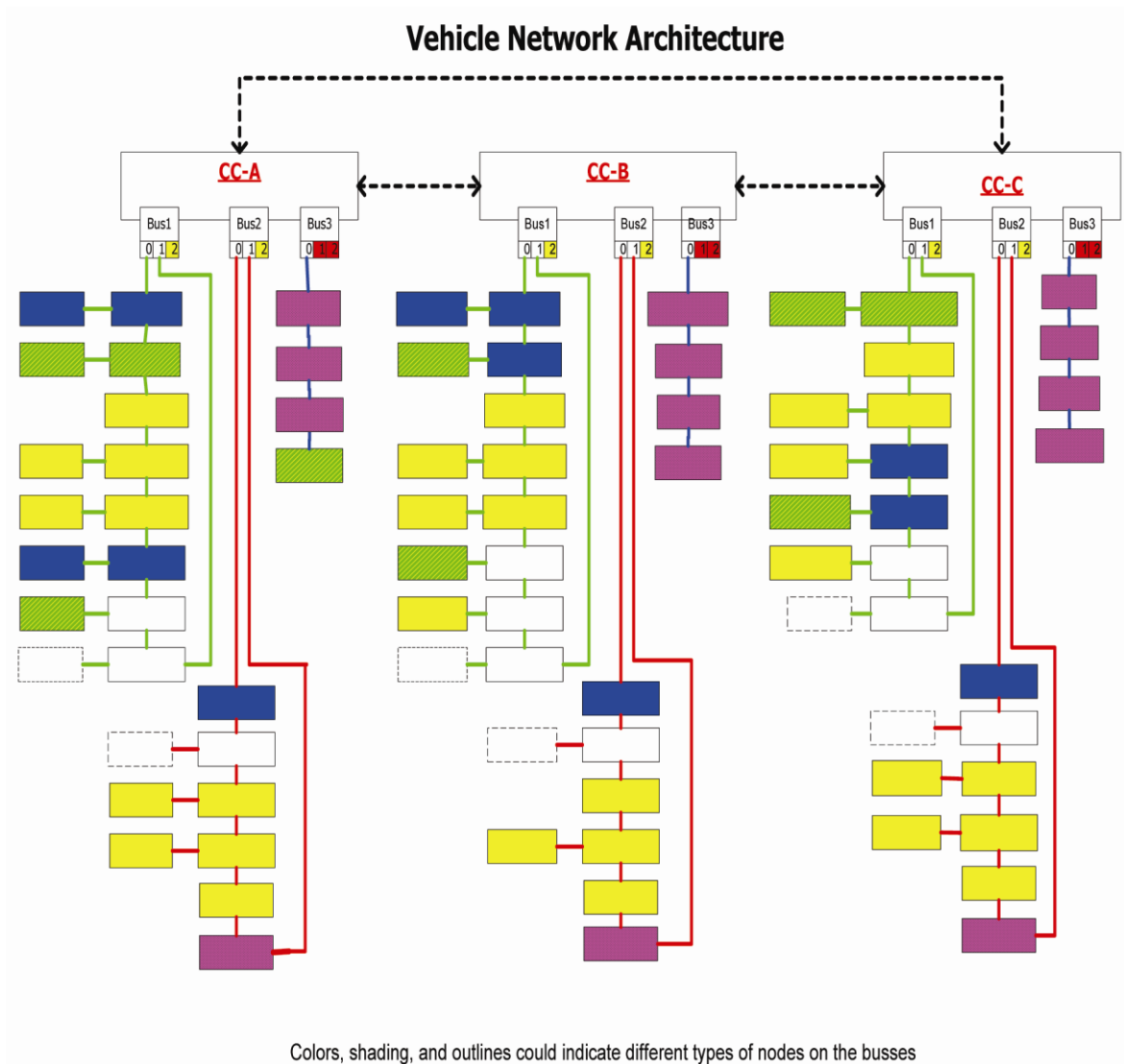


Figure 3 - Representative triplex CC architecture

3.2 Data Bus Characteristics

3.2.1 Data Format

Digital data may be transmitted in any supported form. All data on the bus shall be quadlet (32-bit word) aligned. All floating-point numbers shall be compliant with IEEE-754 floating-point format. Packets, also, shall be quadlet (32-bit word) aligned and must end with a quadlet (32-bit aligned word).

Refer to Table 1 for size definitions of the supported data types. This includes CORBA standard data types.

Table 1 - Supported data types

Data Type	Data Type Description	Bit Length
Boolean Bit	Boolean Bit	1
Very Short Enumerated	Very Short Enumerated	8
Character	Character	8
Boolean Byte	Boolean Byte	8
Signed Very Short Integer	Signed Very Short Integer	8
Unsigned Very Short Integer	Unsigned Very Short Integer	8
Short Packed Boolean	Short Packed Boolean	16
Short Enumerated	Short Enumerated	16
Signed Short Integer	Signed Short Integer	16
Unsigned Short Integer	Unsigned Short Integer	16
Long Enumerated	Long Enumerated	32
Long Packed Boolean	Long Packed Boolean	32
Signed Long Integer	Signed Long Integer	32
Unsigned Long Integer	Unsigned Long Integer	32
IEEE Floating Point	IEEE Floating Point	32
Variable Length Data Stream	Variable Length Data Stream	32
Unicode	Unicode	32
String	ASCII Character String	32
Signed Long Long Integer	Signed Long Long Integer	64
Unsigned Long Long Integer	Unsigned Long Long Integer	64
IEEE Double Floating Point	IEEE Double Floating Point	64

3.2.2 Bit Ordering

All data (bytes and bits) transmitted on the 1394 network shall be in Big Endian format.

In Big Endian format, bit 0 is the most significant bit (msb) and bit 31 is the least significant bit (lsb). Figure 4 depicts the two bit ordering schemes.

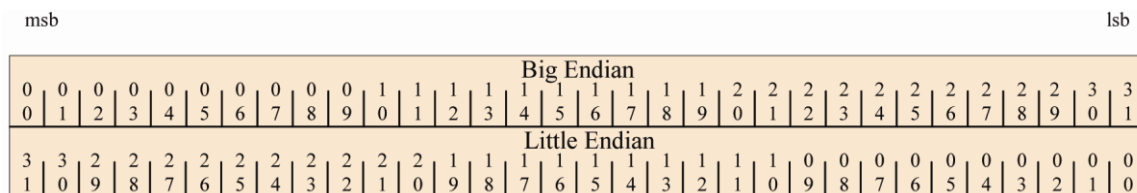


Figure 4 - Bit ordering

3.2.3 Transmission Method

3.2.3.1 Transmission Bit Rate

Transmission bit rates of S100 (100 Mbps), S200 (200 Mbps), S400 (400 Mbps), S800 (800 Mbps), S1600 (1600 Mbps), and S3200 (3200 Mbps) are permitted and may be supported, as defined in the physical layer slash sheets, slash sheets, and handbook for the target application.

3.2.3.2 Packet Size

The maximum packet size for a given asynchronous stream transmission bit rate shall be set consistent with that specified in the IEEE Std 1394™-2008 specification. Refer to IEEE Std 1394™-2008 Section 6.2.2.3 Table 6-4 for limitations on this size.

3.2.4 IEEE 1394 Packet Formats

The data packet format shall conform to IEEE Std 1394™-2008. The supported packet formats are shown in the following sections.

3.2.4.1 Asynchronous Stream Packets

Asynchronous stream packets are the same format as isochronous packets but are sent during the asynchronous time interval. Figure 5 shows a typical asynchronous stream packet as seen on the bus. These packets, as defined in this specification, consist of the 1394 header, inserted by the hardware, the Anonymous Subscriber Messaging Header, the Payload Data Area, the Packet Trailer, and the 1394 CRC, inserted by the hardware.

3.2.4.1.1 Data Length

The Data Length field shall specify the number of data bytes in the packet. This includes the ASM Header, Payload Data, and Packet Trailer. This shall be an Unsigned Short Integer (16 bits). The number of actual data bytes in the Payload Data area can be determined by subtracting the size of the ASM Header (16 bytes) and the size of the Packet Trailer (16 bytes) from the Data Length field.

3.2.4.1.2 Tag

The Tag field indicates the format of data carried by isochronous packets (00 = formatted, 01 - 11 are reserved). This field shall be set to zero (00).

3.2.4.1.3 Channel

The Channel field shall identify the destination of the asynchronous stream. An example of remote node channel number assignments is defined in 4.1.

3.2.4.1.4 Tcode

The Tcode shall be set to 1010 binary to identify the asynchronous stream packet type.

3.2.4.1.5 Sy

The Sy field is unused and shall be set to zero (0).

3.2.4.1.6 Header CRC/Data CRC

The Header and Data CRC fields are generated by the 1394 link layer. Refer to the IEEE Std 1394™-2008 specification for the CRC algorithm.