NMRA Standard	
Layout Command Control™ (LCC) **CAN Frame Transfer**	
Apr 25, 2021	**S-9.7.2.1**

Adopted as a NMRA Standard

The OpenLCB Standard document appended to this cover sheet has been formally adopted as a NMRA Standard by the NMRA Board of Directors on the date shown in the *Adopted* column in the *Version History* table below.

Version History

Date	Adopted	Summary of Changes
Feb 17, 2015	Feb 20, 2016	Initial version submitted for public comment
Apr 25, 2021	**July 2, 2021**	Changed LCC logo to include the ® symbol Changed “Layout Command Control” to have the ™ symbol Added the NMRA Legal Disclaimer fine-print Changed the OpenLCB license to “Creative Commons Attribution-ShareAlike 4.0 International”

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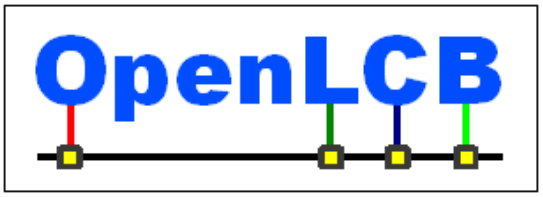

OpenLCB Standard	
CAN Frame Transfer	
Apr 25, 2021	Adopted

1 Introduction (Informative)

The OpenLCB suite of protocols can be used on multiple physical transports; this document defines the specifics that relate to using a CAN bus segment as a transport layer. The CAN protocol is frame based, so OpenLCB messages on a CAN bus segment are expressed as frames. This Standard defines unique headers to prevent CAN arbitration errors and frame loss, and to provide message traceability, node addressing and priority management.

2 Intended Use (Informative)

This Standard is intended for use whenever OpenLCB nodes are communicating on a single CAN segment. It is not intended to cover OpenLCB communications over other types of communications links.

3 References and Context (Normative)

In this document, the term "OpenLCB-CAN" refers to details of OpenLCB nodes that are specific to using a CAN transport, as opposed to generic OpenLCB protocol or OpenLCB using other transports.

This Standard should be interpreted in the the context of the following OpenLCB Standards:

- The OpenLCB CAN Physical Layer Standard, which specifies the physical layer for transporting OpenLCB-CAN frames
- The OpenLCB Unique Identifiers Standard, which specifies the mechanism(s) for providing a unique identifier for each node

“CAN” refers to the electrical and protocol specifications as defined in ISO 11898-1:2003 and ISO 11898-2:2003 and their successors.

Each OpenLCB node (independent of transport layer in use) shall have a unique identifier. When using a CAN bus transport, that identifier shall be used as its node identifier (NodeID).

4 Frame Format (Normative)

OpenLCB-CAN frames shall be sent and received using only the CAN extended format (29-bit header).

OpenLCB-CAN nodes shall operate properly when the CAN segment carries error-free standard-format (11-bit header) frames.

OpenLCB-CAN nodes shall not transmit extended-format remote frames (frames with RTR set). Nodes shall operate properly when the CAN segment carries extended-format remote frames.

Nodes shall operate properly when the CAN segment carries overload frames.

The most-significant bit of each OpenLCB-CAN frame is reserved for future use. It shall be transmitted as a 1 bit, and ignored upon receipt.

The second-most-significant bit is the Frame Type indicator. A value of 0 indicates a CAN-specific Control Frame. A value of 1 indicates an OpenLCB Message.

The next 15 bits are the Variable Field. The format and contents of the Variable Field depends on the Frame Type bit value. Section 6.1 Control Frame Format of this document defines the Variable Field content for CAN Control Frames. The OpenLCB Message content is defined in the OpenLCB Message Standard(s).

The least significant twelve bits are the Source Node ID Alias value of the source (sending) node.

Bit number[1]:	Bit 28	Bit 27	Bits 26-12	Bits 11-0
Content:	Reserved: Send as 1, ignore upon receipt	Frame Type 1: OpenLCB Message 0: CAN Control Frame	Variable Field	Source NID Alias
Mask:	0x1000,0000	0x0800,0000	0x07FF,F000	0x0000,0FFF
Location:	Solo top bit	Top bit of 6th nibble from right	3 bits, then three nibbles	Right-most three nibbles

Table 1: Frame Format

After the header, the frame shall contain from zero to eight bytes of data. Length and content are defined by specific frame and message definitions elsewhere.

5 States

The frame transfer layer of a node has two states:

- Inhibited
- Permitted

Nodes shall start in the Inhibited state.

A node in the Inhibited state may transmit Check ID, Reserve ID, and Alias Map Definition frames. A node in the Inhibited state shall not transmit any other frame type.

Nodes in Permitted state may transmit any frame type.

[1]See the OpenLCB Common Information Technical Note for detailed conventions on bit and byte numbering. Briefly, the least significant bit of a field is numbered with zero in OpenLCB descriptions, but note that other technologies may use other conventions.

6 CAN-specific Control Frames and Interactions (Normative)

OpenLCB CAN control frames shall be carried in frames with a 0 in the Frame Type field.

6.1 Control Frame Format

The format and contents of CAN-specific Control frames are defined in the following table:

Name	Variable Field	Source Alias	Data Bytes
Check ID (CID) frame	0bMMM,NNNN,NNNN,NNNN MMM is the frame sequence number, with valid values from 0x7 through 0x4 or, for non-OpenLCB protocols, down to 0x1. NNNN,NNNN,NNNN is the 12-bit Node ID section being checked	sss	None
Reserve ID (RID) frame	0x0700	sss	None
Alias Map Definition (AMD) frame	0x0701	sss	Full Node ID
Alias Mapping Enquiry (AME) frame	0x0702	sss	Optional Full Node ID
Alias Map Reset (AMR) frame	0x0703	sss	Full Node ID
Error Information Report 0-3	0x0710 – 0x713	sss	Full Node ID
Reserved; shall not be sent, and shall be ignored upon receipt	All others	sss	To be defined

Table 2: Control Frame Format

6.2 Interactions

This section describes the interactions which use the above frames.

6.2.1 Reserving a Node ID Alias

To reserve a Node ID alias while in the Inhibited state, a node shall:

- Generate a tentative source Node ID alias value
- Transmit a Check ID frame (CID) with MMM = 0x7, NNNN, NNNN, NNNN = bits 36-47 of the full Node ID in the Variable Field, and the tentative source Node ID alias value in the Source NID Alias field.
- Transmit a Check ID frame (CID) with MMM = 0x6, NNNN, NNNN, NNNN = bits 24-35 of the full Node ID in the Variable Field, and the tentative source Node ID alias value in the Source NID Alias field.
- Transmit a Check ID frame (CID) with MMM = 0x5, NNNN, NNNN, NNNN = bits 12-23 of the full Node ID in the Variable Field, and the tentative source Node ID alias value in the Source NID Alias field.

- Transmit a Check ID frame (CID) with MMM = 0x4, NNNN, NNNN, NNNN = bits 0-11 of the full Node ID in the Variable Field, and the tentative source Node ID alias value in the Source NID Alias field.
- Wait at least 200 milliseconds
- Transmit a Reserve ID frame (RID) with the tentative source Node ID alias value in the Source NID Alias field.

The alias is reserved when that sequence completes without error.

The node shall restart the process at the beginning if, before completion of the process, a frame is received that carries a source Node ID alias value that is identical to the alias value being tested by this procedure.

The node shall restart the process at the beginning if, before completion of the process, any error is encountered during frame transmission.

6.2.2 Transition to Permitted State

To transition from the Inhibited state to the Permitted state, a node shall, in order:

- Have or obtain a validly reserved Node ID alias
- Transmit an Alias Map Definition (AMD) frame with the node's Node ID alias and Node ID

6.2.3 Node ID Alias validation

A node in Permitted state receiving a Alias Mapping Enquiry frame shall compare the full Node ID in the CAN data segment to the node's own Node ID. If and only if they match in length and content and the receiving node is in Permitted state, the node shall reply with a Alias Map Definition frame carrying the node's full Node ID in the data segment of the frame.

A node in Permitted state receiving an Alias Mapping Enquiry frame with no data content shall reply with an Alias Map Definition frame carrying the node's full Node ID in the data segment of the frame.

A node in Inhibited state shall not reply to a Alias Mapping Enquiry frame.

6.2.4 Transition to Inhibited State

To transition from the Permitted state to the Inhibited state, a node shall successfully transmit an Alias Map Reset frame with the node's reserved Node ID alias and Node ID.

If a node receives an Alias Map Reset (AMR) frame referencing an alias for another node, the receiving node shall stop using that alias to refer to the AMR-sending node within 100 milliseconds.

6.2.5 Node ID Alias Collision Handling

A node shall compare the source Node ID alias in each received frame against all reserved Node ID aliases it currently holds. In case of a match, the receiving node shall:

- If the frame is a Check ID (CID) frame, send a Reserve ID (RID) frame in response.
- If the frame is not a Check ID (CID) frame, the node is in Permitted state, and the received source Node ID alias is the current Node ID alias of the node, the node shall immediately transition to Inhibited state, send an AMR frame to release and then stop using the current Node ID alias.
- If the frame is not a Check ID (CID) frame and the node is not in Permitted state, the node shall immediately stop using the matching Node ID alias.

- If the frame is not a Check ID (CID) frame and the received source Node ID alias is not the current Node ID alias of the node, the node shall immediately stop using the matching node ID alias.

6.2.6 Duplicate Node ID Handling

Each node shall compare the node ID in each received Alias Map Definition frame with its own Node ID. Should they match, in addition to any other actions that may be required by the incoming message, the node

- may, but is not required to, signal the user that duplicate Node ID values exist using a other directly-visible indicator
- if in Permitted state, may, but is not required to, notify other nodes of the condition by transmitting the CAN frame

  [195B4sss] 01.01.00.00.00.00.02.01

  where 'sss' is the current alias of the transmitting node[2]. If that frame is emitted, the node is then required to not send any more CAN frames on the OpenLCB-CAN link until reset by the user.

6.2.7 Reporting CAN Link Status

When a node's CAN interface enters the “Error Passive” state from the “Error Active” state, it may, but is not required to, emit an Error Information Report 0 frame.

When a node's CAN interface enters the “Error Passive” state from the “Bus Off” state, it may, but is not required to, emit an Error Information Report 1 frame.

When a node's CAN interface enters the “Error Active” state from the “Error Passive” state, it may, but is not required to, emit an Error Information Report 2 frame.

When a node's CAN interface enters the “Error Active” state from the “Bus Off” state, it may, but is not required to, emit an Error Information Report 3 frame.

Nodes shall not emit a Error Information 0 through Error Information 3 frame except as described above.

6.3 Node ID Alias Generation

Alias values shall not be zero. Nodes shall not depend on other nodes properly handling zero values in the source and/or destination alias fields.

The first alias values generated by nodes of the same type with node ID values within 255 of each other shall not be identical.

An alias generation algorithm shall ensure that when two different nodes using that alias generation algorithm generate the same alias value at two different points in their sequence, there shall be more than a 99% probability that the next alias values generated by the two nodes are different.

A node may, but need not, save the current alias generation state so that it restarts the sequence at the same point, hence the same alias value, after a reset or power cycle.

[2]This message is a Producer-Consumer Event Report (PCER) message with the reserved Event ID “Duplicate Node ID Detected”. More information is available in the OpenLCB Event Transport Standard and associated documentation.

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