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Road vehicles — Local Interconnect Network (LIN) —

Part 3: Protocol specification

Véhicules routiers — Réseau Internet local (LIN) —

Partie 3: Spécification du protocole

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

The committee responsible for this document is ISO/TC 22, *Road vehicles*, Subcommittee SC 31, *Data communication*.

A list of all parts in the ISO 17987 series can be found on the ISO website.

Introduction

ISO 17987 (all parts) specifies the use cases, the communication protocol and physical layer requirements of an in-vehicle communication network called Local Interconnect Network (LIN).

The LIN protocol as proposed is an automotive focused low speed UART-based network (Universal Asynchronous Receiver Transmitter). Some of the key characteristics of the LIN protocol are signal-based communication, schedule table-based frame transfer, master/slave communication with error detection, node configuration and diagnostic service communication.

The LIN protocol is for low cost automotive control applications, for example, door module and air condition systems. It serves as a communication infrastructure for low-speed control applications in vehicles by providing the following:

— signal-based communication to exchange information between applications in different nodes;

— bit rate support from 1 kbit/s to 20 kbit/s;

— deterministic schedule table based frame communication;

— network management that wakes up and puts the LIN cluster into sleep mode in a controlled sanner;

— status management that provides error handling and error signalling;

— transport layer that allows large amount of data to be transmitted (such as diagnostic services);

— specification of how to handle diagnostic services;

— electrical physical layer specifications;

— node description language describing properties of slave nodes;

— network description file describing behaviour of communication;

— application programmer’s interface.

ISO 17987 (all parts) is based on the Open Systems Interconnection (OSI) Basic Reference Model as specified in ISO/IEC 7498-1 which structures communication systems into seven layers.

The OSI model structures data communication into seven layers called (top down) *application layer* (layer 7), *presentation layer*, *session layer*, *transport layer*, *network layer*, *data link layer* and *physical layer* (layer 1). A subset of these layers is used in ISO 17987 (all parts).

ISO 17987 (all parts) distinguishes between the services provided by a layer to the layer above it and the protocol used by the layer to send a message between the peer entities of that layer. The reason for this distinction is to make the services, especially the application layer services and the transport layer services, reusable also for other types of networks than LIN. In this way, the protocol is hidden from the service user and it is possible to change the protocol if special system requirements demand it.

ISO 17987 (all parts) provides all documents and references required to support the implementation of the requirements related to.

— ISO 17987-1: This part provides an overview of ISO 17987 (all parts) and structure along with the use case definitions and a common set of resources (definitions, references) for use by all subsequent parts.

— ISO 17987-2: This part specifies the requirements related to the transport protocol and the network layer requirements to transport the PDU of a message between LIN nodes.

— ISO 17987-3: This part specifies the requirements for implementations of the LIN protocol on the logical level of abstraction. Hardware related properties are hidden in the defined constraints.

— ISO 17987-4: This part specifies the requirements for implementations of active hardware components which are necessary to interconnect the protocol implementation.

— ISO/TR 17987-5: This part specifies the LIN API (Application Programmers Interface) and the node configuration and identification services. The node configuration and identification services are specified in the API and define how a slave node is configured and how a slave node uses the identification service.

— ISO 17987-6: This part specifies tests to check the conformance of the LIN protocol implementation according to ISO 17987-2 and ISO 17987-3. This comprises tests for the data link layer, the network layer and the transport layer.

— ISO 17987-7: This part specifies tests to check the conformance of the LIN electrical physical layer implementation (logical level of abstraction) according to ISO 17987-4.

Road vehicles — Local Interconnect Network (LIN) —

Part 3: Protocol specification

1 Scope

This document specifies the LIN protocol including the signal management, frame transfer, schedule table handling, task behaviour and status management and LIN master and slave node. It contains also OSI layer 5 properties according to ISO 14229-7 UDSonLIN-based node configuration and identification services (SID: $B0_{16}$ to $B8_{16}$) belonging to the core protocol specification.

A node (normally a master node) that is connected to more than one LIN network is handled by higher layers (i.e. the application) not within the scope of this document.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 17987-2:2016, *Road vehicles — Local Interconnect Network (LIN) — Part 2: Transport protocol and network layer services*

ISO 17987-4:2016, *Road vehicles — Local Interconnect Network (LIN) — Part 4: Electrical Physical Layer (EPL) specification 12V/24V*

ISO 17987-6:2016, *Road vehicles — Local Interconnect Network (LIN) — Part 6: Protocol conformance test specification*

3 Terms, definitions, symbols and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 17987-1 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

3.1.1
big-endian
method of storage of multi-byte numbers with the most significant bytes at the lowest memory addresses

3.1.2
broadcast NAD
addressing every slave node on LIN

3.1.3
bus interface
hardware (transceiver, UART, etc.) of a node that is connected to the physical bus wire in a *cluster* (3.1.6)

3.1.4
bus sleep state
state in which a node only expects an internal or external wake up

Note 1 to entry: The nodes switch output level to the recessive state.

[SOURCE: ISO 17987-2:2016, 6.1.2]

3.1.5
classic checksum
used for *diagnostic frames* (3.1.10) and legacy LIN slave nodes frames of protocol version 1.x

Note 1 to entry: The classic checksum considers the frame response data bytes only.

3.1.6
cluster
communication system comprising the LIN wire and all connected nodes

3.1.7
cluster design
process of designing the LDF

[SOURCE: ISO 17987-2:2016, 11.2.3]

3.1.8
data
response (3.1.27) part of a frame carrying one to eight *data bytes* (3.1.9)

3.1.9
data byte
one of the bytes in the data

3.1.10
diagnostic frame
master request frame (3.1.21) and the *slave response frame* (3.1.29)

3.1.11
diagnostic trouble code
DTC
value making reference to a specific fault in a system implemented in the server

3.1.12
enhanced checksum
checksum model used for all non-diagnostic frames and legacy 1.x LIN slave nodes

3.1.13
event-triggered frame
allowing multiple slave nodes to provide their *response* (3.1.27) to the same header

3.1.14
frame
communication entity consisting of a header and *response* (3.1.27)

3.1.15
frame identifier
value identifier uniquely a frame

3.1.16
frame slot
time period reserved for the transfer of a specific frame on LIN

Note 1 to entry: This corresponds to one entry in the schedule table.

3.1.17
go-to-sleep command
special *master request frame* (3.1.21) issued to force slave nodes to *bus sleep state* (3.1.4)

[SOURCE: ISO 17987-2:2016, 6.1.4]

3.1.18
header
first part of a frame consists of a break field, sync byte field and protected identifier; it is always sent by the LIN master node

3.1.19
LIN product identification
number containing the supplier and function and variant identification in a LIN slave node

3.1.20
little-endian
method of storage of multi-byte numbers with the least significant bytes at the lowest memory addresses

3.1.21
master request frame
diagnostic frames (3.1.10) issued by the master node *frame identifier* (3.1.15)

3.1.22
node capability file
NCF
file format describes a slave node as seen from the LIN network

3.1.23
operational state
slave node may transmit/receive frames in this state

[SOURCE: ISO 17987-2:2016, 5.1.2]

3.1.24
protected identifier
PID
8-bit value consisting of a unique 6-bit *frame identifier* (3.1.15) and 2-bit parity

3.1.25
publisher
node providing a frame response containing *signals* (3.1.30)

3.1.26
request
diagnostic frame (3.1.10) transmitted by the master node requesting data from a slave nodes

3.1.27
response
answer sent by a slave node on a diagnostic *request* (3.1.26)

3.1.28
service
combination of a diagnostic *request* (3.1.26) and *response* (3.1.27)

3.1.29
slave response frame
frame used for diagnostic communication sent by one of the slave nodes

3.1.30
signal
value or byte array transmitted in the *cluster* (3.1.6) using a *signal carrying frame* (3.1.31)

3.1.31
signal carrying frame
unconditional frames (3.1.34), *sporadic frames* (3.1.32), and *event-triggered frames* (3.1.13) containing *signals* (3.1.30)

3.1.32
sporadic frame
group of *unconditional frames* (3.1.34) assigned to a schedule slot published by the master node

3.1.33
subscriber
master or slave node that receives the data within a LIN frame

3.1.34
unconditional frame
frame carrying *signals* (3.1.30) that is always sent in its allocated *frame slot* (3.1.16)

3.2 Symbols

⊕ exclusive disjunction (exclusive or)

EXAMPLE a ⊕ b; exclusive or. True if exactly one of ‘a’ or ‘b’ is true.

¬ negation

∈ element of

EXAMPLE f ∈ S; belongs to. True if ‘f’ is in the set ‘S’.

3.3 Abbreviated terms

API	application programmers interface
ASIC	application specific integrated circuit
DTC	diagnostic trouble code
LDF	LIN description file
LIN	Local Interconnect Network
LSB	least significant bit
MRF	master request frame
MSB	most significant bit
NAD	node address
NCF	node capability file
NRC	negative response code

NVRAM non-volatile random access memory

OSI Open Systems Interconnection

PCI protocol control information

PDU protocol data unit

PID protected identifier

ROM read only memory

RSID response service identifier

SID service identifier

SRF slave response frame

TL transport layer

VRAM volatile RAM

4 Node concept

4.1 General

The LIN specifications assumes a software implementation of most functions, alternative realizations are promoted.

A node in a cluster interfaces to the physical bus wire using a frame transceiver. The frames are not accessed directly by the application; a signal-based interaction layer is added in between. As a complement, a transport layer (TL) interface exists between the application and the frame handler; see Figure 1.

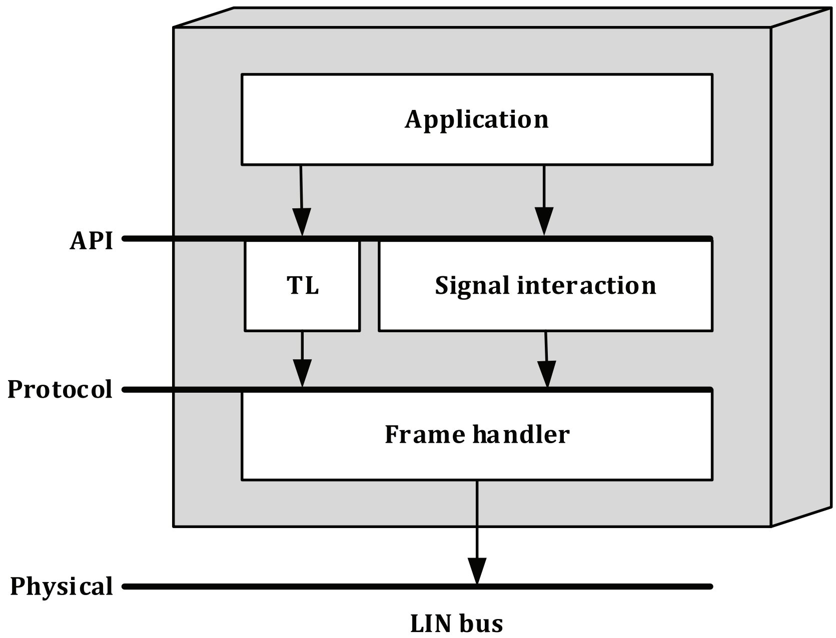

Figure 1 — Node concept

4.2 Concept of operation

4.2.1 Master and slave

A cluster consists of one master node and several slave nodes. A master node contains a master task as well as a slave task. All slave nodes contain a slave task only.

NOTE The slave task in the master node and in the slave node is not identical due to differences in PID handling.

A master node may participate in more than one cluster with one dedicated bus interfaces for each cluster. A sample cluster with one master node and two slave nodes is shown in Figure 2.

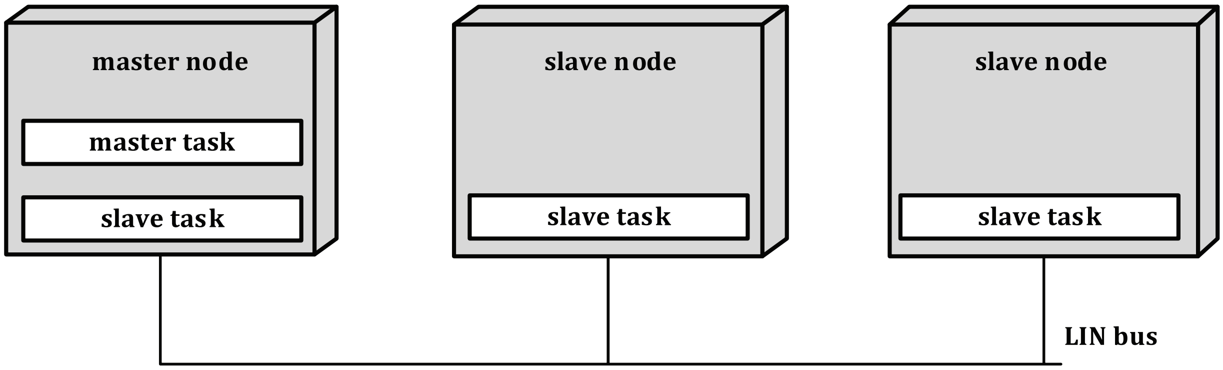

Figure 2 — Master and slave tasks

The master task decides when and which frame shall be transferred on the bus. The slave tasks provide the data transmitted by each frame. Both, the master task and the slave task are parts of the frame handler.

4.2.2 Frames

A frame consists of a header (provided by the master task) and a response (provided by a slave task).

The header consists of a break field and sync byte field followed by a protected identifier. The protected identifier uniquely defines the purpose of the frame and node providing the response. The slave task of the node assigned as response transmitter provides the response. In case of diagnostic frames, not only the frame identifier but also the NAD assigns the transmitting node.

The response consists of a data field and a checksum field. The slave tasks interested in the data associated with the frame identifier receives the response, verifies the checksum and uses the data transmitted.

Figure 3 shows the LIN frame header and response fields.

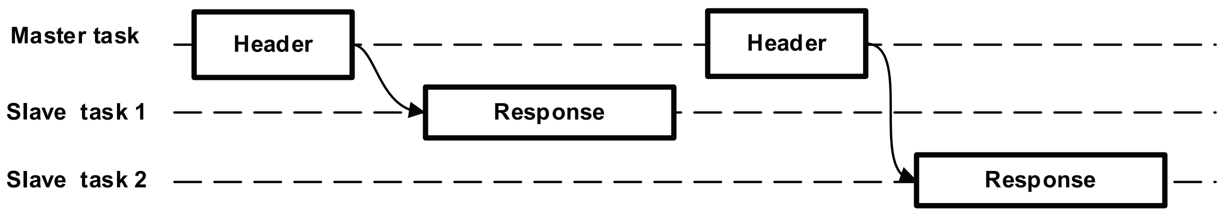

Figure 3 — LIN frame header and response fields

This results in the following desired features.

— System flexibility: Nodes can be added to the LIN cluster without requiring hardware or software changes in other slave nodes.

— Message routing: The content of a message is defined by the frame identifier (similar to CAN).

— Multicast: Any number of nodes can simultaneously receive and act upon a single frame.

4.2.3 Data transport

The following two types of data may be transmitted in a frame.

— Signals:

Signals are scalar values or byte arrays that are packed into the data field of a frame. A signal is always present at the same position of the data field for all frames with the same frame identifier.

— Diagnostic messages:

Diagnostic messages are transmitted in frames with two reserved frame identifiers. The interpretation of the data field depends on the data field itself as well as the state of the communicating nodes.

5 Protocol requirements

5.1 Signal

5.1.1 Management

A signal is transmitted in the data field of a frame.

5.1.2 Types

A signal is either a scalar value or a byte array.

A scalar signal is between 1 bit and 16 bit long. Scalar signals are treated as unsigned integers. A 1-bit scalar signal is called a Boolean signal.

A byte array is an array of one up to eight bytes.

Each signal shall have one publisher, i.e. it shall be always sent by the same node in the cluster. Zero, one or multiple nodes may subscribe to the signal.

All signals shall have initial values. The initial value for a published signal should be valid until the node writes a new value to this signal. The initial value for a subscribed signal should be valid until a new updated value is received from another node.

5.1.3 Consistency

Scalar signal writing or reading shall be atomic operations, i.e. it shall not be possible for an application to receive a signal value that is partly updated. This shall also apply to byte arrays. However, no consistency is guaranteed between any signals.

5.1.4 Packing

There is no restriction on packing scalar signals over byte boundaries. Each byte in a byte array shall map to a single frame byte starting with the lowest numbered data byte, see 5.2.2.6.

