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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*

ICS: 01.040.43; 43.020



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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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ISO 17987-3 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 31, *Electrical and electronic equipment*.

ISO 17987 consists of the following parts, under the general title *Road vehicles — Local Interconnect Network (LIN)*:

- *Part 1: General information and use case definition*
- *Part 2: Transport protocol and network layer services*
- *Part 3: Protocol specification*
- *Part 4: Electrical Physical Layer (EPL) specification (12 V / 24 V)*
- *Part 5: Application Programmers Interface (API)*
- *Part 6: Protocol conformance test specification*
- *Part 7: Electrical Physical Layer (EPL) conformance test specification*



 

# Introduction

This document set 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:

— 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 manner;

— 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 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.

ISO 17987 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.

This document set provides all documents and references required to support the implementation of the requirements related to.

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

- Part 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.

- Part 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.

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

- Part 5 (published as a non-normative technical report):
  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.

- Part 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.

- Part 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 part of ISO 17987 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 (e.g. the application) not in the scope of this document.



## 2 Normative references

The following referenced documents are indispensable for the application 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 (Part 2, 4, 6 and 7), *Road vehicles – Local Interconnect Network (LIN)*

## 3 Terms, definitions, symbols and abbreviated terms

### 3.1 Terms and definitions

For the purposes of this document, the following terms and definitions and those given in ISO 17987-1:2015 apply.

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

**broadcast NAD**
a broadcast NAD is addressing every slave node on LIN

**3.1.2**
**bus interface**
the hardware (transceiver, UART, etc.) of a node that is connected to the physical bus wire in a cluster

**3.1.3**
**bus sleep state**
state in which a node only expects an internal or external wake up. The nodes switch output level to the recessive state
[SOURCE ISO 17987-2:2015, 6.1.2]

**3.1.4**
**classic checksum**
used for diagnostic frames and legacy LIN slave nodes frames of protocol version 1.x. The classic checksum considers the frame response data bytes only

**3.1.5**
**cluster**
communication system comprising the LIN wire and all connected nodes

**3.1.6**
**cluster design**
process of designing the LDF
[SOURCE ISO 17987-2:2015, 11.2.3]

**3.1.7**
**data**
response part of a frame carrying one to eight data bytes

**3.1.8**
**data byte**
One of the bytes in the data

**3.1.9**
**diagnostic frame**
master request frame and the slave response frame

**3.1.10**
**diagnostic trouble code DTC**
value making reference to a specific fault in a system implemented in the server

**3.1.11**
**enhanced checksum**
checksum model used for all non-diagnostic frames and legacy 1.x LIN slave nodes

**3.1.12**
**event triggered frame**
allowing multiple slave nodes to provide their response to the same header

**3.1.13**
**frame**
communication entity consisting of a header and response

**3.1.14**
**frame identifier**
value identifier uniquely a frame

**3.1.15**
**frame slot**
time period reserved for the transfer of a specific frame on LIN. This corresponds to one entry in the schedule table

**3.1.16**
**go-to-sleep command**
special master request frame issued to force slave nodes to bus sleep state
[SOURCE ISO 17987-2:2015, 6.1.4]



 

**3.1.17**
**header**
the 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

**3.1.18**
**LIN product identification**
number containing the supplier and function and variant identification in a LIN slave node

**3.1.19**
**little-endian**
method of storage of multi-byte numbers with the least significant bytes at the lowest memory addresses.

**3.1.20**
**master request frame**
diagnostic frames issued by the master node frame identifier

**3.1.21**
**node capability file NCF**
file format describes a slave node as seen from the LIN network

**3.1.22**
**operational state**
slave node may transmit/receive frames in this state, see [SOURCE ISO 17987-2:2015, 5.1.2].

**3.1.23**
**protected identifier PID**
8-bit value consisting of a unique 6-bit frame identifier and 2-bit parity

**3.1.24**
**publisher**
node providing a frame response containing signals

**3.1.25**
**request**
diagnostic frame transmitted by the master node requesting data from a slave nodes

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

**3.1.27**
**service**
the combination of a diagnostic request and response

**3.1.28**
**slave response frame**
frame used for diagnostic communication sent by one of the slave nodes

**3.1.29**
**signal**
is a value or byte array transmitted in the cluster using a signal carrying frame

**3.1.30**
**signal carrying frame**
unconditional frames, sporadic frames, and event triggered frames containing signals

**3.1.31**
**sporadic frame**
a group of unconditional frames assigned to a schedule slot published by the master node

**3.1.32**
**subscriber**
a master or slave node that receives the data within a LIN frame.

**3.1.33**
**unconditional frame**
frame carrying signals that is always sent in its allocated frame slot

## 3.2 Symbols

$\oplus$ exclusive disjunction (exclusive or)

EXAMPLE $a \oplus b$; exclusive or. True if exactly one of 'a' or 'b' is true.

$\neg$ Negation

$\in$ element of

EXAMPLE $f \in S$; 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

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.



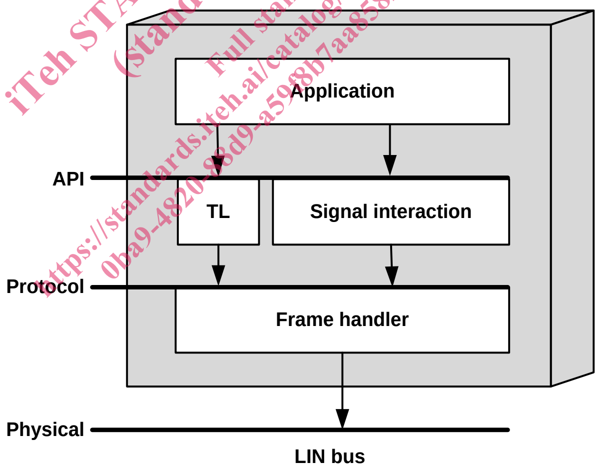


**Figure 1 — Node concept**

## 4.1 Concept of operation

### 4.1.1 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.

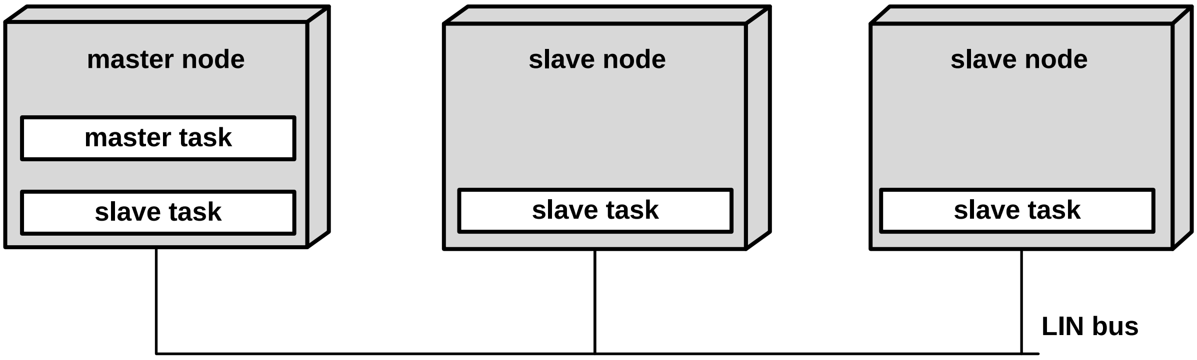


**Figure 2 — Master and slave tasks**

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.

### 4.1.2 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.

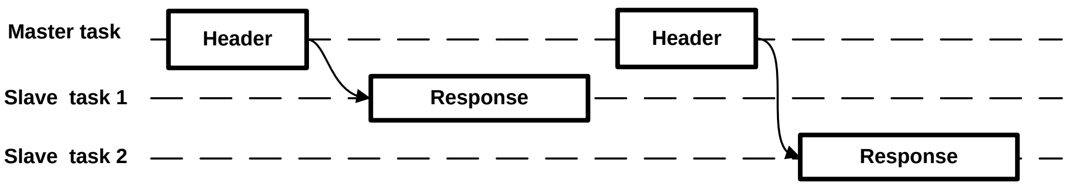


**Figure 3 — LIN frame header and response fields**

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.

#### 4.1.3 Data transport

Two types of data may be transmitted in a frame; signals or diagnostic messages.

— 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 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.

Several signals may be packed into one frame as long as they do not overlap each other.

NOTE Signal packing/unpacking is implemented more efficient in software based nodes if signals are byte aligned and/or if they do not cross byte boundaries.