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Road vehicles — Local Interconnect Network (LIN) —

Part 2: Transport protocol and network layer services

Véhicules routiers — Réseau Internet local (LIN) —

Partie 2: Protocole de transport et couches de services réseau

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Foreword

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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).

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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.

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

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

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Introduction

This 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 universal asynchronous receiver transmitter (UART) based network. 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 transportation.

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;

— bitrate 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 transported (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.

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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 the following.

— ISO 17987-1: This part provides an overview of the 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.

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— 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 application programmers interface (API) 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.

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Road vehicles — Local Interconnect Network (LIN) —

Part 2:
Transport protocol and network layer services

1 Scope

This document specifies a transport protocol and network layer services tailored to meet the requirements of LIN-based vehicle network systems on local interconnect networks. The protocol specifies an unconfirmed communication.

The LIN protocol supports the standardized service primitive interface as specified in ISO 14229-2.

This document provides the transport protocol and network layer services to support different application layer implementations like

— normal communication messages, and

— diagnostic communication messages.

The transport layer defines transportation of data that is contained in one or more frames. The transport layer messages are transported by diagnostic frames. A standardized API is specified for the transport layer.

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Use of the transport layer is targeting systems where diagnostics are performed on the backbone bus (e.g. CAN) and where the system builder wants to use the same diagnostic capabilities on the LIN sub-bus clusters. The messages are in fact identical to the ISO 15765-2 and the PDUs carrying the messages are very similar.

The goals of the transport layer are

— low load on LIN master node,

— to provide full (or a subset thereof) diagnostics directly on the LIN slave nodes, and

— targeting clusters built with powerful LIN nodes (not the mainstream low cost).

A typical system configuration is shown in Figure 1.

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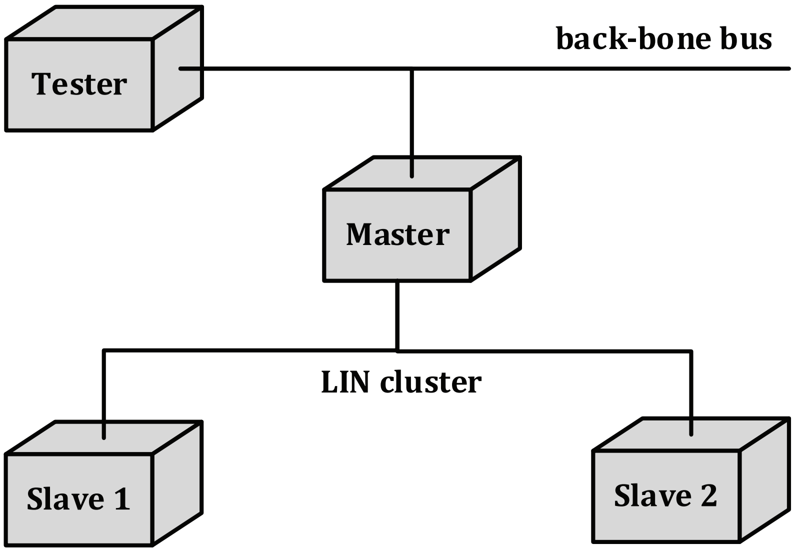

Figure 1 — Typical system setup for a LIN cluster using the transport layer

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.

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ISO 14229-1, *Road vehicles — Unified diagnostic services (UDS) — Part 1: Specification and requirements*

ISO 14229-2, *Road vehicles — Unified diagnostic services (UDS) — Part 2: Session layer services*

ISO 14229-7:2015, *Road vehicles — Unified diagnostic services (UDS) — Part 7: UDS on local interconnect network (UDSonLIN)*

ISO 17987-3:2016, *Road vehicles — Local Interconnect Network (LIN) — Part 3: Protocol 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/IEC 7498-1 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
broadcast NAD
slave node receiving a message with a NAD equal to the broadcast NAD $7F_{16}$ the message is received and processed

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3.1.2
configured NAD
value in the range of (01_{16} to $7D_{16}$) which is assigned to each slave node

Note 1 to entry: The assignment of configured NAD to each slave node is defined in the LDF. The configured NAD is used for node configuration and identification services, as well as UDS services according to ISO 14229-7.

Note 2 to entry: When communication is initialized configured NADs of slave nodes may be identical. The master shall assign unique configured NADs to all slave nodes before diagnostic communication begins.

Note 3 to entry: Setting or altering the configured NAD in a slave node can be done by the following ways:

— the master node assigns a new configured NAD to a slave node supporting the “Assign NAD” service;

— an API call in a slave node assigns the configured NAD;

— the configured NAD is assigned with a static configuration.

3.1.3
functional NAD
($7E_{16}$)
used to broadcast diagnostic requests

3.1.4
initial NAD
constant/static value in the range of (01_{16} to $7D_{16}$)

Note 1 to entry: initial NAD value may be derived from a pin configuration, EEPROM or slave node position detection algorithm before entering the operational state (regular LIN communication).

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Note 2 to entry: The combination of initial NAD, Supplier ID and Function ID unique for each slave node is used in the “Assign NAD” command allowing an unambiguous configured NAD assignment.

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Note 3 to entry: If no initial NAD is defined for a slave node (LDF, NCF) the value is identical to the configured NAD.

3.1.5
P2 timing parameter
application timing parameter for the ECU(s) and the external test equipment

3.1.6
P2* timing parameter
enhanced response timing parameter for the ECU(s) application after response pending frame transmission

3.1.7
P4 timing parameter
timing parameter for the ECU(s) application defining the time between reception of a request and the final response

3.1.8
proprietary NAD
NAD values in the range [80_{16} – FF_{16}] are used for not standardized communication purpose, such as Tier-1 slave node diagnostics

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3.2 Symbols

% percentage

µs microsecond

ms millisecond

| The vertical bar indicates choice. Either the left hand side or the right hand side of the vertical bar shall appear

3.3 Abbreviated terms

API	application programmers interface
BNF	Bachus-Naur format
CAN	Controller Area Network
CF	ConsecutiveFrame
FF	FirstFrame
LDF	LIN description file
L_Data	data link data
MRF	master request frame
N_AI	network address information
N_As	network layer timing parameter As
N_As_{max}	timeout on As
N_Cr	network layer timing parameter Cr
N_Cr_{max}	timeout on Cr
N_Cs	network layer timing parameter Cs
N_Cs_{max}	timeout on Cs
N_Data	network data
N_PCI	network protocol control information
N_PCItype	network protocol control information type
N_PDU	network protocol data unit
N_SA	network source address
N_SDU	network service data unit
N_TAtype	network target address type
N_USData	network layer LIN data transfer service name
NAD	node address for slave nodes

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NCF node capability file

NCL node capability language

NRC negative response code

NWL network layer

OBD on-board diagnostics

OSI Open Systems Interconnection

PDU protocol data unit

PID protected identifier

RSID response service identifier

SF SingleFrame

SID service identifier

SN SequenceNumber

SRF slave response frame

ST_{min} SeparationTime minimum

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4 Conventions

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ISO 17987 (all parts) and ISO 14229-7 are based on the conventions specified in the OSI Service Conventions (ISO/IEC 10731) as they apply for physical layer, protocol, transport protocol and network layer services and diagnostic services.

5 Network management

5.1 Network management general information

Network management in a LIN cluster refers to cluster wake up and go-to-sleep only. Other network management features, for example, configuration detection and limp home management are left to the application.

5.2 LIN node communication state diagram

The state diagram in Figure 2 shows the behaviour model for LIN communication state.

— Bus Sleep

Bus Sleep state is entered after first connection to power source and the system initialization, reset or when a go-to-sleep command is transmitted by the master or received by the slave node. The level on the bus is set to recessive. Only the wake up signal may be transmitted on the cluster.

— Operational

The protocol behaviour (transmitting and receiving frames) specified in this document only applies to the Operational state.

NOTE The LIN “Bus Sleep” state does not necessarily correlate to the node’s power state.

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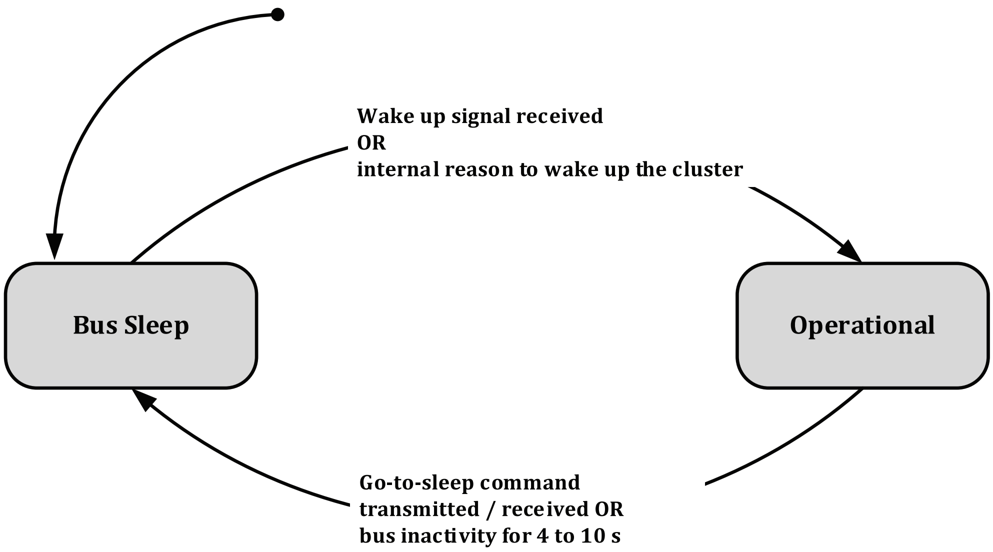

Figure 2 — LIN node communication state diagram

5.3 Wake up

5.3.1 Wake up general information

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Any node in a sleeping LIN cluster may request a wake up, by transmitting a wake up signal. The wake up signal is started by forcing the bus to the dominant state for 250 µs to 5 ms, and is valid with the return of the bus signal to the recessive state.

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5.3.2 Master generated wake up

The master node may issue a break field, e.g. by issuing an ordinary header since the break acts as a wake up signal (in this case, the master shall be aware of that this frame may not be processed by the slave nodes since they may not yet awake and ready to listen to headers).

Every slave node (connected to power) should detect the wake up signal (a dominant pulse longer than 150 µs followed by a rising edge of the bus signal) and be ready to listen to bus commands within 100 ms, measured from the ending edge of the dominant pulse (see Figure 3). The check for the rising edge shall be done by the transceiver and also could be done by the microcontroller LIN interface.

A detection threshold of 150 µs combined with a 250 µs pulse generation gives a detection margin that is enough for uncalibrated slave nodes. Following the detection of the wake up pulse, the Slave task machine (ISO 17987-3:2016, 7.5.3) shall start and enter into the idle state. During the idle state, the slave shall never issue a dominant level pulse on the bus until the state machine enters into an active state.

5.3.3 Slave generated wake up

If the node that transmitted the wake up signal is a slave node, it shall be ready to receive or transmit frames immediately. The master node shall also wake up and, when the slave nodes are ready (>100 ms), start transmitting headers to find out the cause (using signals) of the wake up.

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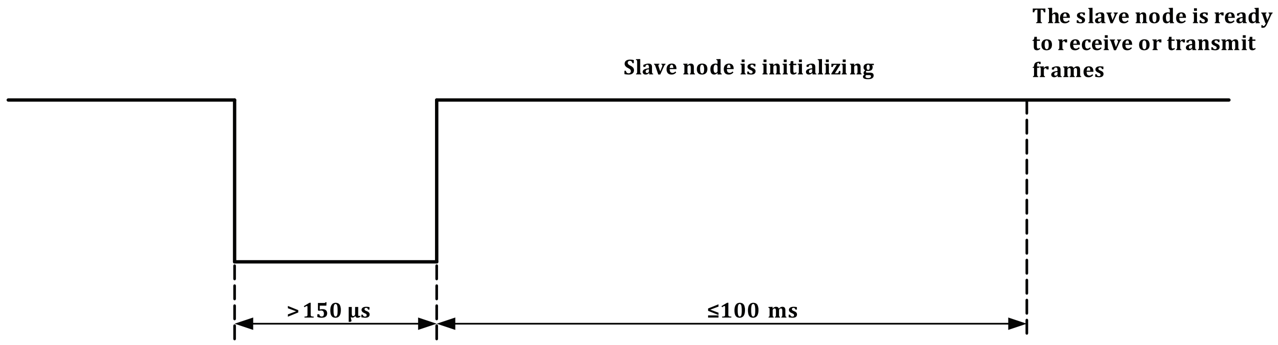

Figure 3 — Wake up signal reception in slave nodes

The master node shall detect the wake up signal (a dominant pulse longer than 150 µs followed by a rising edge of the bus signal) and be ready to start communication within a time that is decided by the cluster designer or application specific. The check for the rising edge shall be done by the transceiver and also could be done by the microcontroller LIN interface.

If the master node does not transmit a break field (i.e. starts to transmit a frame) or if the node issuing the wake up signal does not receive a wakeup signal (from another node) within 150 ms to 250 ms from the wake up signal, the node issuing the wake up signal shall transmit a new wake up signal (see Figure 4). In case the slave node transmits a wake up signal in the same time as the master node transmits a break field, the slave shall receive and recognize this break field.

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Figure 4 — One block of wake up signals

After three (failing) requests, the node shall wait minimum 1,5 s before issuing a fourth wake up signal. The reason for this longer duration is to allow the cluster to communicate in case the waking slave node has problems, e.g. if the slave node has problems with reading the bus it probably retransmit the wake up signal infinitely. There is no restriction of how many times a slave may transmit the wake up signal. However, it is recommended that a slave node transmits not more than one block of three wake up signals for each wake up condition. Figure 5 shows how wake up signals are transmitted over a longer time

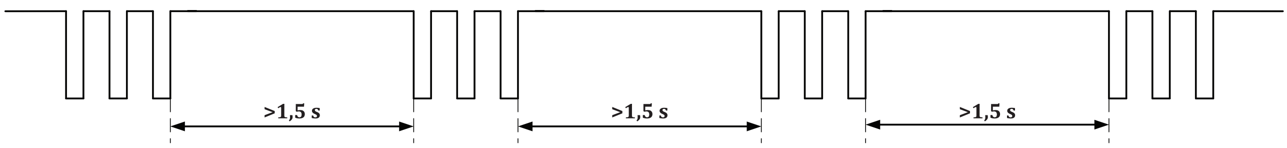

Figure 5 — Wake up signals over long time