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Road vehicles — Local Interconnect Network (LIN) —

Part 4: Electrical Physical Layer (EPL) specification 12V/24V

Véhicules routiers — Réseau Internet local (LIN) —

Partie 4: Spécification de la couche électrique physique (EPL) 12V/24V

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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.

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.

ISO 17987-4 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 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 state 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;

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 4: Electrical Physical Layer (EPL) specification 12V/24V

1 Scope

This part of ISO 17987 specifies the 12 V and 24 V electrical physical layers (EPL) of the LIN communications system.

The electrical physical layer for LIN is designed for low cost networks with bit rates up to 20 kbit/s to connect automotive electronic control units (ECUs). The medium that is used is a single wire for each, receiver and transmitter with reference to ground.

This part of ISO 17987 includes the definition of electrical characteristics of the transmission itself and also documentation of basic functionality for bus driver devices.

All parameters in this specification are defined for the ambient temperature range from -40°C to 125°C.

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, 3, 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 apply.

3.1.1
BR_Range_20K
LIN systems which operate at speeds up to 20 kbit/s

3.1.2
BR_Range_20K 12 V
12 V LIN systems which operate at speeds up to 20 kbit/s

3.1.3
BR_Range_20K 24 V
24 V LIN systems which operate at speeds up to 20 kbit/s

3.1.4
BR_Range_10K
LIN systems which operate at speeds up to 10,417 kbits/s

3.1.5
BR_Range_10K 12 V
12 V LIN systems which operate at speeds up to 10,417 kbits/s

3.1.6
BR_Range_10K 24 V
24 V LIN systems which operate at speeds up to 10,417 kbit/s

3.2 Symbols

%	percentage
µs	microsecond
C'_{LINE}	line capacitance
C_{BUS}	total bus capacitance
C_{MASTER}	capacitance of master node
C_{RXD}	RXD capacitance (LIN receiver, RXD capacitive load condition)
C_{SLAVE}	capacitance of slave node
d^2V/dt^2	second derivative of voltage (Volt² per second²)
di/dt	instantaneous rate of current change (amps per second)
D_{ser_int}	serial internal diode at transceiver IC
D_{ser_master}	serial master diode
$F_{TOL\_RES\_MASTER}$	master bit rate deviation from nominal bitrate
$F_{TOL\_RES\_MASTER\_A}$	master bit rate deviation from nominal bitrate in BR_Range_20K systems
$F_{TOL\_RES\_MASTER\_B}$	master bit rate deviation from nominal bitrate in BR_Range_10K systems
$F_{TOL\_RES\_SLAVE}$	slave bit rate deviation from nominal bitrate
$F_{TOL\_RES\_SLAVE\_A}$	slave bit rate deviation from nominal bitrate in BR_Range_20K systems
$F_{TOL\_RES\_SLAVE\_B}$	slave bit rate deviation from nominal bitrate in BR_Range_10K systems
$F_{TOL\_RES\_SLAVE\_1}$	slave node 1 bit rate deviation from nominal bitrate
$F_{TOL\_RES\_SLAVE\_2}$	slave node 2 bit rate deviation from nominal bitrate
$F_{TOL\_SLAVE\_to\_SLAVE}$	slave to slave bit rate deviation
F_{TOL_SYNCH}	slave node bit rate deviation from master node bit rate after synchronization
$F_{TOL\_SYNCH\_A}$	slave node bit rate deviation from master node bit rate after synchronization in BR_Range_20K systems
$F_{TOL\_SYNCH\_B}$	slave node bit rate deviation from master node bit rate after synchronization in BR_Range_10K systems

$F_{TOL\_SYNCH\_1}$	slave node 1 bit rate deviation from master node bit rate after synchronization
$F_{TOL\_SYNCH\_2}$	slave node 2 bit rate deviation from master node bit rate after synchronization
$F_{TOL\_UNSYNCH}$	slave node bit rate deviation from nominal bit rate before synchronization
$F_{TOL\_UNSYNCH\_A}$	slave node bit rate deviation from nominal bit rate before synchronization in BR_Range_20K systems
$F_{TOL\_UNSYNCH\_B}$	slave node bit rate deviation from nominal bit rate before synchronization in BR_Range_10K systems
I_{BUS}	current into the ECU bus line
I_{BUS_LIM}	current limitation for driver dominant state driver on $V_{BUS} = V_{BAT\_max}$ into ECU bus line
$I_{BUS\_NO\_BAT}$	current at ECU bus line when V_{BAT} is disconnected
$I_{BUS\_NO\_GND}$	current at ECU bus line when V_{GND_ECU} is disconnected
$I_{BUS\_PAS\_dom}$	current at ECU bus line when driver off (passive) at dominant LIN bus level
$I_{BUS\_PAS\_rec}$	current at ECU bus line when driver off (passive) at recessive LIN bus level
GND_{Device}	GND of ECU
KΩ	kilo ohm
kbit/s	kilo bit per second
LEN_{BUS}	total length of LIN bus line
LIN_{Bus}	LIN network
ms	millisecond
nF	nano farad
pF	pico farad
pF/m	pico farad per meter (line capacitance)
R_{BUS}	total bus-resistor including all slave and master resistors $R_{BUS} = R_{MASTER} \parallel R_{SLAVE\_1} \parallel R_{SLAVE\_2} \parallel$ to $\parallel R_{SLAVE\_N}$
R_{MASTER}	master resistor
R_{pull_up}	pull-up resistor
R_{SLAVE}	slave resistor
t_{BFS}	byte field synchronization time
t_{BIT}	basic bit times
t_{EBS}	earliest bit sample time
t_{rx_pd}	propagation delay of receiver

t_{rx_sym}	symmetry of receiver propagation delay rsising edgepropagation delay of receiver
t_{LBS}	latest bit sample time
$t_{rx\_pdf(1)}$	propagation delay time of receiving node 1 at falling (recessive to dominant) LIN bus edge
$t_{rx\_pdf(2)}$	propagation delay time of receiving node 2 at falling (recessive to dominant) LIN bus edge
$t_{rx\_pdr(1)}$	propagation delay time of receiving node 1 at rising (dominant to recessive) LIN bus edge
$t_{rx\_pdr(2)}$	propagation delay time of receiving node 2 at rising (dominant to recessive) LIN bus edge
t_{SR}	sample window repetition time
$TH_{Dom(max)}$	max. dominant threshold of receiving node (Volt)
$TH_{Dom(min)}$	min. dominant threshold of receiving node (Volt)
$TH_{Rec(max)}$	max. recessive threshold of receiving node (Volt)
$TH_{Rec(min)}$	min. recessive threshold of receiving node (Volt)
V	voltage
V_{ANODE}	voltage at the anode of the diode
V_{BAT}	voltage across the ECU supply connectors
$V_{BATTERY}$	voltage across the vehicle battery connectors
V_{BUS}	voltage on the LIN bus
V_{BUS_CNT}	center point of receiver threshold
V_{BUS_rec}	receiver recessive voltage
$V_{CATHODE}$	voltage at the cathode of the diode
$V_{GND\_BATTERY}$	battery ground voltage
V_{GND_ECU}	voltage on the local ECU ground connector with respect to vehicle battery ground connector ($V_{GND\_BATTERY}$)
V_{HYS}	receiver hysteresis voltage
V_{Rec}	recessive voltage
$V_{SerDiode}$	voltage drop at the serial diodes
V_{Shift_BAT}	battery shift
$V_{Shift\_Difference}$	difference between battery shift and GND shift
V_{Shift_GND}	GND shift

V_{SUP}	voltage at transceiver supply pins
$V_{SUP\_NON\_OP}$	voltage which the device is not destroyed; no guarantee of correct operation
V_{th_dom}	receiver threshold voltage of the recessive to dominant LIN bus edge
V_{th_rec}	receiver threshold voltage of the dominant to recessive LIN bus edge
$\Delta F / F_{MASTER}$	deviation of node bit rate from the master node bit rate
$\Delta F / F_{Nom}$	deviation from nominal bit rate
τ	time constant
Ω	ohm

3.3 Abbreviated terms

AC	alternate current
API	application programmers interface
ASIC	application specific integrated circuit
BFS	byte field synchronization
DC	direct current
EBS	earliest bit sample
EMC	electromagnetic compatibility
EMI	electromagnetic interference
EPL	electrical physical layer
ESD	electrostatic discharge
EVT	event
GND	ground
LBS	latest bit sample
Max	maximum
Min	minimum
OSI	open systems interconnection
RC	RC time constant τ ($\tau = C_{BUS} * R_{BUS}$)
RX	Rx pin of the transceiver
RXD	receive data