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Road vehicles — Local Interconnect Network (LIN) —

Part 4:
Electrical physical layer (EPL) specification 12 V/24 V

Véhicules routiers — Réseau Internet local (LIN) —

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

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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.

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 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;

— 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 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 (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.

— 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 this document.

Road vehicles — Local Interconnect Network (LIN) —

Part 4:
Electrical physical layer (EPL) specification 12 V/24 V

1 Scope

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

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

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.

IEC 61000-4-2, *Electromagnetic compatibility (EMC) — Part 4-2: Testing and measurement techniques — Electrostatic discharge immunity test*

3 Terms, definitions, symbols and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions 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
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 (Volt^2 per second^2)
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 bit rate
$F_{TOL\_RES\_MASTER\_A}$	master bit rate deviation from nominal bit rate in BR_Range_20K systems
$F_{TOL\_RES\_MASTER\_B}$	master bit rate deviation from nominal bit rate in BR_Range_10K systems
$F_{TOL\_RES\_SLAVE}$	slave bit rate deviation from nominal bit rate
$F_{TOL\_RES\_SLAVE\_A}$	slave bit rate deviation from nominal bit rate in BR_Range_20K systems
$F_{TOL\_RES\_SLAVE\_B}$	slave bit rate deviation from nominal bit rate in BR_Range_10K systems
$F_{TOL\_RES\_SLAVE\_1}$	slave node 1 bit rate deviation from nominal bit rate
$F_{TOL\_RES\_SLAVE\_2}$	slave node 2 bit rate deviation from nominal bit rate
$F_{TOL\_SLAVE\_to\_SLAVE}$	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 $R_{BUS} = R_{MASTER} \| \| R_{SLAVE\_1} \| \| R_{SLAVE\_2} \| \|$ to $\| \| R_{SLAVE\_N}$
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 rising edge propagation 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} centre 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
ECU	electronic control unit
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 ($\tau = C_{BUS} \times R_{BUS}$)
RX	Rx pin of the transceiver
RXD	receive data
SR	sample window repetition
TRX	transceiver
Tx	Tx pin of the transceiver

TXD transmit data

Typ. typical

UART universal asynchronous receiver transmitter

4 Conventions

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

5 Electrical physical layer requirements

5.1 Bit rate deviation

The bit rate deviation of the LIN medium describes the bit rate deviation from a referenced bit rate. It is the sum of the following parameters:

- inaccuracy of setting the bit rate (systematic failure due to granularity of the configurable bit rate);
- clock deviation over temperature and supply voltage range;
- clock source stability of the slave node starting from the end of the sync byte field up to the end of the entire LIN frame (last sampled bit) when performing synchronization;
- bit time measurement failure of the slave node;
- clock source stability of the master node starting from the end of the sync byte field up to the end of the entire LIN frame (last transmitted bit).

On-chip clock may achieve a frequency deviation of better than ±14 % with internal calibration. This bit rate deviation better than ±14 % is sufficient to detect a break field in the message stream. The subsequent bit rate adaptation using the sync byte field ensures the proper reception and transmission of the message. The on-chip oscillator shall allow for accurate bite rate measurement and generation for the remainder of the message frame, taking into account effects of anything, which affects the bit rate, such as temperature and voltage drift during operation.

The bit rates on the LIN bus are specified in the range of 1 kbit/s to 20 kbit/s. The specific bit rate used on a LIN bus is defined as the nominal bit rate, F_{Nom}.

In case a non-LIN electrical physical layer (e.g. ISO 11898-1, ISO 11898-2) is used, the bit rate may have to be adjusted.

5.1.1 12 V LIN systems: Parameters

Table 1 defines the bit rate deviation from nominal bit rate.

