LIN

Conformance Test Specification Package for LIN 2.1

For the LIN Specification Package

Revision 2.1 (November 24th, 2006)

October 10th, 2008

LIN

Conformance Test Specification

LIN OSI Layer 1 – Physical Layer

For LIN devices with Rx and Tx access

For the LIN Physical Layer Specification
Revision 2.1 (November 24th, 2006)

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1 Test Specification overview

1.1 Test Case Organisation

The intention of each test case is described at first, with a short textual explanation.

Before tests are executed the test system must be set to its initial state as described in chapter 2.

The test procedure and the expected results are described in the form of a chart for each test case. The table below is a typical test description.

IUT node as	*Test for master, slave or both*	*Corresponding test number*
Initial State	Parameters: Number of nodes Bus loads Operational Conditions: IUT Mode TX Signal RX Signal V_{BAT},V_{SUP},V_{IUT} Failure GND Shift	 *Number of node in the test implementation* *In order to simulate a LIN network* *Operation Mode for the IUT (e.g. normal mode, low power mode,...)* *State of TX pin at the beginning of the test* Logical output voltages of the Rx pin corresponding to recessive/dominant level at the LIN pin are taken from the data sheet of the IUT. *Value in Volt* *In order to set failure at* *Value in Volt*
Test Steps	*Describe the test stages.*	
Response	*Describe the result expected in order to decide if the test passed or failed*	
Reference	*Corresponding no. in the LIN Physical Layer Specification*	

Remark:

IUT can be a master or slave ECU or an individual transceiver chip. The Rx, Tx and V_{SUP} signals must be accessible for proper test execution. It is recommended to test with Rx/Tx access, if not possible testing according the specification without Rx/Tx access is accepted.

Depending on the type of IUT the supply voltage is V_{BAT} for ECU or V_{SUP} for a chip – called V_{IUT} in this description.

1.2 Symbols and Abbreviated Terms

IUT	Implementation under Test
Tx	Tx pin of the transceiver
Rx	Rx pin of the transceiver
TRX	Transceiver
V_{BAT}	Voltage at ECU supply pins
V_{SUP}	Voltage at transceiver supply pins
V_{IUT}	Voltage at IUT supply pins
V_{BUS}	Voltage on the LIN bus
LIN Bus	LIN network
GND	Ground

1.3 Measurement and Signal Generation – Requirements

Signal Generation:	Rise / Fall Time		< 20ns (Square Wave) < 40ns (Triangle)
	Frequency		20ppm
	Jitter		< 25ns
Signal Measurement:	Dynamic Signals:		Oscilloscope 100MHz Rise Time ≤ 3,5ns
	Static Signals:	DC Voltage	0,5%
		DC Current	0,6%
		Resistance	0,5%
Power Supply (V_{CC}, V_{IUT}, V_{LIN})	Resolution		10mV / 1mA
	Accuracy		0,2% of value

2 Operational Conditions – Calibration

(Electrical input/output, LIN Protocol)

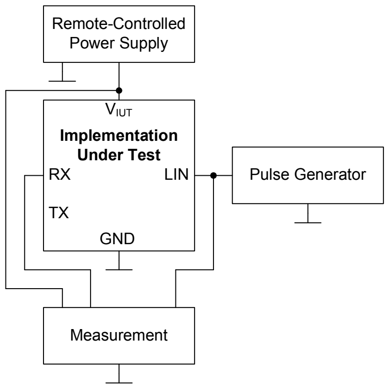
The initial configuration for each test case is defined here. Any requirements for individual tests are specified with the test case.

Initial State	Parameters:	
	Number of nodes	1
	Bus loads	-
	Operational Conditions:	
	IUT Mode	set to normal / active mode
	TX Signal	Recessive
	V_{BAT}, V_{SUP}, V_{IUT}	*Specified for each test*
	Failure	No failure
	GND Shift	0V

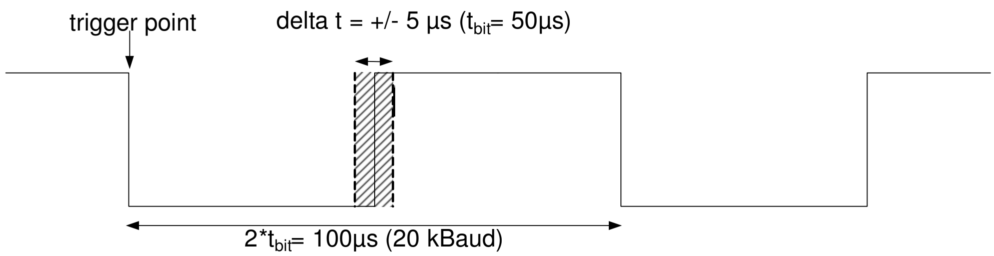
2.1 Operating Voltage Range

This test shall ensure the correct operation in the valid supply voltage ranges, by correct reception of dominant bits. The IUT is therefore supplied with an increasing/decreasing voltage ramp.

Test Configuration:



Schematic 1

IUT node as	Master and slave ECU Transceiver	Test case 2.1.x (2 cases)
Parameter	V_{SUP} / V_{BAT}	See Table 2.1
Test Steps	A voltage ramp is set on the V_{SUP} / V_{BAT} as defined on Table 2.1. The LIN signal is driven with a 10kHz rectangular signal with a duty cycle of 50% and a voltage swing of 18V. The IUT must be in operational / active mode	
Response	The RX pin of the IUT has to show the 10kHz signal. A maximum deviation of 10% (time, voltage) is allowed.  	
Reference	LIN Physical Layer Specification, Rev. 2.1, Ref. 6.5.4 Param 9, Param 10	

# test	V_{SUP} Range / V_{BAT} Range	Signal Ramp
2.1.1	[7.0V…18V] / [8.0V…18V]	0.1V/s
2.1.2	[18V…7.0V] / [18V…8.0V]	0.1V/s

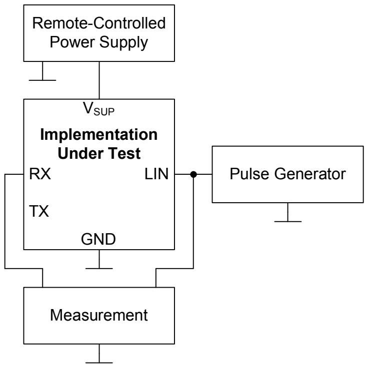
Table 2.1

2.2 Threshold Voltages

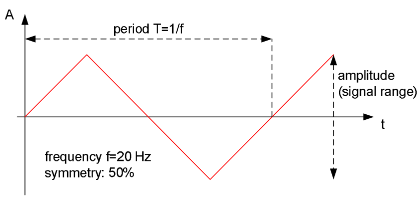
This group of tests checks whether the receiver threshold voltages of the IUT are implemented correctly within the entire specified operating supply voltage range. The LIN Bus voltage is driven with a voltage ramp checking the entire dominant and recessive signal area with respect to the applied supply voltage. In 2.2.1 and 2.2.2 the signal has to stay continuously on recessive or dominant level depending on the test case. In 2.2.3 the RX output transition is detected.

2.2.1 IUT as Receiver: V_{SUP} @ V_{BUS_DOM} (down)

Test Configuration:



Schematic 2

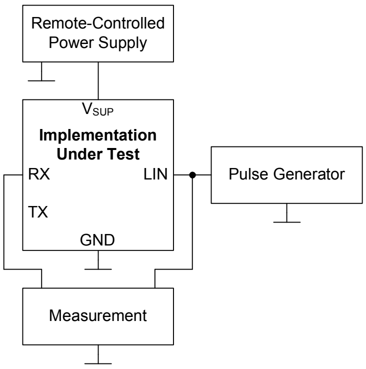
IUT node as	<u>Transceiver</u>	Test case 2.2.1.x (3 cases)
Parameter	V_{SUP}	See Table 2.2.1
Test Steps	A triangle signal with f=20Hz and symmetry of 50% is set on the LIN Bus. 	
Response	The IUT must generate a dominant or recessive value on RX as defined on Table 2.2.1 during the falling slope of the triangle signal.	
Reference	LIN Physical Layer Specification, Rev. 2.1, Ref 6.5.4 Param 17, Param 18 and 6.5.3 Fig. 6.4	

# test	V_{SUP}	Signal Range	Exp. RX Signal
2.2.1.1	7V	[18V…4.2V]	recessive
		[2.8V…-1.05V]	dominant
2.2.1.2	13V	[18V…7.8V]	recessive
		[5.2V…-2.1V]	dominant
2.2.1.3	18V	[20.7V…10.8V]	recessive
		[7.2V…-2.7V]	dominant

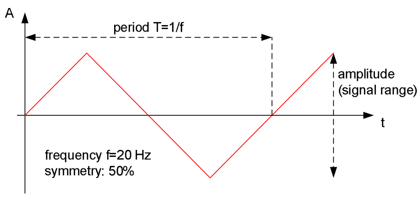
<u>Table 2.2.1</u>

2.2.2 IUT as Receiver: V_{SUP} @V_{BUS_REC} (up)

Test Configuration:



Schematic 3

IUT node as	<u>Transceiver</u>	Test case 2.2.2.x (3 cases)
Parameter	V_{SUP}	See Table 2.2.2
Test Steps	A triangle signal with f=20Hz and symmetry of 50% is set on the LIN Bus. 	
Response	The IUT must generate a dominant or recessive value on RX as defined on Table 2.2.2 during the rising slope of the triangle signal.	
Reference	LIN Physical Layer Specification, Rev. 2.1, Ref 6.5.4 Param 17, Param 18 and 6.5.3 Fig. 6.4	

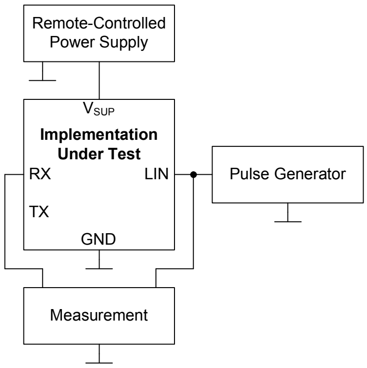
# test	V_{SUP}	Signal Range	Exp. RX Signal
2.2.2.1	7V	[-1.05V…2.8V]	dominant
		[4.2V…18V]	recessive
2.2.2.2	13V	[-2.1V…5.2V]	dominant
		[7.8V…18V]	recessive
2.2.2.3	18V	[-2.7V…7.2V]	dominant
		[10.8V…20.7V]	recessive

<u>Table 2.2.2</u>

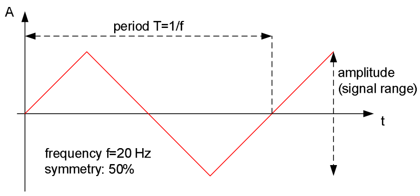
2.2.3 IUT as Receiver: V_{SUP} @V_{BUS}

This test shall verify the symmetry of the receiver thresholds. For this purpose a voltage ramp on V_{BUS} shows the required threshold values.

Test Configuration:



Schematic 4

IUT node as	Transceiver	Test case 2.2.3.x (3 cases)
Parameter	V_{SUP}	See Table 2.2.3
Test Steps	A triangle signal with f=20Hz and symmetry of 50% is set on the LIN Bus. 	
Response	The RX output of the IUT must switch from dominant to recessive when the LIN bus voltage ramps up and it must switch from recessive to dominant when the LIN bus voltage ramps down. The RX output transition must meet the following conditions: $V_{BUS\_CNT} = (V_{th\_dom}+V_{th\_rec})/2$ in the range of [0.475...0.525]*V_{SUP} $V_{HYS} = V_{th\_rec} - V_{th\_dom}$ must be less than 0.175*V_{SUP}	
Reference	LIN Physical Layer Specification, Rev. 2.1, Ref. 6.5.4 Param 19, Param 20	

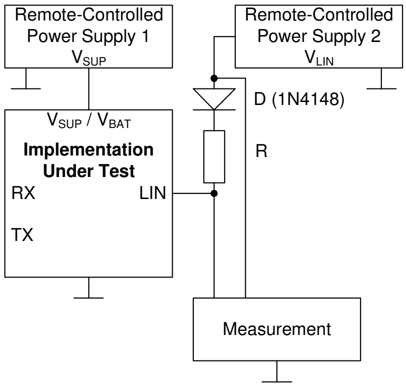
# test	**V_{SUP}**	**Signal Range**
2.2.3.1	7V	[-1.05V...8.05V] up [8.05V...-1.05V] down
2.2.3.2	14V	[-2.1V...16.1V] up [16.1V...-2.1V] down
2.2.3.3	18V	[-2.7V...20.7V] up [20.7V...-2.7V] down

Table 2.2.3

2.3 Variation of $V_{SUP\_NON\_OP} \in$ [- 0.3V ... 7.0V], [18V … 40V]

Within this test it shall be checked, whether the IUT influences the bus during under voltage and over voltage conditions.

Test Configuration:



Schematic 5

IUT node as	Master ECU Slave ECU Transceiver	Test case 2.3.1 Test case 2.3.2 Test case 2.3.3
Parameter	V_{SUP} V_{LIN} Bus Load	Signal with a 1V/s ramp in the range [-0.3V…7V], [18V…40V] See table 2.3 See table 2.3
Test Steps	A voltage ramp (up and down) is set on V_{IUT1}. The stimulus stays for t=30s at V_{IUT1}=40V. The TX signal has to be left open, if an internal pull-up is provided or applied with a recessive level.	
Response	No dominant state on LIN shall occur. The IUT must not be destroyed during the test. The afterward recessive voltage shall have a maximum deviation of ±5% from the before recessive voltage	
Reference	LIN Physical Layer Specification, Rev. 2.1, Ref. 6.5.4 Param 11	

# test	V_{SUP} Range	V_{LIN}	Bus Load
2.3.1	[-0.3V…8V], [18V…40V]	18V	60kΩ + diode (1N4148)
2.3.2	[-0.3V…8V], [18V…40V]	18V	1.1kΩ + diode (1N4148)
2.3.3	[-0.3V…7V], [18V…40V]	18V	1.1kΩ + diode (1N4148)

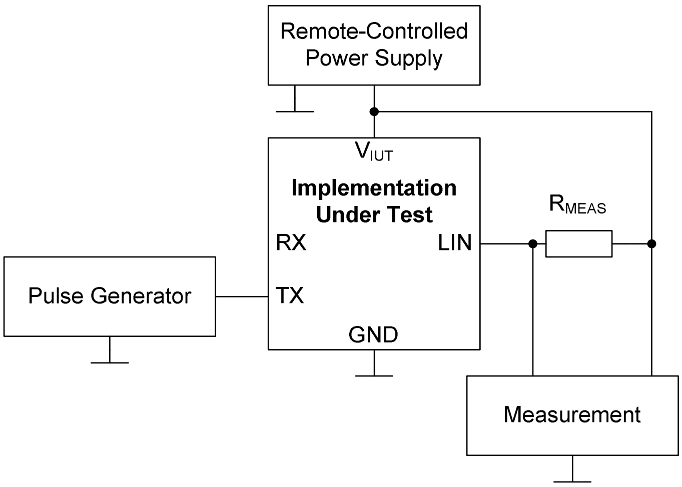
Table 2.3

2.4 I_{BUS} Under Several Conditions

2.4.1 I_{BUS_LIM} @ Dominant State (Driver On)

This test checks the drive capability of the output stage. A LIN driver has to pull the LIN bus below a certain voltage according to the LIN standard. The current limitation is measured indirectly.

Test Configuration:



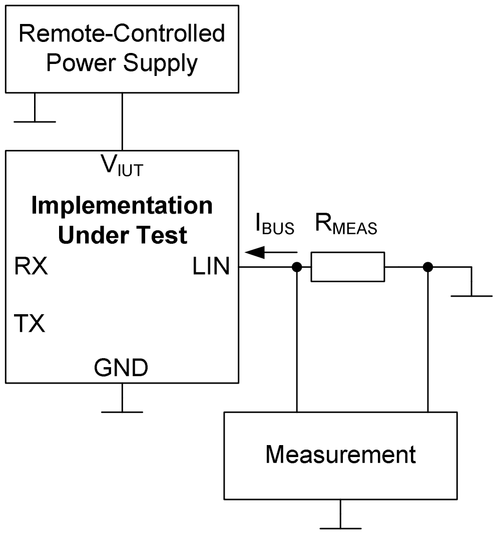
Schematic 6

IUT node as	Master ECU Slave ECU Transceiver	Test case 2.4.1
Parameter	V_{IUT} R_{MEAS}	18V 440 Ω (0.1%)
Test Steps	The LIN pin is connected via R_{MEAS} to V_{IUT}. The TX signal is driven with a rectangular signal (T=10ms) with a duty cycle of 50%.	
Response	LIN has to show the rectangular Signal. The dominant state bus level has to be lower than TH_DOM = 0.251 * V_{IUT}= 4.518V for transceiver. The dominant state bus level has to be lower than TH_DOM = 0.251 * (V_{IUT} – 1V) = 4.267V for ECU's.	
Reference	LIN Physical Layer Specification, Rev. 2.1, Ref. 6.5.4 Param 12	

2.4.2 $I_{BUS\_PAS\_dom}$: IUT in Recessive State : V_{BUS} = 0V

This test case is intended to test the input Leakage Current IBUS_PAS_dom into a node during dominant state of the LIN bus.

Test Configuration:



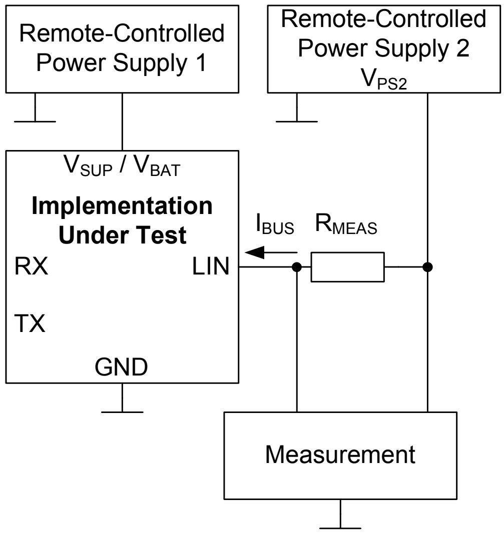
Schematic 7

IUT node as	Slave ECU Transceiver	Test case 2.4.2
Parameter	V_{IUT} R_{MEAS}	12V 499 Ω (0.1%)
Test Steps	The TX signal is set recessive.	
Response	The maximum value of voltage drop shall be higher than -500mV.	
Reference	LIN Physical Layer Specification, Rev. 2.1, Ref. 6.5.4 Param 13	

2.4.3 $I_{BUS\_PAS\_rec}$: IUT in Recessive State : V_{SUP} = 7.0V with Variation of $V_{BUS} \in$ [8.0V .. 18V]

The test 2.4.3 is checking, whether there is a diode implementation within the termination path of the IUT. The reverse current should be limited to $I_{BUS\_PAS\_rec\ (Max)}$ from the LIN wire into the IUT even if V_{BUS} is higher than the IUTs supply voltage V_{IUT}

Test Configuration:



Schematic 8

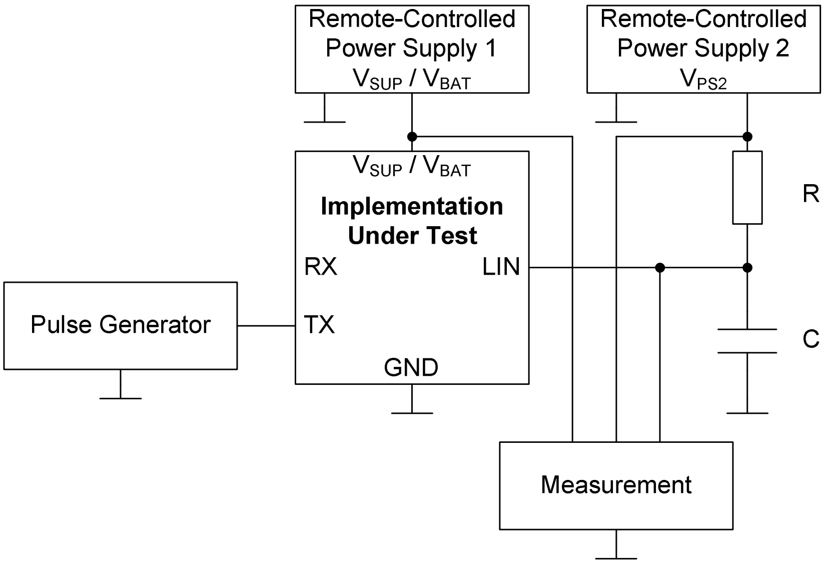
IUT node as	Master ECU Slave ECU Transceiver	Test case 2.4.3
Parameter	V_{SUP} / V_{BAT} R_{MEAS}	7.0V / 8.0V 1000 Ω (0.1%)
Test Steps	V_{PS2} = Signal with a 2V/s ramp in the range [8V .. 18V] up and down The TX signal is set recessive.	
Response	The maximum value of voltage drop shall be less or equal 20mV	
Reference	LIN Physical Layer Specification, Rev. 2.1, Ref. 6.5.4 Param 14	

2.5 Slope Control

Purpose of this test is checking the duty cycle of the driver stage.

2.5.1 Measuring the Duty Cycle @ 10.4 kBit/sec – IUT as Transmitter

Test Configuration:



Schematic 9

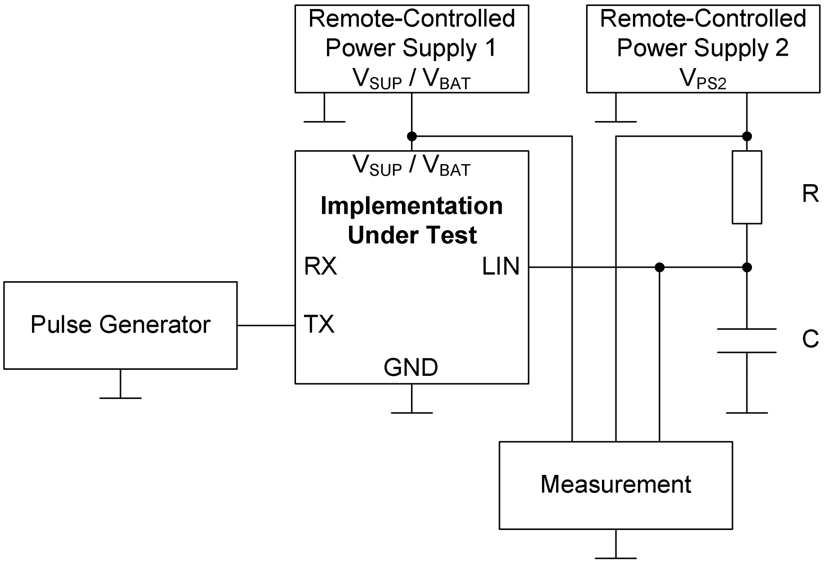
IUT node as	Master / Slave ECU Transceiver	Test case 2.5.1.x (9 cases)
Parameter	Bus loads V_{SUP} / V_{BAT} V_{PS2}	See Table 2.5.1 See Table 2.5.1 See Table 2.5.1
Test Steps	TXD is driven with a rectangular signal (T=192µs) with a duty cycle of 50%, TXD slope time < 500ns, 100% voltage swing.	
Response	The measured duty cycle D3 must be greater or equal than 0.417 for V_{SUP} = [7.0V...18V], the measured duty cycle D4 must be less or equal than 0.590 for V_{SUP} = [7.6V...18V]. If V_{SUP} is not accessible then V_{BAT} – 0.7V has to be used for calculation of the Duty Cycle.	
Reference	LIN Physical Layer Specification, Rev. 2.1, Ref. 6.5.4.1 table 6.9 and Fig. 6.5	

Test case #	V_{SUP} / V_{BAT} (PS 1)	V_{PS2} (PS 2)	Bus loads (C; R)	Duty cycle	
				D3 min	D4 max
2.5.1.1.1	7.0V / 8.0V	6.0V	1nF (1%); 1kΩ (0.1%)	0.417	-
2.5.1.1.2	7.0V / 8.0V	6.6V	1nF (1%); 1kΩ (0.1%)	0.417	-
2.5.1.2.1	7.0V / 8.0V	6.0V	6.8nF (1%); 660 Ω (0.1%)	0.417	-
2.5.1.2.2	7.0V / 8.0V	6.6V	6.8nF (1%); 660 Ω (0.1%)	0.417	-
2.5.1.3.1	7.0V / 8.0V	6.0V	10nF (1%); 500 Ω (0.1%)	0.417	-
2.5.1.3.2	7.0V / 8.0V	6.6V	10nF (1%); 500 Ω (0.1%)	0.417	-
2.5.1.4.1	7.6V / 8.6V	6.6V	1nF (1%); 1kΩ (0.1%)	0.417	0.590
2.5.1.4.2	7.6V / 8.6V	7.2V	1nF (1%); 1kΩ (0.1%)	0.417	0.590
2.5.1.5.1	7.6V / 8.6V	6.6V	6.8nF (1%); 660 Ω (0.1%)	0.417	0.590
2.5.1.5.2	7.6V / 8.6V	7.2V	6.8nF (1%); 660 Ω (0.1%)	0.417	0.590
2.5.1.6.1	7.6V / 8.6V	6.6V	10nF (1%); 500 Ω (0.1%)	0.417	0.590
2.5.1.6.2	7.6V / 8.6V	7.2V	10nF (1%); 500 Ω (0.1%)	0.417	0.590
2.5.1.7.1	18V / 18.6V	17.0V	1nF (1%); 1kΩ (0.1%)	0.417	0.590
2.5.1.7.2	18V / 18.6V	17.6V	1nF (1%); 1kΩ (0.1%)	0.417	0.590
2.5.1.8.1	18V / 18.6V	17.0V	6.8nF (1%); 660 Ω (0.1%)	0.417	0.590
2.5.1.8.2	18V / 18.6V	17.6V	6.8nF (1%); 660 Ω (0.1%)	0.417	0.590
2.5.1.9.1	18V / 18.6V	17.0V	10nF (1%); 500 Ω (0.1%)	0.417	0.590
2.5.1.9.2	18V / 18.6V	17.6V	10nF (1%); 500 Ω (0.1%)	0.417	0.590

Table 2.5.1

2.5.2 Measuring the Duty Cycle @ 20.0 kBit/sec – IUT as Transmitter

Test Configuration:



Schematic 10

IUT node as	Master / Slave ECU Transceiver	Test case 2.5.2.x (9 cases)
Parameter	Bus loads V_{SUP} / V_{BAT} V_{PS2}	See Table 2.5.2 See Table 2.5.2 See Table 2.5.2
Test Steps	TXD is driven with a rectangular signal (T=100µs) with a duty cycle of 50%, TXD slope time < 500ns, 100% voltage swing.	
Response	The measured duty cycle D1 must be greater or equal than 0.396 for V_{SUP} = [7.0V...18V], the measured duty cycle D2 must be less or equal than 0.581 for V_{SUP} = [7.6V...18V]. If V_{SUP} is not accessible then V_{BAT} – 0.7V has to be used for calculation of the Duty Cycle.	
Reference	LIN Physical Layer Specification, Rev. 2.1, Ref. 6.5.4.1 table 6.8 and Fig. 6.5	

TC #	V_{SUP} / V_{BAT} (PS 1)	V_{PS2} (PS 2)	Bus loads (C; R)	Duty cycle	
				D1 min	D2 max
2.5.2.1.1	7.0V / 8.0V	6.0V	1nF (1%); 1kΩ (0.1%)	0.396	-
2.5.2.1.2	7.0V / 8.0V	6.6V	1nF (1%); 1kΩ (0.1%)	0.396	-
2.5.2.2.1	7.0V / 8.0V	6.0V	6.8nF (1%); 660 Ω (0.1%)	0.396	-
2.5.2.2.2	7.0V / 8.0V	6.6V	6.8nF (1%); 660 Ω (0.1%)	0.396	-
2.5.2.3.1	7.0V / 8.0V	6.0V	10nF (1%); 500 Ω (0.1%)	0.396	-
2.5.2.3.2	7.0V / 8.0V	6.6V	10nF (1%); 500 Ω (0.1%)	0.396	-
2.5.2.4.1	7.6V / 8.6V	6.6V	1nF (1%); 1kΩ (0.1%)	0.396	0.581
2.5.2.4.2	7.6V / 8.6V	7.2V	1nF (1%); 1kΩ (0.1%)	0.396	0.581
2.5.2.5.1	7.6V / 8.6V	6.6V	6.8nF (1%); 660 Ω (0.1%)	0.396	0.581
2.5.2.5.2	7.6V / 8.6V	7.2V	6.8nF (1%); 660 Ω (0.1%)	0.396	0.581
2.5.2.6.1	7.6V / 8.6V	6.6V	10nF (1%); 500 Ω (0.1%)	0.396	0.581
2.5.2.6.2	7.6V / 8.6V	7.2V	10nF (1%); 500 Ω (0.1%)	0.396	0.581
2.5.2.7.1	18V / 18.6V	17.0V	1nF (1%); 1kΩ (0.1%)	0.396	0.581
2.5.2.7.2	18V / 18.6V	17.6V	1nF (1%); 1kΩ (0.1%)	0.396	0.581
2.5.2.8.1	18V / 18.6V	17.0V	6.8nF (1%); 660 Ω (0.1%)	0.396	0.581
2.5.2.8.2	18V / 18.6V	17.6V	6.8nF (1%); 660 Ω (0.1%)	0.396	0.581
2.5.2.9.1	18V / 18.6V	17.0V	10nF (1%); 500 Ω (0.1%)	0.396	0.581
2.5.2.9.2	18V / 18.6V	17.6V	10nF (1%); 500 Ω (0.1%)	0.396	0.581

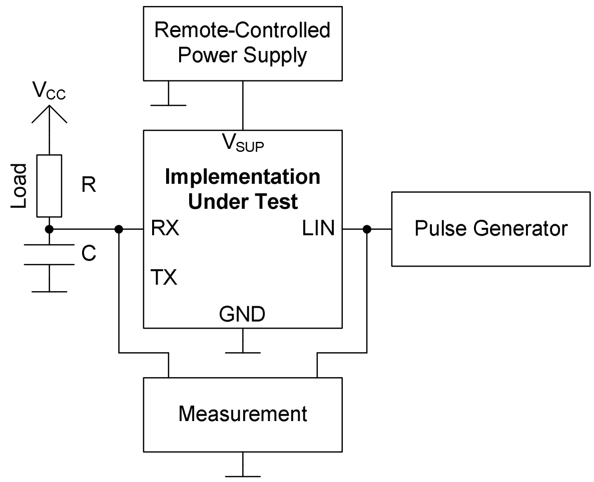
Table 2.5.2

2.6 Propagation Delay

The following test checks the receiver's internal delay and its symmetry. The method for measuring the values is shown in fig. 6.5 in the LIN Physical Layer Specification.

2.6.1 Propagation Delay of the Receiver

Test Configuration:



Schematic 11

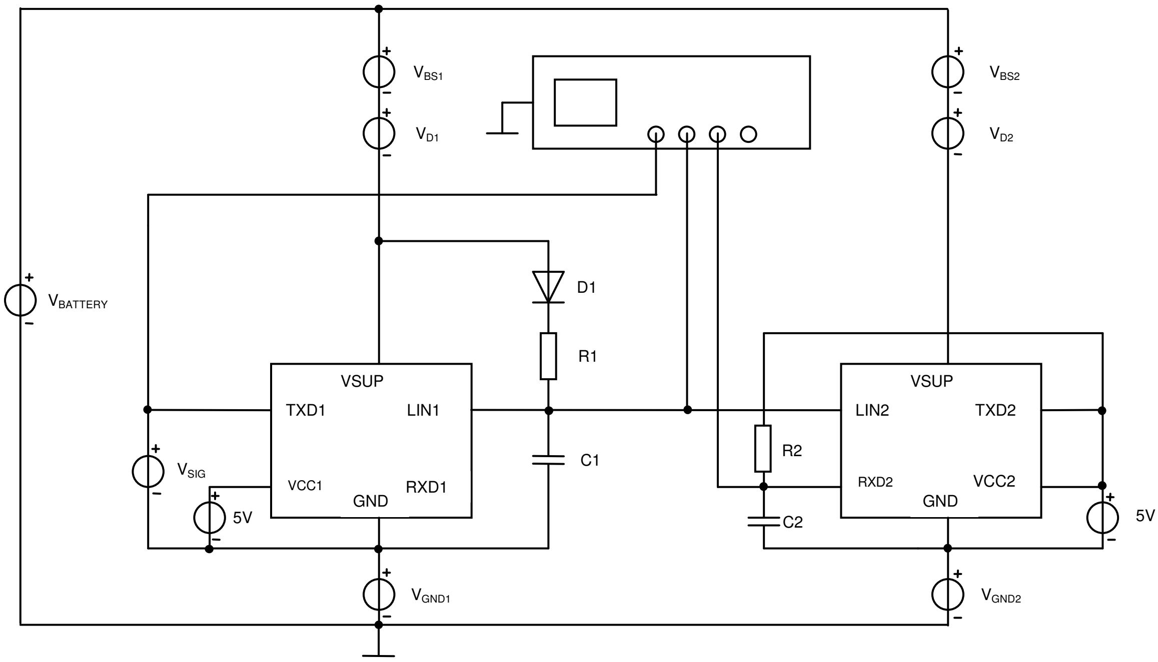
IUT node as	Transceiver	Test case 2.6.1.x (3 cases)
Parameter	RXD	C = 20pF (5%), R = 2.4kΩ (0.1%): pull-up resistor for "open drain" transceiver only
	V_{SUP}	See Table 2.6.1
	V_{cc}	5V
Test Steps	LIN bus is driven with a 10kHz rectangular signal with a duty cycle of 50%, V_{LIN} starts at V_{SUP} and ramps down to 0V within 20ns and vice versa.	
Response	The measured time t_{rx_pd} must be less than 6µs. $t_{rx\_sym} = t_{rx\_pdf} - t_{rx\_pdr}$ must be in the range –2...2µs	
Reference	LIN Physical Layer Specification, Rev. 2.1, Ref. 6.5.4.1 Param 31, 32 and Fig. 6.5	

Test case #	V_{SUP}
2.6.1.1	7.0V
2.6.1.2	14V
2.6.1.3	18V

Table 2.6.1

2.7 GND / V_{BAT} Shift Test – Dynamic

The purpose of the test is to check the robustness in case of VBAT and Ground shift.



Schematic 12

Concept: the two operating voltages (V_{CC} and V_{SUP}) are ground-free and completely decoupled from each other and with that a superposition with each of these voltages with NF and HF can be realised independently.

The operating voltages V_{CC} and V_{SUP} are 5V and 14V. However, they can be varied indirectly via suitable triggering. The two voltages need independent, ground-free direct current supplies, in order to exclude interconnections.

2.7.1 GND Shift Test – Dynamic – IUT as Transceiver

IUT node as	Transceiver	Test case 2.7.1
Parameter	$V_{BATTERY}$ V_{BS1} V_{D1} V_{GND1} V_{BS2} V_{D2} V_{GND2} C2 R2	9.41V 0.115 * $V_{BATTERY}$ 1V 0.035 * $V_{BATTERY}$ 0.035 * $V_{BATTERY}$ 0.4V sinus voltage with 0.115 * $V_{BATTERY}$ amplitude and 0.5 * 0.115 * $V_{BATTERY}$ offset and a frequency of 5 Hz 20pF (including input capacitance of oscilloscope) 2.4 kOhm: only for open drain transceiver assembled
Test Steps	A signal at 10 kHz is set on TxD1. The test has to be done with R1 = 1kOhm and C1 = 1nF. The test has to be repeated with R1 = 500Ohm and C1 = 10nF.	
Response	The duty cycle measured at RXD2 must be in the range of 0.376 ... 0.601 (D1 – 2µs ... D2 + 2µs).	
Reference	LIN Physical Layer Specification, Rev. 2.1, Ref. 6.5.4, Param 23	

2.7.2 GND Shift Test – Dynamic – IUT as Transceiver

IUT node as	Transceiver	Test case 2.7.2
Parameter	$V_{BATTERY}$ V_{BS1} V_{D1} V_{GND1} V_{BS2} V_{D2} V_{GND2} C2 R2	9.41V 0.035 * $V_{BATTERY}$ 0.4V sinus voltage with 0.115 * $V_{BATTERY}$ amplitude and 0.5 * 0.115 * $V_{BATTERY}$ offset and a frequency of 5 Hz 0.115 * $V_{BATTERY}$ 1V 0.035 * $V_{BATTERY}$ 20pF (including input capacitance of oscilloscope) 2.4 kOhm: only for open drain transceiver assembled
Test Steps	A signal at 10 kHz is set on TxD1. The test has to be done with R1 = 1kOhm and C1 = 1nF. The test has to be repeated with R1 = 500Ohm and C1 = 10nF.	
Response	The duty cycle measured at RXD2 must be in the range of 0,376 .. 0,601 (D1 – 2µs .. D2 + 2µs).	
Reference	LIN Physical Layer Specification, Rev. 2.1, Ref. 6.5.4, Param 23	

2.7.3 V_{BAT} Shift Test – Dynamic – IUT as Transceiver

IUT node as	Transceiver	Test case 2.7.3
Parameter	$V_{BATTERY}$ V_{BS1} V_{D1} V_{GND1} V_{BS2} V_{D2} V_{GND2} C2 R2	9.41V sinus voltage with 0.115 * $V_{BATTERY}$ amplitude and 0.5 * 0.115 * $V_{BATTERY}$ offset and a frequency of 5 Hz 1V 0.035 * $V_{BATTERY}$ 0.035 * $V_{BATTERY}$ 0.4V 0.115 * $V_{BATTERY}$ 20pF (including input capacitance of oscilloscope) 2.4 kOhm: only for open drain transceiver assembled
Test Steps	A signal at 10 kHz is set on TxD1. The test has to be done with R1 = 1kOhm and C1 = 1nF. The test has to be repeated with R1 = 500Ohm and C1 = 10nF.	
Response	The duty cycle measured at RXD2 must be in the range of 0,376 .. 0,601 (D1 – 2µs .. D2 + 2µs).	
Reference	LIN Physical Layer Specification, Rev. 2.1, Ref. 6.5.4, Param 23	

2.7.4 V_{BAT} Shift Test – Dynamic – IUT as Transceiver

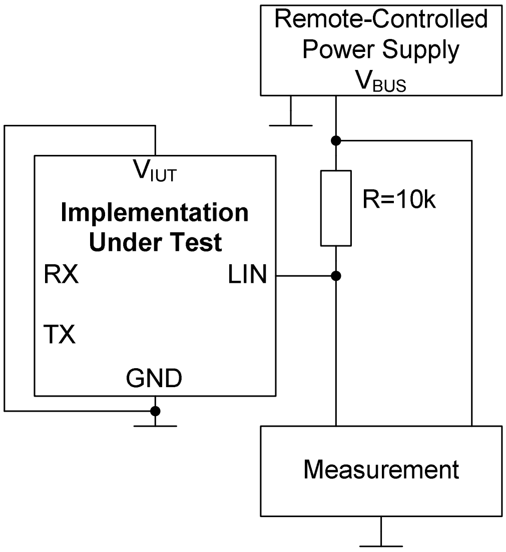
IUT node as	Transceiver	Test case 2.7.4
Parameter	$V_{BATTERY}$ V_{BS1} V_{D1} V_{GND1} V_{BS2} V_{D2} V_{GND2} C2 R2	9.41V 0.035 * $V_{BATTERY}$ 0.4V 0.115 * $V_{BATTERY}$ sinus voltage with 0.115 * $V_{BATTERY}$ amplitude and 0.5 * 0.115 * $V_{BATTERY}$ offset and a frequency of 5 Hz 1V 0.035 * $V_{BATTERY}$ 20pF (including input capacitance of oscilloscope) 2.4 kOhm: only for open drain transceiver assembled
Test Steps	A signal at 10 kHz is set on TxD1. The test has to be done with R1 = 1kOhm and C1 = 1nF. The test has to be repeated with R1 = 500Ohm and C1 = 10nF.	
Response	The duty cycle measured at RXD2 must be in the range of 0,376 .. 0,601 (D1 – 2µs .. D2 + 2µs).	
Reference	LIN Physical Layer Specification, Rev. 2.1, Ref. 6.5.4, Param 23	

2.8 Failure

Purpose of this test is to check, whether some parasitic reverse currents are flowing into the IUT.

2.8.1 Loss of Battery

Test Configuration:

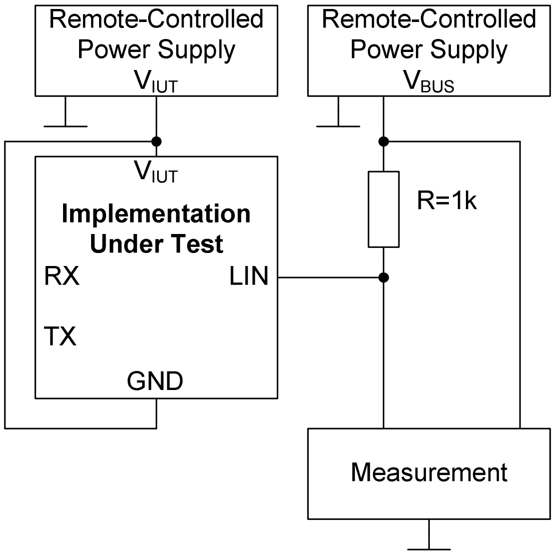


Schematic 13

IUT node as	Master/Slave ECU Transceiver	Test case 2.8.1
Parameter	V_{IUT} = GND Failure 0< V_{BUS} <18V R	 Loss of Battery 10kΩ (0.1%)
Test Steps	The power supply is disconnected from the IUT V_{IUT} PIN. V_{BUS} = Signal with a 2V/s ramp in the range [0V .. 18V] up and down	
Response	During all test, no parasitic current paths must be formed between the bus line and the ECU: I_{BUS} must be less than 100µA, means 1V voltage drop over R=10kΩ. After reconnecting battery line: The IUT must restart after failure recovery.	
Reference	LIN Physical Layer Specification, Rev. 2.1, Ref. 6.5.4, Param 16	

2.8.2 Loss of GND

Test Configuration:



Schematic 14

IUT node as	Slave ECU Transceiver	Test case 2.8.2
Parameter	V_{IUT} GND_{SUP} / GND_{BAT} = V_{IUT} Failure R	12 V local GND shorted to V_{IUT} Loss of ground 1kΩ (0.1%)
Test Steps	The ground is disconnected from the IUT. V_{BUS} = Signal with a 2V/s ramp in the range [0V .. 18V] up and down	
Response	During all test, no parasitic current paths must be formed between the bus line and the ECU: I_{BUS} must be included in ± 1mA, means 1V voltage drop over R=1kΩ. After reconnecting ground line: The IUT must restart after failure recovery.	
Reference	LIN Physical Layer Specification, Rev. 2.1, Ref. 6.5.4, Param 15	

3 Static Test Cases

The motivation of static test cases is to check the availability and the boundaries in the data sheet of the IUT.

For all integrated circuits every related parameter in Table 3 must be part of the data sheet and fulfil the specified boundaries in terms of physical worst case condition. Data sheet parameter names may deviate from the names in Table 3, but in this case a cross-reference list (data sheet versus Table 3) shall be provided for this test. Parameter conditions may deviate from the conditions in Table 3, if the data sheet conditions are according to the physical worst case context in Table 3 at least.

If one parameter does not pass this test, the result of the whole conformance test is failed.

Reference LIN Physical Layer Spec Revision 2.1 November 24th, 2006, section Line Driver/Receiver, 6.5.4 ELECTRICAL DC PARAMETERS, table 6.6 to 6.11

no.	reference	parameter	Min	max	unit	comment / condition	valid for
1.	Param 9	V_{BAT}	8.0	18.0	V	ECU operating voltage	all devices with integrated reverse polarity diode
2.	Param 10	V_{SUP}	7.0	18.0	V	Supply voltage range	all devices without integrated reverse polarity diode
3.	Param 11	$V_{SUP\_NON\_OP}$	-0.3	40.0	V	voltage range within which the device is not destroyed	all devices
4.	Param 12	I_{BUS_LIM}	40	200	mA	Current Limitation for Driver dominant state driver on $V_{BUS} = V_{BAT\_max}$ [d]	all devices with integrated LIN transmitter
5.	Param 13	$I_{BUS\_PAS\_dom}$	-1		mA	Input Leakage Current at the Receiver incl. Slave Pull-Up Resistor as specified in Table 6.7 driver off $V_{BUS} = 0V$ $V_{BAT}= 12V$	all devices with integrated slave pull-up resistor

no.	reference	parameter	Min	max	unit	comment / condition	valid for
6.	Param 14	$I_{BUS\_PAS\_rec}$		20	µA	driver off 8V<V_{BAT}<18V 8V<V_{BUS}<18V V_{BUS} > V_{BAT}	all devices
7.	Param 15	$I_{BUS\_NO\_GND}$	-1	1	mA	Control unit discon-nected from ground GND_{Device} = V_{SUP} 0V<V_{BUS}<18V V_{BAT} = 12V Loss of local ground must not affect com-munication in the residual network.	all devices
8.	Param 16	$I_{BUS\_NO\_BAT}$		100	µA	V_{BAT} disconnected V_{SUP_Device} = GND 0<V_{BUS}<18V Node has to sustain the current that can flow under this condition. Bus must remain op-erational under this condition.	all devices
9.	Param 17	V_{BUSdom}		0.4	V_{SUP}	receiver dominant state	all devices with inte-grated LIN receiver
10.	Param 18	V_{BUSrec}	0.6		V_{SUP}	receiver recessive state	all devices with inte-grated LIN receiver
11.	Param 19	V_{BUS_CNT}	0.475	0.525	V_{SUP}	V_{BUS_CNT} =(V_{th_dom}+V_{th_rec})/2	all devices with inte-grated LIN receiver
12.	Param 20	V_{HYS}		0.175	V_{SUP}	V_{HYS} = V_{th_rec}-V_{th_dom}	all devices with inte-grated LIN receiver
13.	Param 27	D1	0.396			$TH_{Rec(max)}$ = 0.744 x V_{SUP}; $TH_{Dom(max)}$ = 0.581 x V_{SUP}; V_{SUP} = 7.0V...18V; t_{Bit} = 50µs; D1 = $t_{Bus\_rec(max)}$ / (2 x t_{Bit})	all devices with inte-grated LIN transmitter D1 valid for 20kBaud

no.	reference	parameter	Min	max	unit	comment / condition	valid for
14.	Param 28	D2		0.581		$TH_{Rec(min)}$ = 0.422 x V_{SUP}; $TH_{Dom(min)}$ = 0.284 x V_{SUP}; V_{SUP} = 7.6V...18V; t_{Bit} = 50µs; D2 = $t_{Bus\_rec(max)}$ / (2 x tBit)	all devices with integrated LIN transmitter D2 valid for 20kBaud
15.	Param 29	D3	0.417			$TH_{Rec(max)}$ = 0.778 x V_{SUP}; $TH_{Dom(max)}$ = 0.616 x V_{SUP}; V_{SUP} = 7.0V...18V; t_{Bit} = 96µs; D3 = $t_{Bus\_rec(min)}$ / (2 x t_{Bit})	all devices with integrated LIN transmitter D3 valid for 10.4 kBaud
16.	Param 30	D4		0.590		$TH_{Rec(min)}$ = 0.389 x V_{SUP}; $TH_{Dom(min)}$ = 0.251 x V_{SUP}; V_{SUP} = 7.6V...18V; t_{Bit} = 96µs; D4 = $t_{Bus\_rec(max)}$ / (2 x t_{Bit})	all devices with integrated LIN transmitter D4 valid for 10.4 kBaud
17.	Param 31	t_{rx_pd}		6	µs	propagation delay of receiver	all devices with integrated LIN receiver
18.	Param 32	t_{rx_sym}	-2	2	µs	symmetry of receiver propagation delay rising edge w.r.t. falling edge	all devices with integrated LIN receiver
19.	Param 26	R_{slave}	20	60	kΩ		all devices with integrated slave pull-up resistor
20.	Param 25	R_{master}	900	1100	Ω	The serial diode is mandatory. Only for valid for Transceiver with integrated Master pull up resistor	all devices with integrated master pull-up resistor
21.	Param 37	C_{SLAVE}		250	pF	Capacitance of slave node	all LIN slave devices

Table 3: LIN static test parameters for data sheets of integrated circuits

4 References

LIN Conformance Test Working Group	LIN CT Draft

LIN

Conformance Test Specification

LIN OSI Layer 2 – Data Link Layer

For the LIN Protocol Specification
Revision 2.1 (November 24th, 2006)

Version 2.1
October 10th, 2008

Table of contents

1 Global Predefinitions for the Test Specification

1.1 LIN Glossary

See chapter 1.12 and additional LIN Specification 2.1 chapter “1.2 LIN GLOSSARY”.

1.2 General

This test specification is not able to cover all contingencies. Due to the fact of the missing vehicle environment, it is possible that the IUT's behaviour differs.

1.3 Test conditions

The test have to be done at room temperature in a range of 15 to 35 degrees Celsius.

1.4 Mandatory Requirements for IUT as Master

The LIN Description File (LDF) is mandatory to perform the LIN OSI Layer 2 – Data Link Layer and Node Configuration / Network Management Conformance Tests for IUT as Master.

If the LDF is not able to describe all features of the IUT, an additional device specific datasheet is necessary (for example used diagnostic services).

Depending on the implementation of the IUT as Master, it is allowed to use all possible Master request frames (e.g. instead of TST_FRAME_1) for testing, except mandatory supported frames.

IUT initialisation is required before each test case. Deviations will be marked in the test case respectively.

1.5 Mandatory Requirements for IUT as Slave

The Node Capability File (NCF) is mandatory to perform the LIN OSI Layer 2 – Data Link Layer and Node Configuration / Network Management Conformance Tests for IUT as Slave.

The used Test tool has to verify the syntax of the NCF for plausibility (not for the content).

The NCF has to match with the implementation of the device.

If the NCF is not able to describe all features of the IUT, an additional device specific datasheet is necessary (for example used diagnostic services).

If an IUT is not full configured after reset, IUT initialisation is required before each test case. Except if the Assign frame ID range command is part of the test. Preconfigured slaves are fully configured after reset. Deviations will be marked in the test case respectively.

1.6 LIN API requirements

The LIN API requirements for the Data Link Layer part:

The LIN API defines a mandatory interface to a hardware or software LIN device driver implementation. The LIN API should be available to perform the Data Link Layer Conformance Tests. If an API is available the test execution of the Data Link Layer part shall be performed using this LIN API interface.

The LIN API requirements for the Node Configuration / Network Management part:

The LIN API defines a mandatory interface to a hardware or software LIN device driver implementation. Two sections of the LIN API (LIN core API, LIN node configuration and identification API) shall be available to perform the Node Configuration / Network Management Conformance Tests. The test execution of the Node Configuration / Network Management part shall be performed using this LIN API interface. If there is no LIN API available the Node Configuration / Network Management Tests are not applicable.

1.7 Test Case Architecture

In the description of each test case it is specified for which device type the test case is applicable.

Applicable for: **MASTER**

SLAVE

Each specification of a test case consists of four parts:

- **Set Up**
  - defines the IUT as Master or Slave
  - defines settings for the Implementation Under Test (IUT) and the Test System (details see chapter 1.11.1)
  - defines the bit rate for the respective test case

- **System Init**

  Defines to what state the IUT must have been set before starting the execution of the test. If not otherwise defined, the IUT as Master sends requests respective the IUT as Slave waits for requests.

  An initialisation of the IUT must be performed before each test case. To initialise the IUT a reset is carried out and thereafter the IUT must be reconfigured e.g. by a Frame ID configuration process.

- **Test**

  Defines the way of stimulating the IUT.

  NOTE: if more than one step is defined in this field, the steps have to be executed in the order as they are stated in the document.

- **Verification**

  Defines the expected behaviour of the IUT when executing the test steps.

1.8 Classification

The classification describes the LIN integration level.

No.	Classification	Description	Comment
1	class A	Transceiver devices	Data Link Layer and Node Configuration / Network Management Tests not applicable
2	class B	µC based Devices	IUT as Master or Slave with RxD and TxD connectors
3	class C	Integrated Devices (ECU) with µC and Transceiver	IUT as Master or Slave with analog LIN bus connector available

Table 1.8

1.9 Test System Requirements

1.9.1 Generation of LIN Frames

The Test System has to ensure the precision of the bit time of a master node given by the LIN Specification.

1.9.2 Standard requirements for the test cases

For proper measurement and verification of LIN Frames, the Test System has to use a minimum-over sampling factor of 16.

$$\text{Sample Resolution} = \frac{T_{BIT}}{16}$$

1.9.3 Special requirements for bit timing testing (Test case 3.12; 3.13; 3.14)

For proper measurement and verification of the bit timing Tests, the Test System must measure with a minimum over sampling of 10 to the precision of the Master tolerance given by the LIN Specification.

$$\text{Bit time Sample Resolution} = \frac{T_{BIT} \cdot \frac{0.5}{100}}{10}$$

1.10 Test system Definition

A detailed Test System definition is not part of this document. The Test System must be implemented in a way that the test cases can be performed as specified and under protection of the principles of the independency from test persons and from other test cases and of the reproducibility (see above).

1.11 Global Predefinitions for the test setup

1.11.1 Configuration of IUT and Test System

Before executing the tests some settings have to be done concerning

- the Protected Identifier (PID) which have to be sent by a Master
- the contents of the data of a Slave answer
- the delay between Master requests.
- the bit rate which has to be used for the test

In the table below several frames for the IUT and the Test System are defined. In each test case specification there is a row called 'Configuration' mostly referring to a row in the table below. The configuration described in that row has to be applied to the respective test case.

If there is no reference to the table below the settings are described in the test case specification itself.

- If the IUT is not able to support the given Protected Identifier, the table can be adapted to the possibilities of the IUT.

- For the delay between the Master requests see chapter 1.11.2.

TST_Frame	Requirements for the Test Frame
TST_FRAME_1	Assign frame ID range
TST_FRAME_2	Read by Identifier (Identifier = 0) All other parameters has to be filled with default values according to the IUT specification and according to the test case specification.
TST_FRAME_3	Read by Identifier (Identifier ≠ 0) Shall be used with the correct NAD, Supplier ID and Function ID according to the IUT specification. The ID is variable and > 0
TST_FRAME_4_Tx	Device Specific Transmit Frame (IUT is publisher)
TST_FRAME_4_Rx	Device Specific Receive Frame (IUT is subscriber)
TST_FRAME_5	Request for Event Triggered Frame
TST_FRAME_6	Slave Response Command Frame, Identifier = 0x3D
TST_FRAME_7	Read Response Error bit
TST_FRAME_8	reserved frame, Identifier = 0x3F, Identifier = 0x3E
TST_FRAME_9	Go to sleep command
TST_FRAME_10	Conditional change NAD
TST_FRAME_11	Functional request with NAD = 0x7E
TST_FRAME_12	Read by Identifier (Identifier = 0) with different NAD
TST_FRAME_13	Assign NAD
TST_FRAME_14_XX	This is a Master request message (0x3C) which can carry any kind of diagnostic message, except messages of configuration and identification. XX can be SF (single frame), CF (consecutive or FF (first frame))
TST_FRAME_15_XX	This is a Slave response message (0x3D) which can carry any kind of diagnostic message, except messages of configuration and identification. XX can be SF (single frame), CF (consecutive or FF (first frame))
TST_FRAME_UNKNOWN	All not defined (not configured in the IUTs LDF, NCF) frame IDs from 0-59 with all combination of parity bits and all known frame IDs with possible incorrect parity bits Number of data bytes 8, Data bytes 1 to 8 shall be filled with 0x00, 0x01, 0x02, 0x03, 0x04, 0x05, 0x06, 0x07

Note: All used frames must be valid and according to the device specification

Table 1.11.1

1.11.2 Default Delays for frame headers

If not otherwise specified the delay between the Master headers is defined as shown in Table 1.11.2.

bit rate	Master delay
2400 b/s	80 ms
9600 b/s	20 ms
10417 b/s	20 ms
19200 b/s	10 ms

Table 1.11.2

Remark:

Default delay has to be used, unless P2_min or min_period for a frame is defined in the NCF. If P2_min is longer than the default value, P2_min is to use.

1.11.3 Default bit rate

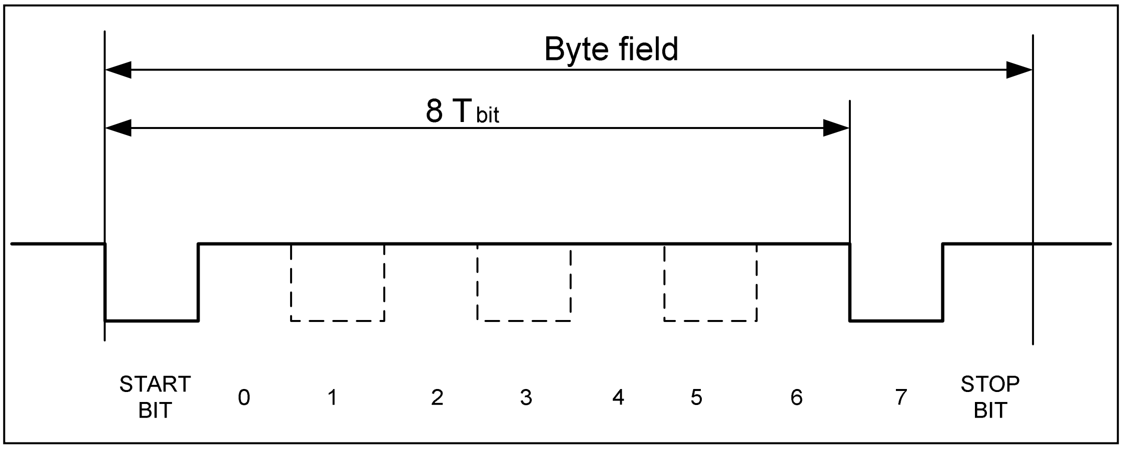
The default bit rate is set to the highest bit rate that is specified by the specification of the IUT.

Test cases with different bit rate settings can only be performed when the required bit rate is in accordance with the specification of the IUT.

1.11.4 Time Measurement

The Time measurement for master nodes is done at the sync byte field as shown below. For slave nodes, the answer to Read by Identifier (ID 2-15) and evaluation of RSID (0x7F) in the mandatory negative response is used. In this case the distance between falling edges of START BIT and BIT 7 is measured.

The time measurement has to be done between falling edges of the pattern. The falling edge is available in a distance of 8 bit times, which allow a simple calculation of the basic bit time T_{BIT}.



Picture 1.11.4: Byte field for Time Measurement

1.11.5 Default Spaces between the different Frame Parts of a LIN Message

If not otherwise specified in the test cases, Inter-byte spaces between the header bytes and data fields are set to zero.

1.12 Symbols and Abbreviated Terms

Symbol / abbreviated word	description	Value / range
BIT_ERROR	difference between bit value sent and bit value monitored	-
$F_{TOL\_RES\_MASTER}$	bit rate tolerance of the master node (absolute value), according to LIN specification	%
$F_{TOL\_RES\_SLAVE}$	bit rate tolerance of a slave node without making use of synchronisation (absolute value), according to LIN specification	%
F_{TOL_SYNC}	bit rate tolerance of a slave node making use of synchronisation (relative value to master node after synchronisation, valid for the complete message), according to LIN specification	%
F_{TOL_UNSYNC}	bit rate tolerance of a slave node making use of synchronisation, according to LIN specification	%
PID	Protected identifier	-
IUT	**I**mplementation **U**nder **T**est	-
T_{BIT}	Length of a bit (time), depending on the bit rate	sec
T_{FRAME}	length of a 8 byte frame, according to LIN Specification 2.1 chapter "2.3.2 FRAME LENGTH" $T_{FRAME} = T_{HEADER} + T_{RESPONSE}$	124 – 174 T_{BIT}
T_{FRAME_MAX}	maximum length of a 8 byte frame, according to LIN specification	174 T_{BIT}
T_{FRAME_NOM}	minimum length of a 8 byte frame, according to LIN specification	124 T_{BIT}
T_{AWAKE}	measured time between end of Wake up signal and start of break of a header	sec
T_{SLEEP}	measured time after that a slave node enters automatically a sleep mode [PROT 2.6.3 GO TO SLEEP]	sec

$T_{H\_INTERBYTE}$	inter-byte space between sync byte field and Identifier	0 - 14 T_{BIT}
T_{HEADER}	length of the header of a message frame based on T_{BIT} nominal	34 – 47.6 T_{BIT}
T_{HEADER_MAX}	maximum length of the header of a message frame, according to LIN specification	47.6 T_{BIT}
T_{HEADER_NOM}	minimum length of the header of a message frame, according to LIN specification	34 T_{BIT}
T_{BRKFLD}	break field low phase, according to LIN specification	13 -26 T_{BIT}
T_{BRKFLD_MAX}	calculated maximum of break field low phase: T_{HEADER_MAX} – (T_{BRKDEL_MIN} + 20 Bits)	26 T_{BIT}
T_{BRKFLD_MIN}	minimum of break field low phase, according to LIN specification	13 T_{BIT}
T_{BRKDEL}	break delimiter, according to LIN specification	1 – 14 T_{BIT}
T_{BRKDEL_MAX}	calculated maximum of break delimiter: T_{HEADER_MAX} – (T_{BRKFLD_MIN} + 20 Bits)	14 T_{BIT}
T_{BRKDEL_MIN}	minimum of break delimiter, according to LIN specification 2.1	1 T_{BIT}
$T_{RESPONSE\_MAX}$	maximum response length	126 T_{BIT}
$T_{RESPONSE\_NOM}$	nominal response length	90 T_{BIT}
$T_{FRAME\_SLOT\_MEASURE}$	shall be measured between falling edges of the break field	sec
$T_{FRAME\_SLOT\_SPECIFIED}$	the length is specified in the LDF	sec
$T_{JITTER\_MEASURE}$	measured jitter as described in [PROT 2.4.2 FRAME SLOT]	sec
$T_{JITTER\_DEFINED}$	jitter according LDF or NCF of the IUT	sec
$T_{BIT\_MIN\_MASTER}$	$T_{BIT\_MIN\_MASTER} = 1/(1/T_{BIT}\ (1 + F_{TOL\_RES\_MASTER}))$	sec
$T_{BIT\_NOM\_MASTER}$	$T_{BIT\_NOM\_MASTER} = T_{BIT}$	sec
$T_{BIT\_MAX\_MASTER}$	$T_{BIT\_MAX\_MASTER} = 1/(1/T_{BIT}\ (1 - F_{TOL\_RES\_MASTER}))$	sec

Table 1.12

2 Essential test cases before test start

These test cases must have the result "pass" otherwise a further execution of the remaining test cases make no sense.

2.1 Diagnostic frame 'Master Request', IUT as Slave

Reference: 2.3.3.4 / 4.2.5.5

This test verifies if the IUT as Slave is able to receive Master request frames.

In this test case the diagnostic frame type 'Master Request' is checked, i.e. a frame to send commands and data from the Master to the Slave.

In this test case the TST_FRAME_7 with the frame ID 0x30 shall be used.(according NCF).

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_1, TST_FRAME_7
	bit rate	default
System Init	default	
Test	The Test System sends TST_FRAME_1 and then TST_FRAME_7.	
Verification	IUT shall answer.	

2.2 Command Frame 'Slave Response Frame', IUT as Slave

Reference: 2.3.1.3

This test verifies if the IUT as Slave is able to answer to command frames.

In this test case the 'Slave Response Frame' is checked, i.e. a frame header that triggers one slave node to send data to the master node.

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_2, TST_FRAME_6
	bit rate	default
System Init	default	
Test	The Test System as Master sends TST_FRAME_2. The Test System as Master sends TST_FRAME_6.	
Verification	The IUT shall answer. The IUT shall receive the request from the Test System and the response shall have 8 data bytes and use the classic checksum.	

2.3 Error in Received Frame, IUT as Slave

Reference: 2.7.3

This test verifies if the IUT as Slave is able to report its status to the network.

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_2, TST_FRAME_7
	bit rate	default
System Init	TST_FRAME_7 shall be sent twice by the Test System to ensure that the Response_error bit is cleared.	
Test	The Test System sends TST_FRAME_2 with inverted checksum. After that TST_FRAME_7 is sent from the Test System.	
Verification	The IUT shall answer to TST_FRAME_7 and sends the mandatory Response_error bit = TRUE.	

3 Timing Parameters

This chapter verifies if the timing parameters of the IUT are conform to the timing parameters that are defined in the LIN specification. The IUT will be stimulated to transmit or receive defined frames and the resulting behaviour will be observed and compared with the expected behaviour.

3.1 Length of break field low phase, IUT as Master

Reference: 2.3.1.1

This test verifies the correct length of the break field low phase T_{BRKFLD} as defined in the LIN specification.

State	Description	
Set Up	IUT as	Master
	Classification	class B, class C devices
	Configuration	TST_FRAME_1
	bit rate	default
System Init	default	
Test	The IUT sends TST_FRAME_1.	
Verification	$T_{BRKFLD\_MIN} \le T_{BRKFLD} \le T_{BRKFLD\_MAX}$	

3.2 Variation of Length of break field low phase, IUT as Slave

Reference: 2.3.1.1

This test verifies if the IUT as Slave recognises an ID request with different length of break field low phase T_{BRKFLD}.

The test is to repeat with different length of break field low phase T_{BRKFLD}. according to the test definition.

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_4_Tx
	bit rate	default
System Init	default	
Test	The Test System as Master sends TST_FRAME_4_Tx with the length of break field low phase T_{BRKFLD} from 11 to 26.6 T_{BIT}, with 0.1 T_{BIT} steps. Every step will be repeated 20 times (in sum 3140 cycles).	
Verification	The IUT shall answer to the request in the range of break field low phase T_{BRKFLD} of 13 to 26.6 T_{BIT}.[1]	

[1] Remark: The answer of the IUT to the request with the length of break field of 11 to 12.9 T_{BIT} shall be documented.

3.3 Length of break delimiter, IUT as Master

Reference: 2.3.1.1

This test verifies the correct length of the break delimiter T_{BRKDEL}.

State	Description	
Set Up	IUT as	Master
	Classification	class B, class C
	Configuration	TST_FRAME_4_Tx, TST_FRAME_4_Rx
	bit rate	default
System Init	default	
Test	The IUT sends TST_FRAME_4_Tx or TST_FRAME_4_Rx.	
Verification	$T_{BRKDEL\_MIN} \leq T_{BRKDEL} \leq T_{BRKDEL\_MAX}$ The verification shall be done as described in the LIN Specification 2.1 chapter "6.5.3 SIGNAL SPECIFICATION".	

3.4 Variation of Length of break delimiter, IUT as Slave

Reference: 2.3.1.1

This test verifies if the IUT as Slave recognizes an ID request with different length of break delimiter T_{BRKDEL}.

The test consists of three separate test cases (test cases 3.4.1 – 3.4.3). The length of break delimiter T_{BRKDEL} is set according to Table 3.4.

NOTE: In case of class C device, the IUT as Slave shall accept a Break delimiter of $0.75*T_{BIT}$. The shortened delimiter on the LIN bus results from the interpretation of the Transceiver TxD input signal.

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_4_Tx
	bit rate	default
System Init	default	
Test	The Test System as Master sends TST_FRAME_4_Tx with the length of break delimiter T_{BRKDEL} as defined in Table 3.4.	
Verification	The IUT shall answer to the request.	

Test Case No.	T_{BRKFLD}	T_{BRKDEL}	$T_{H\_Interbyte}$	Comment
3.4.1	T_{BRKFLD_MIN}	T_{BRKDEL_MIN} class B device: 1 T_{BIT} class C device: 0.75 T_{BIT}	0	
3.4.2	T_{BRKFLD_MIN}	T_{BRKDEL_MAX}	0	
3.4.3	T_{BRKFLD_MIN}	10 Bits	0	

Table 3.4

3.5 Inconsistent break field error, IUT as Slave

Reference: 2.3.1.1

This test verifies if the IUT as Slave detects an Inconsistent break field error. The IUT as Slave shall not accept a zero byte (0x00) as a break field.

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_2, TST_FRAME_6
	bit rate	default
System Init	default	
Test	The Test System as Master sends TST_FRAME_2 with 13 bit break field and TST_FRAME_6. After that the Test System as Master sends TST_FRAME_2 with 9 bit break field and TST_FRAME_6.	
Verification	The IUT shall respond to the first Master request. The IUT must detect the Inconsistent break field error and shall not respond to the second Master request.	

3.6 Inconsistent Sync Byte Field error, IUT as Slave

Reference: 2.3.1.2

This test verifies if the IUT as Slave detects an Sync Byte Field error, i.e. the edges of the sync byte field are not detected within the given tolerance.

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_7
	bit rate	default
System Init	default	
Test	The Test System as Master sends TST_FRAME_7 with sync byte field as defined in Table 3.6.	
Verification	The IUT shall not respond to TST_Frame_7.	

Test Case No.	IUT bit rate	Sync Byte Field
3.6.1	default	0x54
3.6.2	default	0x5D

Table 3.6

3.7 Verification of the sync byte field, IUT as Master

Reference: 6.4.2

This test verifies if the IUT as Master sends a sync byte field with the data '0x55'.

State	Description	
Set Up	IUT as	Master
	Classification	class B, class C devices
	Configuration	TST_FRAME_2
	bit rate	default
System Init	default	
Test	The IUT as Master sends TST_FRAME_2.	
Verification	The IUT must send the sync byte field without failure.	

3.8 Incomplete frame reception, IUT as Slave

Reference: 2.7.3

This test verifies if the IUT as Slave responds to a frame correctly after a known incomplete frame.

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_7, TST_FRAME_4_Rx
	bit rate	default
System Init	TST_FRAME_7 must be sent twice by the Test System to ensure that the Response_error_bit is cleared.	
Test	The Test System as Master sends the profile described in Table 3.8 followed by TST_FRAME_7.	
Verification	The IUT must respond to TST_FRAME_7 by sending the mandatory Response_error bit described in the Table 3.8.	

Test Case No	Profile test	Response error bit during Verification step
3.8.1	The Test System as Master sends only the break field	FALSE
3.8.2	The Test System as Master sends only the break field and the sync byte field	FALSE
3.8.3	The Test System as Master sends just the header of TST_FRAME_4_Rx	FALSE
3.8.4	The Test System as Master sends just the header of TST_FRAME_4_Rx and the first data byte	TRUE

Table 3.8

3.9 Unknown frame reception, IUT as Slave

Reference: 2.7.3

This test verifies if the IUT as Slave ignores an unknown complete or unknown incomplete frame and is not set the Response_error bit to TRUE.

State	**Description**	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_UNKNOWN, TST_FRAME_7
	bit rate	default
System Init	TST_FRAME_7 must be sent twice by the Test System to ensure that the Response_error is cleared.	
Test	The Test System as Master sends TST_FRAME_UNKNOWN with the profile described in Table 3.9 followed by TST_FRAME_7.	
Verification	The IUT shall respond to TST_FRAME_7 by sending the mandatory Response_error bit = FALSE.	

Test Case No	Response field
3.9.1	No response field
3.9.2	Just the first data byte
3.9.3	All data bytes (according to TST_FRAME specification or frame length according to LDF / NCF) but wrong checksum

Table 3.9

3.10 Length of header, IUT as Master

Reference: 2.3.2

This test verifies the correct length of the header T_{HEADER}.

State	Description	
Set Up	IUT as	Master
	Classification	class B, class C devices
	Configuration	TST_FRAME_4_Rx, TST_FRAME_4_Tx
	bit rate	default
System Init	default	
Test	The IUT sends all defined TST_FRAME_4_Rx and all defined TST_FRAME_4_Tx.	
Verification	$T_{HEADER\_NOM} \leq T_{HEADER} \leq T_{HEADER\_MAX}$	

3.11 Variation of Length of header, IUT as Slave

Reference: 2.3.2

This test verifies if the IUT as Slave recognizes an ID request with different length of the header T_{HEADER}.

The test consists of four separate test cases (test cases 3.11.1 – 3.11.4). The length of break field low phase T_{BRKFLD} , break delimiter T_{BRKDEL} and the inter-byte space between sync byte field and Identifier $T_{H\_INTERBYTE}$ are set according to Table 3.11.

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_2, TST_FRAME_6
	bit rate	default
System Init	default	
Test	The Test System as Master sends TST_FRAME_2 followed by TST_FRAME_6. Both frames use the length of the parts of header as defined in Table 3.11.	
Verification	The IUT shall answer to the request.	

Test Case No.	T_{BRKFLD}	T_{BRKDEL}	$T_{H\_INTERBYTE}$	$\Rightarrow T_{HEADER}$	T_{bit}
3.11.1	T_{BRKFLD_MIN}	T_{BRKDEL_MIN}	0 Bits	T_{HEADER_NOM}	$T_{BIT\_MIN\_MASTER}$
3.11.2	19 Bits	2 Bits	6 Bits	T_{HEADER_MAX}	$T_{BIT\_MAX\_MASTER}$
3.11.3	15 Bits	3 Bits	2 Bits	40 Bits	$T_{BIT\_NOM\_MASTER}$
3.11.4	T_{BRKFLD_MIN}	T_{BRKDEL_MIN}	13 Bits	T_{HEADER_MAX}	$T_{BIT\_MAX\_MASTER}$

Table 3.11

3.12 Bit rate Tolerance, IUT as Master

Reference: 6.3

This test verifies if the Master bit rate tolerance $F_{TOL\_RES\_MASTER} < \pm 0.5\%$. For this a bit rate measurement is done in the sync byte field.

State	Description	
Set Up	IUT as	Master
	Classification	class B, class C devices
	Configuration	TST_FRAME_1
	bit rates	According to the IUT specification
System Init	default	
Test	The IUT sends TST_FRAME_1 with all bit rates defined in the IUT specification or LDF.	
Verification	(test case bit rate – $F_{TOL\_RES\_MASTER}$) ≤ measured bit rate ≤ (test case bit rate + $F_{TOL\_RES\_MASTER}$)	

3.13 Bit rate Tolerance, IUT as Slave without making Use of Synchronization

Reference: 6.3

This test verifies if the IUTs bit rate tolerance $F_{TOL\_RES\_SLAVE} < \pm 1.5\%$.

For this a bit rate measurement is done in the Slave answer. The measurement is done according to 1.11.4.

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_3 (Identifier = 2), TST_FRAME_6
	bit rates	According to the IUT specification
System Init	default	
Test	The Test System as Master sends TST_FRAME_3 (Identifier = 2) and TST_FRAME_6 according Table 3.13 with all bit rate specified in the IUT specification or NCF +/- 0.5% tolerance.	
Verification	The IUT shall answer to the request with negative response (RSID = 0x7F). (Test System bit rate – $F_{TOL\_RES\_SLAVE}$) ≤ measured Slave bit rate of the Slave answer ≤ (Test System bit rate + $F_{TOL\_RES\_SLAVE}$)	

Testcase	TST_FRAME	Bit rate tolerance
3.13.1	TST_FRAME_3	+ 0.5%
3.13.2	TST_FRAME_3	- 0.5%

Table 3.13

3.14 Bit rate Tolerance, IUT as Slave with making Use of Synchronization

Reference: 6.3

This test verifies if the IUT (IUT as Slave) is able to synchronize itself with a bit rate tolerance $F_{TOL\_SYNC} < \pm 2\%$ (relative value to the master node). For this a bit rate measurement is done in the Slave answer.

Note: This test case verifies the tolerance of a synchronized node. A slave node making use of synchronization and direct break detection may have a bit rate tolerance F_{TOL_UNSYNC} of $< \pm 14\%$ in case of lost synchronization.

For this a bit rate measurement is done in the Slave answer. The measurement is done according to 1.11.4.

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_3 (Identifier = 2), TST_FRAME_6
	bit rates	Min max bit rates according to the IUT specification
System Init	default	
Test	The Test System as Master sends TST_FRAME_3 (Identifier = 2) followed by TST_FRAME_6 according to Table 3.14 with all bit rate specified in the IUT specification or NCF +/- 0.5% tolerance.	
Verification	The IUT shall answer to the request with negative response (RSID = 0x7F). (Test System bit rate – F_{TOL_SYNC}) ≤ measured Slave bit rate of the Slave answer ≤ (Test System bit rate + F_{TOL_SYNC}).	

Testcase	TST_FRAME	Bit rate tolerance
3.14.1	TST_FRAME_6	+ 0.5%
3.14.2	TST_FRAME_6	- 0.5%

Table 3.14

3.15 Length of response

3.15.1 Length of response, IUT as Slave

Reference: 2.3.2

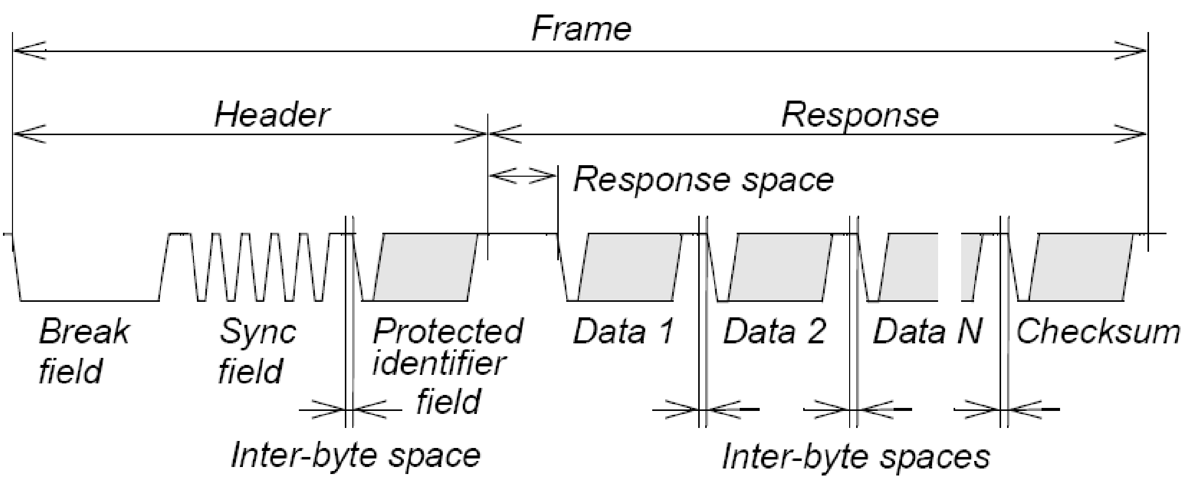
This test verifies if the length of T_{FRAME_MAX} is not exceeded by the IUTs in-frame-response space and inter-byte spaces.

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_4_Tx acc. Table 3.15.1[2]
	bit rate	default
System Init	default	
Test	The header length is set to the maximum T_{HEADER_MAX} (worst case). The Test System as Master sends the headers of all TST_FRAME_4_Tx with different available data length.	
Verification	The IUT shall answer to the request with $T_{Response} \leq T_{RESPONSE\_MAX}$ The verification shall be done as shown in Picture 3.15.1: Frame structure.	

Requirements	value
header size	max.
break field low phase length	19 Bit
Break delimiter length	8 Bit
$T_{H\_Interbyte}$	0

Table 3.15.1

[2] If there is no TST_FRAME_4_Tx available with the data length 8 byte, then use TST_FRAME_2 acc. Table 3.15.1 and TST_FRAME_6 acc. Table 3.15.1 or TST_Frame_3 acc. Table 3.15.1 and TST_FRAME_6 acc. Table 3.15.1



Picture 3.15.1: Frame structure

3.15.2 Length of response, IUT as Master

Reference: 2.3.2

This test verifies if the length of T_{FRAME_MAX} is not exceeded by the IUT in-frame-response space and inter-byte spaces.

State	Description	
Set Up	IUT as	Master
	Classification	class B, class C
	Configuration	TST_FRAME_4_Tx
	bit rate	default
System Init	default	
Test	The IUT as Master sends all TST_FRAME_4_Tx with the maximum length of header.	
Verification	The IUT shall send the response with $T_{Response} \leq T_{RESPONSE\_MAX}$ The verification shall be done as shown in Picture 3.15.1: Frame structure.	

3.15.3 Acceptance of response field, IUT as Slave

Reference: 2.3.2

This test verifies if the IUT accepts frames with different lengths of the response field (variation of length of Response space and inter-byte space).

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_2, TST_FRAME_6
	bit rates	default
System Init	default	
Test	The Test System as Master sends TST_FRAME_2 with the length of the response field as defined in Table 3.15.3. The Test System as Master sends header of TST_FRAME_6.	
Verification	The IUT shall answer to TST_FRAME_6.	

Test Case No	Response space	Inter-byte space	Comments
3.15.3.1	0	each space = 0	$T_{RESPONSE\_NOM}$
3.15.3.2	4 T_{BIT}	each space = 4 T_{BIT}	$T_{RESPONSE\_MAX}$ Maximum spaces if all spaces (Response space and all 8 interbyte spaces) are equal $(T_{RESPONSE\_MAX} – T_{RESPONSE\_NOM})$ / 9 = 4 TBIT
3.15.3.3	0	Space between data byte data 7 and data 8 = $(T_{RESPONSE\_MAX} - T_{RESPONSE\_NOM})$ = 36Tbit. Other spaces = 0	$T_{RESPONSE\_MAX}$ Maximum inter-byte space if no Response space existing
3.15.3.4	$(T_{RESPONSE\_MAX} – T_{RESPONSE\_NOM})$ = 36 T_{BIT}	each space = 0	$T_{RESPONSE\_MAX}$ Maximum response space if no inter-byte space existing

Table 3.15.3

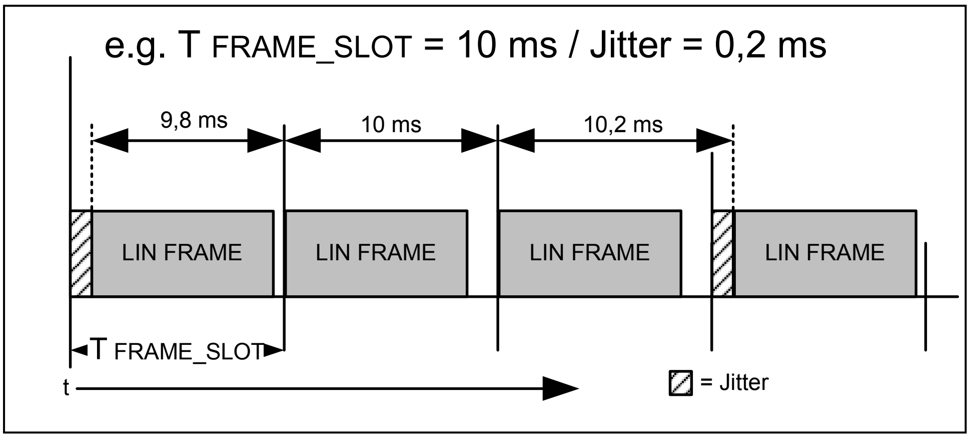
3.16 Verification of schedule table timing

3.16.1 Verification of jitter, IUT as Master

Reference: 2.4.1

This test verifies the jitter based on one application schedule table defined in the LDF file.

State	Description	
Set Up	IUT as	Master
	Classification	class B, class C devices
	Configuration	Defined schedule tables
	bit rate	default
System Init	default	
Test	The IUT as Master sends out at least 100 consecutive frames of the schedule table.	
Verification	The jitter (see Picture 3.16.1) shall be compared with the defined jitter in the LDF. $T_{FRAME\_SLOT\_MEASURE}$ shall be measured between falling edges of the break field. $T_{JITTER\_MEASURE} \leq T_{JITTER\_DEFINED}$	



Picture 3.16.1: Frame structure and jitter

3.16.2 Schedule table management, IUT as Master

Reference: 2.4.2

This test verifies if the IUT as Master respects T_{Frame_Slot} space.

State	Description	
Set Up	IUT as	Master
	Classification	class B, class C devices
	Configuration	Defined schedule tables, TST_FRAME_4_Rx
	bit rate	default
System Init	default	
Test	The IUT as Master sends out at least 100 consecutive frames of the schedule table. The Test System as Slave sends the response field of all the TST_FRAME_4_Rx frames as described in Table 3.16.2.	
Verification	$T_{FRAME\_SLOT\_SPECIFIED}$ - jitter_ldf < $T_{FRAME\_SLOT\_MEASURE}$ < $T_{FRAME\_SLOT\_SPECIFIED}$ + jitter_ldf jitter_ldf is defined in the ldf file. $T_{FRAME\_SLOT\_MEASURE}$ must be measured between falling edges of the break field. The IUT as Master shall respect T_{Frame_Slot} spaces.	

Test Case No	Response field of TST_FRAME_4_Rx frame
3.16.2.1	The Test System as Slave does not send a response field.
3.16.2.2	The Test System as Slave sends only the first data byte of the response field.
3.16.2.3	The Test System as Slave sends the complete response field. The end of the response must correspond with the start of the next slot.

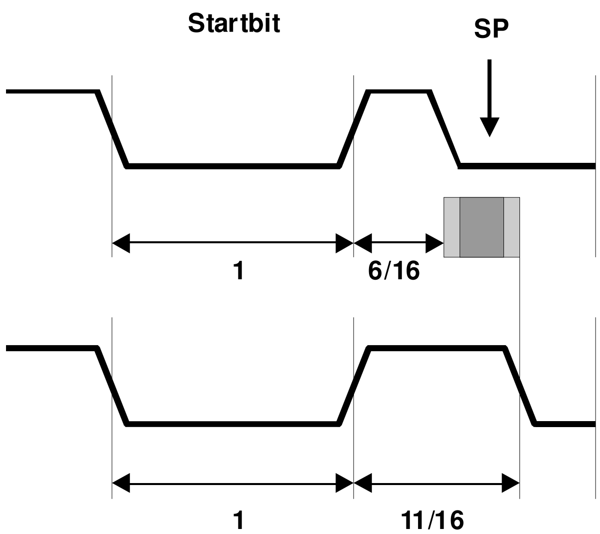
Table 3.16.2

3.17 Sample Point Test, IUT as Slave

Reference: 6.4.3

The bits of a byte field shall be sampled according to the LIN Specification Package Revision 2.1.

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_2, TST_FRAME_6
	bit rate	default
System Init	default	
Test	The Test System as Master sends TST_FRAME_2. After that the Test System sends TST_FRAME_6 with the Protected Identifier (0x3D) as in the following: The Test System shall approach the edge of bit 1 of the Protected Identifier 0x3D to 7/16 T_{bit} in 1 µs steps. The test (sending TST_FRAME_2 and TST_FRAME_6) has to be repeated until the Slave does not respond.	
Verification	The sample point is acquired when the IUT does not respond to the Master request. The sample point for class B devices shall be in range of 7/16 until 10/16 T_{bit} see Picture 3.17. The sample point for class C devices shall be in range of 6/16 until 11/16 T_{bit} see Picture 3.17.	



Picture 3.17: Sample Point Test

4 Communication without Failure

4.1 Variation of LIN Identifier

4.1.1 Variation of LIN Identifier, IUT as Master

Reference: 2.3.1.3

This test verifies if the IUT as Master is able to send supported protected Identifier.

NOTE: According to the device specification all in the LDF defined Identifiers shall be tested in one Schedule Table.

State	Description	
Set Up	IUT as	Master
	Classification	class B, class C devices
	Configuration	TST_FRAME_4_Rx, TST_FRAME_4_Tx, identifier as defined in [2.3.1.3 Protected identifier field]
	bit rate	default
System Init	default	
Test	The IUT sends TST_FRAME_4_Tx or TST_FRAME_4_Rx with all supported protected ID's.	
Verification	The IUT shall send the Identifier Field without failure[3].	

[3] A complete ECU shall only use messages from the LDF. A software driver implementation shall use all PIDs.

4.1.2 Variation of LIN Identifier of subscribed frames, IUT as Slave

Reference: 2.3.1.3

This test verifies if the IUT as Slave is able to recognize all PIDs (ID 00 – 59) to the first subscriber frame (according NCF, section frames).

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_1, TST_FRAME_4_Rx, TST_FRAME_7
	bit rate	default
System Init	All assigned PIDs have to be unassigned before testing. TST_FRAME_7 shall be sent twice by the Test System to ensure that the Response_error bit is cleared.	
Test	The Test System sends TST_FRAME_1 with a frame ID range assignment. The Test System sends TST_FRAME_4_Rx with previously assigned ID and corrupted checksum (invert 4th bit). After that TST_FRAME_7 shall be sent by the Test System.[4]	
Verification	The IUT shall respond to TST_FRAME_7 by sending the mandatory Response_error bit= TRUE.	

[4] For the first test cycle the TST_FRAME_7 uses the ID 59, for the remaining test cycles TST_FRAME_7 uses the ID 00.

4.1.3 Variation of LIN Identifier of published frames, IUT as Slave

Reference: 2.3.1.3

This test verifies if the IUT as Slave is able to recognize all PIDs (ID 00 – 59) to first publisher message identifier (according NCF).

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_1, TST_FRAME_4_Tx
	bit rate	default
System Init	All assigned PIDs have to be unassigned before testing.	
Test	The Test System sends TST_FRAME_1 with a frame ID range assignment with every ID. The Test System as Master sends the header of TST_FRAME_4_Tx.	
Verification	The IUT shall respond to the header of TST_FRAME_4_Tx according to the IUT specification.	

4.2 Transmission of the Checksum Byte

4.2.1 Transmission of the Checksum Byte classic checksum, IUT as Slave

Reference: 2.3.1.5

This test verifies if the IUT as Slave sends a correct checksum byte.

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_2, TST_FRAME_6
	bit rate	default
System Init	default	
Test	The Test System as Master sends TST_FRAME_2 followed by TST_FRAME_6.	
Verification	The IUT shall answer to the request and the checksum byte must be correct.	

4.2.2 Transmission of the Checksum Byte enhanced checksum, IUT as Slave

Reference: 2.3.1.5

This test verifies if the IUT as Slave sends a correct checksum byte.

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	All supported TST_FRAME_4_Tx
	bit rate	default
System Init	default	
Test	The Test System as Master sends the header of all supported TST_FRAME_4_Tx.	
Verification	The IUT shall answer to the request and the checksum byte must be correct.	

4.2.3 Transmission of the Checksum Byte classic checksum, IUT as Master

Reference: 2.3.1.5

This test verifies if the IUT as Master sends a correct checksum byte.

State	Description	
Set Up	IUT as	Master
	Classification	class B, class C devices
	Configuration	TST_FRAME_2
	bit rate	default
System Init	default	
Test	The IUT as Master sends TST_FRAME_2.	
Verification	The IUT must send the correct checksum.	

4.2.4 Transmission of the Checksum Byte of user frames, IUT as Master

Reference: 2.3.1.5

This test verifies that the IUT as Master sends a correct checksum byte according to the checksum model of the subscribing Slave.

State	Description	
Set Up	IUT as	Master
	Classification	class B, class C devices
	Configuration	TST_FRAME_4_Tx
	bit rate	default
System Init	default	
Test	The IUT as Master sends all supported TST_FRAME_4_Tx.	
Verification	The IUT must send the correct checksum.	

4.3 Unused bits

4.3.1 Unused bits, IUT as Master

Reference: 2.3.3

This test verifies if the IUT as Master sends recessive bits if the TST_FRAME_4_Tx contains unused data bits (bits which are not defined in the LDF).

State	Description	
Set Up	IUT as	Master
	Classification	class B, class C devices
	Configuration	TST_FRAME_4_Tx
	bit rate	default
System Init	default	
Test	The IUT as Master sends all TST_FRAME_4_Tx and unused data bits if applicable.	
Verification	The unused bits of TST_FRAME_4_Tx shall be sent as recessive bits.	

4.3.2 Unused bits, IUT as Slave

Reference: 3, 4

This test verifies if the IUT as Slave sends recessive bits if the TST_FRAME_4_Tx contains unused data bits (bits which are not defined in the NCF).

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_4_Tx
	bit rate	default
System Init	default	
Test	The IUT as Slave sends all TST_FRAME_4_Tx and unused data bits if applicable.	
Verification	The unused bits of TST_FRAME_4_Tx shall be sent as recessive bits.	

4.4 Reserved Frame

4.4.1 Reserved Frame, IUT as Slave

Reference: 2.3.1.3

This test verifies if the IUT as Slave ignores a reserved frame. The Test System as Master sends TST_Frame_8 with both ID's.

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_8 with both ID's default delay between Master requests
	bit rate	default
System Init	default	
Test	The Test System as Master sends TST_FRAME_8.	
Verification	The IUT shall not answer to TST_FRAME_8.	

4.4.2 Reserved Frame with error, IUT as Slave

Reference: 2.3.1.3

This test verifies if the IUT as Slave ignores a reserved frame. The Test System as Master sends TST_Frame_8 with both ID's.

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_8 with both ID's default delay between Master requests
	bit rate	default
System Init	TST_FRAME_7 shall be sent twice by the Test System to ensure that the Response_error bit is cleared.	
Test	The Test System as Master sends TST_FRAME_8 with 0x3E and 0x3F with one data byte and checksum. The data byte 1 is 0xFF with inverted Stop bit. After this the Test System sends TST_Frame_7.	
Verification	The IUT shall not answer to TST_FRAME_8 and must respond to TST_Frame_7 with the mandatory Response_error bit = FALSE.	

4.5 Diagnostic frame 'Master Request', IUT as Master

Reference: 2.3.3.4 / 4.2.5.5

This test verifies if the IUT as Master is able to send Master request frames.

In this test case the Master request frame 'Master Request' is checked, i.e. a frame to send commands and data from the Master to the Slave.

State	Description	
Set Up	IUT as	Master
	Classification	class B, class C devices
	Configuration	TST_Frame_1 or, if not available TST_FRAME_9
	bit rate	default
System Init	default	
Test	The IUT sends TST_FRAME_1.	
Verification	The IUT must send the frame without failure. The data field length shall be 8 bytes. The checksum field must be correct.	

4.6 Supported Frames according to the IUT specification

4.6.1 Supported Tx Frames according to the IUT specification, IUT as Slave

Reference: 2.3.1.3

This test verifies if the IUT as Slave is able to send all supported frames according to the specification of the IUT.

The Test System as Master sends all supported frame header (TST_FRAME_4_Tx), according to the IUT specification.

For preconfigured slaves this test has to be repeated without TST_FRAME_1.

After power on reset these slaves have to be operational and use frame IDs according to the NCF.

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_1, TST_FRAME_4_Tx
	bit rate	default
System Init	default	
Test	The Test System sends TST_FRAME_1 with a frame ID assign range command. The Test System as Master sends all supported frames (TST_FRAME_4_Tx), according to IUT specification.	
Verification	The IUT responds to the requests as specified. The Test System verifies by monitoring data length for received frames.	

4.6.2 Supported Rx Frames according to the IUT specification, IUT as Slave

Reference: 2.3.1.3

This test verifies if the IUT as Slave is able to receive all supported frames according to the specification of the IUT.

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_4_Rx, TST_FRAME_7
	bit rate	default
System Init	TST_FRAME_7 shall be sent twice by the Test System to ensure that the Response_error bit is cleared.	
Test	The Test System as Master transmits all supported frames TST_FRAME_4_Rx according to IUT specification. Every TST_FRAME_4_Rx is send twice: first with failure (inverted checksum) then again without failure. TST_FRAME_7 shall be sent in between.	
Verification	Recognition of transmitted frames shall be verified by monitoring the Response_error bit (in case with failure it shall be TRUE, in case without failure it shall be FALSE).	

5 Communication with Failure

This chapter verifies if the IUT does the error and exception handling as specified in the LIN specification.

NOTE: the fault confinement is not part of the LIN protocol, thus the way of verification is implementation specific.

5.1 Bit error, IUT as Slave

Reference: 2.5.2.2

This test verifies if the IUT as Slave detects a BIT_ERROR, i.e. there is a difference between the bit value sent by the IUT and the corresponding bit value monitored by the IUT.

The test consists of separate test cases in order to test the BIT_ERROR detection of the answer sent by the IUT as Slave.

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_3 (Identifier = 2), TST_FRAME_6, TST_FRAME_7
	bit rate	default
System Init	TST_FRAME_7 shall be sent twice by the Test System to ensure that the Response_error bit is cleared.	
Test	The Test System as Master sends TST_FRAME_3 (Identifier = 2) followed by TST_FRAME_6. The Test System inverts recessive bit in the Slave answer sent by the IUT at the position as defined in Table 5.1. Then TST_FRAME_7 shall be sent by the Test System to verify the Response_error bit .	
Verification	The IUT must detect the BIT_ERROR, after detection of the BIT_ERROR the transmission has to be aborted latest at the next byte boundary. The Response_error bit shall be set.	

Test Case No.	Slave Answer Component / Comments	Bit to be Inverted (Note: here counting starts with 0 at start bit of the respective Slave answer component)	Inter-byte Space
5.1.1	data byte 1	Stop Bit	0
5.1.2	data byte 1	Bit 1	0
5.1.3	Inter-byte Data 1-2	Bit 1	≥ 1[5]
5.1.4	data byte 2	Stop Bit	0
5.1.5	data byte 2	Bit 2	0
5.1.6	Inter-byte Data 2-3	Bit 1	≥ 1[5]
5.1.7	data byte 3	Stop Bit	0
5.1.8	data byte 3	Bit 3	0
5.1.9	Inter-byte Data 3-4	Bit 1	≥ 1[5]
5.1.10	data byte 4	Stop Bit	0
5.1.11	data byte 4	Bit 4	0
5.1.12	Inter-byte Data 4-5	Bit 1	≥ 1[5]
5.1.13	data byte 5	Stop Bit	0
5.1.14	data byte 5	Bit 5	0
5.1.15	Inter-byte Data 5-6	Bit 1	≥ 1[5]
5.1.16	data byte 6	Stop Bit	0
5.1.17	data byte 6	Bit 6	0
5.1.18	Inter-byte Data 6-7	Bit 1	≥ 1[5]
5.1.19	data byte 7	Stop Bit	0
5.1.20	data byte 7	Bit 7	0
5.1.21	Inter-byte Data 7-8	Bit 1	≥ 1[5]
5.1.22	data byte 8	Stop Bit	0
5.1.23	data byte 8	Bit 8	0
5.1.24[6]	Inter-byte Data 8-checksum	Bit 1	≥ 1[5]
5.1.25[6]	checksum field	Stop Bit	0

Table 5.1

[5] Testable if the Inter-byte Space is larger or equal than 1 bit. If the Inter-byte Space is larger than 1 bit the inverted bit time shall be at the beginning of the space.

[6] The part of the verification to abort the transmission can not be done.

5.2 Framing error in header of published frame, IUT as Slave

Reference: 2.5.2.2

This test case verifies if a Slave does not respond to a header with inverted stop bit of the PID.

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_4_Tx, TST_FRAME_7
	bit rate	default
System Init	TST_FRAME_7 shall be sent twice by the Test System to ensure that the Response_error bit is cleared.	
Test	The Test System as Master sends the header of TST_FRAME_4_Tx and inverts the stop bit of the PID. Then the Test System sends TST_FRAME_7.	
Verification	TST_FRAME_4_Tx shall not be answered. The Response_error bit shall be FALSE.	

5.3 Framing error in response field of subscribed frame, IUT as Slave

Reference: 2.5.2.2

This test case verifies if a Slave detects a response error in a subscribed frame with a framing error (inverted stop bit of the first data byte).

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_4_Rx, TST_FRAME_7
	bit rate	default
System Init	TST_FRAME_7 shall be sent twice by the Test System to ensure that the Response_error bit is cleared.	
Test	The Test System as Master sends TST_FRAME_4_Rx and inverts the stop bit of the first data byte. Then the Test System sends TST_FRAME_7.	
Verification	The Response_error bit shall be TRUE.	

5.4 Checksum error by inversion, IUT as Slave

Reference: 2.3.1.5

This test verifies if the IUT as Slave detects a wrong checksum, i.e. the sum of the received checksum and the modulo-256 sum over all received data bytes do not result in 0xFF.

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_2, TST_FRAME_7
	bit rate	default
System Init	TST_FRAME_7 shall be sent twice by the Test System to ensure that the Response_error bit is cleared.	
Test	The Test System as Master sends TST_FRAME_2. The Test System inverts the first bit of the checksum byte of the command of TST_FRAME_2. TST_FRAME_7 follows to request for Response_error bit.	
Verification	The Verification is done by monitoring the Response_error bit = TRUE.	

5.5 Checksum error by carry, IUT as Slave

Reference: 2.3.1.5

This test verifies if the IUT as Slave does not add the carry on the sum of all data bytes and checksum byte during the verification of checksum. So the Slave must detect a wrong checksum if the sum of the received checksum and the modulo-256 sum over all received data bytes do result in 0x1FE.

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_7, TST_FRAME_14
	bit rate	default
System Init	TST_FRAME_7 shall be sent twice by the Test System to ensure that the Response_error bit is cleared.	
Test	The Test System as Master sends TST_FRAME_14. The data content of TST_FAME_14 is defined as follow: Data byte 2 to 8 is 0x00. Data byte 1 and checksum is 0xFF[7]. TST_FRAME_7 follows to request the Response_error bit.	
Verification	The Verification is done by monitoring the Response_error bit = TRUE.	

[7] Checksum 0xFF is the inverted value , the correct checksum is 0x00.

6 Event Triggered Frames

These test cases are only applicable if Event Triggered Frames are supported by the IUT.

6.1 Event Triggered Frame, IUT as Slave

Reference: 2.3.3.2

This test verifies if the IUT as Slave is able to answer to event triggered frames, mandatory if the IUT supports event triggered frames.

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_5
	bit rate	default
System Init	default	
Test	The Test System sends the header of TST_FRAME_5 simultaneous with the manually stimulation of the input triggering (e.g. by pulling a switch) the signal update carried by the frame.	
Verification	The Slave shall answer to the first request with the first data byte equal to the corresponding unconditional protected frame ID. Then the Slave shall not answer to the second request.	

6.2 Event Triggered Frame with collision

6.2.1 Event Triggered Frame with collision resolving, IUT as Slave

Reference: 2.3.3.2

This test verifies if the IUT as Slave is able to answer to event triggered frames, mandatory if the IUT supports event triggered frames.

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_5, TST_FRAME_4_Tx
	bit rate	default
System Init	default	
Test	The Test System sends the header of TST_FRAME_5, simultaneous with the manually stimulation of the input triggering (e.g. by pulling a switch) the signal update carried by the frame. The Test System produces a bit error in the response of the Slave. The Test System as Master has to resolve the collision by sending the corresponding TST_FRAME_4_Tx according to the NCF. The Test System sends the header of TST_FRAME_5 without the stimulation of the input triggering.	
Verification	The IUT as Slave shall not respond to the second header of the event triggered frame.	

6.2.2 Event Triggered Frame with errors in collision resolving, IUT as Slave

Reference: 2.3.3.2

This test verifies if the IUT as Slave is able to answer to event triggered frames, mandatory if the IUT supports event triggered frames.

Focus of this test case:

Verifying whether the slave node is able to store the event as long as it can be sent successfully.

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_5, TST_FRAME_4_Tx
	bit rate	default
System Init	default	
Test	The Test System sends the header of TST_FRAME_5, simultaneous with the manually stimulation of the input triggering (e.g. by pulling a switch) the signal update carried by the frame. The Test System produces a bit error in the response of the Slave. The test system overwrites the first data byte of the slave response with 0x00. The test system has to resolve the collision by sending the corresponding TST_FRAME_4_Tx according to the NCF, but it overwrites the first data byte of the slave response with 0x00. The Test System sends the header of TST_FRAME_5 again.	
Verification	The IUT as Slave shall respond to the second header of the event triggered frame TST_FRAME_5, because the event triggered frame could not be sent successfully.	

6.3 Event Triggered Frame with collision resolving, IUT as Master

Reference: 2.3.3.2

This test verifies if the IUT as Master is able to resolve collisions in event triggered frames, mandatory if the IUT supports event triggered frames.

State	Description	
Set Up	IUT as	Master
	Classification	class B, class C devices
	Configuration	TST_FRAME_5
	bit rate	default
System Init	default	
Test	The IUT as Master sends the header of TST_FRAME_5. The Test System responds with only one data byte with 0x00.	
Verification	The IUT as Master shall switch to the event triggered resolving schedule table. The collision resolving schedule table is sent once. After the collision resolving schedule table, the Master shall switch back to the previous schedule table. The Master shall continue with the schedule entry subsequent to the schedule entry where the collision occur.	

6.4 Error in Transmitted Frame with Collision, IUT as Slave

Reference: 2.7.2

This test verifies if the IUT as Slave is able to report its status to the network.

The collision shall not effect status reporting.

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_5, TST_FRAME_7
	bit rate	default
System Init	IUT must be setup to answer to TST_FRAME_5 (IUT specific event occurred). TST_FRAME_7 shall be sent twice by the Test System to ensure that the Response_error bit is cleared.	
Test	The Test System sends TST_FRAME_5 and the response to cause a collision. After that TST_FRAME_7 is sent from the Test System.	
Verification	The IUT shall answer to TST_FRAME_7 and sends the mandatory Response_error bit = FALSE.	

LIN

Conformance Test Specification

Node Configuration / Network Management

For the LIN Specification Package
Revision 2.1 (November 24th, 2006)

Version 2.1
October 10th, 2008

7 Status Management

7.1 Error in Received Frame, IUT as Slave

Reference: 2.7.3

This test verifies if the IUT as Slave is able to report its status to the network.

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_1, TST_FRAME_7
	bit rate	default
System Init	TST_FRAME_7 shall be sent twice by the Test System to ensure that the Response_error bit is cleared.	
Test	The Test System sends TST_FRAME_1 with inverted stop bit of Data Byte 1. After that TST_FRAME_7 is sent from the Test System.	
Verification	The IUT shall answer to TST_FRAME_7 and sends the mandatory Response_error bit = TRUE.	

7.2 Error in Transmitted Frame, IUT as Slave

Reference: 2.7.3

This test verifies if the IUT as Slave is able to report its status to the network.

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_2, TST_FRAME_6, TST_FRAME_7
	bit rate	default
System Init	TST_FRAME_7 shall be sent twice by the Test System to ensure that the Response_error bit is cleared.	
Test	The Test System sends TST_FRAME_2, followed by TST_FRAME_6 (see Table 7.2). After that TST_FRAME_7 is sent from the Test System.	
Verification	The IUT shall answer to TST_FRAME_7 and sends the mandatory Response_error bit = TRUE.	

TC No.	TST_FRAME_6
7.2.1	TST_FRAME_6 with inverted checksum
7.2.2	TST_FRAME_6 with inverted stop bit of Data Byte 1.

Table 7.2

7.3 Response error bit handling, IUT as Slave

Reference: 2.7.3

This test verifies if the IUT as Slave is able to handle the Response error bit correctly.

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_4_Rx, TST_FRAME_7
	bit rate	default
System Init	TST_FRAME_7 shall be sent twice by the Test System to ensure that the Response_error bit is cleared.	
Test	The Test System sends TST_FRAME_4_Rx with inverted checksum. Then the Test System sends TST_FRAME_4_Rx correctly. After that TST_FRAME_7 is sent twice from the Test System.	
Verification	The IUT shall answer to the first TST_FRAME_7 and sends the mandatory Response_error bit = TRUE. Then the IUT must answer to the second TST_FRAME_7 and sends the mandatory Response_error bit = FALSE.	

8 Sleep / Wake up tests

8.1 Send Command Frame 'Sleep Mode Command', IUT as Master

Reference: 2.6.3

This test verifies if the IUT as Master is able to send a Sleep Mode Command.

In this test case the command frame type 'Sleep Mode Command' is checked, i.e. a frame that is used to broadcast the sleep mode to all bus nodes.

State	Description	
Set Up	IUT as	Master
	Classification	class B, class C devices
	Configuration	TST_FRAME_9
	bit rate	default
System Init	default	
Test	The IUT is caused to send Sleep Mode Command.	
Verification	The IUT shall send the frame without failure and the frame content has to be as defined in the LIN Specification (see LIN Spec 2.6.3 Table 2.1: Go to sleep command). The IUT must stop sending after completion of this message and the LIN bus shall be in recessive state.	

8.2 Receive Command Frame 'Goto sleep command ', IUT as Slave

Reference: 2.6.3

This test verifies if the IUT as Slave is able to receive a Sleep Mode Command.

In this test case the command frame type 'Sleep Mode Command' is checked, i.e. a frame that is used to broadcast the sleep mode to all bus nodes.

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_9
	bit rate	default
System Init	default	
Test	See Table 8.2	
Verification	See Table 8.2	

TC No.	Test	Verification
8.2.1	The Test System as Master sends TST_FRAME_9 with 1st data byte = 0x00 (see LIN Spec 2.6.3 Table 2.1: Go to sleep command) and data bytes 2 to 8 are filled with 0xFF.	The IUT must receive the frame without failure. The IUT must go to Sleep Mode[8] within 4 seconds because the IUT shall ignore the data content of the data byte 2 to 8.
8.2.2	The Test System as Master sends TST_FRAME_9 with 1st data byte = 0x00 (see LIN Spec 2.6.3 Table 2.1: Go to sleep command) and data bytes 2 to 8 are filled with 0x01, 0x02, 0x03, 0x04, 0x05, 0x06, 0x07.	The IUT must receive the frame without failure. The IUT must go to Sleep Mode[8] within 4 seconds because the IUT shall ignore the data content of the data byte 2 to 8.

Table 8.2

[8] Verification recommendation:

- Verification can be done by observing the power consumption of the IUT.
- Negative test: If the IUT is in sleep mode after the Go to sleep command then the IUT can be stimulated to send a Wakeup Signal. A Slave shall only be able to send a wakeup if it is in sleep mode.
- Use a monitor / debugger to verify the state of the IUT.

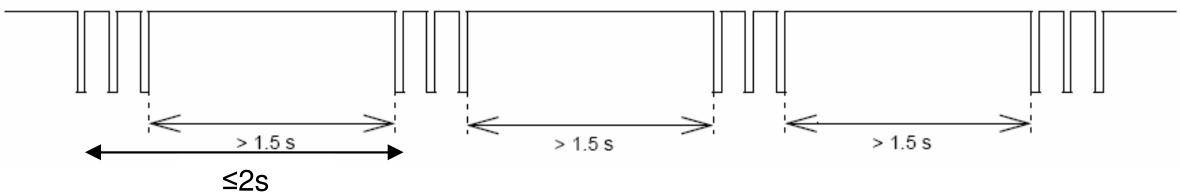
8.3 Receive a Wake up signal, IUT as Master

Reference: 2.6.2

This test verifies if the IUT as Master is able to receive a Wake up signal and to wake up after having received the request if applicable.

If there is a slave node in the network which is able to send a Wake up signal the master node shall also wake up and, when the slave nodes are ready, start transmitting headers to find out the cause (using signals) of the wake up.

State	Description	
Set Up	IUT as	Master
	Classification	class B, class C devices
	Configuration	Wake up signal
	bit rate	default
System Init	The IUT is in Sleep Mode.	
Test	The Test System as Slave sends a signal with a dominant state of 250µs.	
Verification	The IUT shall receive the Wake up signal without failure and must run through the start up procedure. The IUT must start to send frame headers. The Master shall wake up after receiving one block of wake up signals before a second block will be sent (see Picture 8.3). The time T_{AWAKE} shall be measured.	



Picture 8.3

8.4 Receive a Wake up signal, IUT as Slave

Reference: 2.6.2

This test verifies if the IUT as Slave is able to receive a Wake up signal and to wake up after having received the request.

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	Wake up signal, TST_FRAME_2, TST_FRAME_6
	bit rate	default
System Init	The IUT is in Sleep Mode.	
Test	The Test System sends a Wake up signal as defined in Table 8.4. After 100ms TST_FRAME_2 is sent from the Test System, followed by TST_FRAME_6.	
Verification	The IUT must receive the Wake up signal without failure. The IUT must run through the start up procedure and answer to Master request.	

TC No.	Wake Up Signal
8.4.1	250µs
8.4.2	5ms
8.4.3	5 nominal bit times

Table 8.4

8.5 Send a Wake up signal

8.5.1 Send a Wake up signal, IUT as Master and IUT as Slave

Reference: 2.6.2

This test only applies to slaves which are allowed to wake up the bus (see NCF or datasheet) and masters which support the wake up signal.

State	Description	
Set Up	IUT as	Slave, Master
	Classification	class B, class C devices
	Configuration	no definitions required
	bit rate	default
System Init	The IUT is in Sleep Mode.	
Test	The IUT is caused to send a Wake up signal.	
Verification	The IUT shall send the Wake up signal according to [2.6.2 WAKE UP] (250µs < t < 5ms)	

8.5.2 Send a block of wake up signals, IUT as Slave

Reference: 2.6.2

This test only applies to slaves which are allowed to wake up the bus (see NCF or datasheet).

This test verifies if the IUT as Slave repeats a Wake up signal if there is no request from the Master after having sent the Wake up signal.

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	no definitions required
	bit rate	default
System Init	The IUT is in Sleep Mode.	
Test	The IUT is caused to send a Wake up signal. There is no answer from the Test System as Master for the duration of this test.	
Verification	The IUT shall send the Wake up signal according to [2.6.2 WAKE UP] (250µs < t < 5ms) The IUT as Slave shall transmit a new wake up signal within 150 ms to 250 ms as defined in [PROT 2.6.2 WAKE UP, Figure 2.17: One block of wake up signals]. The verification shall be done for the first 3 wake up pulses only.	

8.5.3 Wait after one block of wakeup signals, IUT as Slave

Reference: 2.6.2

This test only applies to slaves which are allowed to wake up the bus (see NCF or datasheet).

This test verifies if the IUT as Slave repeats a Wake up signal if there is no request from the Master after having sent the Wake up signal. The slave node shall not send another Wake Up Signal before 1.5s after the last block of wake up signals.

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	no definitions required
	bit rate	default
System Init	The IUT is in Sleep Mode.	
Test	The IUT is caused to send a Wake up signal. There is no answer from a Master for the duration of this test.	
Verification	The IUT shall send the Wake up signal according to [PROT 2.6.2 WAKE UP] (250µs < t < 5ms) The IUT as Slave shall transmit a new wake up signal within 150 ms to 250 ms as defined in [PROT 2.6.2 WAKE UP, Figure 2.17: One block of wake up signals]. The slave node shall not send another Wake Up Signal before 1.5s after the last Wake Up Signal.	

8.5.4 Send a Wake up signal, Frame header from a Master following, IUT as Slave

Reference: 2.6.2

This test verifies if the IUT as Slave stops repeating Wake up signals if there is a frame header from a Master.

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_2, TST_FRAME_6
	bit rate	default
System Init	The IUT is in Sleep Mode.	
Test	The IUT is caused to send Wake up signals. Test System sends TST_FRAME_2 after 2nd Wake up signal after max. time of 150ms. After that TST_FRAME_6 is send by the Test System.	
Verification	The IUT shall send the Wake up signal according to [PROT 2.6.2 WAKE UP] (250µs < t < 5ms). The IUT retransmits a Wake up signal after 150ms – 250ms.The IUT must stop retransmission and answer to the request.	

8.6 SLEEP MODE after BUS IDLE

8.6.1 SLEEP MODE after BUS IDLE, dominant and recessive level within a frame header and response, IUT as Slave

Reference: 2.6.3

This test verifies if the IUT as Slave automatically enters a sleep mode if the bus is inactive for more than 4 seconds.

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_2, TST_FRAME_6
	bit rate	default
System Init	The IUT is in Normal / Active Mode.	
Test	See Table 8.6.1.	
Verification	See Table 8.6.1.	

TC No.	Test	Verification
8.6.1.1	After sending TST_FRAME_2 and TST_FRAME_6 the Test System receives the response from the IUT. The bus is idle after that.	The IUT must enter the Sleep Mode after t_{SLEEP}, where 4s < t_{SLEEP} < 10s[9]
8.6.1.2	The IUT receives a wake up signal (5 T_{BIT}), after that the IUT is connected to recessive level	After receiving the first wake up signal the IUT shall enter normal mode. The IUT must enter the Sleep Mode (from the start of the connection to recessive level) after t_{SLEEP}, where 4s < t_{SLEEP} < 10s[9]
8.6.1.3	The IUT receives a wake up signal (5 T_{BIT}), after that the IUT is connected to dominant level for 10 seconds. Between the wake up signal and the IUT connection to dominant level is a one T_{BIT} recessive level. After that there is a one ms recessive level . Then a wakeup signal will be send from the test system.	After receiving the first wake up signal the IUT shall enter normal mode. The IUT must enter the Sleep Mode (from the start of the connection to dominant level) after t_{SLEEP}, where 4s < t_{SLEEP} < 10s[9] After receiving the second wake up signal the IUT shall enter normal mode.
8.6.1.4	The Test System as Master sends a break field and a sync byte field. The bus is recessive after that.	The IUT must enter the Sleep Mode after t_{SLEEP}, where 4s < t_{SLEEP} < 10s[9]
8.6.1.5	The Test System as Master sends a break field and a sync byte field. After that the IUT is connected to dominant level.	The IUT must enter the Sleep Mode after t_{SLEEP}, where 4s < t_{SLEEP} < 10s[9]
8.6.1.6	The Test System as Master sends TST_FRAME_2 up to the 3rd Data Byte and stops sending. The bus is recessive after that.	The IUT must enter the Sleep Mode after t_{SLEEP}, where 4s < t_{SLEEP} < 10s[9]
8.6.1.7	The Test System as Master sends TST_FRAME_2 up to the 3rd Data Byte and stops sending. After that the IUT is connected to dominant level.	The IUT must enter the Sleep Mode after t_{SLEEP}, where 4s < t_{SLEEP} < 10s[9]

Table 8.6.1

[9] Verification recommendation:

- Verification can be done by observing the power consumption of the IUT.
- Negative test: If the IUT is in sleep mode after the Go to sleep command then the IUT can be stimulated to send a Wakeup Signal. A Slave shall only be able to send a wakeup if it is in sleep mode.
- Use a monitor / debugger to verify the state of the IUT.

8.6.2 SLEEP MODE after BUS IDLE with power up wake up, IUT as Slave

Reference: 2.6.3

This test verifies if the IUT as Slave automatically enters a sleep mode if the bus is inactive for more than 4 seconds.

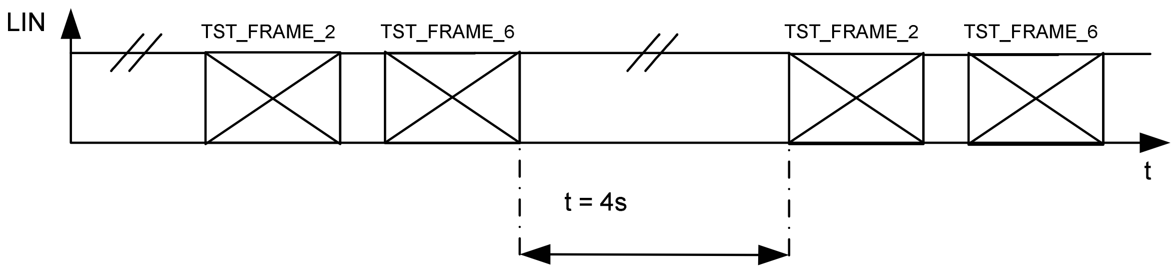
State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	
	bit rate	default
System Init	The IUT gets a power up wake up.	
Test	The IUT is connected to recessive level.	
Verification	The IUT must enter the Sleep Mode after t_{SLEEP}, where $4s < t_{SLEEP} < 10s$[9]	

8.7 Timeout after BUS IDLE, IUT as Slave

Reference: 2.6.3

This test verifies that the IUT is able to process messages for the time of 4s bus silence.

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_2, TST_FRAME_6
	bit rate	default
System Init	The IUT is in Normal / Active Mode.	
Test	The Test System as Master sends TST_FRAME_2 and TST_FRAME_6. After that there shall be a pause of 4s. Then the Test System as Master sends TST_FRAME_2 and TST_FRAME_6 again. (see Picture 8.7)	
Verification	The IUT shall answer to the request of the Test System without entering Sleep Mode.	



Picture 8.7

9 Node Configuration

9.1 Frame ID range assignment

9.1.1 Frame ID range assignment with indirect response, IUT as Slave

Reference: 4.2.5.5

This test verifies if the IUT as Slave is able to recognize the start indexes. The test is executed indirectly as no mandatory response is defined. No predefined PIDs shall be used.

If the IUT supports only one application message TST_FRAME_4_Tx shall be assigned with start index 0.

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_1, TST_FRAME_4_Rx, TST_FRAME_4_Tx, TST_FRAME_7[10]
	bit rate	default
System Init	TST_FRAME_7 shall be sent twice by the Test System to ensure that the Response_error bit is cleared.	
Test	The Test System sends TST_FRAME_1 with a frame ID assignment range command with start index 0. Only the PID with the start index shall be assigned, the other PIDs shall be filled with don't care value. The Test System sends TST_FRAME_1 with a frame ID range assignment command with start index 1. Only the PID with the start index shall be assigned, the other PIDs shall be filled with don't care value. After that TST_FRAME_7 shall be sent by the Test System	
Verification	The assigned PID's to the messages with index 0 and index 1 has to be verified. In case of TST_FRAME_4_Tx the IUT must respond to the request. In case of TST_FRAME_4_Rx with corrupted checksum the IUT must respond to TST_FRAME_7 by sending the mandatory Response_Error_Bit = TRUE.	

[10] The TST_FRAME_7 could also be a TST_FRAME_4_Tx.

9.1.2 Frame ID range unassignment with indirect response, IUT as Slave

Reference: 4.2.5.5

This test verifies if the IUT as Slave is able to unassign PIDs.

If the IUT supports only one application message TST_FRAME_4_Tx shall be assigned with start index 0.

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_1, TST_FRAME_4_Rx, TST_FRAME_4_Tx, TST_FRAME_7[11]
	bit rate	default
System Init	TST_FRAME_7 shall be sent twice by the Test System to ensure that the Response_error bit is cleared.	
Test	The Test System sends TST_FRAME_1 with a frame ID assignment range command with start index 0. The PIDs with the index 0 and index 1 shall be unassigned.	
Verification	The unassignment of the messages with index 0 and index 1 has to be verified. In case of TST_FRAME_4_Tx the IUT shall not respond to the request. In case of TST_FRAME_4_Rx with corrupted checksum the IUT must respond to TST_FRAME_7 by sending the mandatory Response_Error_Bit = FALSE.	

[11] The TST_FRAME_7 could also be a TST_FRAME_4_Tx.

9.2 LIN Product ID

9.2.1 LIN Product ID with direct response, IUT as Slave

Reference: 8.2.3.2 / 4.2.1 / 4.2.6.1

This test verifies if the IUT as Slave is able to answer to the Product ID request.

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_2, TST_FRAME_6
	bit rate	default
System Init	default	
Test	The Test System sends TST_FRAME_2 with the “Read by Identifier” command with correct NAD. After that the TST_FRAME_6 header shall be issued.	
Verification	The IUT shall respond on TST_FRAME_6 header with the LIN product ID	

9.2.2 LIN Product ID – with delayed response, IUT as Slave

Reference: 8.2.3.2 / 4.2.1 / 4.2.6.1

This test verifies if the IUT as Slave is able to answer to the Product ID request with a non-diagnostic frame send between Master request command frame and the Slave response command frame.

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_2, TST_FRAME_7, TST_FRAME_6
	bit rate	default
System Init	default	
Test	The Test System sends TST_FRAME_2 with the “Read by Identifier” command. After that the non-diagnostic frame TST_FRAME_7 is send by the Test System. The TST_FRAME_6 header is send by the Test System.	
Verification	The IUT shall respond on TST_FRAME_6 header with the LIN product ID	

10 Wildcards

10.1 Request with direct response, IUT as Slave

Reference: 4.2.1.1

This test verifies if the IUT as Slave is able to answer to wildcards.

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_2, TST_FRAME_6
	bit rate	default
System Init	default	
Test	The Test System sends TST_FRAME_2 with the “Read by Identifier” command as defined in Table 10.1. After that the TST_FRAME_6 header shall be issued.	
Verification	The IUT shall respond to TST_FRAME_6 header with the LIN product ID.	

Test case No.	substitution
10.1.1	NAD as wildcard
10.1.2	Supplier ID as wildcard
10.1.3	Function ID as wildcard
10.1.4	SupplierID AND FunctionID as wildcard

Table 10.1

11 Read by Identifier command

11.1 Read by Identifier command with correct NAD, IUT as Slave

Reference: 4.2.6.1

The IUT must be able to respond to all Identifiers.

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_3, TST_FRAME_6
	bit rate	default
System Init	default	
Test	The Test System sends TST_FRAME_3 with the “Read by Identifier” command followed by TST_FRAME_6. This sequence is repeated with all Identifiers. The request of the Test System shall be sent with correct Supplier ID and correct Function ID. Wildcards shall not be used.	
Verification	The IUT shall respond positive if the Identifier is supported. For all reserved or not supported ID’s, the IUT must respond with the negative response. User defined area: If the ID is supported, the pos. response will be checked for correct NAD, valid PCI (range 0x02 – 0x06) and RSID	

11.2 Read by Identifier command with incorrect addressing, IUT as Slave

Reference: 4.2.6.1

[4.2.6.1 Read by identifier] specifies, that an answer shall only be sent if NAD, Supplier ID and Function ID match.

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_2, TST_FRAME_6
	bit rate	default
System Init	default	
Test	Wildcards shall not be used. The Test System sends TST_FRAME_2 with valid parameters except the values of Table 11.2 followed by TST_FRAME_6.	
Verification	The IUT must not respond to the request.	

TC No.	Read by Identifier
11.2.1	Incorrect NAD (but valid: 1-125)
11.2.2	Incorrect supplier ID MSB First bit of incorrect field shall be inverted.
11.2.3	Incorrect supplier ID LSB First bit of incorrect field shall be inverted.
11.2.4	Incorrect function ID MSB First bit of incorrect field shall be inverted.
11.2.5	Incorrect function ID LSB First bit of incorrect field shall be inverted.

Table 11.2

12 NAD Assignment

Assign NAD is used to resolve conflicting node addresses. A response shall only be sent if the NAD, the Supplier ID and the Function ID match.

The test cases in this chapter can only be performed if the IUT supports this optional service, which is listed in the according NCF.

12.1 NAD Assignment – followed by ”Read by Identifier”, IUT as Slave

Reference: 4.2.5 / 4.2.5.1

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_13, TST_FRAME_2, TST_FRAME_6
	bit rate	default
System Init	default	
Test	The new NAD shall not be the same value as the old NAD. The Test System sends TST_FRAME_13 with the “Assign NAD” command. Use correct NAD. The Test system sends TST_FRAME_2 “Read by Identifier” command with new NAD followed by TST_FRAME_6. The Test System sends TST_FRAME_2 “Read by Identifier” command with old NAD followed by TST_FRAME_6.	
Verification	The IUT must answer to the request with the newly assigned NAD. The IUT must not answer to the request with the old NAD.	

12.2 NAD Assignment – with positive response, IUT as Slave

Reference: 4.2.5 / 4.2.5.1

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_13, TST_FRAME_6
	bit rate	default
System Init	default	
Test	The Test System sends TST_FRAME_13. After that the TST_FRAME_6 header is send by the Test System.	
Verification	The IUT shall respond with the positive assign NAD response and its initial NAD.	

12.3 Conditional change NAD, IUT as Slave

Reference: 4.2.5.2

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_10, TST_FRAME_6
	bit rate	default
System Init	default	
Test	The Test System sends TST_FRAME_10 with the “Conditional change NAD” command followed by TST_FRAME_6.	
Verification	The IUT shall respond with the Positive Conditional change NAD response.	

13 Transport layer

13.1 Transport layer Functional Request, IUT as Slave

This test case is applicable if diagnostic is supported by the IUT.

Reference: 4.2.3.2 / 5.5

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_2, TST_FRAME_11, TST_FRAME_6
	bit rate	default
System Init	default	
Test	The Test System as Master sends TST_FRAME_2. Then the Test System sends TST_FRAME_11 with a functional request (functional NAD), After that the TST_FRAME_6 header is send by the Test System.	
Verification	The IUT shall respond to TST_FRAME_6 with a positive response according to test TST_FRAME_2.	

13.2 Abort Diagnostic communication with Diagnostic request

13.2.1 Abort Diagnostic communication with new Diagnostic request, IUT as Slave

Reference: 3.2.2 / 4.2.4

The test case is applicable if diagnostics is supported by the IUT

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_2, TST_FRAME_6, TST_FRAME_12
	bit rate	default
System Init	default	
Test	The Test System as Master sends TST_FRAME_2. After that the TST_FRAME_6 header is send by the Test System. The Test System as Master sends TST_FRAME_2, then TST_FRAME_12. After that the TST_FRAME_6 header is send by the Test System.	
Verification	The IUT shall not respond to the second TST_FRAME_6.	

13.2.2 Abort Diagnostic communication with corrupted Diagnostic request, IUT as Slave

Reference: 3.2.2 / 4.2.4

The test case is applicable if diagnostics is supported by the IUT

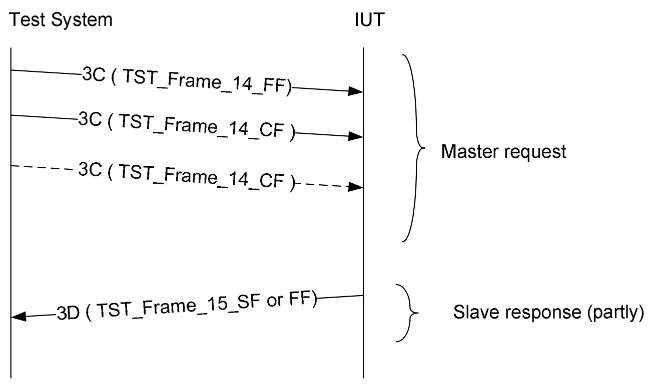
State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_2, TST_FRAME_6
	bit rate	default
System Init	default	
Test	The Test System as Master sends TST_FRAME_2. After that the TST_FRAME_6 header is send by the Test System. The Test System as Master sends TST_FRAME_2 twice. The first TST_FRAME_2 is correct, the second TST_FRAME_2 is send with a wrong CS. After that the TST_FRAME_6 header is send by the Test System.	
Verification	The IUT shall not respond to the second TST_FRAME_6.	

13.3 IUT receives a segmented request as specified, IUT as Slave

Reference: 3.2.2.2

This test shall ensure that a Slave is able to receive segmented requests.

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_14, TST_FRAME_15
	bit rate	default
System Init	default	
Test	The IUT receives a segmented request which shall be answered by a (segmented) response. Then the IUT sends the (first segment of the) response according to the received request before. Procedure see Picture 13.3.	
Verification	The IUT shall send a correct answer to the Master request.	



Picture 13.3

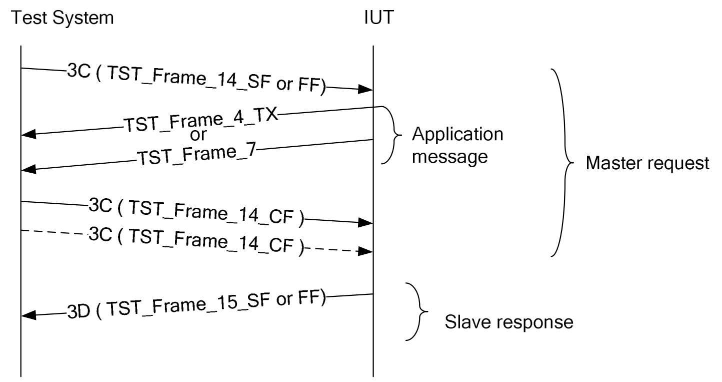
13.4 IUT receiving a segmented request interrupted by normal communication

13.4.1 IUT receiving a segmented request if user frames between request parts, IUT as Slave

Reference: 5.4.1

This test shall ensure that the Slave is able to receive segmented requests with user frames in between.

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_14, TST_FRAME_15, TST_FRAME_4_Tx, TST_FRAME_7
	bit rate	default
System Init	default	
Test	The IUT receives a segmented request which shall be answered by a (segmented) response. The Test system sends (initiates) a TST_FRAME_4_Tx (or TST_FRAME_7) between two segmented messages. The IUT shall send the (first segment of the) response according to the request before. Procedure see Picture 13.4.1.	
Verification	The IUT shall send a correct answer to the Master request.	



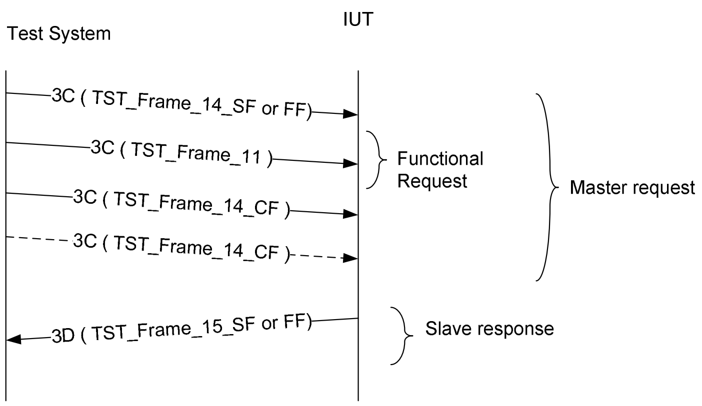
Picture 13.4.1

13.4.2 IUT receiving a segmented request with functional request between request parts, IUT as Slave

Reference: 5.5

This test shall ensure that a Slave is able to receive segmented requests with functional request between.

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_11, TST_FRAME_14, TST_FRAME_15
	bit rate	default
System Init	default	
Test	The IUT receives a segmented request which shall be answered by a (segmented) response. The Test system sends a functional request between two frames of a segmented message. The IUT shall send the (first segment of the) response according to the request before. Procedure see Picture 13.4.2.	
Verification	The IUT shall send a correct answer to the Master request and shall ignore the functional addressed request..	



Picture 13.4.2

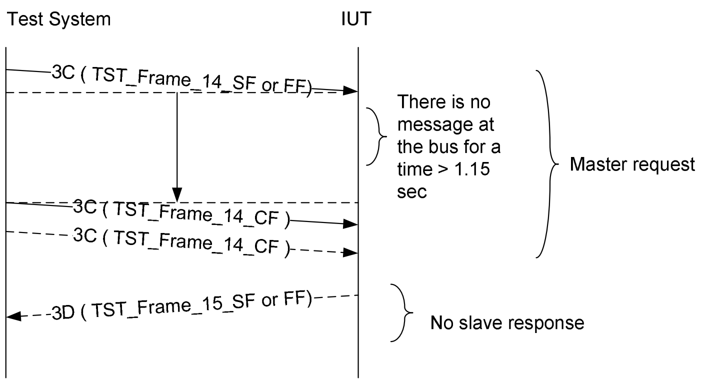
13.5 IUT shall ignore request after timeout

13.5.1 IUT shall ignore segmented requests, IUT as Slave

Reference: 3.2.3

This test shall ensure that a Slave ignores a Master request if a N_Cr_LIN timeout occurs. It shall be tested that if the time between 2 segmented messages of a Master request is < 1 sec, the IUT shall not answer.

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_14, TST_FRAME_15
	bit rate	default
System Init	default	
Test	The IUT receives a segmented request which shall be answered by a (segmented) response. There is no segmented message at the bus for a time > 1.15 sec. Procedure see Picture 13.5.1.	
Verification	The IUT shall not answer to the Master request.	



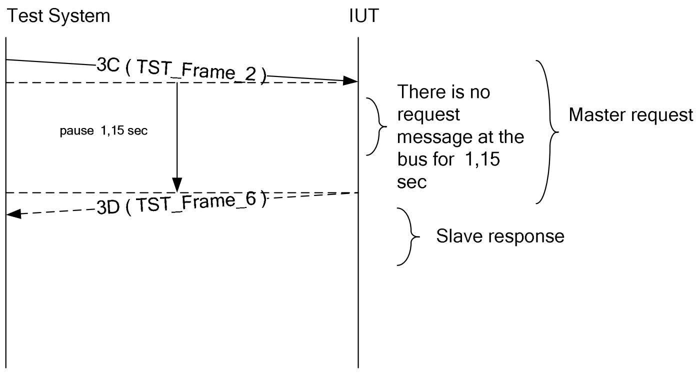
Picture 13.5.1

13.5.2 IUT shall observe Transport Layer timeout, IUT as Slave

Reference: 3.2.3

This test shall ensure that a Slave ignores a Master request if a N_Cr_LIN timeout occurs. It shall be tested that if the time between 2 TL messages is > 1.15 sec[12] and < 4 sec the IUT shall not answer. Only the 1.15 sec shall be tested.

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_2, TST_FRAME_6
	bit rate	default
System Init	default	
Test	The IUT receives a Master request which the slave shall respond to. There shall be no bus communication at the bus for 1.15 sec. Procedure see Picture 13.5.2.	
Verification	The IUT shall not answer to the Master request.	



Picture 13.5.2

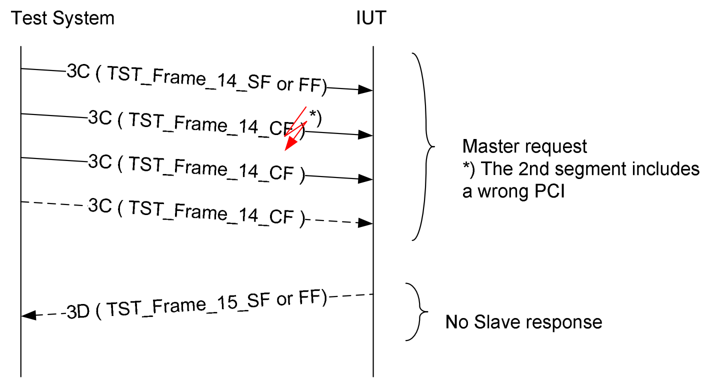
[12] The time measurement results of N_Cr_LIN = max. 1 sec + slaves tolerance 14 % -> (approx. 1,14 sec.)

13.6 IUT shall ignore segmented requests with wrong sequence numbering, IUT as Slave

Reference: 3.2.3

This test shall ensure that a Slave ignores segmented requests with wrong sequence numbering.

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_14, TST_FRAME_15
	bit rate	default
System Init	default	
Test	The IUT receives a segmented request which shall be answered by a (segmented) response. The 2nd segment includes a wrong PCI, 0x22 instead of 0x21. The other segments are sent with a correct PCI. Procedure see Picture 13.6.	
Verification	The IUT shall not answer to the Master request.	



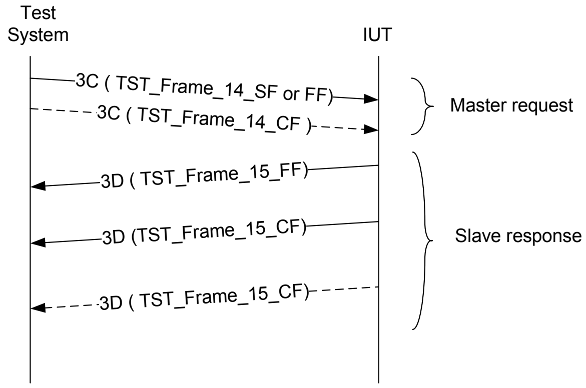
Picture 13.6

13.7 IUT shall respond with correct segmented response, IUT as Slave

Reference: 3.2.2.2

This test shall ensure that the IUT responds with correct length, PCI and sequence number. The data content is not in the focus of this test .

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_14, TST_FRAME_15
	bit rate	default
System Init	default	
Test	The IUT receives a segmented request which shall be answered by a (segmented) response. Procedure see Picture 13.7.	
Verification	The IUT shall answer to the Master request with a segmented response with correct length, PCI and sequence number. It is allowed that the IUT sends a response pending before.	



Picture 13.7

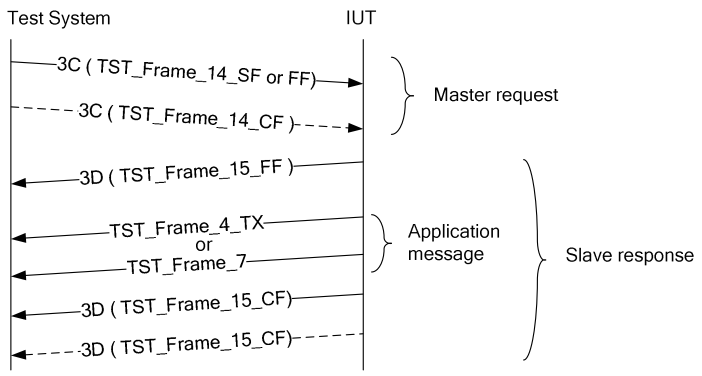
13.8 IUT sending a segmented response with frames between response parts

13.8.1 IUT sending a segmented response with user frames between response parts, IUT as Slave

Reference: 5.4.2

This test shall ensure that a Slave is able to send a segmented response if user frames are in between.

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_4_Tx, TST_FRAME_7 , TST_FRAME_14, TST_FRAME_15
	bit rate	default
System Init	default	
Test	The IUT receives a (segmented) request which shall be answered by a segmented response. The Test system sends (initiates) a TST_FRAME_4_Tx (or TST_FRAME_7) between two segmented response messages. The IUT sends the response according to the request before. Procedure see Picture 13.8.1.	
Verification	The IUT shall send a correct answer to the Master request.	



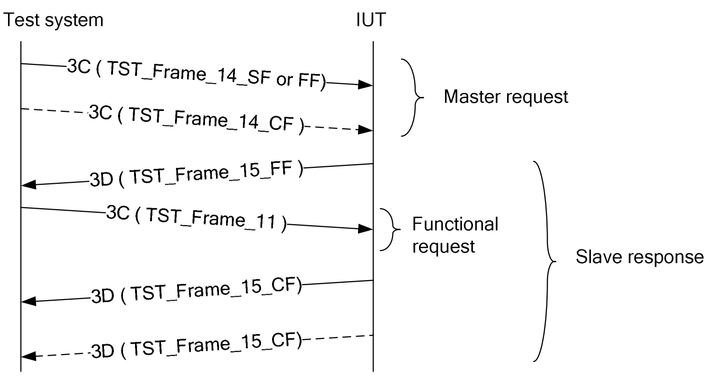
Picture 13.8.1

13.8.2 IUT sending a segmented response with functional request between response parts, IUT as Slave

Reference: 5.5

This test shall ensure that the Slave is able to send a segmented response if a functional request is sent in between.

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_11 , TST_FRAME_14, TST_FRAME_15
	bit rate	default
System Init	default	
Test	The IUT receives a master request which shall be answered by a segmented slave response. The Test system sends a functional request between two segmented response messages. The IUT sends the response according to the request before. Procedure see Picture 13.8.2.	
Verification	The IUT shall send a correct answer to the Master request.	



Picture 13.8.2

13.9 IUT shall not respond to 0x3D if there is no request before, IUT as Slave

Reference: 5.5 (Figure 5.12, transition 9)

This test shall ensure that the IUT responds only if a Master request is sent before.

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_15
	bit rate	default
System Init	default	
Test	The IUT shall go awake. After a time > 1.15 sec (= transport layer timeout) and < 4 sec a TST_Frame_15 is sent by the Test System.	
Verification	The IUT shall not answer.	

13.10 IUT shall not respond to 0x3D if the response is already sent, IUT as Slave

Reference: 5.5 (Figure 5.12, transition 6)

This test shall ensure that the IUT responds only if a Master request is sent before.

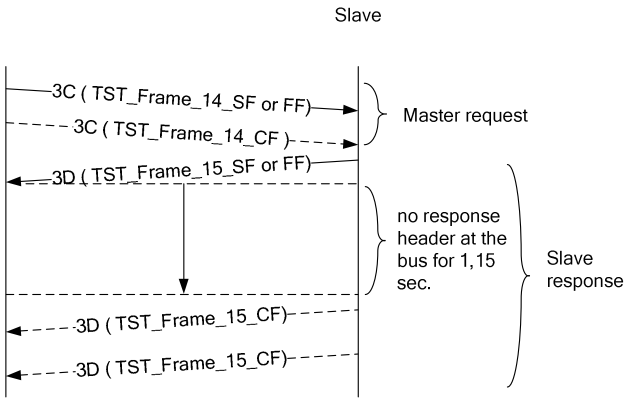
State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_2, TST_FRAME_6
	bit rate	default
System Init	default	
Test	The Test System sends TST_FRAME_2 and then two times the header of TST_FRAME_6.	
Verification	The IUT shall respond to the first header of TST_FRAME_6. The second header of TST_FRAME_6 shall not be answered by the IUT.	

13.11 IUT shall ignore segmented request, IUT as Slave

Reference: 3.2.3

This test shall ensure that a Slave aborts the segmented response if a N_Cr_LIN timeout occurs.

State	Description	
Set Up	IUT as	Slave
	Classification	class B, class C devices
	Configuration	TST_FRAME_14, TST_FRAME_15
	bit rate	default
System Init	default	
Test	The IUT receives a (segmented) request which shall be answered by a segmented response. There is no segmented response header at the bus for a time > 1.15 sec. The timeout shall be initiated after the first frame of the response. Procedure see Picture 13.11.	
Verification	The IUT abort the response after timeout.	



Picture 13.11

LIN

Conformance Test Specification

LIN EMC Test Specification

For the LIN Physical Layer Specification
Revision 2.1 (November 24th, 2006)

Version 2.1
October 10th, 2008

Table of Contents

1 Scope

This test specification shall be used as a standardized common scale for EMC evaluation of LIN transceivers. For this reason, this instruction does not include any limits, but only test procedures, failure criteria, test set-ups, and test signals concerning:

- the emission in the frequency domain caused by the slew rates of the bus signal,
- the immunity against conducted disturbances (function and damage),
- the immunity against transients (function and damage) and
- the immunity against electrostatic discharges (damage).

The final judgment of the tested device, whether if it can be released or not is still to be decided by the customer.

Basically no external protection circuits are regarded in this test specification in order to keep the rating limited to the transceiver chip only. Tests with an additional capacitor on the LIN bus line give more information about the EMC behavior of the LIN transceiver in an application (e.g. automotive application).

The described EMC tests are based on present stand-alone LIN transceivers.

Therefore EMC test definitions for transceivers with a Wake-up pin and transceivers with a V_{cc} pin are made. These definitions are valid for standard LIN transceivers according to LIN Specification 2.1 with the following features:

- LIN communication,
- normal and sleep mode adjustable,
- Wake-up capability via LIN Bus line and local Wake-up pin and
- Inhibit output to control an external voltage stabilization IC.

The test specification includes also LIN transceivers with a reduced functionality. In this case, only the implemented functions are tested under influence of electromagnetic disturbances.

For ASICs with an integrated LIN transceiver, the test conditions cannot be fixed for any type of IC. Therefore, if it is possible, the test conditions of standard stand-alone LIN transceiver should be used. The configuration of the physical layer of the LIN bus is fixed in any case. To achieve comparable test results to common EMC IC tests at ASICs the coupling at the V_{Bat} pin should be concentrated at one device at the test network. In this case the V_{Bat} connection of the other two devices should be RF decoupled from the injection point.

To connect the pins of the LIN transceiver for transmit and receive data, for mode control (SPI) or inhibit (reset or interrupt outputs) use an adaptation according to the application circuit of the semiconductor manufacturer.

2 Test Conditions

2.1 General

The common value for voltage supply V_{Bat} is 14 V.

A function test related to functional status class A according to ISO 11452-1 means:

During and after the immunity test all functions of the transceiver are working properly:

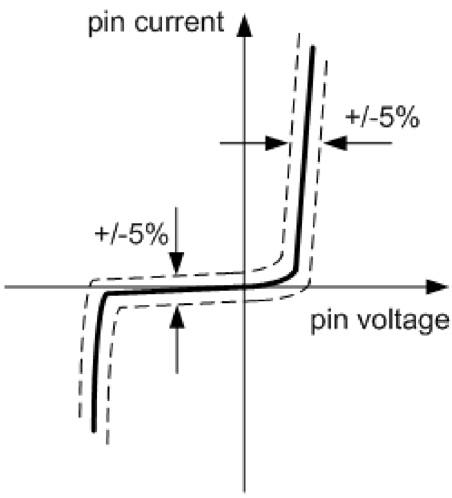
- send and receive functionality,
- Wake-up capability of the LIN pin and of the Wake-up pin (if available) and
- operation mode setting (if available)

  within the specifications given by the semiconductor manufacturer.

A damage test related to functional status class C according to ISO 11452-1 means:

At least one function of the transceiver stops working properly during the test and comes back into proper operation automatically when the exposure to the disturbance has ended. Two evaluation criteria have to be used:

- Evaluation criterion 1: The characteristic curve of pin voltage versus pin current of the tested pin to GND pin must be measured using a Semiconductor Parameter Analyzer. Any change of more than ± 5% to the initial state is not allowed.



- Evaluation criterion 2: The TX test must be used: apply the TX1 signal to the tested transceiver and measure the LIN signal. Any change of the LIN signal of more than ± 5% to the initial state is not allowed.

2.2 Test conditions for RF and transient disturbances

For the transceiver EMC analysis a minimum network of three bus nodes has to be set up according to figure 1.

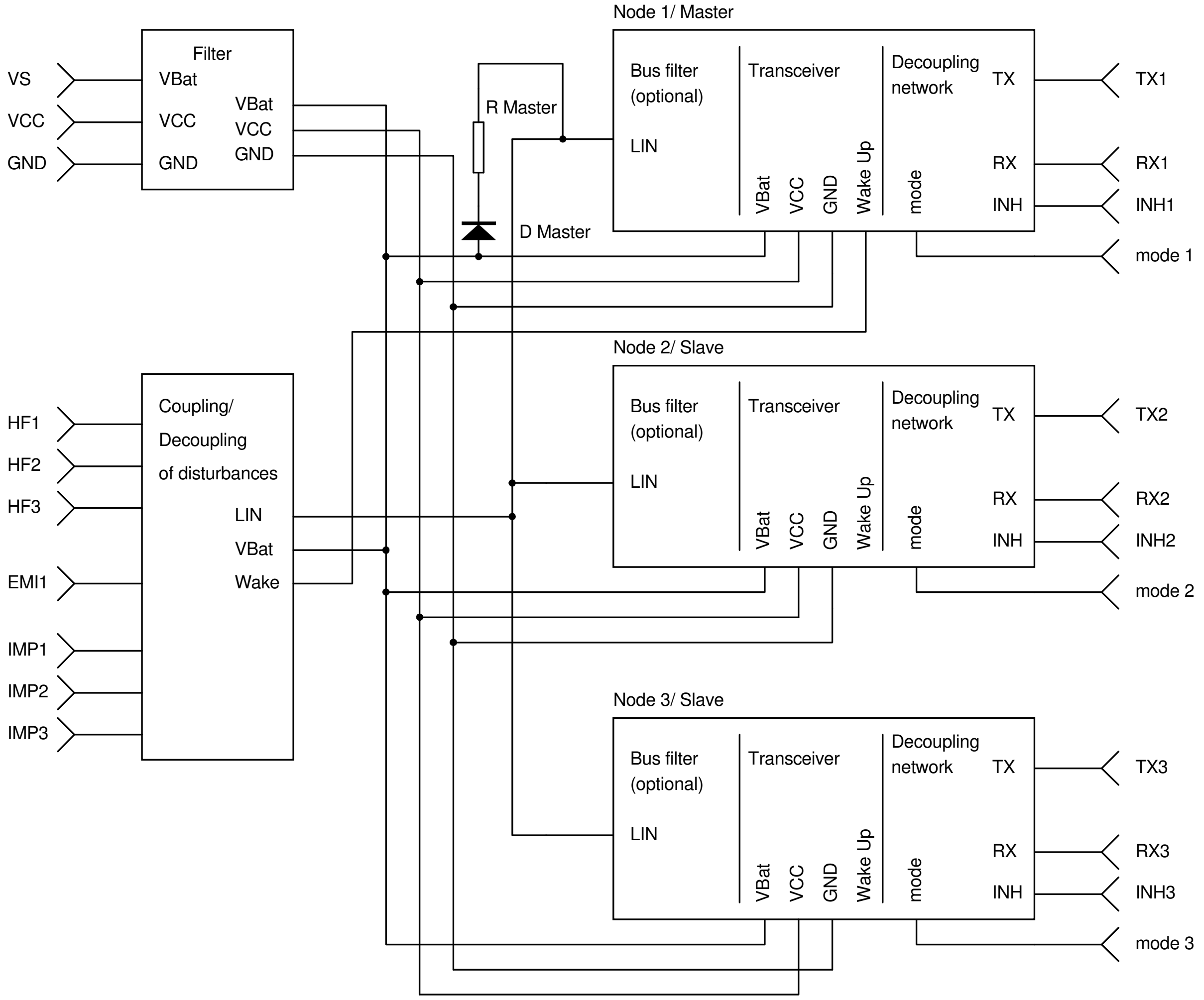


Figure 1 Overview of a minimum configuration of a LIN system for emission and immunity tests against transient and RF disturbances

<u>LIN nodes:</u>

A LIN node consists of a transceiver and the decoupling network and an optional filter on the bus line. Node 1 operates as a transmitter for a bit pattern that simulates a LIN message to be received and monitored at the RX output ports of all nodes in the configured network. Node 1 is the master and nodes 2 and 3 are slaves in the LIN bus system.

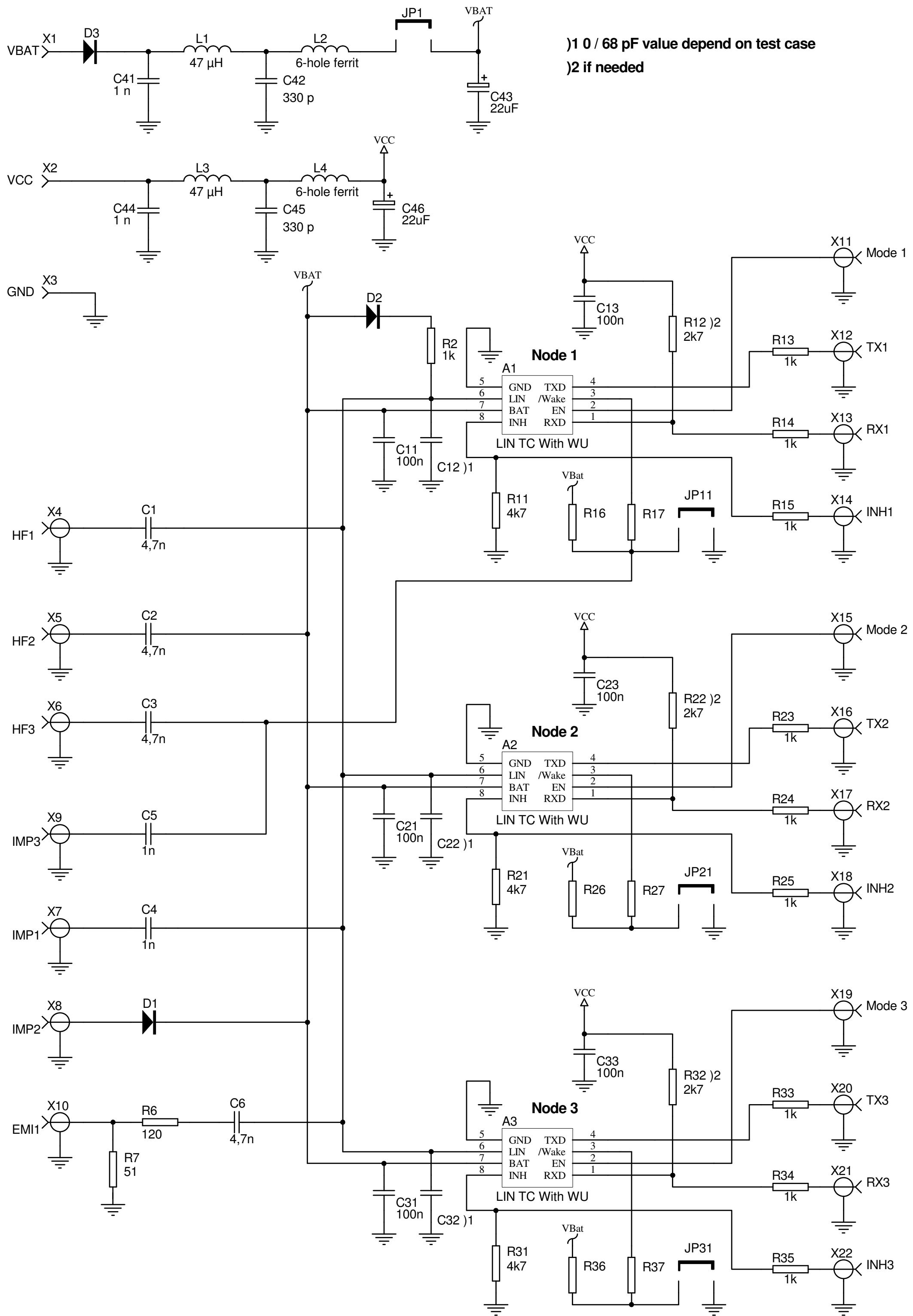


Figure 2 Example for the circuit diagram of the minimum network for the bus system with LIN transceiver with Wake-up pin for measuring emission and immunity in respect to RF disturbances and transients.

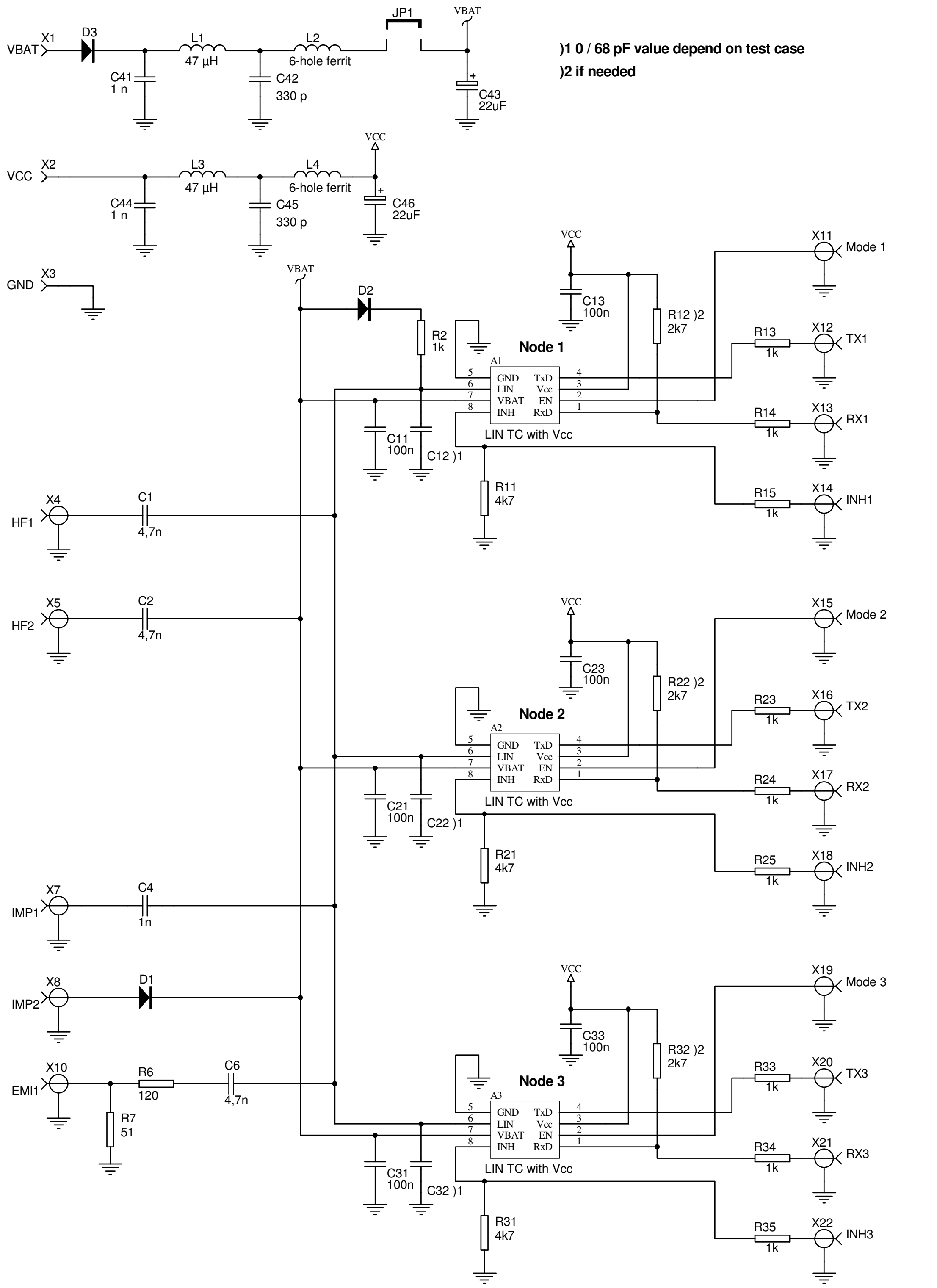


Figure 3 Example for the circuit diagram of the minimum network for the bus system with LIN transceiver with V_{CC} pin for measuring emission and immunity in respect to RF disturbances and transients.

The master node (1) has a bus termination resistor with a value of 1 kΩ via a diode.

The resistors at the Wake-up pin (if available, R_{16}, R_{17}, R_{26}, R_{27}, R_{36}, R_{37}) are to be chosen corresponding to the manufacturers specifications in the following way:

- resistors R_{16}, R_{26} and R_{36}: maximum specified value (Default: 10 kΩ)
- resistors R_{17}, R_{27} and R_{37}: minimum specified value (Default: 33 kΩ)

Every control input for operation modes setting shall be connected according to the manufacturers specifications for a setting either to normal or sleep mode. Connections to the peripheral control equipment must be decoupled from the test circuit board.

For RF decoupling of outputs RX_1 to RX_3, INH_1 to INH_3 as well as the input TX_1 resistors (value R = 1 kΩ) are used (R_{13}, R_{14}, R_{15}, R_{23}, R_{24}, R_{25}, R_{33}, R_{34}, R_{35}). A buffer ceramic capacitor (C_{12}, C_{13}, C_{22} C_{23}, C_{32}, C_{33} = 100 nF) shall be used at the supply ports V_{CC} and V_{BAT} of every transceiver IC.

Filter:

The central voltage supplies V_{BAT} and V_{CC} are buffered by electrolytic capacitors C_{43} = 22 µF and C_{46} = 22 µF. For the decoupling of the external connected voltage supplies V_{CC} and V_{BAT} two- stage LC-filters are connected to each of them (L_1, C_{41}, L_2, C_{42} at V_{BAT} and L_3, C_{44}, L_4, C_{45} at V_{CC}). The parts L_2 and L_4 are carried out as 6- hole- ferrites (e.g. WE 742 750 4). The jumper J1 is used for decoupling the supply V_{BAT} from the two-stage filter in case of a directly connected transient test signal and supply via the input IMP2.

Coupling of disturbances:

The coupling of disturbances shall be realized by passive components. The maximum components tolerance is 1 %.

Port	Purpose	Components
HF1	RF coupling to LIN	C_1 = 4.7 nF
HF2	RF coupling to V_{Bat}	C_2 = 4.7 nF
HF3	RF coupling to Wake-up	C_3 = 4.7 nF
IMP1	Transient coupling to LIN	C_4 = 1 nF
IMP2	Transient coupling to V_{Bat}	Diode D1 (repetitive peak reverse voltage V_{RRM} > 150 V, non-repetitive peak forward current I_{FSM} > 10 A)
IMP3	Transient coupling to Wake-up	C_5 = 1 nF
EMI1	RF decoupling at LIN	Voltage divider and DC- block: R_6 = 120 Ω, R_7 = 51 Ω, C_6 = 4.7nF

Table 1 Overview of coupling and decoupling ports

Definitions for transceiver communication in the minimum network:

For immunity tests with communication and emission measurements in the frequency domain the following test signal shall be used:

Test signal	TX1
Signal type	Square wave
Duty cycle	50 %
Frequency	10 kHz
Bit rate	20 kBit/s
Amplitude	Vcc +/- 0.1 V

Table 2 Characteristics of communication test signal

Evaluation of bus system immunity:

The immunity of the LIN bus system shall be tested for the different transceiver modes according to the scheme below:

Mode	Type of disturbance	Failure validation on pin
Normal	RF/ Transients	RX, INH
Sleep	RF/ Transients	INH or RX)$_1$

)$_1$ depends on transceiver type

Table 3 Basic scheme for immunity evaluation

In sleep mode it will be tested if RF or transient disturbances can cause an unwanted wake-up. If an unwanted wake-up occurs, all nodes must set to sleep mode before again the next step of test can be proceeded.

Fault criteria for failure validation related to functional status class A:

Mode	Type of disturbance	TX signal	Maximum voltage variations $)_1$ [V]		Maximum time variations $)_1$ [µs]	
			RX$)_{2,3}$	INH$)_4$	RX	INH
Normal	RF/ Transient	TX 1	± 0.9	- 5	± 7.5	– $)_5$
Sleep		without	± 0.9	+ 2	– $)_5$	– $)_5$

$)_1$ The given values are the maximum allowed variations to the undisturbed signal. The undisturbed voltage level depends on the tested transceiver.

$)_2$ For the immunity evaluation the RX signals of all 3 transceivers in the network with and without applied disturbances at the tested pin shall be compared by using a DSO. The TX signal must be used to trigger the DSO.

$)_3$ The definition for the maximum deviation of the voltage level on the RX pin was done according the transceiver data sheet.

$)_4$ The definition for the maximum deviation the voltage levels on the pin INH was done under the following limit conditions:

$V_{drop\_typ\ LIN\_}$ = 0.8 V,

$V_{on\_typ\_Volt.Reg.}$ = 2.5 V,

$V_{off\_typ\_Volt.Reg.}$ = 0.8 V and

possible RF superposition on pin INH with RF influencing of V_{BAT} an amplitude of approx. 2 V

$)_5$ independent of the duration

Table 4 Fault criteria for immunity tests related to functional status class A

The fault criteria apply to all three transceivers. As soon as at least one transceiver in the network fulfils the fault criteria the error event for this test has occurred.

2.3 Test Conditions for ESD

ESD immunity tests shall be carried out with a transceiver without voltage supply and with a minimum-wiring network in accordance with figure 4 and/or figure 5.

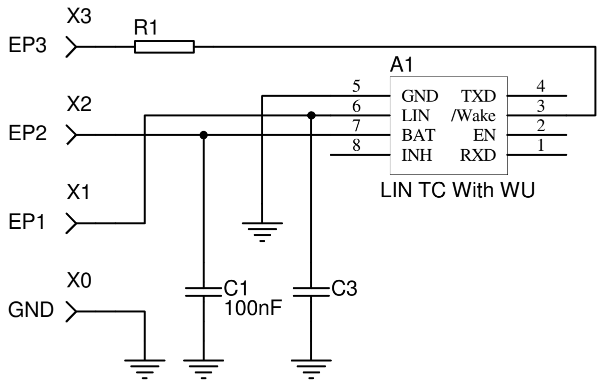


Figure 4 Circuit diagram of the test set-up for ESD tests at LIN transceivers with Wake-up pin

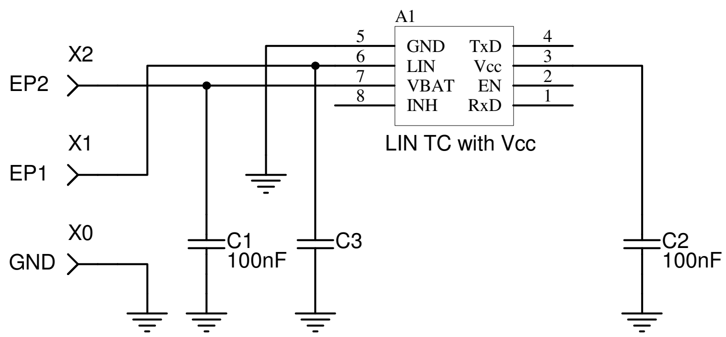


Figure 5 Circuit diagram of the test set-up for ESD tests at LIN transceivers with Vcc pin

The LIN transceiver shall be tested without voltage supply and with a minimum external wiring network. The value for the series resistor on the pin Wake-up (R1) should be chosen according to the definitions of the semiconductor manufacturer with the possible minimum value (default value: 33 kΩ). For decoupling of the power supply lines V_{CC} and V_{BAT} ceramic capacitors (C_1, C_2 = 100 nF) shall be used.

Default values for C_1, C_2 and C_3:

- Capacity: 100 nF ± 10 % (C_1, C_2); 220 pF ± 10 % (C_3)
- Material: X7R
- Voltage resistance: 50 V
- Type: SMD 1206 or 0805

All resistors shall be of the SMD types 1206 or 0805 with a maximum tolerance of 1%. The exact type ID and manufacturer of the used capacitors and resistors are to be documented in the test report.

Coupling of the disturbances:

The ESD coupling shall be realized in a direct galvanic way by using a Contact Discharge Module according to IEC 61000-4-2 [5] (C = 150 pF, R = 330 Ω). For this purpose, the discharge points EP 1 to 3 – carried out as a rounded vias in the layout of the ESD test board – are directly connected by a trace (15 (–0 +5) mm) with the respective pin of the transceiver.

Coupling point	Purpose	Components
EP1	ESD coupling for LIN	direct connection
EP2	ESD coupling for V_{Bat}	direct connection
EP3	ESD coupling for Wake-up	direct connection

Table 5 Summery of ESD coupling points

Special environmental conditions:

The requirements of IEC 61000-4-2 to the climatic environmental conditions shall be fulfilled.

Evaluation of transceiver immunity:

The transceiver immunity against damage shall be evaluated after applying the test procedures of section 4.3 and using the definitions for functional status class C of section 2.1.

3 Test set-up

3.1 Immunity against transients

For testing the immunity against transients on the LIN pin, power supply pins, as well as the Wake-up pin (if available) tests with a test set-up according to figure 6 shall be done. All networks for RF coupling and decoupling must be disconnected from the test circuit.

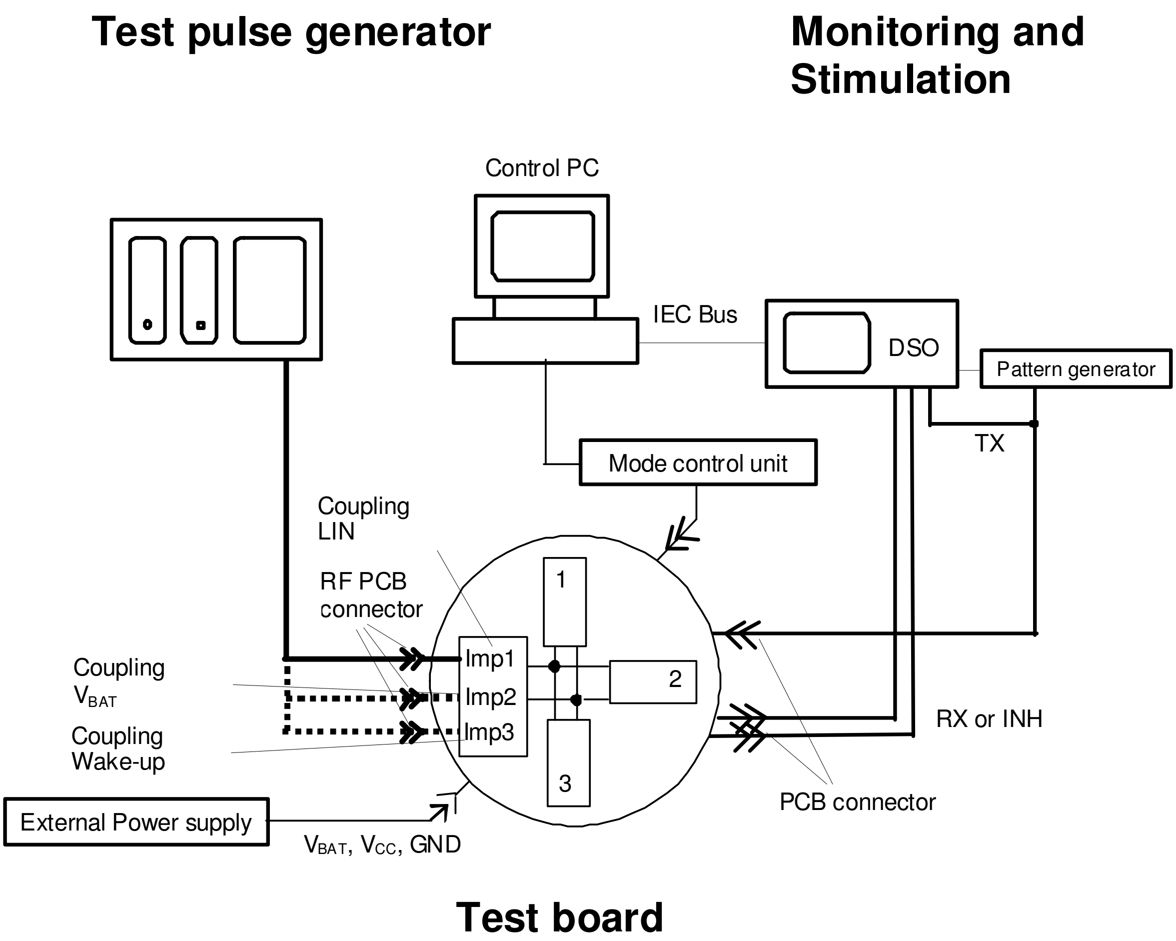


Figure 6 Test set-up for Direct Capacitive Pulse Coupling

Test equipment requirements:

Test pulse generator	according to ISO 7637-2 [6]
Test board	according to section 3.5
DSO	bandwidth >= 500 MHz
Pattern generator	
External power supply	
Mode control unit	(if possible remotely controlled by the PC)
PC	

Check of test board coupling

The transition of the test pulses from the ports IMP1, IMP2 and IMP3 to the respective pad for the transceiver signals shall be measured on the test board (without transceiver) and documented in the test report.

3.2 Immunity against RF disturbances

The test of the RF immunity of the LIN transceiver shall be carried out by Direct Power Injection (DPI Test method) according to the IEC 62132-4 [4]. A general test set-up is illustrated in figure 7.

All networks for transient coupling and emission measurement must be disconnected from the test circuit. For test level definition the forward RF power shall be used.

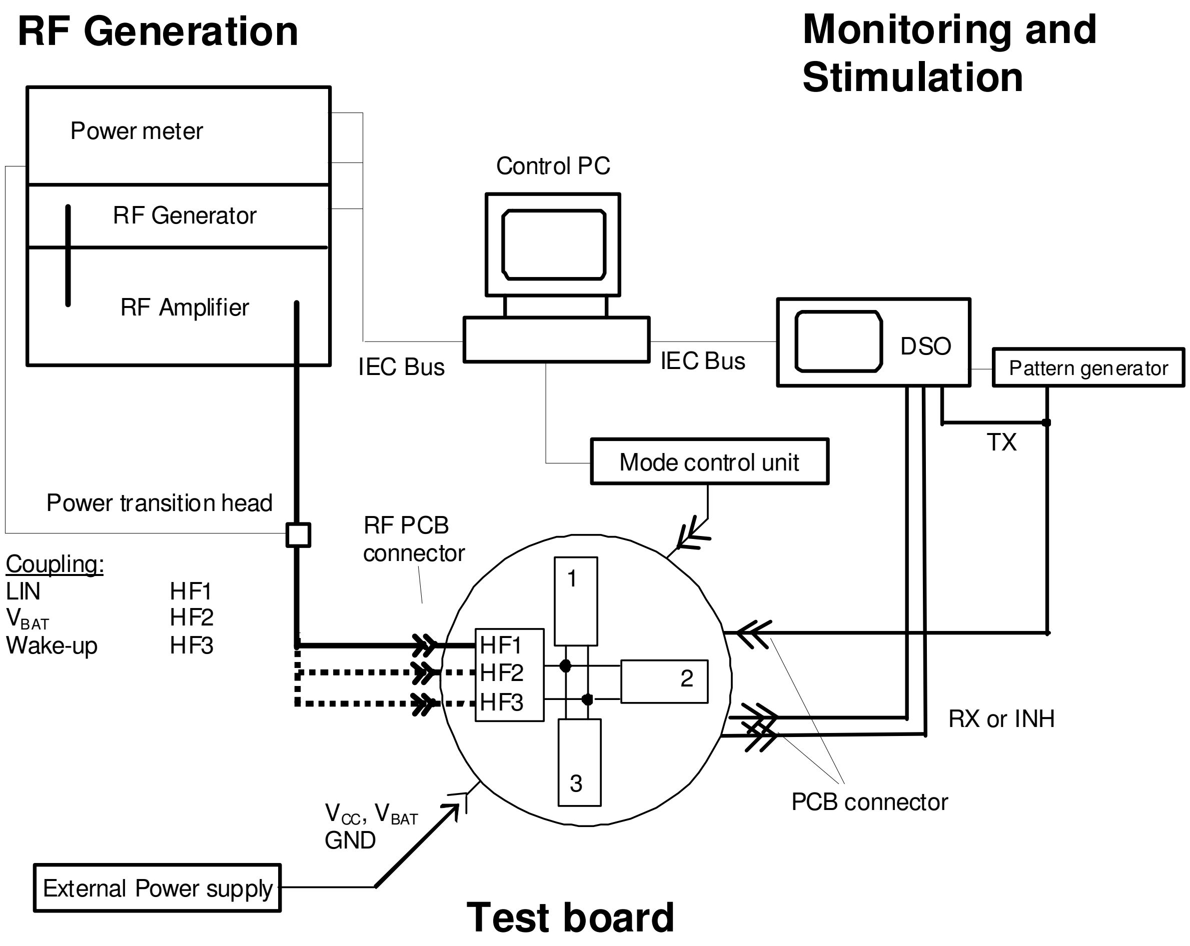


Figure 7 Test set-up for DPI tests

Test equipment requirements:

RF Generator	f = 1- 1000 MHz, AM
RF Amplifier	P_{CW} >= 10 W
Power meter with directional coupler	f = 1- 1000 MHz
Test board	according to section 3.5
DSO	bandwidth >= 500 MHz
Pattern generator	
External power supply	
Mode control unit	(if possible remotely controlled by the PC)
PC	

Check of test board coupling

The insertion losses of the ports HF1 to HF3 to the respective transceiver signal pad of the test board (without transceiver) shall be measured and documented in the test report.

3.3 Immunity against ESD

For testing the ESD immunity of the LIN pin, power supply pins as well as the Wake-up pin (if available) measurements according to IEC 61000-4-2 shall be done. The test set-up is shown in figure 8.

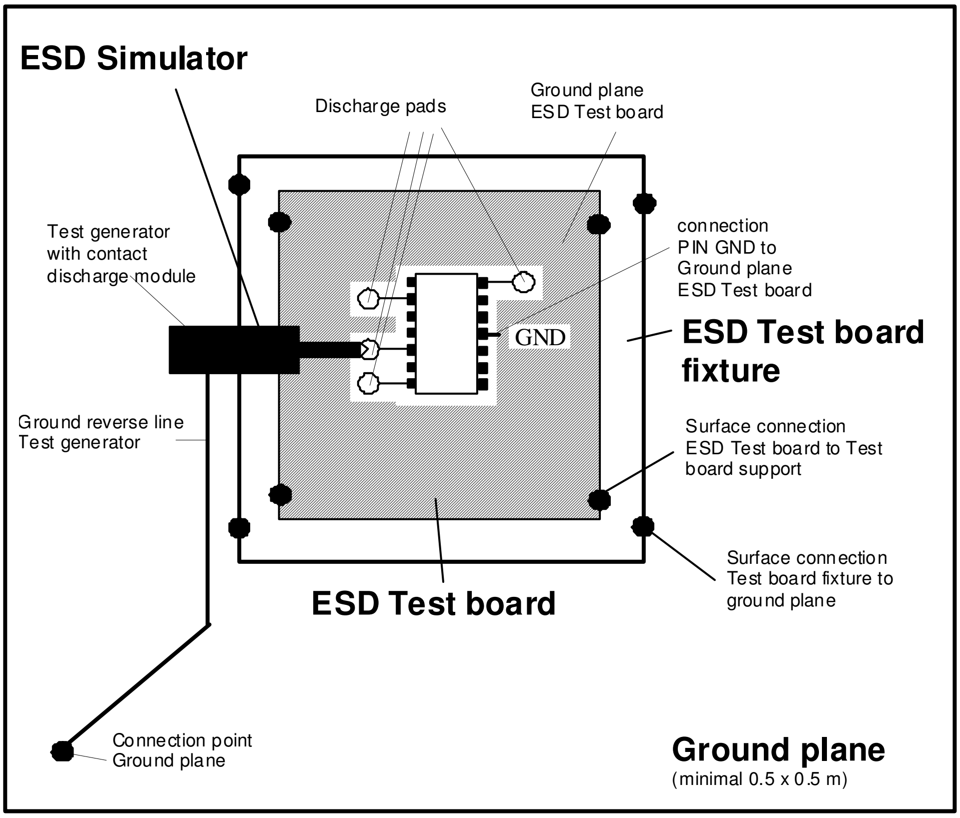


Figure 8 Test set-up for ESD tests

The ground plane with a minimum size of 0.5 x 0.5 m builds the reference ground plane for the ESD test set-up and must be connected with the electrical grounding system of test laboratory. The ESD test generator ground cable shall be connected to this reference plane. The test board fixture realizes the positioning of the ESD test board and the electrical connection of the ESD test board ground plane with the reference ground plane. This connection must have a low impedance ($R<25m\Omega$) and should be built by a surface contact.

On testing the tip of the ESD test generator discharge module shall be directly contacted with one of the discharge pads EP1 to 3 of the ESD test board.

Test Equipment Requirements:

ESD Test generator	according to IEC 61000-4-2: 2001-12; contact discharge module (IEC- Relays) with discharge capacitor 150 pF and discharge resistor 330 Ω
ESD Test board	according to section 3.5

For the evaluation of damages using the TX test a specific test extension frame or IC adapter may be used for this purpose for contacting all pins of the transceiver.

3.4 Emission of RF disturbances

The measurement of emission of RF disturbances on the LIN pin shall be carried out according to figure 9 based on IEC 61967-4 [2]. All networks for transient and RF coupling must be disconnected from the test circuit.

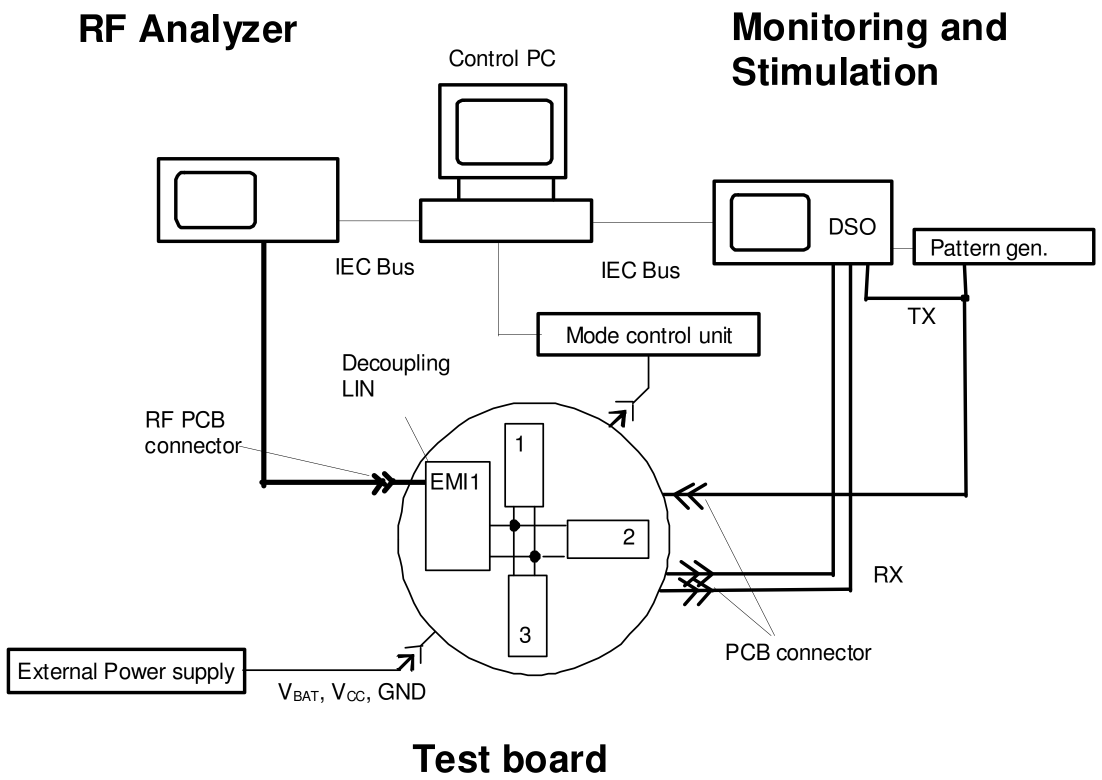


Figure 9 Test set-up for measurement of RF disturbances on the bus line

Test equipment requirements:

Spectrum analyzer / Measuring receiver	according to CISPR 16
DSO	bandwidth >= 500 MHz
Test board	according to section 3.5
Pattern generator	
External power supply	
Mode control unit	(if possible remotely controlled by the PC)
PC	

Check of test board decoupling:

The insertion loss of the pad for the LIN port on the master node 1 (PCB without transceiver) to the port HF1 have to be measured and documented in the test report.

3.5 Test Circuit Boards

RF and transient tests:

For RF and transient tests with the minimal network according to figures 2 and/or 3 a printed circuit board shall be used. To ensure good RF parameters of the coupling and decoupling networks symmetric nodes 1 to 3 and a two layer PCB in minimum should be used. The length of the coupling paths on the test board should be kept as short as possible. For a better shielding of all connections to the test peripherals of the test board (except for the filtered 'on'-ends for V_{BAT} and GND) should be realized through coaxial printed circuit board sockets.

The insertion losses of ports HF1 to HF3 as well as IMP1 to IMP3 to the respective transceiver signal pads of the test board shall be measured and documented in the test report.

Examples for test board for the LIN minimal network:

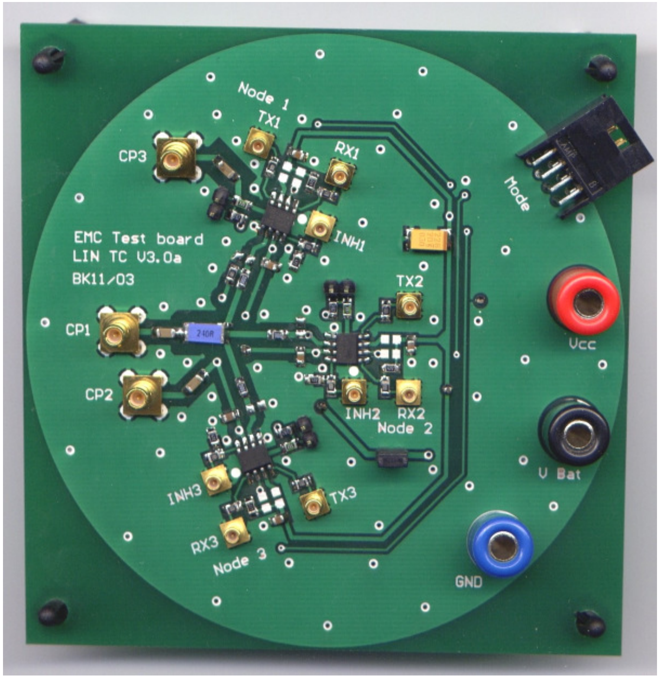


Figure 10 Example test board LIN (transceiver with Wake-up pin), Top layer

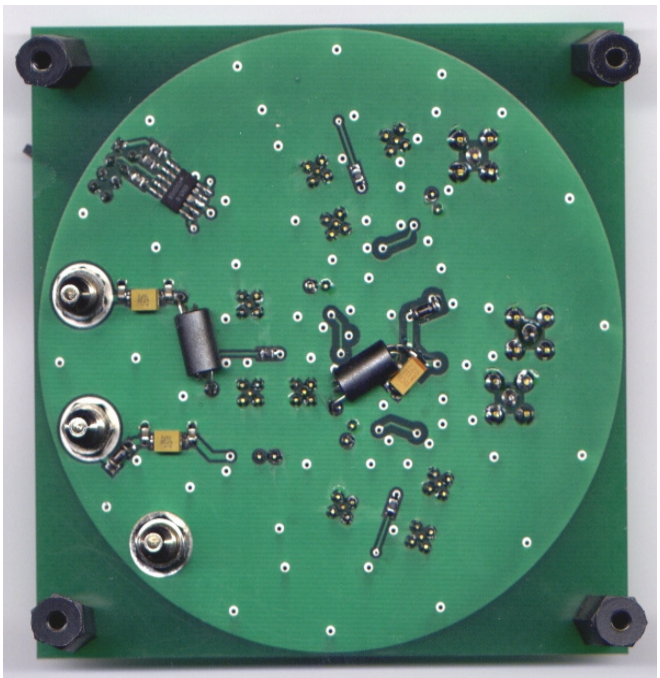


Figure 11 Example test board LIN (transceiver with Wake-up pin), Bottom layer

ESD Test:

For ESD tests according to figures 4 and/or 5 a printed circuit board shall be used. A two-layer construction of the PCB with an extensive ground area shall be chosen. The pads for the discharge points EP 1 to 3 are to be carried out in such a way, that a safe contact to the discharge tip of the testing generator is guaranteed. The passive components of the minimal wiring network shall be placed in direct proximity of the transceiver.

The insulation distance between the signal lines and pads of the passive components and the extensive ground area should be chosen in such a way, that a disruptive discharge at a test voltage of 8 kV is impossible at these points.

Further requirements apply to the ESD test board:

- Trace length between transceiver pads and discharge point: 15 (–0 + 5) mm
- Track width of the conducting path: 0.254 mm (10 mil)
- Substrate material: FR4
- Thickness substrate: 1.5 mm

The test adapter used for functional and leakage current examination makes direct contacting of the transceiver pins possible.

Examples for ESD test board for LIN transceiver:

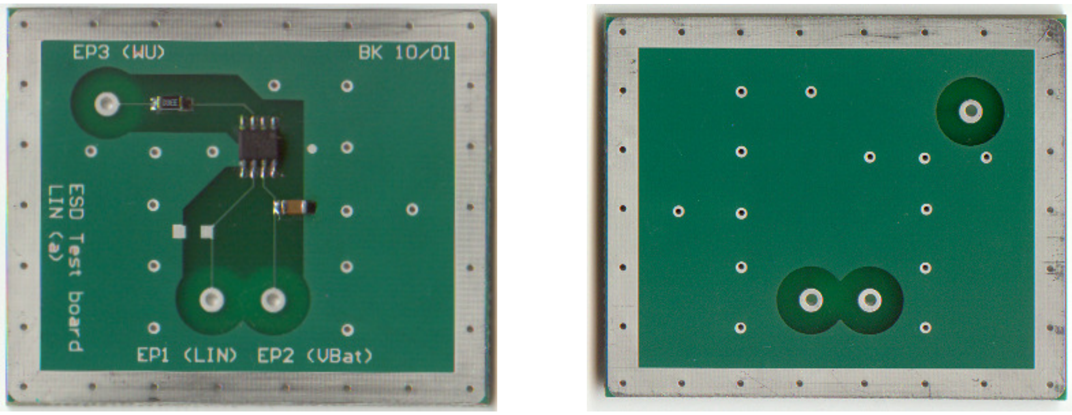


Figure 12 Example ESD test board LIN (transceiver with Wake-up pin), Top and Bottom Layer

4 Requirements

The requirements in this section are valid for all types of LIN transceivers. In case of stand-alone transceivers with V_{CC} pin the requirements on pin Wake-up are not become applied.

4.1 Immunity against transients

To prove transceiver immunity against transients tests with standard pulses (defined in ISO 7637-2) using the test set-up given in section 3.1 with the following parameters shall be carried out:

Test pulse)1	Us [V]	R_i [Ω]	Pulse repetition frequency [Hz] (1/T_1)1)	Test duration [min])3	Remarks
1)2	- 100	10	2	1 respectively 10	t_2 = 0 s
2a	+ 75	2	2		
3a	- 150	50	10		
3b	+ 100	50	10		

)1 according to ISO 7637-2
)2 parameters for 12 V- Systems
)3 1 minute for function test , 10 minutes for damage test

Table 6 Parameters for transient test

Functional test to functional status class A:

The functional tests shall be carried out according to the scheme given in table 7. The amplitudes of the standard impulses shall be increased up to the malfunction and/or to the respective peak values with an increment of 10 V. For every voltage level, a dwell time of 5 s is required. The maximum voltage level for the immunity achieved in this test case shall be proved with a dwell time of 1 minute.

As a test result the respective peak voltage values of each standard pulse for the coupled pin and the evaluated pin function for functional status class A shall be documented in the test report.

Mode	Coupling				Failure validation on pin	
	Port	Pin	Test signal	Bus filter)₃	RX	INH
Normal	IMP1	LIN	TX 1	-	X	X
			TX 1	C = 68 pF	X	X
	IMP2	V_{BAT}	TX 1	-	X	X
	IMP3 $)_1$	Wake-up $)_1$	TX 1	-	X	X
Sleep	IMP1	LIN	-	-	X $)_2$	X $)_2$
			-	C = 68 pF	X $)_2$	X $)_2$
	IMP2	V_{BAT}	-	-	X $)_2$	X $)_2$
	IMP3 $)_1$	Wake-up $)_1$	-	-	X $)_2$	X $)_2$

$)_1$ if available
$)_2$ validation on pin RX or INH depends on the transceiver type
$)_3$ used at each transceiver

Table 7 Required transient tests for function tests

Damage test related to functional status class C:

The damage tests shall be carried out according to the scheme given in table 8. Test duration of 10 minute for each standard pulse is required.

Mode	Coupling				Failure validation
	Port	Pin	Test signal	Bus filter $)_2$	
Normal	IMP1	LIN	TX 1	-	after each single test
				C = 68 pF	
	IMP2	V_{BAT}		-	
	IMP3 $)_1$	Wake-up $)_1$		-	

$)_1$ if available
$)_2$ used at each transceiver

Table 8 Required transient tests for damage

4.2 Immunity against RF disturbances

To prove transceiver immunity against RF disturbances (defined in IEC 62132-1 [1]) tests using the test set-up given in section 3.2 with the following parameters shall be carried out:

	Parameters	
Frequency [MHz]	Range	Step
	1 to 10	0.25
	10 to 100	1
	100 to 200	2
	200 to 400	4
	400 to 1000	10
Presentation of immunity	Immunity threshold curve with forward power as the parameter	
Minimum test power	10 dBm	
Maximum test power	34 dBm for tests without bus filter at LIN 36 dBm for tests with bus filter at LIN, V_{Bat} and Wake-up	
Power step size	0.5 dB	
Power control procedure	Searching for malfunction while power is increased. A combined control procedure to reduce the measurement time can be used. Example: Procedure for each frequency: 1. Start with maximum forward power or with the power of immunity for the last frequency 2. Test with half power in each case of malfunction 3. increase the power by power step size to malfunction	
Dwell time	1 s	
Modulation	CW, AM 80 %, 1 kHz)$_1$	

)$_1$ use peak conversation for the forward power ($\hat{P}_{AM} = \hat{P}_{CW}$) according to IEC 62132-1

Table 9 Parameters for DPI tests

Functional test related to functional status class A:

The functional tests shall be carried out according to the scheme given in table 10.

Mode	Coupling				Failure validation on PIN	
	Port	Pin	Test signal	Bus filter)$_3$	RX	INH
Normal	HF1	LIN	TX 1	-	X	X
				C = 68 pF	X	X
	HF2	V_{BAT}	TX 1	-	X	X
	HF3)$_1$	Wake-up)$_1$	TX 1	-	X	X
Sleep	HF1	LIN	-	-	X)$_2$	X)$_2$
				C = 68 pF	X)$_2$	X)$_2$
	HF2	V_{BAT}	-	-	X)$_2$	X)$_2$
	HF3)$_1$	Wake-up)$_1$	-	-	X)$_2$	X)$_2$

)$_1$ if available
)$_2$ validation on pin RX or INH depends on the transceiver type
)$_3$ used at each transceiver

Table 10 Required DPI measurements for function test

For each test an immunity threshold curve with the forward power as parameter has to be carried out and presented in a diagram in the test report.

To give more information about the failure mechanisms in case of a disturbed communication on the LIN bus additional investigations can be done:

Measurement and documentation of the signal on pin RX of a transceiver with coupling on the bus line and normal mode of the transceiver. This have to be done under influence of at least 4 single frequencies and 3 defined power levels. The selection of the single frequencies depends on the immunity threshold curves. Default frequency values are 1 MHz, 10 MHz, 30 MHz and 100 MHz. The recommended power levels are 34 dBm, 30 dBm and the power level at the immunity threshold curve for the corresponding frequency.

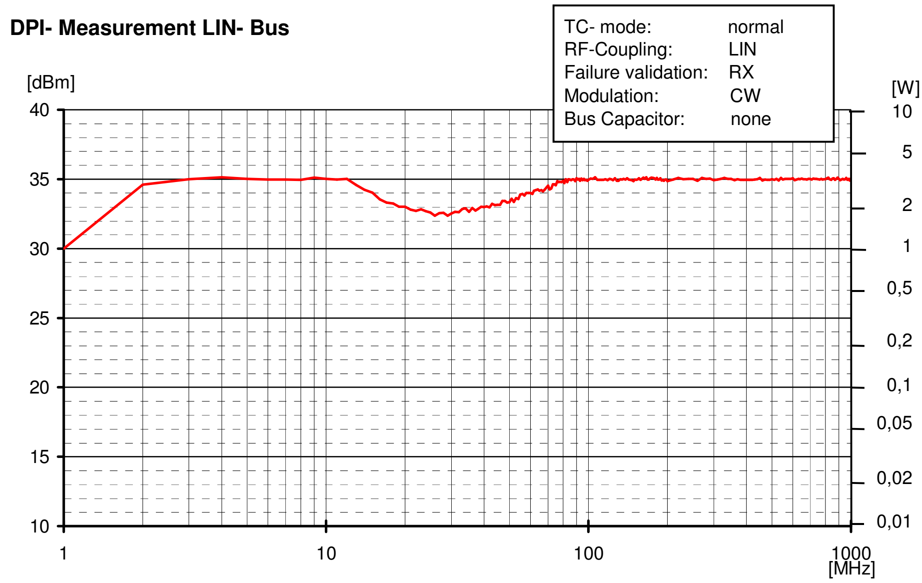


Figure 13 Example for presentation of DPI test results

<u>Damage test to functional status class C:</u>

The damage tests shall be carried out according to the scheme given in table 11. The test power values have to be agreed between the semiconductor manufacturer and the customer. As default values for the maximum test power the given values in table 9 can be used.

Mode	Coupling				Failure validation
	Port	Pin	Test signal	Bus filter)$_2$	
Normal	IMP1	LIN	TX 1	C = 68 pF	after each single test
	IMP2	V_{BAT}	TX 1	-	
	IMP3)$_1$	Wake-up)$_1$	TX 1	-	

)$_1$ if available
)$_2$ used at each transceiver

Table 11 Required DPI tests for damage

4.3 Immunity against ESD

To prove transceiver immunity against ESD tests using the test set-up given in section 3.3 with the following parameters shall be carried out:

	Parameters
Type of discharge:	contact
Discharge circuit:	R = 330 Ω, C = 150 pF (IEC 61000-4-2)
Discharge voltage levels:	1 kV to V_{ESD_damage} (max. 30 kV)
Discharge voltage steps:	up to V_{ESD} = 15 kV: 1 kV above 15 kV: V_{ESD} = 20, 25, 30 kV
Test procedure:	1. 3 Discharges with positive polarity on discharge pad (EP) V_{Bat} with 5 s delay between the discharges 2. connect the discharge pad via a 1 MΩ resistor to the ground reference plane to get zero potential on the pin 3. failure test 4. Proceed with points 1 to 3 with discharge pad Wake-up 5. Proceed with points 1 to 3 with discharge pad LIN 6. Proceed with points 1 to 5 with negative polarity 7. the next higher ESD test voltage ...

Table 12 Parameters for ESD tests

Damage test to functional status class C:

The damage tests shall be carried out at an unpowered transceiver according to the scheme given in table 13. As a minimum 3 transceivers have to be tested for the set-up without bus filter and 3 transceivers for set-up with bus filter.

Mode	Coupling			Failure validation
	Point	Pin	Bus filter	
Normal	EP1	LIN	-	after each single test
			C = 220 pF	
	EP2	V_{BAT}	-	
	EP3)$_1$	Wake-up)$_1$	-	

)$_1$ if available

Table 13 Required ESD damage tests

4.4 Emission

For characterization of the emission levels (defined in IEC 61967-1 [1]) on the LIN pin measurements using the test set-up given in section 3.4 shall be performed and documented in a diagram in the test report. In case of adjustable slope for the LIN signal, the maximum slew rate for LIN protocol 2.1 must be used for this test.

The settings of the spectrum analyzer or measure receivers are given in table 14.

Measuring equipment	Spectrum analyzer	Measuring receiver
Detector	Peak	
Frequency range	0.15 to 1000 MHz	
Resolution bandwidth (RBW) 150 kHz to 30 MHz: 30 MHz to 500 MHz:	 10 kHz 100 kHz	 9 kHz 120 kHz
Video bandwidth (VBW)	equal to RBW	-
Numbers of passes	10 (max hold)	
Measurement time per step	-	≥ 1 ms
Frequency sweep time	≥ 20 s	-
Frequency step width 150 kHz to 30 MHz: 30 MHz to 1000 MHz:	-	≤ 9 kHz ≤ 120 kHz

Table 14 Settings of the measurement device for measurement of emission in the frequency domain

Mode	Decoupling			
	Port	Pin	Test signal	Bus filter$)_1$
Normal	EMI1	LIN	TX 1	-
				C = 68 pF

$)_1$ used at each transceiver

Table 15 Required Emission measurements

5 References

[1] IEC 61967-1: 2002, Integrated circuits, Measurement of electromagnetic emissions, 150 kHz to 1 GHz – Part 1: General and definitions.

[2] IEC 61967-4: 2002, Integrated circuits, Measurement of electromagnetic emissions, 150 kHz to 1 GHz – Part 4: Measurement of conducted emissions – 1 Ω/150 Ω direct coupling method

[3] IEC 62132-1: 2006, Integrated circuits, Measurement of electromagnetic immunity, 150 kHz to 1 GHz – Part 1: General and definitions.

[4] IEC 62132-4 2006, Integrated circuits, Measurement of electromagnetic immunity, 150 kHz to 1 GHz – Part 4: Direct RF power injection method.

[5] IEC 61000-4-2: 2001, Electromagnetic compatibility, Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test.

[6] ISO 7637-2: 2002, Road vehicles – Electrical disturbances from conduction and coupling - Part 2: Electrical transient conduction along supply lines only

[7] ISO 7637-3: 2007, Road vehicles — Electrical disturbance from conduction and coupling - Part 3: Electrical transient transmission by capacitive and inductive coupling via lines other than supply lines