ZMD30010

LIN-Transceiver

Features

- ❒ data rate up to 20 kBaud
- ❒ operation voltage from 6.5 to 18 V DC
- ❒ low standby current consumption
- ❒ very low electromagnetic emission
- ❒ high electromagnetic immunity
- ❒ low power consumption in recessive state
- ❒ local and remote wake-up function
- ❒ slew rate control enables low radio frequency interferences
- ❒ ±4kV ESD protection on LIN-, WAKE-, VSUP- and GND-pin
- ❒ protection against thermal overload, short circuit and load dump

Description

The LIN Transceiver ZMD30010 is an integrated circuit realised in CMOS technology and packed into a SOP 8 case.
The device works as an interface between a protocol controller and the physical bus in a Local Interconnect Network.
The functionality corresponds to the "LIN Specification Rev. 1.2".
The ZMD30010 is especially suitable to drive the bus line in automotive and industrial applications.
Therefore it is designed to withstand the particular conditions of an automotive environment.
The device has an internal voltage regulator to supply itself.
It is also equipped with a sleep mode and a wake-up-function in order to reduce current consumption.

As an additional capability the ZMD30010 enables to control an external voltage regulator which supplies other devices.

Ordering Information

Device	Operation Temperature Range	Package
ZMD30010AF	-40°C . . . 125°C	SOP8

Pin Configuration and Description

PIN	Symbol	Description
1	RXD	receive data output
2	EN	sleep control input normal mode=high sleep mode=low
3	WAKE	local wake-up input
4	TXD	transmit data input
5	GND	ground
6	LIN	single wire bus input/output
7	VSUP	battery supply input
8	INH	battery related inhibit output to control an external voltage regulator

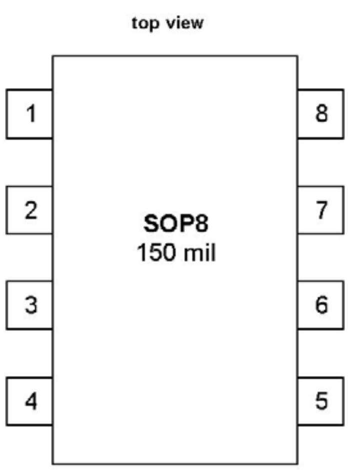


Figure 1: Block Diagram

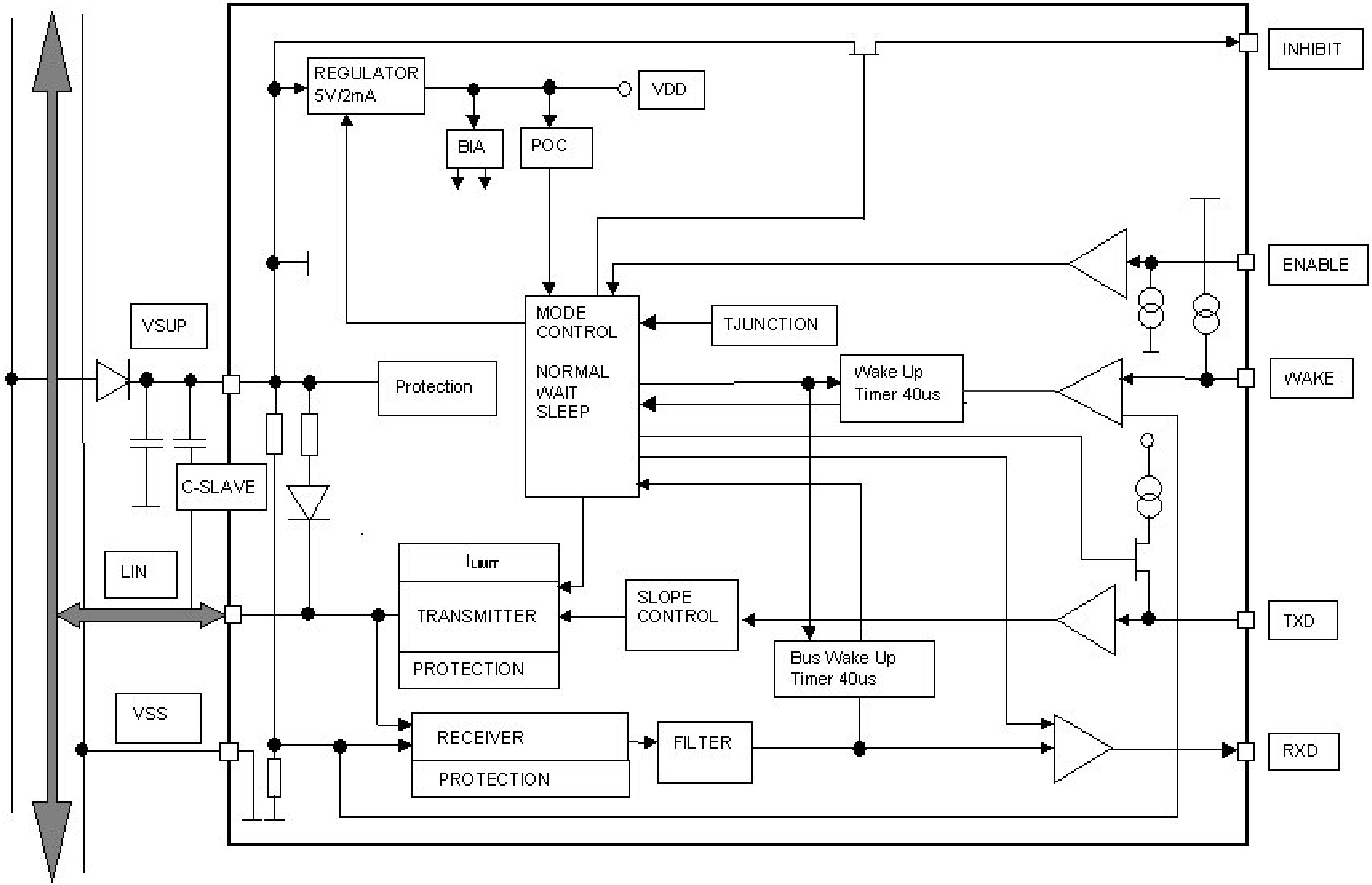
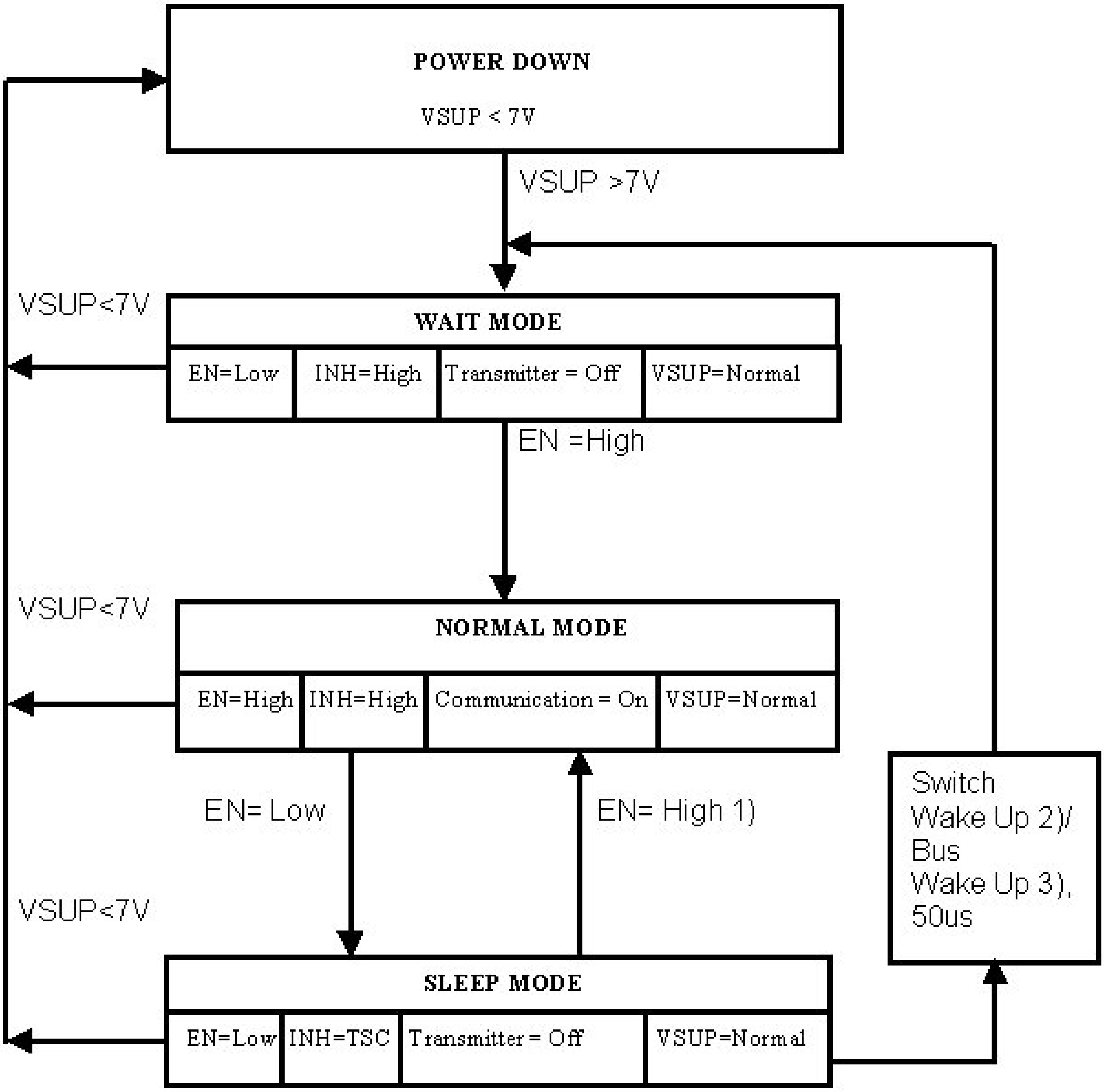


Figure 2: State Machine

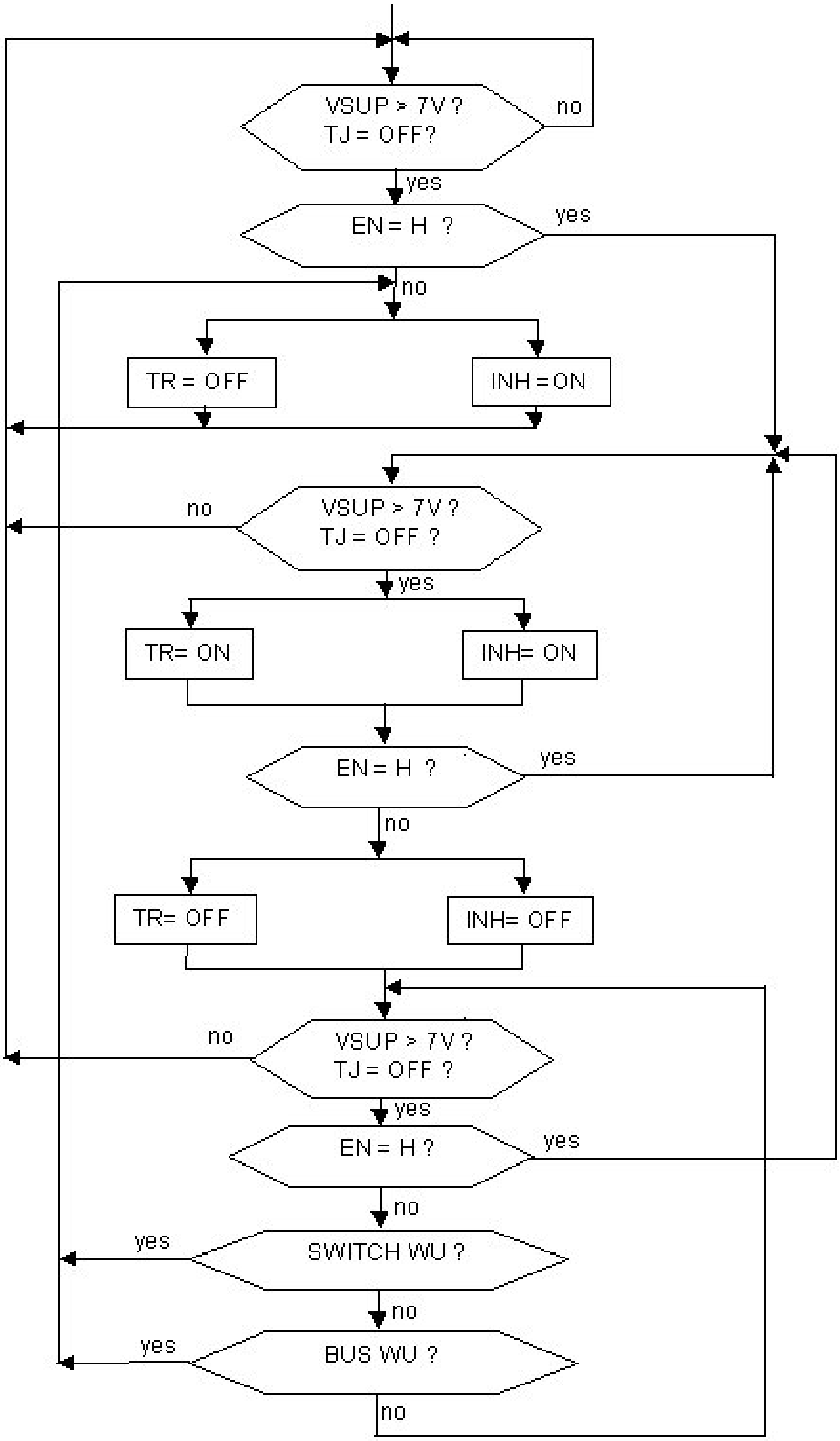


Wake Up Events:

1) Internal Node Activity
2) Wake Switch
3) LIN-Bus Wake Up

TSC: three state current

Figure 3: Flow Diagram State Machine



TR = transmitter, EN = enable, INH = inhibition, WU = wake-up, TJ=Tjunction

Functional Description

Supply Voltage VSUP

The VSUP-pin has to be protected by an external diode against pole interchange of the battery supply. The protection against galvanic and capacitive coupled transients is realised by a special internal circuitry combined with the external capacitances C_{SUP}, C_{LIN} and C_{SLAVE}.
The nominal supply voltage is between 6.5 and 18 V DC. A voltage control prevents an incorrect bus transfer below the operating voltage range.
The quiescent current in the sleep-mode amounts to appr. 25 µA. In the normal-mode the quiescent current amounts to max. 2 mA in the state of dominant LIN-bus.

VSS-PIN

The VSS-pin represents the ground level. Level suspensions ≤ 2.5 V don't influence the data transfer. A ground loss in the recessive state does not lead to a significant current at the LIN-pin.

LIN-Bus-Pin

The modules receiver and transmitter realise the bidirectional LIN-bus-connection.

Receiver:

The input voltage of the receiver depends on the supply voltage ratiometricly. The threshold amounts to 0.4 respective 0.6 VSUP with a hysteresis of < 10 % VSUP. The receiver is active in the sleep mode too. The filter in the input signal path suppresses spikes with a duration of <± 4 µs.

Transmitter:

The transmitter consists of a low-side-driver supplying 40 mA at a output-voltage of 1.2 V.
It transmits a low level if there is a low level on the TXD-pin. An internal pull-up resistor of 30 kΩ pushes the bus node to the high level in the locked transmitter state.
A diode which is switched in-line to the resistor prevents a reflow current from the bus into the battery supply line in the case of a local supply loss or a ground level suspension.

The transmitter is only active in the normal-mode. In the sleep-mode and in the wait-mode the transmitter is tristated.
In the case of short circuits to battery supply or to ground the drivers current limitation begins to work at 90 mA typically. The driver is also protected against thermal overloads.
In the range from -18 V to 30 V the current VSUP-LIN is determined only by the pull-up-resistor. The in-line-switched diode prevents a current from the LIN-pin to the VSUP-pin.

A VSUP loss in the recessive driver state does not lead to a significant current at the LIN-pin.
A slope-control adjusts both edges (falling edge from the recessive to the dominant driver state and rising edge from the dominant to the recessive driver state) to 2V/µs typically. As a result the electromagnetic emission is minimal.
The capacitive LIN-bus-load has to be restricted to a total <10 nF at a total resistance <1 kΩ. This is done to ensure the symmetry of both edges.

RXD-Pin

This push-pull-output connects the transceiver output to the external protocol controller. A LIN-low-level is transmitted as a CMOS-low-level. A recessive LIN-state is transmitted as a CMOS-high-level. The driver is tristated in the sleep-mode.

TXD-Pin

This CMOS-input connects the external protocol controller to the transceiver. A TXD-low-level is transmitted as a LIN-low-level too. The LIN-driver is tristated if TXD is high. If so than the bus is set to recessive high using the pull-up-resistor. The TXD-input has an internal pull-up-resistor to VDD which is switched off in the sleep-mode.

Error Protection:

If the protocol unit does not transmit a defined level than the internal pull-up-resistor sets TXD=high. As a result the transmitter is tristated.

EN-pin

This input determines the operation mode of the device. EN=high sets the device to the normal-mode, EN=low sets the device to the sleep-mode reducing the current consumption drastically.
In the sleep-mode the receiver stands in the active state and the driver is tristated. The current consumption from the battery amounts to 20 µA typically.
If the signal is floating than the EN-pin is held on low by an internal pull-down-resistor. The pull-down-current is restricted to 25 µA typically. The return into the normal mode is caused by setting EN=high or by other wake-up-events.
After a power-down the transceiver stands in the wait-mode. If EN is switched to high than the transceiver switches into the normal-mode.

INH-Pin

The INH-pin ("inhibit-pin") is a high-voltage-output which is controlled by the EN-input. In the normal-mode and in the wait-mode the inhibit-high-side-driver sets INH=V_{SUP} if EN=high. It also switches on an external regulator or sets external switches active for an interrupt request. The inhibit-driver-capability is limited to 280 µA typically.

If EN is set to low than the transceiver switches to the sleep-mode and separates external modules from V_{SUP} by tristating the INH-pin. A WAKE-UP-event or EN=high sets INH=high.
If applications need an external supply in the sleep-mode too than INH can be activated by switching EN=high directly. In these cases the INH-output can be used to control an external transistor, e.g. for the generation of an interrupt request.

WAKE-Pin

The wake-pin is a high-voltage-input. A low-signal from the system (trigger) wakes up the transceiver from the sleep-mode (local wake-up). An input filter prevents unintended wake-up in the case of transients. An internal pull-up-resistor to VSUP prevents floating of the pin in the unconnected state. If the application does not require a local wake-up than the wake-pin has to be connected with VSUP. The wake-pin needs an external resistor to limit the inverse current in the case of a local ground loss during wake-up-source=low.

Wake-Up-Events

There are three methods to wake up the transceiver from sleep-mode:

(1) Wake-up by WAKE-pin active

An internal timer supervises the level at the WAKE-pin. If the WAKE-level falls from WAKE-high to WAKE-low and stays there for minimal 40 µs than the timer activates the INH-output. The transceiver switches into the wait-mode.
When the external regulator has reached its output level and the system is ready than the protocol-controller switches EN=high. The transceiver changes into to the normal-mode and gets ready for bus transfers.

(2) Wake-up by bus-message:

The reception of a LIN-low-level (minimal 40 µs) in the sleep-mode triggers the following wake-up-sequence:
After about 50 µs the transceiver activates the system regulator by setting INH=high and goes to the wait-mode. After a system reaction time (until regulator and application active) the protocol-controller sets EN=high. The device switches to the normal-mode and gets ready for bus transfers.

(3) Internal wake-up-activity:

There are systems with an external regulator which is also active in the LIN-transceivers sleep-mode. If the application of such a system gets active than the protocol controller sets EN=high. The transceiver switches to normal-mode at once and is ready for the transfer of a wake-up-frame from the protocol controller to the LIN-bus.
As a result the INH-pin can be used for other purposes, e.g. for an interrupt request.

Internal Regulator

The transceiver has an internal regulator generating an internal voltage V_{DD}=5V from the battery supply V_{SUP}. This works in all modi.
In the sleep-mode the regulator changes into an economic-mode. This mode guaranties the supply of the receiver and the sequence control.

Battery Voltage Control

The battery voltage control is realised indirectly by a power-on-clear-circuit supervising the internal supply V_{DD}. This circuit gives a signal to the sequence control if the operation voltage falls below 4.5V. In this case a contingent bus transfer can be prevented and the transceiver changes into the wait-mode.

Sequence Control

The internal sequence control manages the operation modi and their transient states until the transceiver is ready for communication (see figure 3).

normal-mode:	INH=high, EN=high, bus transfer permitted
sleep-mode:	INH tristated, EN=low, only bus reception possible
wait-mode:	INH=high, EN=low, bus transfer impossible, end of the wait-mode by setting EN=high by the protocol controller, change into the wait-mode from another mode if V_{DD} falls below 4.5 V or if the junction temperature rises over 150°C

Electromagnetic Compatibility

Emission:

The built-in slope-control adjusts the slew rates to 2 V/µs for the rising and the falling edges. As a result the electromagnetic emission is at a minimum.

Sensitivity:

The pins LIN, WAKE, VSUP and GND are equipped with protective circuits resistant to electromagnetic imission. The ESD-protection is guaranteed for ±4kV (Human Body Model).

The protection against transients (test impulses 1...5 according to ISO 7637/1) is improved by the external slave- or master-capacitors between VSUP and LIN.

Immunity against short circuits

The LIN-interface is short-circuit-proof against V_{SUP} and ground.

Electrical Parameters

Maximum Ratings

In accordance with the Absolute Maximum Rating System (IEC 60134)

Electrical Ratings

Parameter	Symbol	Min	Max	Units	Remarks
Continuous VSUP Transients	V_{SUP} V_{SUP}	-0.3	30 40	V V	 pulse 1...3 ISO 7637/1 (test circuit figure 8)
Input Voltage LIN DC Transients	 V_{LIN} V_{LIN}	 -18 -150	 30 +100	 V V	 pulse 1...3 ISO 7637/1 (test circuit figure 8)
Input Voltages TxD, RXD, EN	V_{IN}	-0.3	6.5	V	
Input Voltages WAKE DC Transients	 V_{INWAKE} V_{INWAKE}	 -18	 30 40	 V V	 pulse 1...3 ISO 7637/1 (test circuit figure 8)
ESD at the pins TXD, RXD, EN, INH	V_{ESD}	-2	+2	KV	Human Body Model (100pF via 1.5kΩ)
ESD at the pins LIN, VSUP, GND, WAKE	V_{HBM}	-4	4	KV	Human Body Model 1.5KOhm, 100pF
ESD at all pins	V_{MM}	-200	200	V	Machine Model 220pF

Thermal Ratings

Parameter	Symbol	Min	Max	Units	Remarks
Junction Temperature	T_J	-40	150	ºC	
Storage Temperature	T_{STG}	-55	150	ºC	
Ambient Operation Temperature	T_A	-40	125	ºC	
Thermal Resistance Junction to Ambient	R_{THA}		150	ºC/W	SOP8 (150) in free air
Thermal Shutdown [1)]	T_{SHUT}	150	170	ºC	
Thermal Shutdown [1)] Hysteresis	T_{HYST}		20	ºC	

[1)] not tested, guaranteed by design

Electrical Characteristics

V_{SUP} = 6.5...18 V, T_J = -40 ...+150 °C, typical values specified for V_{SUP} = 12 V,
$R_{VSUP-LIN}$ = 500 Ω (if not otherwise defined)

Battery Supply VSUP

Parameter	Symbol	Min	typ.	Max	Units	Conditions
DC voltage range	V_{SUP}	6.5	12	18	V	
supply current in the normal mode, dominant state	I_{SDOM}	0.7	1.3	2.0	mA	EN = 5V TXD = 0V R_{RXD} = ∞
supply current in the normal mode, recessive state	I_{SREC}	0.4	0.9	1.3	mA	EN = 5 V TXD = 5 V R_{RXD} = ∞
supply current in the sleep mode	I_{SLEEP}	10	25	50	µA	EN = 0V TXD = 5V V_{LIN} > V_{SUP} - 0.5V

Receive Data Output RXD

Parameter	Symbol	Min	typ.	Max	Units	Conditions
Low Level Voltage Output	V_{RXDOL}	0.1	0.15	0.3	V	EN = 5V TXD = 0V I_{OUT} = 2mA
High Level Voltage Output	V_{RXDOH}	4.3	4.6	5.0	V	EN = 5V TXD = 5V I_{OUT} = -2mA

Transmit Data Input TXD

Parameter	Symbol	Min	Typ	Max	Units	Conditions
Low Level Voltage Input	V_{TXDINL}	1.4	1.5	1.8	V	V_{DD} = 5V external
High Level Voltage Input	V_{INH}	2.5	`	5.5	V	V_{DD} = 5V external
Pull Up Current Source TXD	I_{PU}	-20	-28	-35	µA	EN = 5V TXD = 0V

Mode Control Input Enable EN

Parameter	**Symbol**	**Min**	**Typ**	**Max**	**Units**	**Conditions**
Low Level Voltage Input	V_{ENINL}	1.4	1.5	1.8	V	external VDD=5V, TXD=5V
Input Current Low	V_{ENINH}	2.5		5.5	V	external VDD=5V, TXD=5V
Pull Down current ENABLE	I_{PDEN}	10	20	35	µA	EN = 4V

Bus Input/Output LIN

Parameter	**Symbol**	**Min**	**Typ**	**Max**	**Units**	**Remarks**
Input Low Level Voltage Receiver	$\mathbf{V_{RECL}}$	0		0.4 V_{SUP}		EN = 5V TXD = 5V
Input High Level Voltage Receiver	$\mathbf{V_{RECH}}$	0.6 V_{SUP}		V_{SUP}		EN = 5V TXD = 5V
Input Hysteresis Receiver	$\mathbf{V_{RECHYS}}$	0.05 V_{SUP}		0.1 V_{SUP}	V	EN = 5V TXD = 5V
Output Low Level Voltage Transmitter	$\mathbf{V_{LINL}}$	0.6	1.1	1.8	V	EN = 5V, TXD = 0V R_{BUS}= 500Ω
Output High Level Transmitter	$\mathbf{V_{LINH}}$	0.8V_{SUP}		V_{SUP}	V	TXD = 5V I_{LIN}=0mA
Pull Up Current VSUP to LIN	$\mathbf{I_{LINPU}}$	-200	-450	-800	µA	V_{SUP}=12V V_{LIN} = 0V, TxD=5V
Output Current Limitation LIN	$\mathbf{I_{LIM}}$	70	90	120	mA	EN=5V TxD =0V V_{SUP}=V_{LIN}=12V
Input Current LIN Recessiv	$\mathbf{I_{LINLEAK1}}$	2	8	15	µA	V_{SUP}=V_{LIN} TXD=5V
Input Current LIN Recessiv, Bus no GND	$\mathbf{I_{LINLEAK2}}$	-1.3	-1.7	-2.5	mA	V_{LIN} = -18V TXD =5V

Local Wake-up-input WAKE

Parameter	Symbol	Min	Typ	Max	Units	Remarks
Wake Up Threshold High to Low Transition	V_{WUTHL}			0.4 V_{SUP}	V	EN=0V
WAKE Pull Up Current	I_{WUPU}	-2	-8	-15	µA	V_{WAKE}=0V
Wake Up Leakage Current	I_{WULeak}	1	4	8	µA	EN=0V V_{WAKE}=18V V_{SUP}=18V

Inhibit Output INH

Parameter	Symbol	Min	Typ	Max	Units	Remarks
INHIBIT Output High Level	V_{INHH}	V_{SUP}–0.5	V_{SUP}–0.3	V_{SUP}	V	EN=5V I_{INH}=250µA
INHIBIT Leakage Current	$I_{INHLEAK}$			-1	µA	EN=0V, TXD=5V WAKE=VSUP =12V V_{INH}=0V

TIMING CHARACTERICTICS

VSUP = 6.5...18V, T_J=-40...150°C, typical values are specifed for V_{SUP}=12V, otherwise unless defined. For timing characteristics see the test schematic and timing diagrams (fig. 4...6).

LIN-BUS-Interface

Parameter	Symbol	Min.	Typ.	Max.	Units	Remarks
LIN Falling Edge Slew Rate	T_{FALL}		2		V/µs	C_{BUS}=10nF R_{BUS}=500Ω
LIN Rising Edge Slew Rate	T_{RISE}		2		V/µs	C_{BUS}=10nF R_{BUS}=500Ω
LIN Rise/Fall Symmetry	$T_{LINSYM1}$	-2		+2	µs	T_{rise}-T_{fall} C_{BUS}=100pF R_{BUS}=1KΩ
Propagation Delay TXD=Low to LIN=Low	$T_{TXDLINL}$		3		µs	C_{BUS}=100pF R_{BUS}=1KΩ
Propagation Delay TXD=High to LIN=High	$T_{TXDLINH}$		3		µs	C_{BUS}=100pF R_{BUS}=1KΩ
Propagation Delay LIN=Low to RXD=Low	$T_{LINRXDL}$		5		µs	C_{BUS}=100pF R_{BUS}=1KΩ C_{RXD}=20pF R_{RXD2}=2.25KΩ
Propagation Delay LIN=High to RXD=High	$T_{LINRXDH}$		5		µs	C_{BUS}=100pF R_{BUS}=1KΩ C_{RXD}=20pF R_{RXD1}=2.25KΩ
Propagation Delay TXD=Low to RXD =Low	$T_{TXDRXDL}$		8		µs	C_{BUS}=10nF R_{BUS}=500Ω C_{RXD}=20pF R_{RXD1}=2.25KΩ
Propagation Delay TXD=High to RXD =High	$T_{TXDRXDH}$		10		µs	C_{BUS}=10nF R_{BUS}=500Ω C_{RXD}=20pF R_{RXD2}=2.25KΩ
Bus Wake Up to INH=High Propagation Delay	$T_{LINWAKE}$		45		µs	EN=0V
WAKE Propagation Delay WAKE to INH=High	T_{WAKE}		45		µs	EN=0V

Figure 4: Timing description

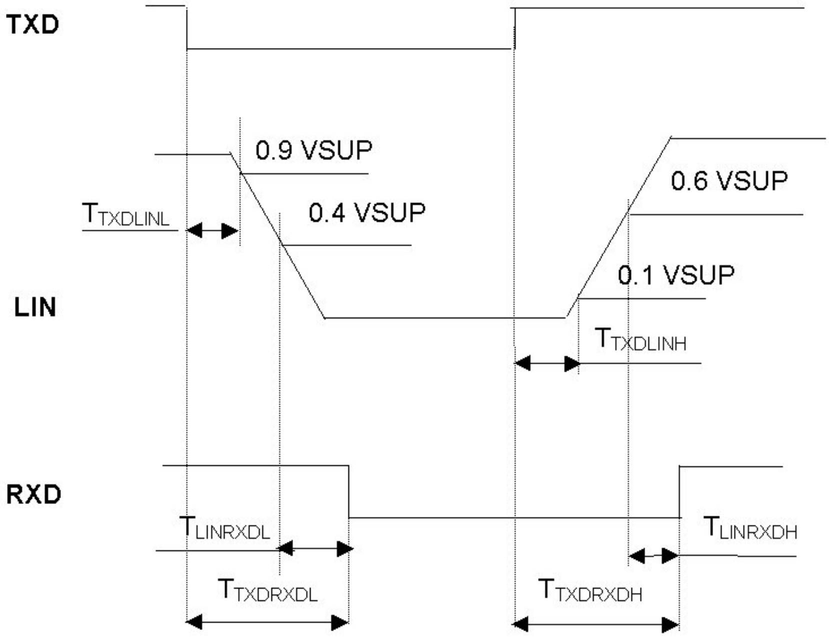


Figure 5: Rise/fall-time description

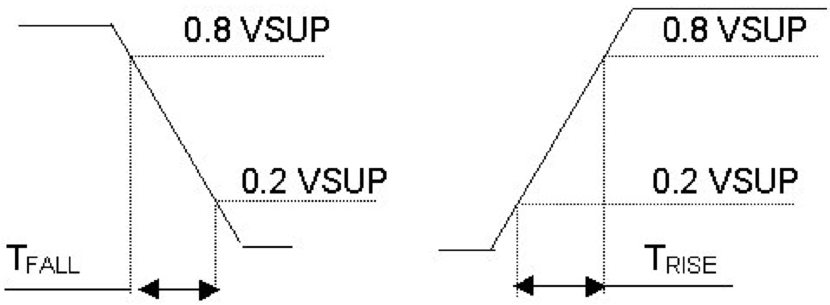


Figure 6: Bus Wake Up and WAKE timing description

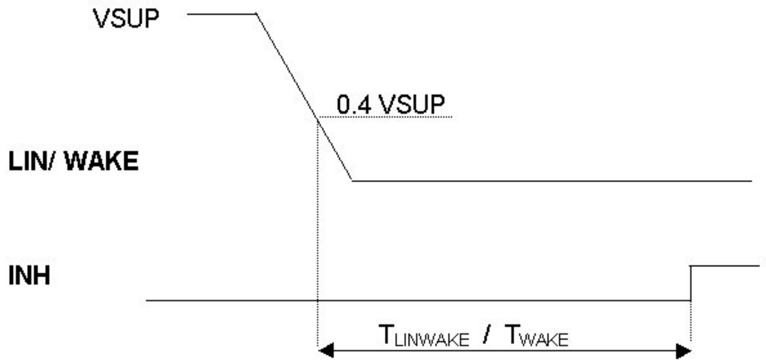


Figure 7: Test circuit for timing characteristics

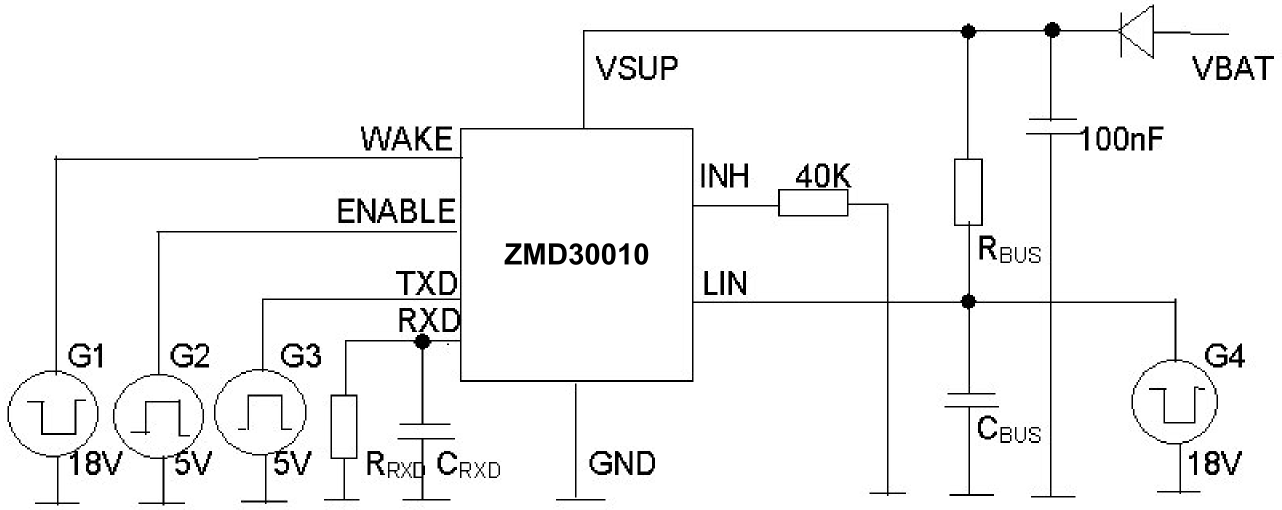
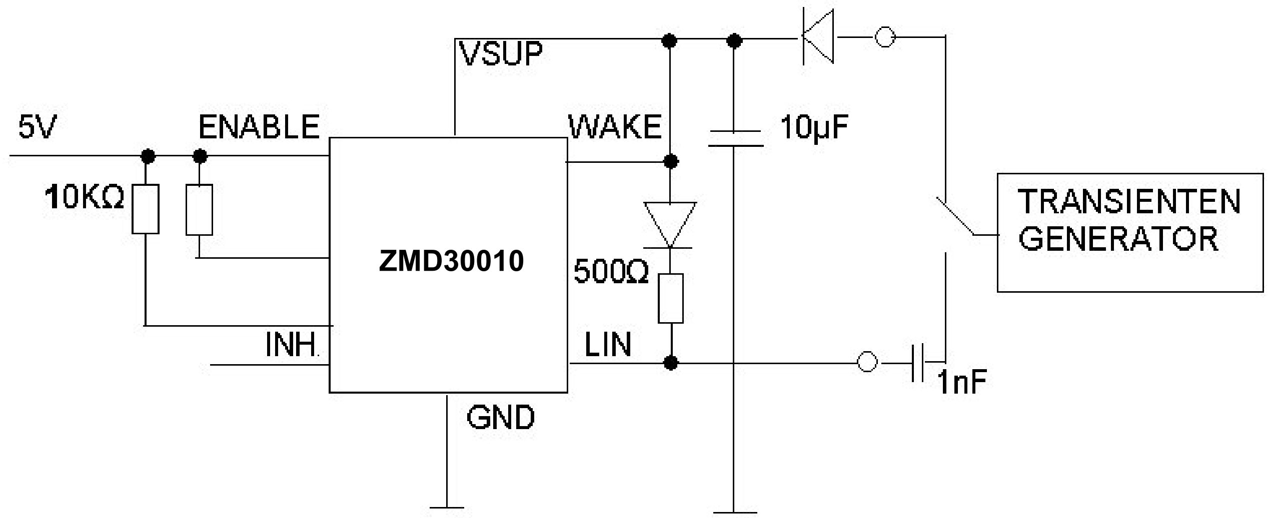


Figure 8: Test circuit for automotive transients



The waveforms of the applied transients on pin LIN , WAKE and VSUP are according to ISO 7637 part 1, test pulses 1, 2, 3a, 3b .

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