ZMD30011

LIN Transceiver

Datasheet PRELIMINARY

Features

- Compliant with LIN Specifications 1.3 and 2.0
- Sleep mode and wake-up-function to reduce power consumption
- Wake-up via WAKE-pin, EN-pin, or bus wake-up-message
- Battery related output to control an external voltage regulator
- Interfaces MCU with 3.3V or 5V
- LIN bus speed up to 20kBaud
- Supply voltage 6.5V to 18V
- Operating temperature –40 to +125°C
- 8kV ESD protection for pins LIN, INH, WAKE, VSUP
- Thermal overload protection
- SOP8 package

Benefits

- Very low standby current in sleep mode (typical 14µA)
- Excellent electromagnetic compatibility
- Bus I/O slew rate control ensures low RF-emission

Description

ZMD30011 is a CMOS integrated circuit for application in a Local Interconnect Network (LIN).

The device is used as a part of a master or slave node and works as an interface between the physical bus and the protocol controller.
It realizes data switching (between bus and TXD/RXD) and level shifting (between battery voltage and controller voltage).

ZMD30011 is equipped with sleep mode and wake-up-function to reduce power consumption. It has a battery related output to control an external voltage regulator which supplies other devices.

The IC is optimised for automotive environments by it’s very low standby current, excellent electromagnetic compatibility, ESD protection and thermal overload protection.

LOCAL INTERCONNECT NETWORK

Application Circuit (Example)

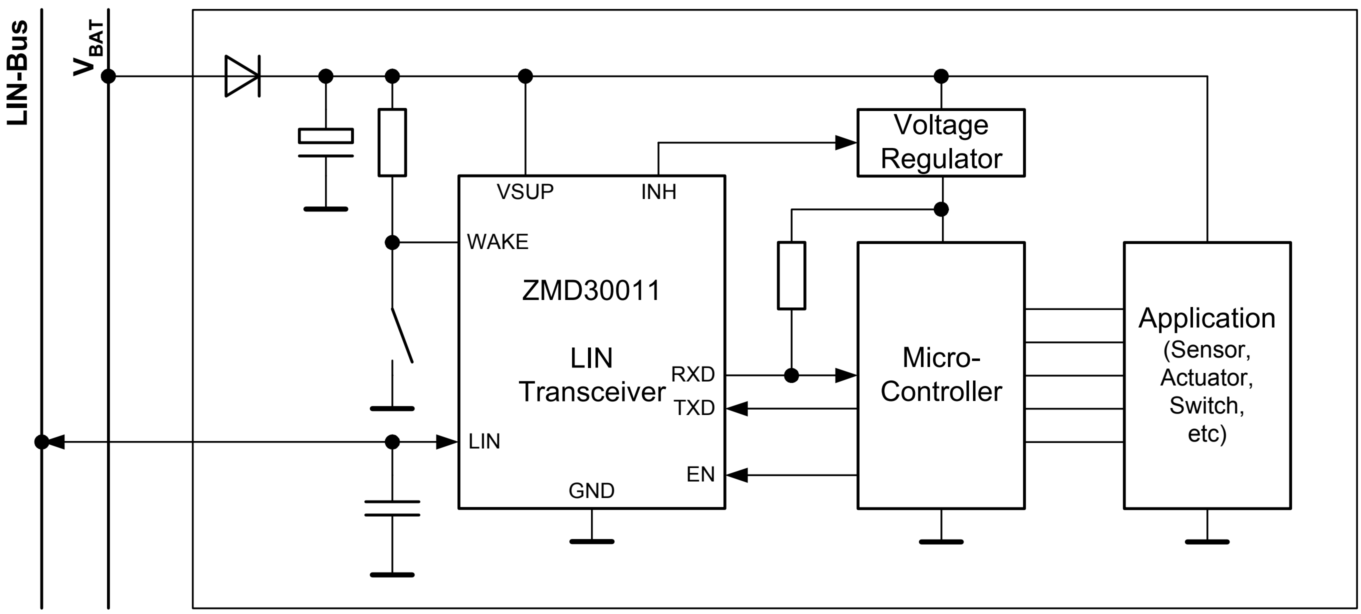


Fig.1: Application Circuit Example

Content

1. Block Schematic

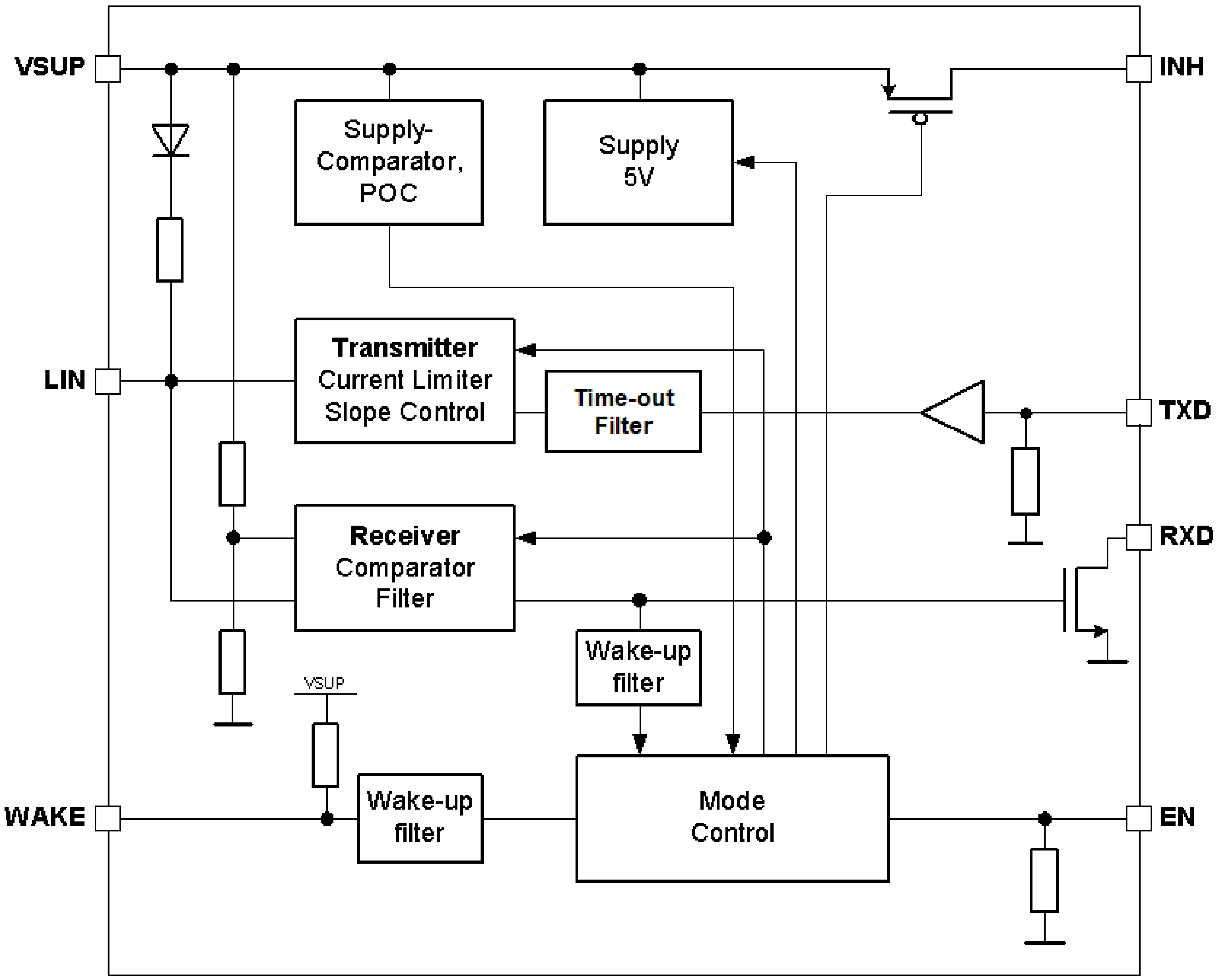


Fig.2: Block Schematic

2. Pin Description

2.1 Pin Configuration

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

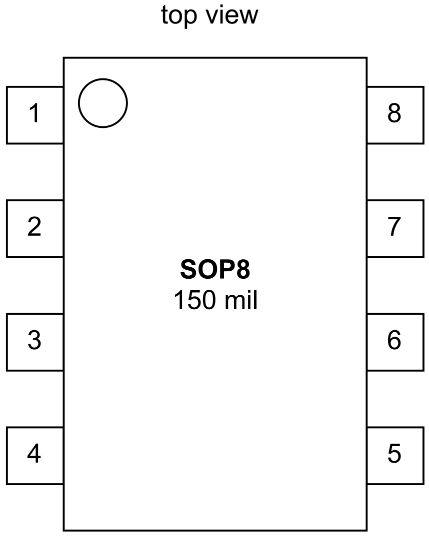


Fig. 3: Pin Configuration

2.2 RXD-Pin

This pin reports the state of the LIN bus voltage to the protocol controller. A LIN-low-level (dominant state) is transmitted as a CMOS-low-level. A recessive LIN-state (LIN-high-level) is transmitted as a CMOS-high-level. The RXD output structure is an open-drain output stage. This allows the ZMD30011 to be used with 3.3 V or 5 V I/O protocol controllers. If the controller's RXD pin does not have an integrated pull-up, an external pull-up resistor to the microcontroller I/O supply voltage is required. The driver is tristated in the sleep-mode.

2.3 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 significantly reducing the current consumption.
If the signal is floating then the EN-pin is held on low by an internal pull-down-resistor. The pull-down-current is restricted to 25 µA typically.

2.4 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 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.

2.5 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, hence the bus is set to recessive state using the pull-up-resistor. The TXD-input has an internal pull-up-resistor which is switched off in the sleep-mode.

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

2.6 GND-Pin

The GND-pin represents the ground level. Level suspensions ≤ 2 V do not influence the data transfer. A ground loss in the recessive state does not lead to a significant current at the LIN-pin.

2.7 LIN-Bus-Pin

The circuit blocks receiver and transmitter realize the bi-directional 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 typical 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 20 mA at a typical output-voltage of 1 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 is located in series to the resistor and prevents a reflow current from the bus into the battery supply line in the case of a local supply loss or a ground level shift.

The transmitter is only active in the normal-mode. In the sleep-mode and in the wait-mode the transmitter is tristated. 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 of <=10 nF at a total resistance 0.5 kΩ in order to ensure the symmetry of both edges.
In the case of short circuits to battery supply the drivers current limitation begins to work at 180 mA typical. 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. A VSUP loss in the recessive driver state does not lead to a significant current at the LIN-pin.

2.8 VSUP-Pin

The VSUP-pin has to be protected by an external diode against reverse polarity of the battery supply.
The protection against galvanic and capacitive coupled transients is realized by a special internal circuitry.
The operational supply voltage reaches from 6.5 to 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 typical 14µA. In the normal-mode the quiescent current amounts to max. 2 mA in the state of dominant LIN-bus.

2.9 INH-Pin

The INH-pin ("inhibit-pin") is a high-voltage-output controlled by the EN-input. In the normal-mode and in the wait-mode the inhibit high-side-driver sets INH=V_{SUP} (EN=high).
The INH-pin may be used to switch on an external regulator or to set external switches active for an interrupt request. The inhibit-driver is capable to source 40mA typically.
If EN is set to low then the transceiver switches to the sleep-mode and separates external modules from V_{SUP} by tristating the INH-pin. Hence, a voltage regulator with its inhibit pin connected to INH will be disabled. If the master node pull-up resistor is connected to INH then it will be disabled from the LIN bus.
A WAKE-UP-event or EN=high sets INH=high.

3. Functional Description

3.1 Sequence Control

The internal sequence control manages the operation modi and their transient states (see figure 2).

normal-mode: INH=high, EN=high, bus transfer permitted

sleep-mode: INH tristated, EN=low, only bus reception possible

The receiver stands in the active state and the driver is tristated. Setting EN to high brings the transceiver into the normal-mode. Applying Wake=high at the WAKE pin or a LIN bus wake-up message bring the device into the wait-mode.

wait-mode: INH=high, EN=low, bus transfer impossible,

Switching EN to high switches the transceiver into the normal-mode from another mode.

The transceiver switches to the power-down state from any operation mode if V_{SUP} falls below 6.5 V. As soon as V_{SUP} rises over 6.5V again the transceiver changes from power-down into the wait-mode.
The transceiver changes into the wait-mode too from another mode if the junction temperature rises over 150°C. The change from wait-mode into the normal mode is caused by setting EN to high.

3.2 Wake-Up-Events

There are three methods how 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 40µs than the timer activates the INH-output. The transceiver switches into the wait-mode within maximal 150 µs after the falling edge of the WAKE pin. By doing so spike pulses are filtered out effectively. 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 (dominant state for 250µs to 5ms) in the sleep-mode triggers the following wake-up-sequence:
At the latest 150µs after the falling edge of the LIN signal the transceiver activates the system's voltage 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. An anti-bounce filter suppresses spike pulses from the LIN bus.

(3) Wake-up by EN-pin active:

There are systems with an external power supply which are also active in the LIN-transceiver's sleep-mode. If the application of such a system gets active then 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. In such applications the INH-pin can be used for other purposes, e.g. for an interrupt request.

3.3 Internal Voltage Regulator

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

3.4 Battery Voltage Control

The battery voltage control is realized indirectly by a power-on-clear-circuit supervising the internal supply V_{DD}. This circuit gives a signal to the sequence control if the external supply voltage V_{SUP} falls below 6.5V. In this case a contingent bus transfer can be prevented and the transceiver changes into the wait-mode.

3.5 3.3V and 5V Logic Capability

The ZMD30011 can be used for 3.3V and 5V micro controllers. EN, RXD and TXD are capable to operate with both voltage levels. Therefore an external pull-up resistor is required at the RXD pin.

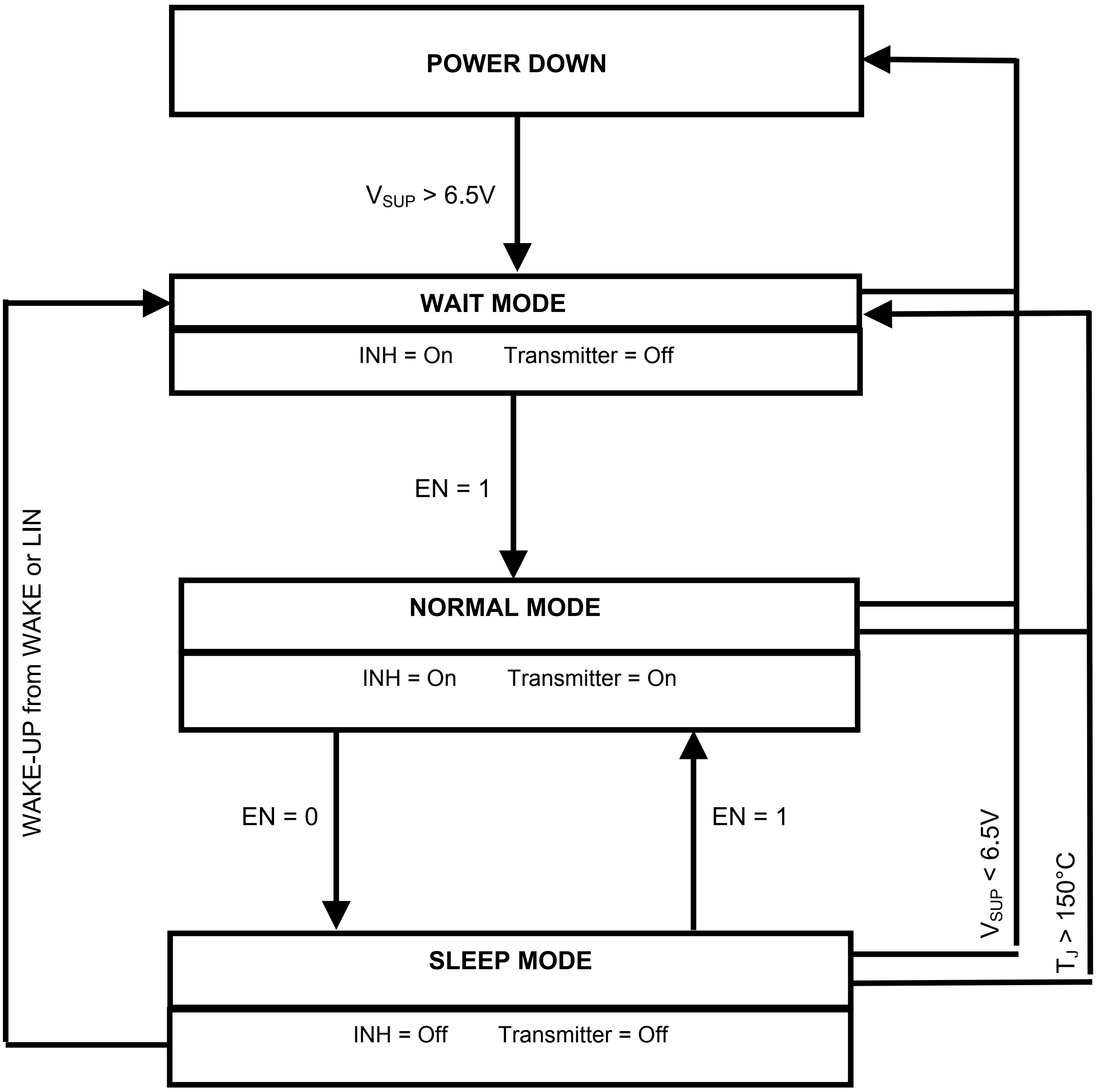


Fig. 4: State Diagram

Wake Up Events:

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

TSC…three state current

4. Electromagnetic Compatibility and Short-circuit Immunity

Electromagnetic 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.

Electromagnetic Sensitivity:

The pins LIN, WAKE, VSUP and INH are equipped with protective circuits resistant to electromagnetic imission.
The ESD-protection at these pins is guaranteed for ± 8 kV (Human Body Model).
The protection against transients (test impulses 1...3 according to ISO 7637/1) is improved by the external slave- or master-capacitors between VSUP and GND and between LIN and GND.

Short Circuit Immunity:

The LIN-interface is short-circuit-proof against VSUP and ground.

5. Fail-Safe-Features

Short-circuit at LIN

The current of the transmitter output stage is limited to I_{LIM} in order to protect the transmitter against short-circuit to V_{BAT} or GND. In case of such a short-circuit the temperature exceeds the shutdown temperature T_{SHUT} due to the power dissipation – the ZMD30011 goes into the wait-mode and the transmitter switches off.

The ZMD30011 has a special circuitry implemented that protects the battery from running out of charge in the case of a short circuit between LIN and GND. In this failure case a normal master termination (1k resistor and diode in series between LIN and VSUP) would cause a constant drawn current (even in sleep mode). The ZMD30011's special circuitry avoids this drawn current.
This feature is only applicable, if the master termination is connected with the INH pin, instead of VSUP.

Loss of Ground or V_{SUP}

A loss of power (pins GND or VSUP) has no impact to the bus line and the protocol handler. Since there are no reverse currents from the bus the LIN transceiver can be disconnected from the power supply without influencing the LIN bus. Pin RXD is set floating if VSUP is disconnected.

Thermal Overload

The output driver at pin LIN is protected against thermal overload conditions. If the junction temperature exceeds the shutdown temperature T_{SHUT}, the thermal protection circuit disables the output driver. The driver is enabled again if the junction temperature has been decreased about T_{HYST}.

TXD Disconnection

Pin TXD provides a pull-up resistor to force the transceiver into recessive mode if TXD is disconnected.

EN Disconnection

Pin EN provides an internal pull-down resistor in order to force the transceiver into sleep mode in case the pin EN is unsupplied.

6. Electrical Parameters

6.1 Maximum Ratings

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

Electrical Ratings

Parameter	Symbol	Min	Max	Units	Remarks
continuous voltage at VSUP transients	V_{SUP} V_{SUP}	-0.3	30 40	V V	pulse 1...3 ISO 7637/1 (test circuit figure 8)
input voltage at 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 at TxD, RXD, EN	V_{IN}	-0.3	6.5	V	
input voltages at WAKE DC transients	V_{INWAKE} V_{INWAKE}	-18	30 40	V V	pulse 1...3 ISO 7637/1 (test circuit figure 8)
ESD at TXD, RXD, EN	V_{ESD}	-4	+4	KV	Human Body Model MIL-STD 883 (100pF via 1.5kΩ)
ESD at LIN, VSUP, INH, WAKE	V_{HBM}	-8	8	KV	Human Body Model MIL-STD 883 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	195	ºC	
thermal shutdown [1)] hysteresis	T_{HYST}	10	30	ºC	

[1)] not tested, guaranteed by design

6.2 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	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	1.0	1.4	mA	EN = 5 V TXD = 5 V R_{RXD} = ∞
supply current in the sleep mode	I_{SLEEP}	8	14	20	µA	EN = 0V TXD = 5V $V_{LIN} > V_{SUP}$ - 0.5V

Receive Data Output RXD

Parameter	Symbol	Min	typ.	Max	Units	Conditions
Low Level Output Current	I_{RXL}	2			mA	EN = 5V TXD = 0V V_{RXD} = 0.9V
High Level Leakage Current	I_{RXH}	-5		5	µA	EN = 5V TXD = 5V V_{RXD} = 5V

Transmit Data Input TXD

Parameter	Symbol	Min	typ.	Max	Units	Conditions
Low Level Voltage Input	V_{TXDINL}	-0.3		0.8	V	
High Level Voltage Input	V_{TXDINH}	2.0		7	V	
Pull-Down Current Source TXD	I_{TXDPU}	-20	-10	-20	µA	EN = 5V TXD = 5V

Mode Control Input Enable EN

Parameter	Symbol	Min	typ.	Max	Units	Conditions
Low Level Voltage Input	V_{ENINL}	-0.3		1.4	V	external VDD=5V, TXD=5V
High Level Voltage Input	V_{ENINH}	2.5		7	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	V_{RECL}	0		0.4 V_{SUP}	V	EN = 5V TXD = 5V
Input High Level Voltage Receiver	V_{RECH}	0.6 V_{SUP}		V_{SUP}	V	EN = 5V TXD = 5V
Input Hysteresis Receiver	V_{RECHYS}	0.08 V_{SUP}		0.12 V_{SUP}	V	EN = 5V TXD = 5V
Input Centerpoint Receiver	V_{BUS_CNT}	0.475 V_{SUP}	0.5 V_{SUP}	0.525 V_{SUP}	V	$V_{BUS\_CNT} = (V_{th\_dom}+V_{th\_rec})/2$ *)
Output Low Level Voltage Transmitter	V_{LINL}	0.6	1.1	1.8	V	EN = 5V, TXD = 0V R_{BUS}= 500Ω
Output High Level Transmitter	V_{LINH}	0.8V_{SUP}		V_{SUP}	V	TXD = 5V I_{LIN}=0mA
Pull Up Current VSUP to LIN	I_{LINPU}	-550	-450	-300	µA	V_{SUP}=12V V_{LIN} = 0V, TXD=5V
Output Current Limitation LIN	I_{LIM}	120	180	200	mA	EN=5V TXD =0V V_{SUP}=V_{LIN}=12V
Input Current LIN Recessive	$I_{LINLEAK1}$	4	10	18	µA	V_{SUP}=V_{LIN} TXD=5V
Input Current LIN Recessive, Bus no GND	$I_{LINNOGND}$	-1.0		1.0	mA	V_{LIN} = -12V TXD = 5V

*) V_{th_dom} receiver threshold of the recessive to dominant LIN bus edge
V_{th_rec} receiver threshold of the dominant to recessive LIN bus edge

Local Wake-up-input WAKE

Parameter	Symbol	Min	typ.	Max	Units	Remarks
Wake Up Threshold High to Low Transition	$\mathbf{V}_{WUTHL}$			0.6 V_{SUP}	V	EN=0V

Inhibit Output INH

Parameter	Symbol	Min	typ.	Max	Units	Remarks
INHIBIT Output Current High Level	$\mathbf{I}_{INHH}$	40		40	mA	V_{INH} = 0V
INHIBIT Output Resistance High Level	$\mathbf{R}_{INHH}$		30		Ohm	I_{INHH}=15mA
INHIBIT Leakage Current	$\mathbf{I}_{INHLEAK}$	-5			µA	EN=0V, TXD=5V WAKE=0V VSUP=18V V_{INH}=0V

7. Timing Characteristics

VSUP = 6.5...18V, T_J=-40...150°C, typical values are specified for V_{SUP}=12V, unless otherwise defined.

Internal Timers

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
Propagation delay receiver	t_{rx_pd} *			6	µs	C_{RxD}=20pF
Symmetry of receiver propagation delay rising edge w.r.t. falling edge	t_{rx_sym}	-2		2	µs	C_{RxD}=20pF
Bus Wake Up to INH=High Propagation Delay	$t_{LINWAKE}$		80	150	µs	EN=0V
WAKE Propagation Delay WAKE to INH=High	t_{WAKE}		80	150	µs	EN=0V

* t_{rx_pd} = max(t_{rx_pdf}; t_{rx_pd})

LIN Bus Drivers (see Fig. 5)

Load Conditions at LIN: (R_{BUS}=1kΩ C_{BUS}=1nF C_{RXD}=20pF) or (R_{BUS}=500Ω C_{BUS}=10nF C_{RXD}=20pF)

LIN Bus Speed	Parameter	Symbol	Min.	typ.	Max.	Units	Remarks
20kBaud	Duty Cycle 1	**D1**	0.396				$TH_{Rec(max)}$=0.744* V_{SUP} $TH_{Dom(max)}$=0.581* V_{SUP} V_{SUP}=7.0…18V; t_{Bit}=50µs; D1= $t_{BUS\_rec(min)}$=/(2* t_{Bit})
	Duty Cycle 2	**D2**			0.581		$TH_{Rec(min)}$=0.422* V_{SUP} $TH_{Dom(min)}$= 0.284* V_{SUP} V_{SUP}=7.6…18V; t_{Bit}=50µs; D1= $t_{BUS\_rec(max)}$=/(2* t_{Bit})

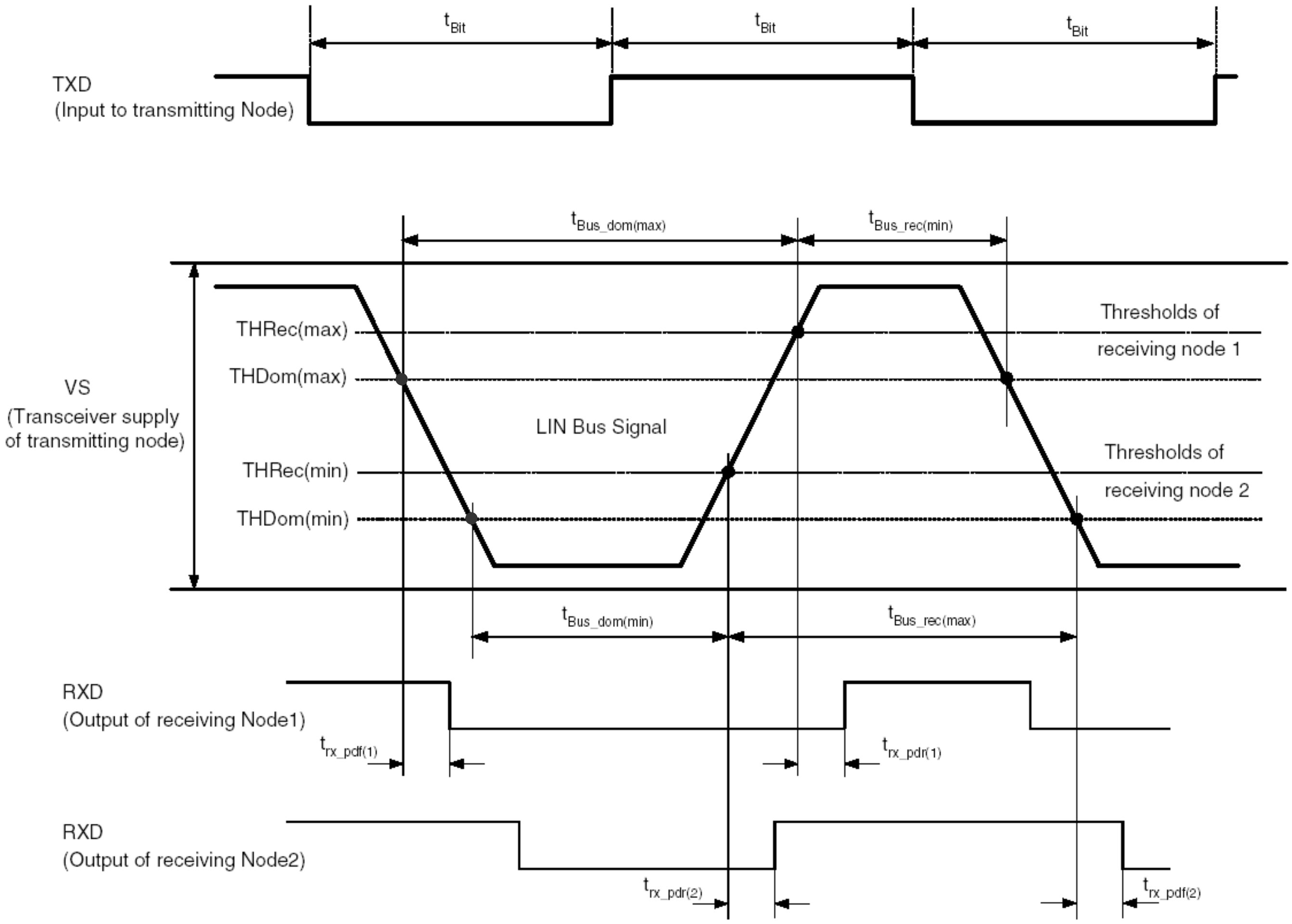


Fig. 5: LIN Bus Driver Timing Characteristics

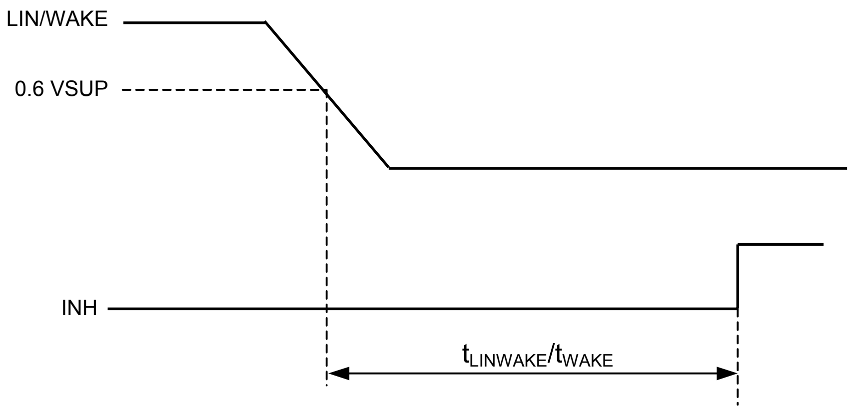


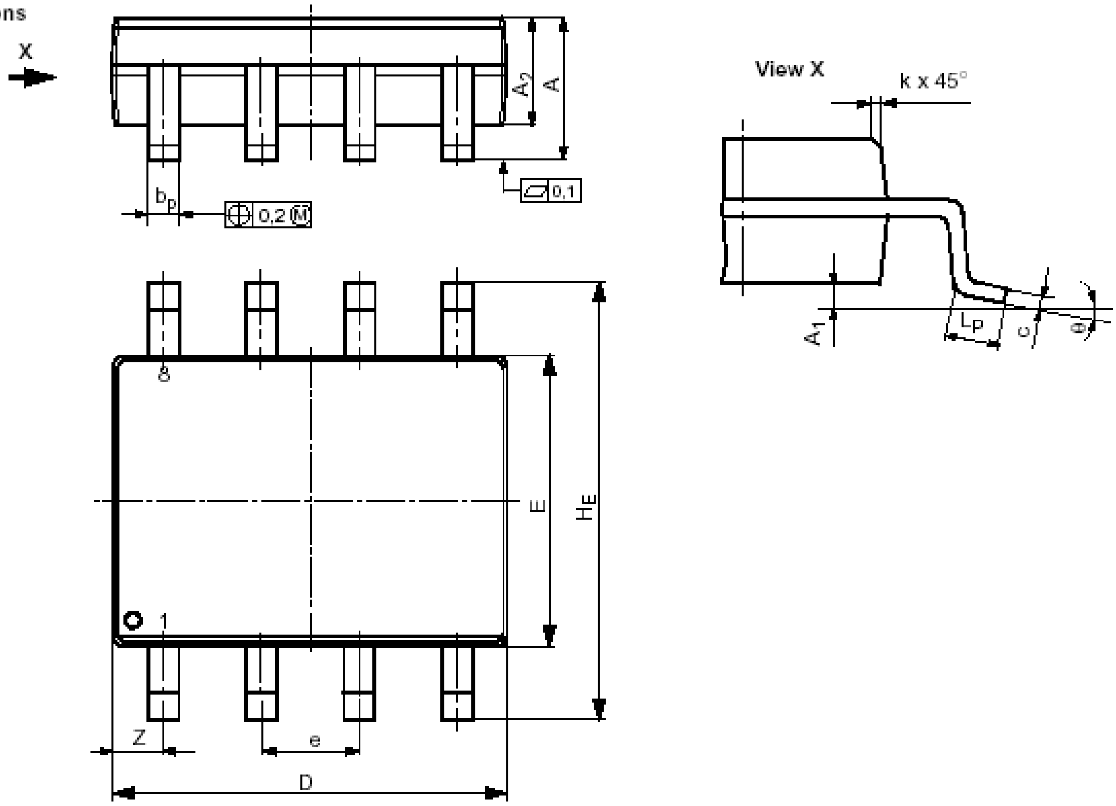
Figure 6: Bus Wake Up and WAKE Timing Description

8. Package

Dimensions in millimetres

Based on IEC 191-2Q: Type 076E35 B

1 Dimensions



Dimensions of Sub-Group B1	
A_{max}	1,95
b_{Pmin}	0,35
b_{Pmax}	0,49
e_{nom}	1,27
H_{Emin}	5,80
H_{Emax}	6,30
L_{Pmin}	0,40
Z_{max}	0,635

Dimensions of Sub-Group C1	
A_{min}	1,55
A_{1min}	0,10
A_{1max}	0,30
A_{2min}	1,40
A_{2max}	1,80
c_{min}	0,15
c_{max}	0,25
D_{min}*	4,80
D_{max}*	5,00
E_{min}*	3,80
E_{max}*	4,00
k_{min}	0,25
θ_{min}	0°
θ_{max}	8°

* without mold-flash

2	**Weight**	≤ 0,3 g
3	**Package Body Material**	Low Stress Epoxy
4	**Lead Material**	FeNi-Alloy or Cu-Alloy
5	**Lead Finish**	solder plating
6	**Lead Form**	Z-bends

9. Related Documents

- ZMD30011 Feature Sheet

Note: For the current revision of this document and for additional information please go to www.zmd.biz.

10. Ordering Information

Ordering Code	Description	Operation Temperature	Package Type	Device Marking	Shipping Form*
ZMD30011AAG1-T	"green" finished parts in tube	-40°C to +125°C	SOP8	ZMD 30011AAG1 YYWW	tube (97 parts/tube)
ZMD30011AAG1-R	"green" finished parts in tape on reel	-40°C to +125°C	SOP8	ZMD 30011AAG1 YYWW	tape on reel (2500 parts/reel)

* The quantity ordered should be a multiple of the quantity / packing unit as specified

For further information:

ZMD AG
Grenzstrasse 28
01109 Dresden, Germany
Phone +49 (0)351-8822-366
Fax +49 (0)351-8822-337
sales@zmd.de
www.zmd.biz