

TJA1021

LIN 2.1/SAE J2602 transceiver

Rev. 7 — 25 March 2011

Product data sheet

1. General description

The TJA1021 is the interface between the Local Interconnect Network (LIN) master/slave protocol controller and the physical bus in a LIN. It is primarily intended for in-vehicle sub-networks using baud rates from 1 kBd up to 20 kBd and is LIN 2.1/SAE J2602 compliant. The TJA1021 is pin-to-pin compatible with the TJA1020 with an improved ElectroStatic Discharge (ESD) specification.

The transmit data stream of the protocol controller at the transmit data input (TXD) is converted by the TJA1021 into a bus signal with optimized slew rate and wave shaping to minimize ElectroMagnetic Emission (EME). The LIN bus output pin is pulled HIGH via an internal termination resistor. For a master application, an external resistor in series with a diode should be connected between pin INH or pin V_{BAT} and pin LIN. The receiver detects the data stream at the LIN bus input pin and transfers it via pin RXD to the microcontroller.

In Sleep mode, the power consumption of the TJA1021 is very low. In failure modes, the power consumption is reduced to a minimum.

2. Features and benefits

2.1 General

- LIN 2.1/SAE J2602 compliant
- Baud rate up to 20 kBd
- Very low ElectroMagnetic Emission (EME)
- High ElectroMagnetic Immunity (EMI)
- Passive behavior in unpowered state
- Input levels compatible with 3.3 V and 5 V devices
- Integrated termination resistor for LIN slave applications
- Wake-up source recognition (local or remote)
- K-line compatible
- Pin-to-pin compatible with TJA1020
- Available in SO8 and HVSON8 packages
- Leadless HVSON8 package (3.0 mm × 3.0 mm) with improved Automated Optical Inspection (AOI) capability

2.2 Low power management

- Very low current consumption in Sleep mode with local and remote wake-up



2.3 Protection mechanisms

- High ESD robustness: ± 6 kV according to IEC 61000-4-2 for pins LIN, V_{BAT} and WAKE_N
- Transmit data (TXD) dominant time-out function
- Bus terminal and battery pin protected against transients in the automotive environment (ISO 7637)
- Bus terminal short-circuit proof to battery and ground
- Thermally protected

3. Quick reference data

Table 1. Quick reference data

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|-----------|------------------------------|--|------|-----|------|--------------|
| V_{BAT} | battery supply voltage | with respect to GND | -0.3 | - | +40 | V |
| I_{BAT} | battery supply current | Sleep mode; $V_{LIN} = V_{BAT}$; $V_{WAKE_N} = V_{BAT}$ $V_{TXD} = 0$ V; $V_{SLP_N} = 0$ V | 2 | 7 | 10 | μ A |
| | | Standby mode; bus recessive $V_{INH} = V_{BAT}$; $V_{LIN} = V_{BAT}$; $V_{WAKE_N} = V_{BAT}$ $V_{TXD} = 0$ V; $V_{SLP_N} = 0$ V | 150 | 450 | 1000 | μ A |
| | | Standby mode; bus dominant $V_{BAT} = 12$ V; $V_{INH} = 12$ V; $V_{LIN} = 0$ V $V_{WAKE_N} = 12$ V; $V_{TXD} = 0$ V; $V_{SLP_N} = 0$ V | 300 | 800 | 1200 | μ A |
| | | Normal mode; bus recessive $V_{INH} = V_{BAT}$; $V_{LIN} = V_{BAT}$; $V_{WAKE_N} = V_{BAT}$ $V_{TXD} = 5$ V; $V_{SLP_N} = 5$ V | 300 | 800 | 1600 | μ A |
| | | Normal mode; bus dominant $V_{BAT} = 12$ V; $V_{INH} = 12$ V; $V_{WAKE_N} = 12$ V $V_{TXD} = 0$ V; $V_{SLP_N} = 5$ V | 1 | 2 | 4 | mA |
| V_{LIN} | voltage on pin LIN | with respect to GND, V_{BAT} and V_{WAKE_N} | -40 | - | +40 | V |
| T_{vj} | virtual junction temperature | | -40 | - | +150 | $^{\circ}$ C |

4. Ordering information

Table 2. Ordering information

| Type number ^[1] | Package | | Version |
|------------------------------|---------|--|----------|
| | Name | Description | |
| TJA1021T/10 TJA1021T/20 | SO8 | plastic small outline package; 8 leads; body width 3.9 mm | SOT96-1 |
| TJA1021TK/10 TJA1021TK/20 | HVSON8 | plastic thermal enhanced very thin small outline package; no leads; 8 terminals; body $3 \times 3 \times 0.85$ mm | SOT782-1 |

- [1] TJA1021T/10 and TJA1021TK/10: for the low slope version that supports baud rates up to 10.4 kBd (SAE J2602);
TJA1021T/20 and TJA1021TK/20: for the normal slope version that supports baud rates up to 20 kBd.

5. Block diagram

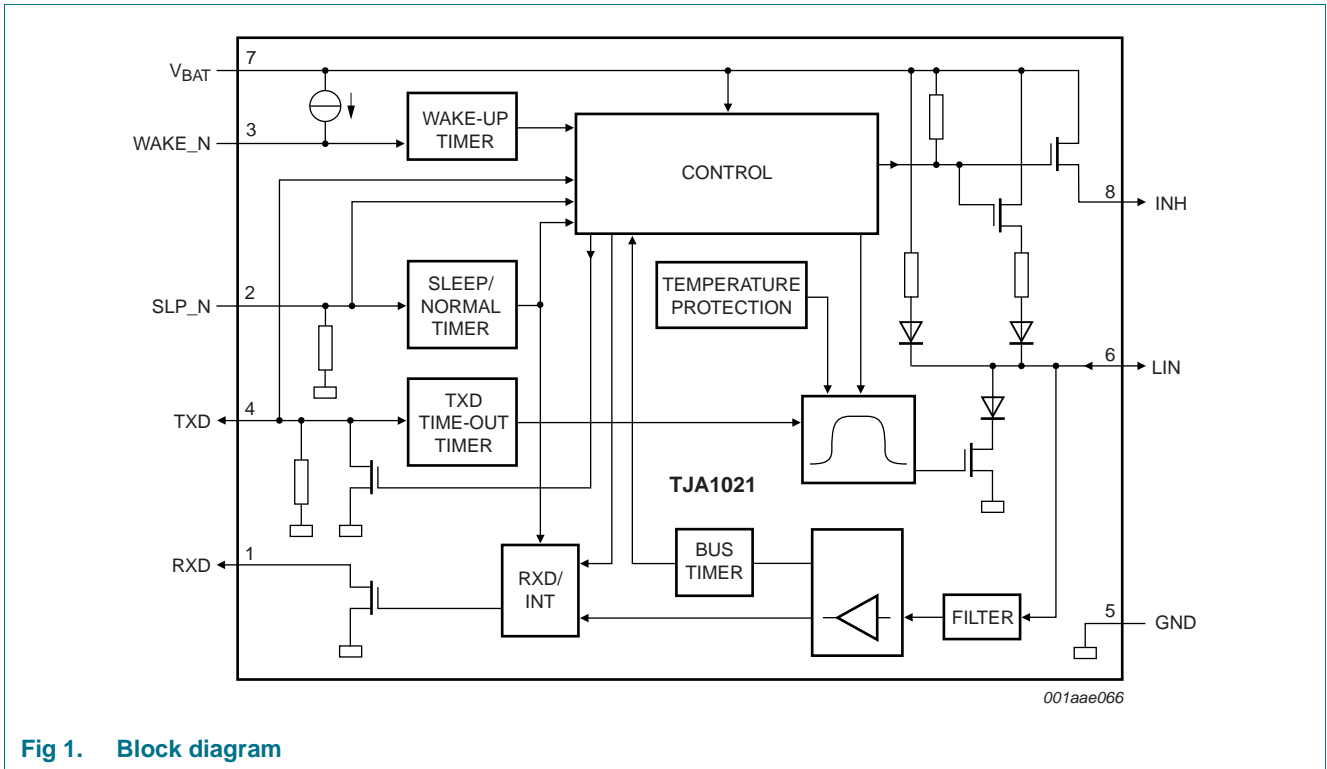
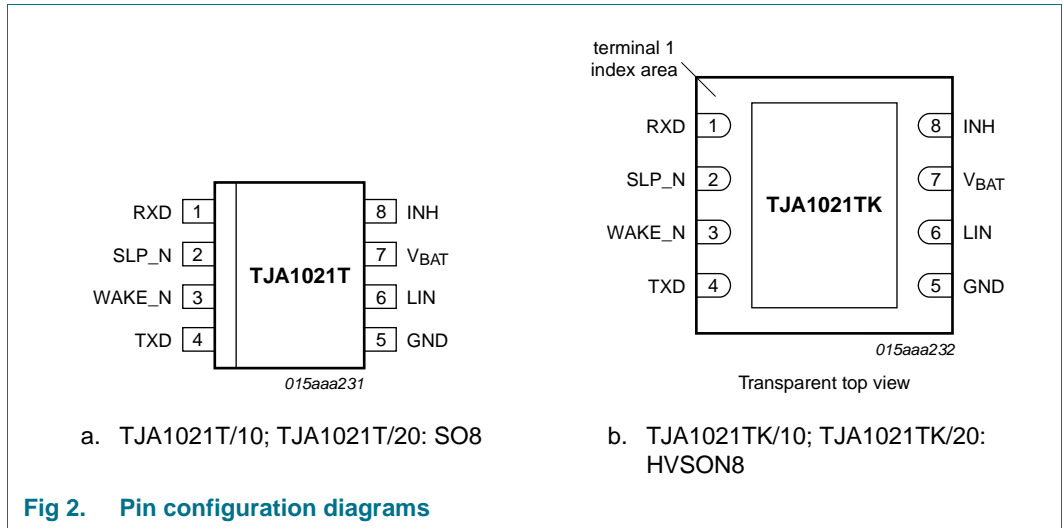


Fig 1. Block diagram

6. Pinning information

6.1 Pinning



6.2 Pin description

Table 3. Pin description

| Symbol | Pin | Description |
|------------------|------------------|---|
| RXD | 1 | receive data output (open-drain); active LOW after a wake-up event |
| SLP_N | 2 | sleep control input (active LOW); controls inhibit output; resets wake-up source flag on TXD and wake-up request on RXD |
| WAKE_N | 3 | local wake-up input (active LOW); negative edge triggered |
| TXD | 4 | transmit data input; active LOW output after a local wake-up event |
| GND | 5 ^[1] | ground |
| LIN | 6 | LIN bus line input/output |
| V _{BAT} | 7 | battery supply voltage |
| INH | 8 | battery related inhibit output for controlling an external voltage regulator; active HIGH after a wake-up event |

[1] HVSON8 package die supply ground is connected to both the GND pin and the exposed center pad. The GND pin must be soldered to board ground. For enhanced thermal and electrical performance, it is recommended that the exposed center pad also be soldered to board ground.

7. Functional description

The TJA1021 is the interface between the LIN master/slave protocol controller and the physical bus in a Local Interconnect Network (LIN). The TJA1021 is LIN 2.1/SAE J2602 compliant and provides optimum ElectroMagnetic Compatibility (EMC) performance due to wave shaping of the LIN output.

The TJA1021T/20 and TJA1021TK/20 are optimized for the maximum specified LIN transmission speed of 20 kBd; the TJA1021T/10 and TJA1021TK/10 are optimized for the LIN transmission speed of 10.4 kBd as specified by the SAE J2602.

7.1 Operating modes

The TJA1021 supports modes for normal operation (Normal mode), power-up (Power-on mode) and very-low-power operation (Sleep mode). An intermediate wake-up mode between Sleep and Normal modes is also supported (Standby mode). [Figure 3](#) shows the state diagram.

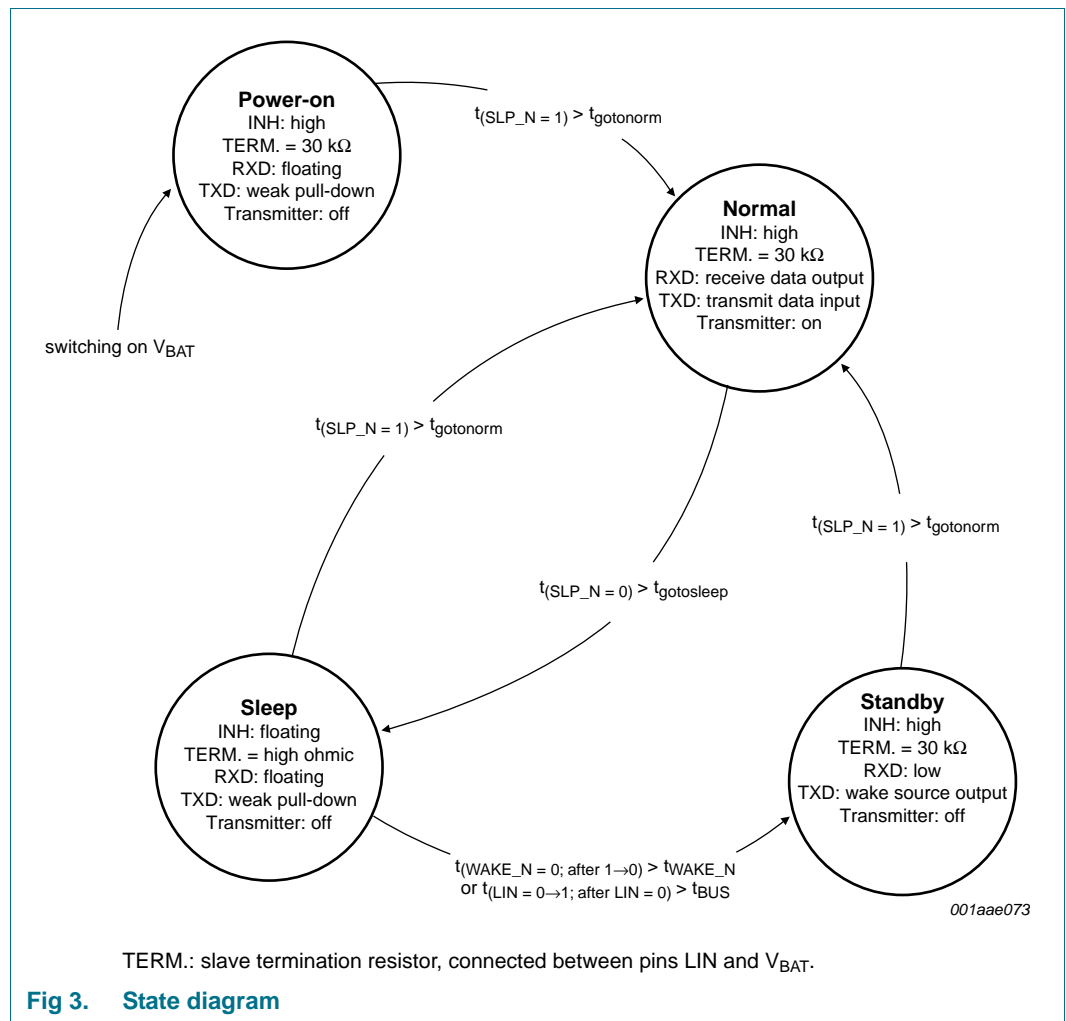


Table 4. Operating modes

| Mode | SLP_N | TXD (output) | RXD | INH | Transmitter | Remarks |
|-----------------------------|-------|--|--|----------|-------------|---|
| Sleep mode | 0 | weak pull-down | floating | floating | off | no wake-up request detected |
| Standby ^[1] mode | 0 | weak pull-down if remote wake-up; strong pull-down if local wake-up ^[2] | LOW ^[3] | HIGH | off | wake-up request detected; in this mode the microcontroller can read the wake-up source: remote or local wake-up |
| Normal mode | 1 | HIGH: recessive state LOW: dominant state | HIGH: recessive state LOW: dominant state | HIGH | Normal mode | ^[2] ^[3] ^[4] |
| Power-on mode | 0 | weak pull-down | floating | HIGH | off | ^[5] |

- [1] Standby mode is entered automatically upon any local or remote wake-up event during Sleep mode. Pin INH and the 30 kΩ termination resistor at pin LIN are switched on.
- [2] The internal wake-up source flag (set if a local wake-up did occur and fed to pin TXD) will be reset after a positive edge on pin SLP_N.
- [3] The wake-up interrupt (on pin RXD) is released after a positive edge on pin SLP_N.
- [4] Normal mode is entered after a positive edge on SLP_N. As long as TXD is LOW, the transmitter is off. In the event of a short-circuit to ground on pin TXD, the transmitter will be disabled.
- [5] Power-on mode is entered after switching on V_{BAT}.

7.2 Sleep mode

This mode is the most power-saving mode of the TJA1021. Despite its extreme low current consumption, the TJA1021 can still be woken up remotely via pin LIN, or woken up locally via pin WAKE_N, or activated directly via pin SLP_N. Filters at the inputs of the receiver (LIN), of pin WAKE_N and of pin SLP_N prevent unwanted wake-up events due to automotive transients or EMI. All wake-up events must be maintained for a certain time period ($t_{\text{wake(dom)LIN}}$, $t_{\text{wake(dom)WAKE_N}}$ and t_{gotonorm}).

Sleep mode is initiated by a falling edge on pin SLP_N in Normal mode. To enter Sleep mode successfully (INH becomes floating), the sleep command (pin SLP_N = LOW) must be maintained for at least $t_{\text{gotosleep}}$.

In Sleep mode the internal slave termination between pins LIN and V_{BAT} is disabled to minimize the power dissipation in the event that pin LIN is short-circuited to ground. Only a weak pull-up between pins LIN and V_{BAT} is present.

Sleep mode can be activated independently from the actual level on pin LIN, pin TXD or pin WAKE_N. This guarantees that the lowest power consumption is achievable even in case of a continuous dominant level on pin LIN or a continuous LOW on pin WAKE_N.

When V_{BAT} drops below the power-on-reset threshold $V_{\text{th(POR)L}}$, the TJA1021 enters Sleep mode.

7.3 Standby mode

Standby mode is entered automatically whenever a local or remote wake-up occurs while the TJA1021 is in Sleep mode. These wake-up events activate pin INH and enable the slave termination resistor at the pin LIN. As a result of the HIGH condition on pin INH the voltage regulator and the microcontroller can be activated.

Standby mode is signalled by a LOW-level on pin RXD which can be used as an interrupt for the microcontroller.

In Standby mode (pin SLP_N is still LOW), the condition of pin TXD (weak pull-down or strong pull-down) indicates the wake-up source: weak pull-down for a remote wake-up request and strong pull-down for a local wake-up request.

Setting pin SLP_N HIGH during Standby mode results in the following events:

- An immediate reset of the wake-up source flag; thus releasing the possible strong pull-down at pin TXD before the actual mode change (after t_{gotonorm}) is performed
- A change into Normal mode if the HIGH level on pin SLP_N has been maintained for a certain time period (t_{gotonorm})
- An immediate reset of the wake-up request signal on pin RXD

7.4 Normal mode

In Normal mode the TJA1021 is able to transmit and receive data via the LIN bus line. The receiver detects the data stream at the LIN bus input pin and transfers it via pin RXD to the microcontroller (see [Figure 1](#)): HIGH at a recessive level and LOW at a dominant level on the bus. The receiver has a supply-voltage related threshold with hysteresis and an integrated filter to suppress bus line noise. The transmit data stream of the protocol controller at the TXD input is converted by the transmitter into a bus signal with optimized slew rate and wave shaping to minimize EME. The LIN bus output pin is pulled HIGH via an internal slave termination resistor. For a master application an external resistor in series with a diode should be connected between pin INH or V_{BAT} on one side and pin LIN on the other side (see [Figure 7](#)).

When in Sleep, Standby or Power-up mode, the TJA1021 enters Normal mode whenever a HIGH level on pin SLP_N is maintained for a time of at least t_{gotonorm} .

The TJA1021 switches to Sleep mode in case of a LOW-level on pin SLP_N, maintained for a time of at least $t_{\text{gotosleep}}$.

7.5 Wake-up

When V_{BAT} exceeds the power-on-reset threshold voltage $V_{\text{th(POR)H}}$, the TJA1021 enters Power-on mode. Though the TJA1021 is powered-up and INH is HIGH, both the transmitter and receiver are still inactive. If $\text{SLP_N} = 1$ for $t > t_{\text{gotonorm}}$, the TJA1021 enters Normal mode.

There are three ways to wake-up a TJA1021 which is in Sleep mode:

1. Remote wake-up via a dominant bus state of at least $t_{\text{wake(dom)LIN}}$
2. Local wake-up via a negative edge at pin WAKE_N
3. Mode change (pin SLP_N is HIGH) from Sleep mode to Normal mode

7.6 Remote and local wake-up

A falling edge at pin LIN followed by a LOW level maintained for a certain time period ($t_{\text{wake(dom)LIN}}$) and a rising edge at pin LIN respectively (see [Figure 4](#)) results in a remote wake-up. It should be noted that the time period $t_{\text{wake(dom)LIN}}$ is measured either in Normal mode while TXD is HIGH, or in Sleep mode irrespective of the status of pin TXD.

A falling edge at pin WAKE_N followed by a LOW level maintained for a certain time period ($t_{\text{wake}(\text{dom})\text{WAKE_N}}$) results in a local wake-up. The pin WAKE_N provides an internal pull-up towards pin V_{BAT} . In order to prevent EMI issues, it is recommended to connect an unused pin WAKE_N to pin V_{BAT} .

After a local or remote wake-up, pin INH is activated (it goes HIGH) and the internal slave termination resistor is switched on. The wake-up request is indicated by a LOW active wake-up request signal on pin RXD to interrupt the microcontroller.

7.7 Wake-up via mode transition

It is also possible to set pin INH HIGH with a mode transition towards Normal mode via pin SLP_N. This is useful for applications with a continuously powered microcontroller.

7.8 Wake-up source recognition

The TJA1021 can distinguish between a local wake-up request on pin WAKE_N and a remote wake-up request via a dominant bus state. A local wake-up request sets the wake-up source flag. The wake-up source can be read on pin TXD in the Standby mode. If an external pull-up resistor on pin TXD to the power supply voltage of the microcontroller has been added, a HIGH level indicates a remote wake-up request (weak pull-down at pin TXD) and a LOW level indicates a local wake-up request (strong pull-down at pin TXD; much stronger than the external pull-up resistor).

The wake-up request flag (signalled on pin RXD) as well as the wake-up source flag (signalled on pin TXD) are reset immediately after the microcontroller sets pin SLP_N HIGH.

7.9 TXD dominant time-out function

A TXD dominant time-out timer circuit prevents the bus line from being driven to a permanent dominant state (blocking all network communication) if pin TXD is forced permanently LOW by a hardware and/or software application failure. The timer is triggered by a negative edge on pin TXD. If the duration of the LOW-level on pin TXD exceeds the internal timer value ($t_{\text{to}(\text{dom})\text{TXD}}$), the transmitter is disabled, driving the bus line into a recessive state. The timer is reset by a positive edge on pin TXD.

7.10 Fail-safe features

Pin TXD provides a pull-down to GND in order to force a predefined level on input pin TXD in case the pin TXD is unpowered.

Pin SLP_N provides a pull-down to GND in order to force the transceiver into Sleep mode in case the pin SLP_N is unpowered.

Pin RXD is set floating in case of lost power supply on pin V_{BAT} .

The current of the transmitter output stage is limited in order to protect the transmitter against short circuit to pins V_{BAT} or GND.

A loss of power (pins V_{BAT} and GND) has no impact on the bus line and the microcontroller. There are no reverse currents from the bus. The LIN transceiver can be disconnected from the power supply without influencing the LIN bus.

The output driver at pin LIN is protected against overtemperature conditions. If the junction temperature exceeds the shutdown junction temperature $T_{j(sd)}$, the thermal protection circuit disables the output driver. The driver is enabled again when the junction temperature has dropped below $T_{j(sd)}$ and a recessive level is present at pin TXD.

If V_{BAT} drops below $V_{th(VBATL)L}$, a protection circuit disables the output driver. The driver is enabled again when $V_{BAT} > V_{th(VBATL)H}$ and a recessive level is present at pin TXD.

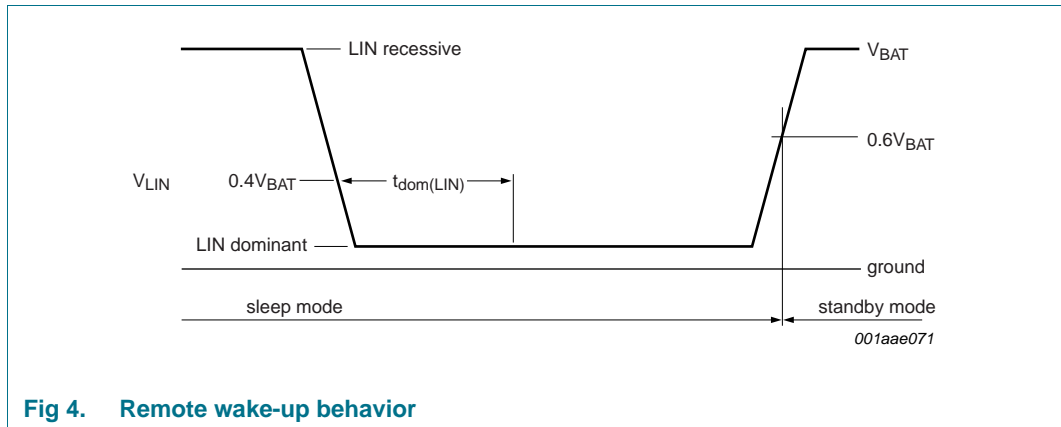


Fig 4. Remote wake-up behavior

8. Limiting values

Table 5. Limiting values

In accordance with the Absolute Maximum Rating System (IEC 60134). All voltages are referenced to pin GND; unless otherwise specified. Positive currents flow into the IC.

| Symbol | Parameter | Conditions | Min | Max | Unit | |
|---------------------|---------------------------------|---|------|------------------------|------|----|
| V _{BAT} | battery supply voltage | with respect to GND | -0.3 | +40 | V | |
| V _{TXD} | voltage on pin TXD | I _{TXD} no limitation | -0.3 | +6 | V | |
| | | I _{TXD} < 500 μA | -0.3 | +7 | V | |
| V _{RXD} | voltage on pin RXD | I _{RXD} no limitation | -0.3 | +6 | V | |
| | | I _{RXD} < 500 μA | -0.3 | +7 | V | |
| V _{SLP_N} | voltage on pin SLP_N | I _{SLP_N} no limitation | -0.3 | +6 | V | |
| | | I _{SLP_N} < 500 μA | -0.3 | +7 | V | |
| V _{LIN} | voltage on pin LIN | with respect to GND, V _{BAT} and V _{WAKE_N} | -40 | +40 | V | |
| V _{WAKE_N} | voltage on pin WAKE_N | | -0.3 | +40 | V | |
| I _{WAKE_N} | current on pin WAKE_N | only relevant if V _{WAKE_N} < V _{GND} - 0.3 current will flow into pin GND | -15 | - | mA | |
| V _{INH} | voltage on pin INH | | -0.3 | V _{BAT} + 0.3 | V | |
| I _{O(INH)} | output current on pin INH | | -50 | +15 | mA | |
| V _{ESD} | electrostatic discharge voltage | | | | | |
| | according to IEC 61000-4-2 | on pins WAKE_N, LIN and V _{BAT} | [1] | -6 | +6 | kV |
| | human body model | on pins WAKE_N, LIN, V _{BAT} and INH | [2] | -8 | +8 | kV |
| | | on pins RXD, SLP_N and TXD | [2] | -2 | +2 | kV |
| | charge device model | all pins | | -750 | +750 | V |
| machine model | all pins | [3] | -200 | +200 | V | |
| T _{vj} | virtual junction temperature | | [4] | -40 | +150 | °C |
| T _{stg} | storage temperature | | -55 | +150 | °C | |

[1] Equivalent to discharging a 150 pF capacitor through a 330 Ω resistor; verified by an external test house.

[2] Equivalent to discharging a 100 pF capacitor through a 1.5 kΩ resistor.

[3] Equivalent to discharging a 200 pF capacitor through a 10 Ω resistor and a 0.75 μH coil.

[4] Junction temperature in accordance with IEC 60747-1. An alternative definition is: $T_j = T_{amb} + P \times R_{th(j-a)}$, where $R_{th(j-a)}$ is a fixed value. The rating for T_{vj} limits the allowable combinations of power dissipation (P) and ambient temperature (T_{amb}).

9. Thermal characteristics

Table 6. Thermal characteristics

According to IEC 60747-1.

| Symbol | Parameter | Conditions | Typ | Unit |
|----------------------|---|-----------------------------|-----|------|
| R _{th(j-a)} | thermal resistance from junction to ambient | SO8 package; in free air | 145 | K/W |
| | | HVSON8 package; in free air | 50 | K/W |

10. Static characteristics

Table 7. Static characteristics

$V_{BAT} = 5.5\text{ V to }27\text{ V}$; $T_{vj} = -40\text{ }^{\circ}\text{C to }+150\text{ }^{\circ}\text{C}$; $R_{L(LIN-VBAT)} = 500\ \Omega$; all voltages are defined with respect to ground; positive currents flow into the IC; typical values are given at $V_{BAT} = 12\text{ V}$; unless otherwise specified.^[1]

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|-----------------------|---|---|------|-----|------|------------------|
| Supply | | | | | | |
| I_{BAT} | battery supply current | Sleep mode $V_{LIN} = V_{BAT}$; $V_{WAKE_N} = V_{BAT}$ $V_{TXD} = 0\text{ V}$; $V_{SLP_N} = 0\text{ V}$ | 2 | 7 | 10 | μA |
| | | Standby mode; bus recessive $V_{INH} = V_{BAT}$; $V_{LIN} = V_{BAT}$ $V_{WAKE_N} = V_{BAT}$; $V_{TXD} = 0\text{ V}$ $V_{SLP_N} = 0\text{ V}$ | 150 | 450 | 1000 | μA |
| | | Standby mode; bus dominant $V_{BAT} = 12\text{ V}$; $V_{INH} = 12\text{ V}$ $V_{LIN} = 0\text{ V}$; $V_{WAKE_N} = 12\text{ V}$ $V_{TXD} = 0\text{ V}$ $V_{SLP_N} = 0\text{ V}$ | 300 | 800 | 1200 | μA |
| | | Normal mode; bus recessive $V_{INH} = V_{BAT}$; $V_{LIN} = V_{BAT}$ $V_{WAKE_N} = V_{BAT}$; $V_{TXD} = 5\text{ V}$ $V_{SLP_N} = 5\text{ V}$ | 300 | 800 | 1600 | μA |
| | | Normal mode; bus dominant $V_{BAT} = 12\text{ V}$; $V_{INH} = 12\text{ V}$ $V_{WAKE_N} = 12\text{ V}$; $V_{TXD} = 0\text{ V}$ $V_{SLP_N} = 5\text{ V}$ | 1 | 2 | 4 | mA |
| Power-on reset | | | | | | |
| $V_{th(POR)L}$ | LOW-level power-on reset threshold voltage | power-on reset | 1.6 | 3.1 | 3.9 | V |
| $V_{th(POR)H}$ | HIGH-level power-on reset threshold voltage | | 2.3 | 3.4 | 4.3 | V |
| $V_{hys(POR)}$ | power-on reset hysteresis voltage | | 0.05 | 0.3 | 1 | V |
| $V_{th(VBATL)L}$ | LOW-level V_{BAT} LOW threshold voltage | | 3.9 | 4.4 | 4.7 | V |
| $V_{th(VBATL)H}$ | HIGH-level V_{BAT} LOW threshold voltage | | 4.2 | 4.7 | 4.9 | V |
| $V_{hys(VBATL)}$ | V_{BAT} LOW hysteresis voltage | | 0.05 | 0.3 | 1 | V |
| Pin TXD | | | | | | |
| V_{IH} | HIGH-level input voltage | | 2 | - | 7 | V |
| V_{IL} | LOW-level input voltage | | -0.3 | - | +0.8 | V |
| V_{hys} | hysteresis voltage | | 50 | 200 | 400 | mV |
| $R_{PD(TXD)}$ | pull-down resistance on pin TXD | $V_{TXD} = 5\text{ V}$ | 140 | 500 | 1200 | $\text{k}\Omega$ |
| I_{IL} | LOW-level input current | $V_{TXD} = 0\text{ V}$ | -5 | - | +5 | μA |
| I_{OL} | LOW-level output current | local wake-up request Standby mode; $V_{WAKE_N} = 0\text{ V}$ $V_{LIN} = V_{BAT}$; $V_{TXD} = 0.4\text{ V}$ | 1.5 | - | - | mA |

Table 7. Static characteristics ...continued

$V_{BAT} = 5.5\text{ V to }27\text{ V}$; $T_{vj} = -40\text{ }^{\circ}\text{C to }+150\text{ }^{\circ}\text{C}$; $R_{L(LIN-VBAT)} = 500\ \Omega$; all voltages are defined with respect to ground; positive currents flow into the IC; typical values are given at $V_{BAT} = 12\text{ V}$; unless otherwise specified.^[1]

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|-----------------------------|--|---|----------------|--------------|-----------------|---------------|
| Pin SLP_N | | | | | | |
| V_{IH} | HIGH-level input voltage | | 2 | - | 7 | V |
| V_{IL} | LOW-level input voltage | | -0.3 | - | +0.8 | V |
| V_{hys} | hysteresis voltage | | 50 | 200 | 400 | mV |
| $R_{PD(SLP_N)}$ | pull-down resistance on pin SLP_N | $V_{SLP_N} = 5\text{ V}$ | 140 | 500 | 1200 | k Ω |
| I_{IL} | LOW-level input current | $V_{SLP_N} = 0\text{ V}$ | -5 | 0 | +5 | μA |
| Pin RXD (open-drain) | | | | | | |
| I_{OL} | LOW-level output current | Normal mode $V_{LIN} = 0\text{ V}$; $V_{RXD} = 0.4\text{ V}$ | 1.5 | - | - | mA |
| I_{LH} | HIGH-level leakage current | Normal mode $V_{LIN} = V_{BAT}$; $V_{RXD} = 5\text{ V}$ | -5 | 0 | +5 | μA |
| Pin WAKE_N | | | | | | |
| V_{IH} | HIGH-level input voltage | | $V_{BAT} - 1$ | - | $V_{BAT} + 0.3$ | V |
| V_{IL} | LOW-level input voltage | | -0.3 | - | $V_{BAT} - 3.3$ | V |
| $I_{pu(L)}$ | LOW-level pull-up current | $V_{WAKE_N} = 0\text{ V}$ | -30 | -12 | -1 | μA |
| I_{LH} | HIGH-level leakage current | $V_{WAKE_N} = 27\text{ V}$; $V_{BAT} = 27\text{ V}$ | -5 | 0 | +5 | μA |
| Pin INH | | | | | | |
| $R_{sw(VBAT-INH)}$ | switch-on resistance between pins V_{BAT} and INH | Standby; Normal and Power-on modes; $I_{INH} = -15\text{ mA}$ $V_{BAT} = 12\text{ V}$ | - | 20 | 50 | Ω |
| I_{LH} | HIGH-level leakage current | Sleep mode $V_{INH} = 27\text{ V}$; $V_{BAT} = 27\text{ V}$ | -5 | 0 | +5 | μA |
| Pin LIN | | | | | | |
| I_{BUS_LIM} | current limitation for driver dominant state | $V_{BAT} = 18\text{ V}$; $V_{LIN} = 18\text{ V}$ $V_{TXD} = 0\text{ V}$ | 40 | - | 100 | mA |
| R_{pu} | pull-up resistance | Sleep mode; $V_{SLP_N} = 0\text{ V}$ | 50 | 160 | 250 | k Ω |
| $I_{BUS_PAS_rec}$ | receiver recessive input leakage current | $V_{LIN} = 27\text{ V}$; $V_{BAT} = 5.5\text{ V}$ $V_{TXD} = 5\text{ V}$ | - | - | 1 | μA |
| $I_{BUS_PAS_dom}$ | receiver dominant input leakage current including pull-up resistor | Normal mode; $V_{TXD} = 5\text{ V}$ $V_{LIN} = 0\text{ V}$; $V_{BAT} = 12\text{ V}$ | -600 | - | - | μA |
| $V_{SerDiode}$ | voltage drop at the serial diode | in pull-up path with R_{slave} $I_{SerDiode} = 10\ \mu\text{A}$ | [2] 0.4 | - | 1.0 | V |
| $I_{BUS_NO_GND}$ | loss-of-ground bus current | $V_{BAT} = 27\text{ V}$; $V_{LIN} = 0\text{ V}$ | -750 | - | +10 | μA |
| $I_{BUS_NO_BAT}$ | loss-of-battery bus current | $V_{BAT} = 0\text{ V}$; $V_{LIN} = 27\text{ V}$ | - | - | 1 | μA |
| V_{BUSdom} | receiver dominant state | | - | - | $0.4V_{BAT}$ | V |
| V_{BUSrec} | receiver recessive state | | $0.6V_{BAT}$ | - | - | V |
| V_{BUS_CNT} | receiver center voltage | $V_{BUS_CNT} = (V_{BUSrec} + V_{BUSdom}) / 2$ | $0.475V_{BAT}$ | $0.5V_{BAT}$ | $0.525V_{BAT}$ | V |
| V_{HYS} | receiver hysteresis voltage | $V_{HYS} = V_{BUSrec} - V_{BUSdom}$ | - | - | $0.175V_{BAT}$ | V |
| R_{slave} | slave resistance | connected between pins LIN and V_{BAT} ; $V_{LIN} = 0\text{ V}$; $V_{BAT} = 12\text{ V}$ | 20 | 30 | 47 | k Ω |

Table 7. Static characteristics ...continued

$V_{BAT} = 5.5\text{ V to }27\text{ V}$; $T_{vj} = -40\text{ }^{\circ}\text{C to }+150\text{ }^{\circ}\text{C}$; $R_{L(LIN-VBAT)} = 500\ \Omega$; all voltages are defined with respect to ground; positive currents flow into the IC; typical values are given at $V_{BAT} = 12\text{ V}$; unless otherwise specified.^[1]

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|--------------|-------------------------|---|-------|-----|-----|------|
| C_{LIN} | capacitance on pin LIN | | [2] - | - | 30 | pF |
| $V_{o(dom)}$ | dominant output voltage | Normal mode; $V_{TXD} = 0\text{ V}$ $V_{BAT} = 7.0\text{ V}$ | - | - | 1.4 | V |
| | | Normal mode; $V_{TXD} = 0\text{ V}$ $V_{BAT} = 18\text{ V}$ | - | - | 2.0 | V |

Thermal shutdown

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|-------------|-------------------------------|------------|---------|-----|-----|--------------------|
| $T_{j(sd)}$ | shutdown junction temperature | | [2] 150 | 175 | 200 | $^{\circ}\text{C}$ |

[1] All parameters are guaranteed over the virtual junction temperature range by design. Factory testing uses correlated test conditions to cover the specified temperature and power supply voltage range.

[2] Not tested in production; guaranteed by design.

11. Dynamic characteristics**Table 8.** Dynamic characteristics

$V_{BAT} = 5.5\text{ V to }18\text{ V}$; $T_{vj} = -40\text{ }^{\circ}\text{C to }+150\text{ }^{\circ}\text{C}$; $R_{L(LIN-VBAT)} = 500\ \Omega$; all voltages are defined with respect to ground; positive currents flow into the IC; typical values are given at $V_{BAT} = 12\text{ V}$; see [Figure 6](#); unless otherwise specified.^[1]

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|-------------------------------|--------------|--|--------------|-------|-----|--------------------|
| Duty cycles | | | | | | |
| $\delta 1$ | duty cycle 1 | $V_{th(rec)(max)} = 0.744 \times V_{BAT}$ $V_{th(dom)(max)} = 0.581 \times V_{BAT}$ $t_{bit} = 50\ \mu\text{s}$; $V_{BAT} = 7\text{ V to }18\text{ V}$ | [2][3][4][7] | 0.396 | - | - |
| | | $V_{th(rec)(max)} = 0.76 \times V_{BAT}$ $V_{th(dom)(max)} = 0.593 \times V_{BAT}$ $t_{bit} = 50\ \mu\text{s}$; $V_{BAT} = 5.5\text{ V to }7.0\text{ V}$ | [2][3][4][7] | 0.396 | - | - |
| $\delta 2$ | duty cycle 2 | $V_{th(rec)(min)} = 0.422 \times V_{BAT}$ $V_{th(dom)(min)} = 0.284 \times V_{BAT}$ $t_{bit} = 50\ \mu\text{s}$; $V_{BAT} = 7.6\text{ V to }18\text{ V}$ | [2][4][5][7] | - | - | 0.581 |
| | | $V_{th(rec)(min)} = 0.41 \times V_{BAT}$ $V_{th(dom)(min)} = 0.275 \times V_{BAT}$ $t_{bit} = 50\ \mu\text{s}$; $V_{BAT} = 6.1\text{ V to }7.6\text{ V}$ | [2][4][5][7] | - | - | 0.581 |
| $\delta 3$ | duty cycle 3 | $V_{th(rec)(max)} = 0.778 \times V_{BAT}$ $V_{th(dom)(max)} = 0.616 \times V_{BAT}$ $t_{bit} = 96\ \mu\text{s}$; $V_{BAT} = 7\text{ V to }18\text{ V}$ | [3][4][7] | 0.417 | - | - |
| | | $V_{th(rec)(max)} = 0.797 \times V_{BAT}$ $V_{th(dom)(max)} = 0.630 \times V_{BAT}$ $t_{bit} = 96\ \mu\text{s}$; $V_{BAT} = 5.5\text{ V to }7\text{ V}$ | [3][4][7] | 0.417 | - | - |
| $\delta 4$ | duty cycle 4 | $V_{th(rec)(min)} = 0.389 \times V_{BAT}$ $V_{th(dom)(min)} = 0.251 \times V_{BAT}$ $t_{bit} = 96\ \mu\text{s}$; $V_{BAT} = 7.6\text{ V to }18\text{ V}$ | [4][5][7] | - | - | 0.590 |
| | | $V_{th(rec)(min)} = 0.378 \times V_{BAT}$ $V_{th(dom)(min)} = 0.242 \times V_{BAT}$ $t_{bit} = 96\ \mu\text{s}$; $V_{BAT} = 6.1\text{ V to }7.6\text{ V}$ | [4][5][7] | - | - | 0.590 |
| Timing characteristics | | | | | | |
| t_f | fall time | | [2][4] | - | - | 22.5 μs |

Table 8. Dynamic characteristics ...continued

$V_{BAT} = 5.5\text{ V to }18\text{ V}$; $T_{vj} = -40\text{ °C to }+150\text{ °C}$; $R_{L(LIN-VBAT)} = 500\ \Omega$; all voltages are defined with respect to ground; positive currents flow into the IC; typical values are given at $V_{BAT} = 12\text{ V}$; see [Figure 6](#); unless otherwise specified.^[1]

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|------------------------|--|---|--------|------|------|---------------|
| t_r | rise time | | [2][4] | - | 22.5 | μs |
| $\Delta t_{(r-f)}$ | difference between rise and fall time | $V_{BAT} = 7.3\text{ V}$ | [2][4] | -5 | +5 | μs |
| t_{tx_pd} | transmitter propagation delay | rising and falling | [2] | - | 6 | μs |
| t_{tx_sym} | transmitter propagation delay symmetry | | | -2.5 | +2.5 | μs |
| t_{rx_pd} | receiver propagation delay | rising and falling | [6] | - | 6 | μs |
| t_{rx_sym} | receiver propagation delay symmetry | | [6] | -2 | +2 | μs |
| $t_{wake(dom)LIN}$ | LIN dominant wake-up time | Sleep mode | 30 | 80 | 150 | μs |
| $t_{wake(dom)WAKE_N}$ | dominant wake-up time on pin WAKE_N | Sleep mode | 7 | 30 | 50 | μs |
| $t_{gotonorm}$ | go to normal time | time period for mode change from Sleep, Power-on or Standby mode into Normal mode | 2 | 5 | 10 | μs |
| $t_{init(norm)}$ | normal mode initialization time | | 5 | - | 20 | μs |
| $t_{gotosleep}$ | go to sleep time | time period for mode change from Normal slope mode into Sleep mode | 2 | 5 | 10 | μs |
| $t_{to(dom)TXD}$ | TXD dominant time-out time | $V_{TXD} = 0\text{ V}$ | 27 | 55 | 90 | ms |

[1] All parameters are guaranteed over the virtual junction temperature range by design. Factory testing uses correlated test conditions to cover the specified temperature and power supply voltage range.

[2] Not applicable for the /10 versions of the TJA1021.

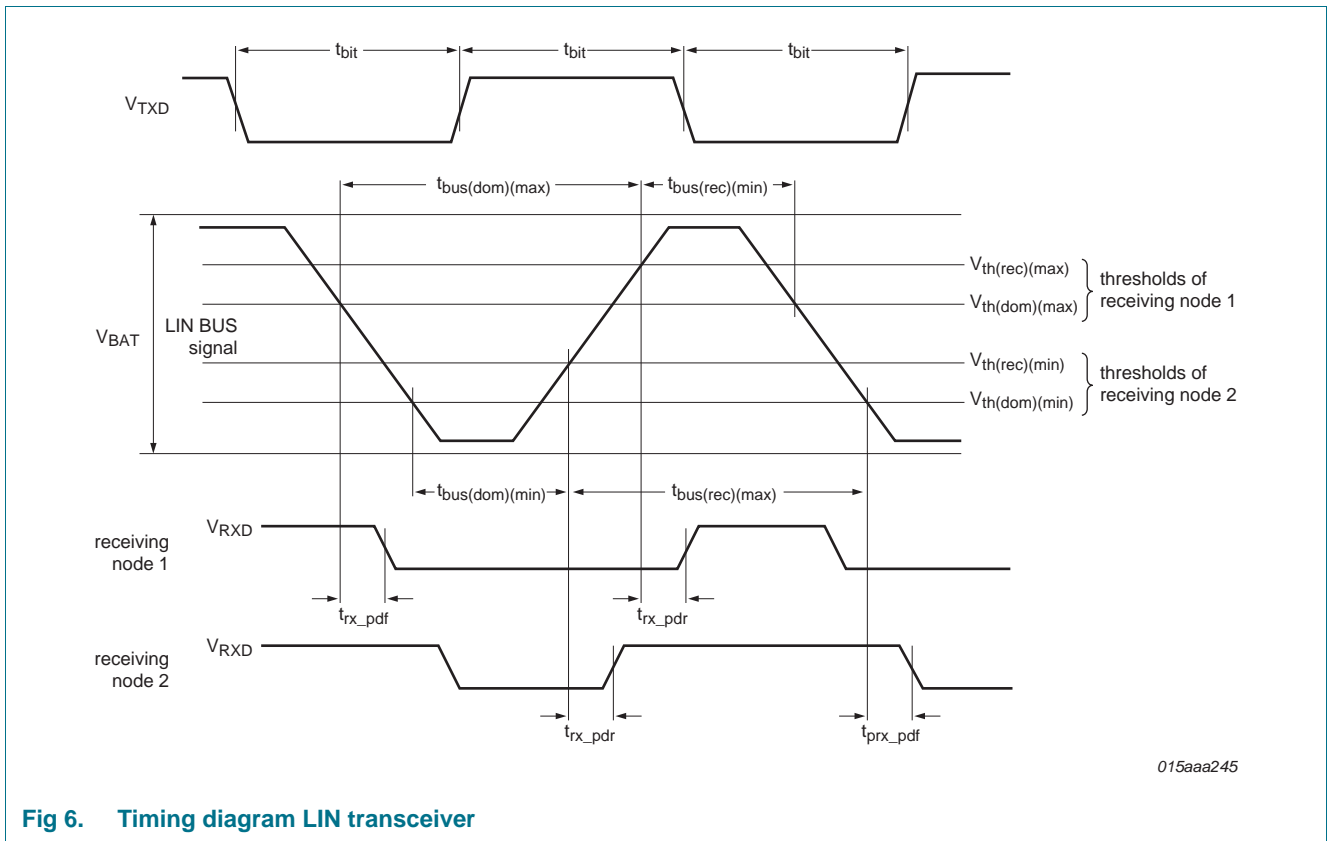
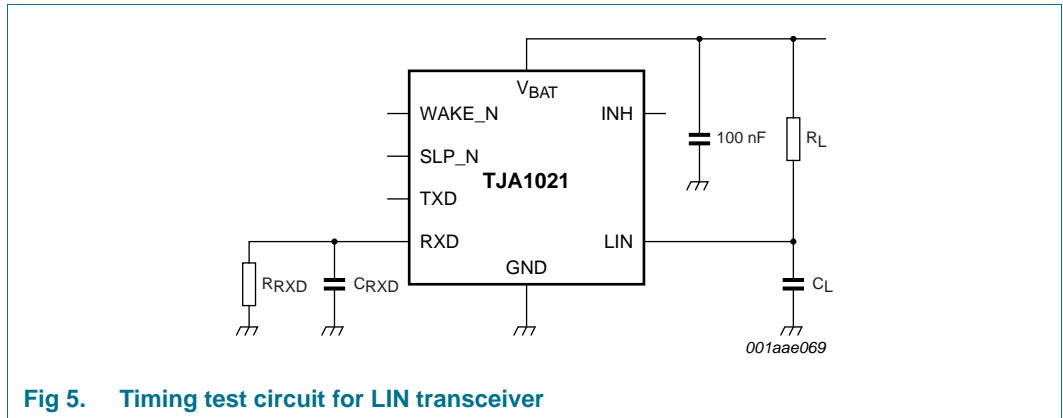
[3] $\delta 1, \delta 3 = \frac{t_{bus(rec)(min)}}{2 \times t_{bit}}$. Variable $t_{bus(rec)(min)}$ is illustrated in the LIN timing diagram in [Figure 6](#).

[4] Bus load conditions are: $C_{BUS} = 1\text{ nF}$ and $R_{BUS} = 1\text{ k}\Omega$; $C_{BUS} = 6.8\text{ nF}$ and $R_{BUS} = 660\ \Omega$; $C_{BUS} = 10\text{ nF}$ and $R_{BUS} = 500\ \Omega$.

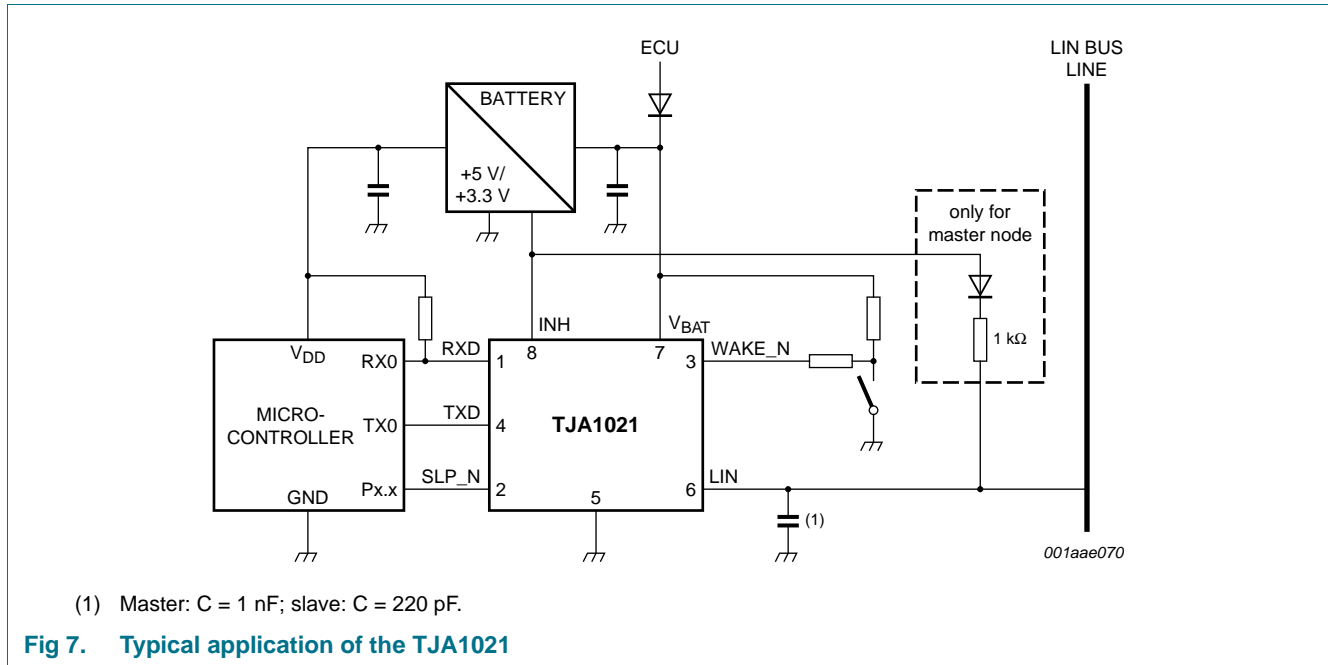
[5] $\delta 2, \delta 4 = \frac{t_{bus(rec)(max)}}{2 \times t_{bit}}$. Variable $t_{bus(rec)(max)}$ is illustrated in the LIN timing diagram in [Figure 6](#).

[6] Load condition pin RXD: $C_{RXD} = 20\text{ pF}$ and $R_{RXD} = 2.4\text{ k}\Omega$.

[7] For $V_{BAT} > 18\text{ V}$ the LIN transmitter might be suppressed. If TXD is HIGH then the LIN transmitter output is recessive.



12. Application information



13. Test information

Immunity against automotive transients (malfunction and damage) in accordance with LIN EMC Test Specification / Version 1.0; August 1, 2004.

The waveforms of the applied transients are according to ISO7637-2: Draft 2002-12, test pulses 1, 2a, 3a and 3b.

13.1 Quality information

This product has been qualified to the appropriate Automotive Electronics Council (AEC) standard Q100 or Q101 and is suitable for use in automotive applications.

14. Package outline

SO8: plastic small outline package; 8 leads; body width 3.9 mm

SOT96-1

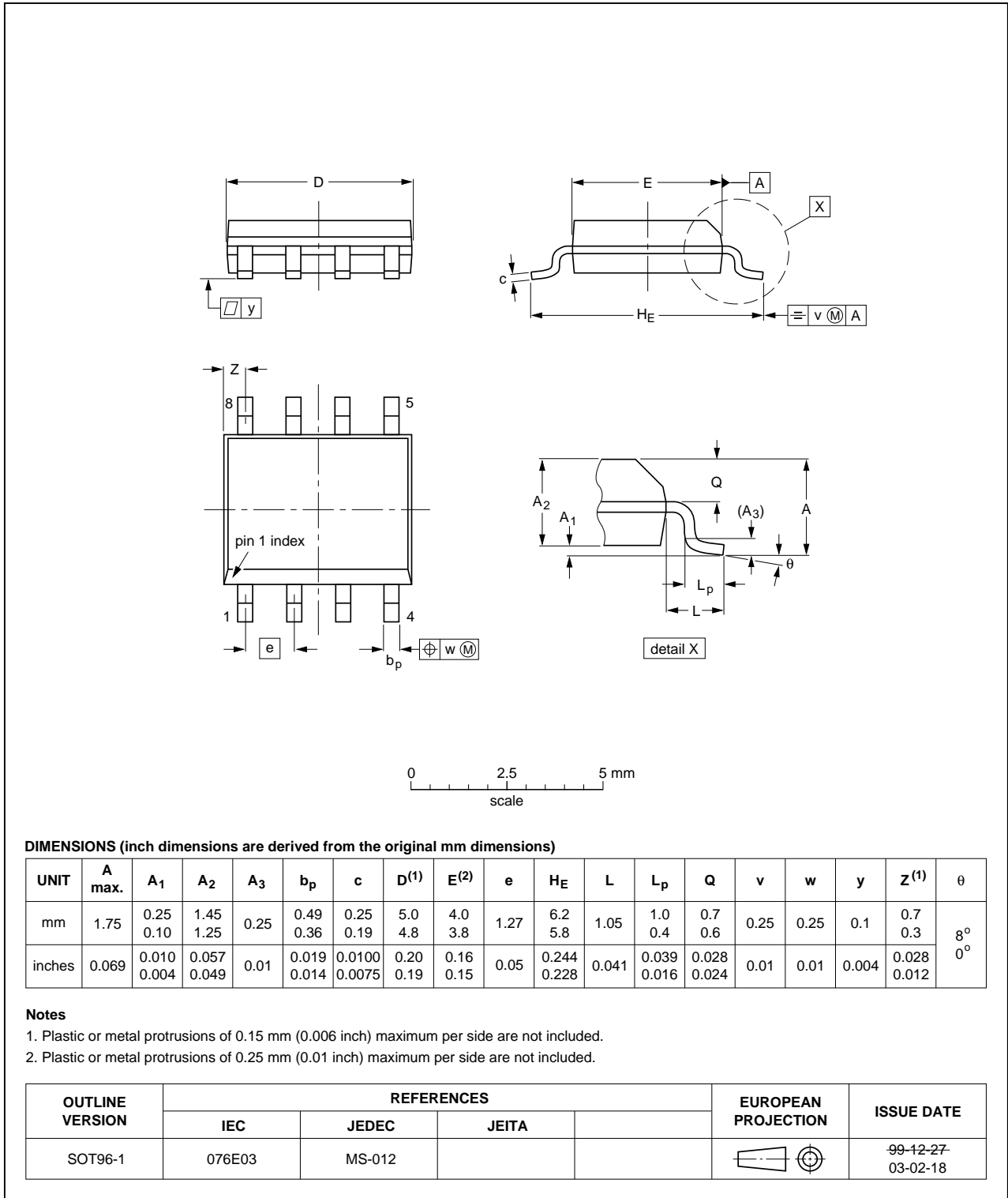


Fig 8. Package outline SOT96-1 (SO8)

HVSON8: plastic thermal enhanced very thin small outline package; no leads;
8 terminals; body 3 x 3 x 0.85 mm

SOT782-1

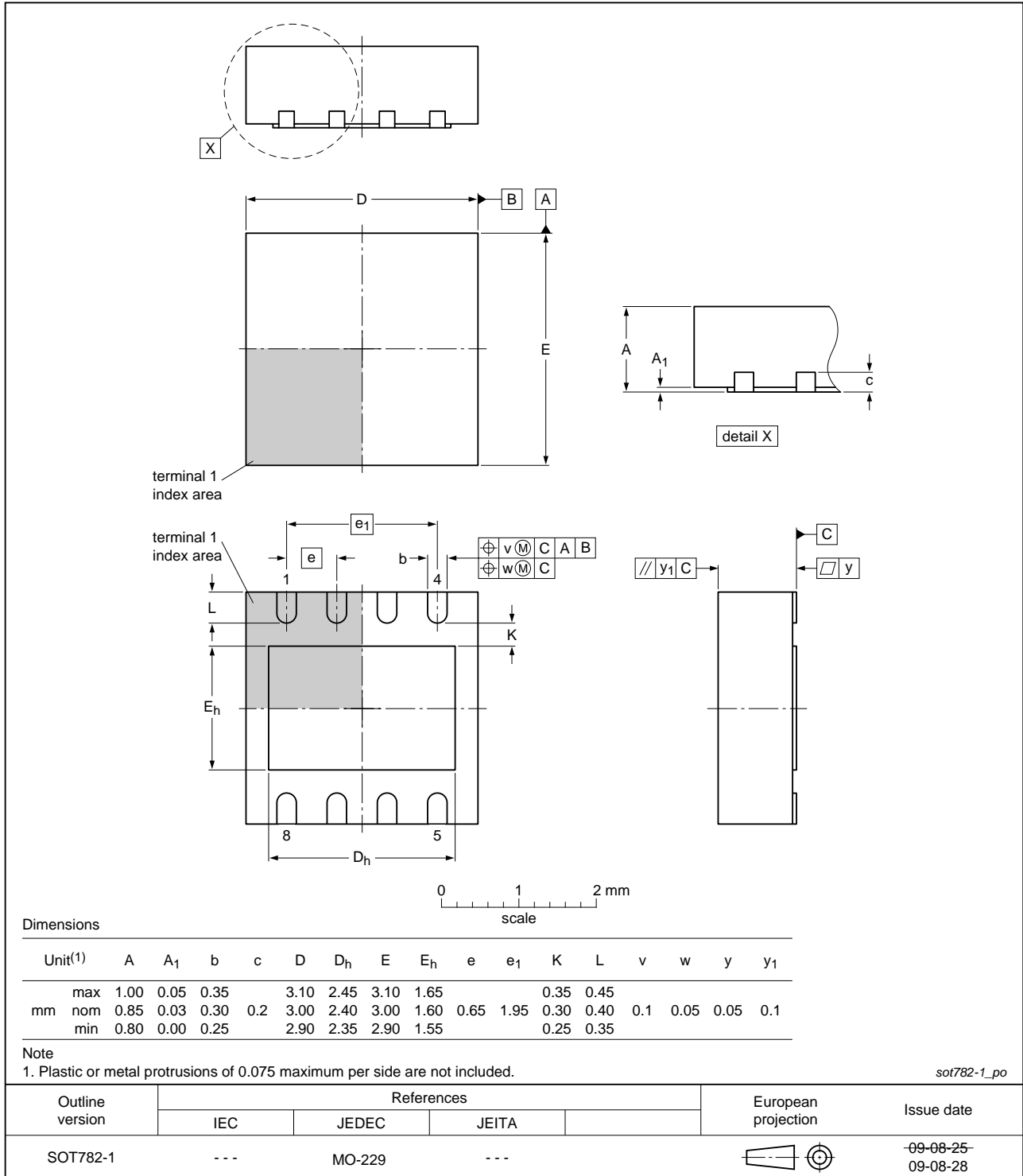


Fig 9. Package outline SOT782-1 (HVSON8)

15. Handling information

All input and output pins are protected against ElectroStatic Discharge (ESD) under normal handling. When handling ensure that the appropriate precautions are taken as described in *JESD625-A* or equivalent standards.

16. Soldering of SMD packages

This text provides a very brief insight into a complex technology. A more in-depth account of soldering ICs can be found in Application Note *AN10365 "Surface mount reflow soldering description"*.

16.1 Introduction to soldering

Soldering is one of the most common methods through which packages are attached to Printed Circuit Boards (PCBs), to form electrical circuits. The soldered joint provides both the mechanical and the electrical connection. There is no single soldering method that is ideal for all IC packages. Wave soldering is often preferred when through-hole and Surface Mount Devices (SMDs) are mixed on one printed wiring board; however, it is not suitable for fine pitch SMDs. Reflow soldering is ideal for the small pitches and high densities that come with increased miniaturization.

16.2 Wave and reflow soldering

Wave soldering is a joining technology in which the joints are made by solder coming from a standing wave of liquid solder. The wave soldering process is suitable for the following:

- Through-hole components
- Leaded or leadless SMDs, which are glued to the surface of the printed circuit board

Not all SMDs can be wave soldered. Packages with solder balls, and some leadless packages which have solder lands underneath the body, cannot be wave soldered. Also, leaded SMDs with leads having a pitch smaller than ~0.6 mm cannot be wave soldered, due to an increased probability of bridging.

The reflow soldering process involves applying solder paste to a board, followed by component placement and exposure to a temperature profile. Leaded packages, packages with solder balls, and leadless packages are all reflow solderable.

Key characteristics in both wave and reflow soldering are:

- Board specifications, including the board finish, solder masks and vias
- Package footprints, including solder thieves and orientation
- The moisture sensitivity level of the packages
- Package placement
- Inspection and repair
- Lead-free soldering versus SnPb soldering

16.3 Wave soldering

Key characteristics in wave soldering are:

- Process issues, such as application of adhesive and flux, clinching of leads, board transport, the solder wave parameters, and the time during which components are exposed to the wave
- Solder bath specifications, including temperature and impurities

16.4 Reflow soldering

Key characteristics in reflow soldering are:

- Lead-free versus SnPb soldering; note that a lead-free reflow process usually leads to higher minimum peak temperatures (see [Figure 10](#)) than a SnPb process, thus reducing the process window
- Solder paste printing issues including smearing, release, and adjusting the process window for a mix of large and small components on one board
- Reflow temperature profile; this profile includes preheat, reflow (in which the board is heated to the peak temperature) and cooling down. It is imperative that the peak temperature is high enough for the solder to make reliable solder joints (a solder paste characteristic). In addition, the peak temperature must be low enough that the packages and/or boards are not damaged. The peak temperature of the package depends on package thickness and volume and is classified in accordance with [Table 9](#) and [10](#)

Table 9. SnPb eutectic process (from J-STD-020C)

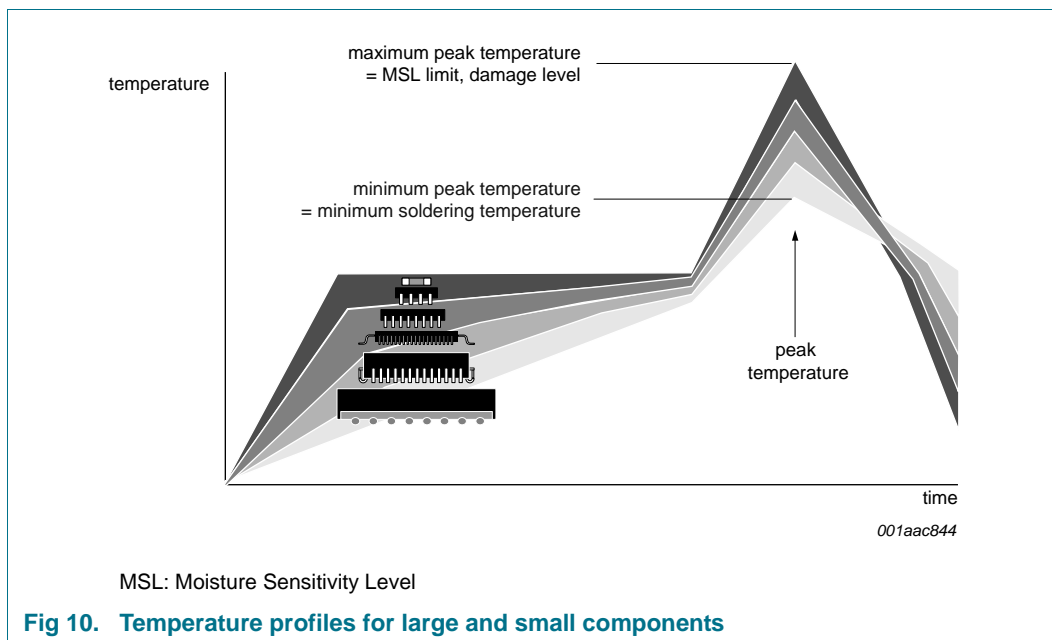
| Package thickness (mm) | Package reflow temperature (°C) | |
|------------------------|---------------------------------|-------|
| | Volume (mm ³) | |
| | < 350 | ≥ 350 |
| < 2.5 | 235 | 220 |
| ≥ 2.5 | 220 | 220 |

Table 10. Lead-free process (from J-STD-020C)

| Package thickness (mm) | Package reflow temperature (°C) | | |
|------------------------|---------------------------------|-------------|--------|
| | Volume (mm ³) | | |
| | < 350 | 350 to 2000 | > 2000 |
| < 1.6 | 260 | 260 | 260 |
| 1.6 to 2.5 | 260 | 250 | 245 |
| > 2.5 | 250 | 245 | 245 |

Moisture sensitivity precautions, as indicated on the packing, must be respected at all times.

Studies have shown that small packages reach higher temperatures during reflow soldering, see [Figure 10](#).



For further information on temperature profiles, refer to Application Note *AN10365* “*Surface mount reflow soldering description*”.

17. Soldering of HVSON packages

[Section 16](#) contains a brief introduction to the techniques most commonly used to solder Surface Mounted Devices (SMD). A more detailed discussion on soldering HVSON leadless package ICs can be found in the following application notes:

- *AN10365* “*Surface mount reflow soldering description*”
- *AN10366* “*HVQFN application information*”

18. Revision history

Table 11. Revision history

| Document ID | Release date | Data sheet status | Change notice | Supersedes |
|----------------|--------------|--|---------------|-------------|
| TJA1021 v.7 | 20110325 | Product data sheet | - | TJA1021 v.6 |
| Modifications: | | <ul style="list-style-type: none">• Section 2.1: features added• Table 5: parameter deleted - T_{amb}; conditions changed for V_{ESD}• Table 7, Table 8: parameter names, descriptions and table notes revised• Figure 6: revised (parameter names corrected) | | |
| TJA1021 v.6 | 20101230 | Product data sheet | - | TJA1021 v.5 |
| TJA1021 v.5 | 20091022 | Product data sheet | - | TJA1021 v.4 |
| TJA1021 v.4 | 20090119 | Product data sheet | - | TJA1021 v.3 |
| TJA1021 v.3 | 20071008 | Product data sheet | - | TJA1021 v.2 |
| TJA1021 v.2 | 20070903 | Preliminary data sheet | - | TJA1021 v.1 |
| TJA1021 v.1 | 20061016 | Objective data sheet | - | - |

19. Legal information

19.1 Data sheet status

| Document status ^{[1][2]} | Product status ^[3] | Definition |
|-----------------------------------|-------------------------------|---|
| Objective [short] data sheet | Development | This document contains data from the objective specification for product development. |
| Preliminary [short] data sheet | Qualification | This document contains data from the preliminary specification. |
| Product [short] data sheet | Production | This document contains the product specification. |

[1] Please consult the most recently issued document before initiating or completing a design.

[2] The term 'short data sheet' is explained in section "Definitions".

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21. Contents

| | | | | | |
|-----------|--|-----------|-----------|---------------------------|-----------|
| 1 | General description | 1 | 21 | Contents | 25 |
| 2 | Features and benefits | 1 | | | |
| 2.1 | General | 1 | | | |
| 2.2 | Low power management | 1 | | | |
| 2.3 | Protection mechanisms | 2 | | | |
| 3 | Quick reference data | 2 | | | |
| 4 | Ordering information | 2 | | | |
| 5 | Block diagram | 3 | | | |
| 6 | Pinning information | 4 | | | |
| 6.1 | Pinning | 4 | | | |
| 6.2 | Pin description | 4 | | | |
| 7 | Functional description | 5 | | | |
| 7.1 | Operating modes | 5 | | | |
| 7.2 | Sleep mode | 6 | | | |
| 7.3 | Standby mode | 6 | | | |
| 7.4 | Normal mode | 7 | | | |
| 7.5 | Wake-up | 7 | | | |
| 7.6 | Remote and local wake-up | 7 | | | |
| 7.7 | Wake-up via mode transition | 8 | | | |
| 7.8 | Wake-up source recognition | 8 | | | |
| 7.9 | TXD dominant time-out function | 8 | | | |
| 7.10 | Fail-safe features | 8 | | | |
| 8 | Limiting values | 10 | | | |
| 9 | Thermal characteristics | 10 | | | |
| 10 | Static characteristics | 11 | | | |
| 11 | Dynamic characteristics | 13 | | | |
| 12 | Application information | 16 | | | |
| 13 | Test information | 16 | | | |
| 13.1 | Quality information | 16 | | | |
| 14 | Package outline | 17 | | | |
| 15 | Handling information | 19 | | | |
| 16 | Soldering of SMD packages | 19 | | | |
| 16.1 | Introduction to soldering | 19 | | | |
| 16.2 | Wave and reflow soldering | 19 | | | |
| 16.3 | Wave soldering | 19 | | | |
| 16.4 | Reflow soldering | 20 | | | |
| 17 | Soldering of HVSON packages | 21 | | | |
| 18 | Revision history | 22 | | | |
| 19 | Legal information | 23 | | | |
| 19.1 | Data sheet status | 23 | | | |
| 19.2 | Definitions | 23 | | | |
| 19.3 | Disclaimers | 23 | | | |
| 19.4 | Trademarks | 24 | | | |
| 20 | Contact information | 24 | | | |

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