

# TJA1028

## LIN transceiver with integrated voltage regulator

Rev. 4 — 25 July 2012

Product data sheet

### 1. General description

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The TJA1028 is a LIN 2.0/2.1/SAE J2602 transceiver with an integrated low-drop voltage regulator. The voltage regulator can deliver up to 70 mA and is available in 3.3 V and 5.0 V variants. TJA1028 facilitates the development of compact nodes in Local Interconnect Network (LIN) bus systems. To support robust designs, the TJA1028 offers strong ElectroStatic Discharge (ESD) performance and can withstand high voltages on the LIN bus. In order to minimize current consumption, the TJA1028 supports a Sleep mode in which the LIN transceiver and the voltage regulator are powered down while still having wake-up capability via the LIN bus.

The TJA1028 comes in an SO8 package, and also in a 3 mm × 3 mm HVSON8 package that reduces the required board space by over 70 %. This feature can prove extremely valuable when board space is limited.

### 2. Features and benefits

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- LIN 2.0/2.1/2.2 compliant
- SAE J2602 compliant
- Downward compatible with LIN 1.3
- Internal LIN slave termination resistor
- Voltage regulator offering 5 V or 3.3 V, 70 mA capability
- $\pm 2$  % voltage regulator accuracy over specified temperature and supply ranges
- Voltage regulator output undervoltage detection with reset output
- Voltage regulator is short-circuit proof to ground
- Voltage regulator stable with ceramic, tantalum and aluminum electrolyte capacitors
- Robust ESD performance;  $\pm 8$  kV according to IEC61000-4-2 for pins LIN and  $V_{BAT}$
- Pins LIN and  $V_{BAT}$  protected against transients in the automotive environment (ISO 7637)
- Very low LIN bus leakage current of  $< 2 \mu A$  when battery not connected
- LIN pin short-circuit proof to battery and ground
- Transmit data (TXD) dominant time-out function
- Thermally protected
- Very low ElectroMagnetic Emission (EME)
- High ElectroMagnetic Immunity (EMI)
- Typical Standby mode current of  $45 \mu A$
- Typical Sleep mode current of  $12 \mu A$
- LIN bus wake-up function
- K-line compatible
- Available in SO8 and HVSON8 packages



- Leadless HVSON8 package (3.0 mm × 3.0 mm) with improved Automated Optical Inspection (AOI) capability
- Dark green product (halogen free and Restriction of Hazardous Substances (RoHS) compliant)

### 3. Ordering information

Table 1. Ordering information

| Type number                        | Package |   |          |
|------------------------------------|---------|---|----------|
|                                    | Name    | Description   | Version  |
| TJA1028T/xxx/xx <sup>[1][2]</sup>  | SO8     | plastic small outline package; 8 leads; body width 3.9 mm   | SOT96-1  |
| TJA1028TK/xxx/xx <sup>[1][2]</sup> | HVSON8  | plastic thermal enhanced very thin small outline package; no leads; 8 terminals; body 3 × 3 × 0.85 mm | SOT782-1 |

- [1] TJA1028T/5V0/xx and TJA1028TK/5V0/xx for the versions with the 5 V regulator; TJA1028T/3V3/xx and TJA1028TK/3V3/xx for the versions with the 3.3 V regulator.
- [2] TJA1028T/xxx/20 and TJA1028TK/xxx/20 for the normal slope versions that support baud rates up to 20 kBd; TJA1028T/xxx/10 and TJA1028TK/xxx/10 for the low slope versions that support baud rates up to 10.4 kBd (SAE J2602).

### 4. Marking

Table 2. Marking codes

| Type number      | Marking |
|------------------|---------|
| TJA1028T/5V0/10  | 1028/51 |
| TJA1028T/5V0/20  | 1028/52 |
| TJA1028T/3V3/10  | 1028/31 |
| TJA1028T/3V3/20  | 1028/32 |
| TJA1028TK/5V0/10 | 28/51   |
| TJA1028TK/5V0/20 | 28/52   |
| TJA1028TK/3V3/10 | 28/31   |
| TJA1028TK/3V3/20 | 28/32   |

5. Block diagram

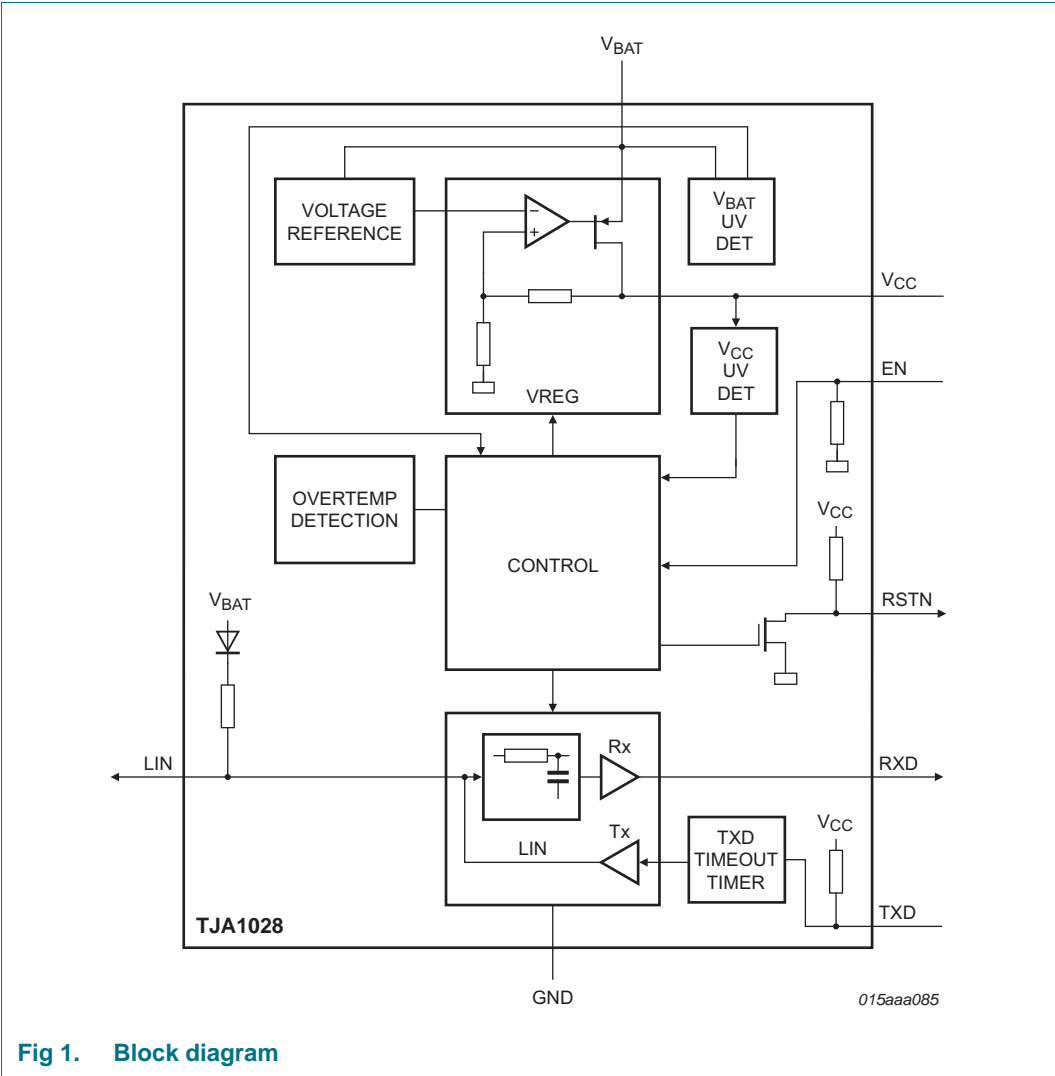
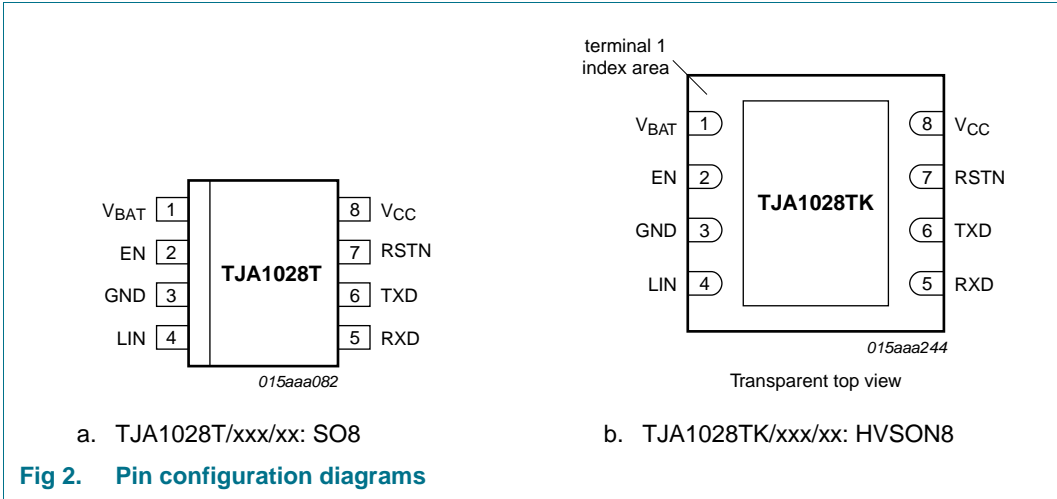


Fig 1. Block diagram

6. Pinning information

6.1 Pinning



6.2 Pin description

Table 3. Pin description

| Symbol           | Pin              | Description                    |
|------------------|------------------|--------------------------------|
| V <sub>BAT</sub> | 1                | battery supply for the TJA1028 |
| EN               | 2                | enable input                   |
| GND              | 3 <sup>[1]</sup> | ground                         |
| LIN              | 4                | LIN bus line                   |
| RXD              | 5                | LIN receive data output        |
| TXD              | 6                | LIN transmit data input        |
| RSTN             | 7                | reset output (active LOW)      |
| V <sub>CC</sub>  | 8                | voltage regulator output       |

[1] For enhanced thermal and electrical performance, the exposed center pad of the HVSON8 package should be soldered to board ground (and not to any other voltage level).

7. Functional description

The TJA1028 combines the functionality of a LIN transceiver and a voltage regulator in a single chip and offers wake-up by bus activity. The voltage regulator is designed to power the Electronic Control Unit's (ECU) microcontroller and its peripherals.

The LIN transceiver is the interface between a LIN master/slave protocol controller and the physical bus in a LIN network. According to the Open System Interconnect (OSI) model, these modules make up the LIN physical layer.

The TJA1028T/xxx/20 and TJA1028TK/xxx/20 versions are optimized for a transmission speed of 20 kBd, the maximum specified in the LIN standard. The TJA1028T/xxx/10 and TJA1028TK/xxx/10 versions are optimized for a transmission speed of 10.4 kBd, as specified in SAE J2602. All versions achieve optimum ElectroMagnetic Compatibility (EMC) performance by wave shaping the LIN output.

## 7.1 LIN 2.x/SAE J2602 compliant

The TJA1028 is fully LIN 2.0, LIN 2.1, LIN 2.2 and SAE J2602 compliant. Since the LIN physical layer is independent of higher OSI model layers (e.g. the LIN protocol), nodes containing a LIN 2.2-compliant physical layer can be combined, without restriction, with LIN physical layer nodes that comply with earlier revisions (i.e. LIN 1.0, LIN 1.1, LIN 1.2, LIN 1.3, LIN 2.0 and LIN 2.1).

## 7.2 Operating modes

The TJA1028 supports four operating modes: Normal, Standby, Sleep and Off. The operating modes, and the transitions between modes, are illustrated in [Figure 3](#).

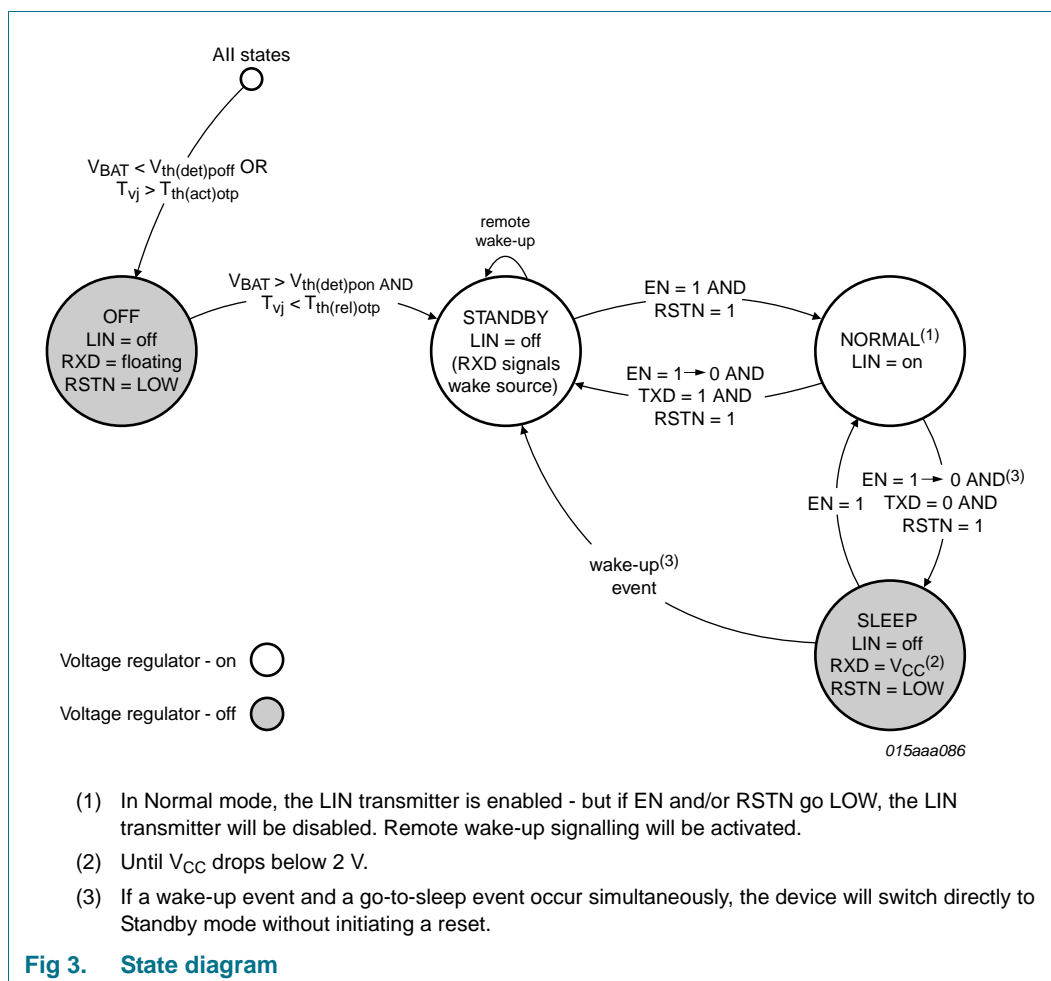


Fig 3. State diagram

### 7.2.1 Off mode

The TJA1028 switches to Off mode from all other modes if the battery supply voltage drops below the power-off detection threshold ( $V_{th(det)poff}$ ) or the junction temperature exceeds the overtemperature protection activation threshold ( $T_{th(act)otp}$ ).

The voltage regulator and the LIN physical layer are disabled in Off mode, and pin RSTN is forced LOW.

### 7.2.2 Standby mode

Standby mode is a low-power mode that guarantees very low current consumption.

The TJA1028 switches from Off mode to Standby mode as soon as the battery supply voltage rises above the power-on detection threshold ( $V_{BAT} > V_{th(det)pon}$ ), provided the junction temperature is below the overtemperature protection release threshold ( $T_{vj} < T_{th(rel)otp}$ ).

The TJA1028 switches to Standby mode from Normal mode during the mode select window if TXD is HIGH and EN is LOW (see [Section 7.2.5](#)), provided RSTN = 1.

A remote wake-up event will trigger a transition to Standby mode from Sleep mode. The remote wake-up event will be signalled by a continuous LOW level on pin RXD.

In Standby mode, the voltage regulator is on, the LIN physical layer is disabled and remote wake-up detection is active. The wake-up source is indicated by the level on RXD (LOW indicates a remote wake-up).

### 7.2.3 Normal mode

If the EN pin is pulled HIGH while the TJA1028 is in Standby mode (with RSTN = 1) or Sleep mode, the device will enter Normal mode. The LIN physical layer and the voltage regulator are enabled in Normal mode.

#### 7.2.3.1 The LIN transceiver in Normal mode

The LIN transceiver is activated when the TJA1028 enters Normal mode.

In Normal mode, the transceiver can transmit and receive data via the LIN bus. The receiver detects data streams on the LIN pin and transfers them to the microcontroller via pin RXD. LIN recessive is represented by a HIGH level on RXD, LIN dominant by a LOW level.

The transmit data streams of the protocol controller at the TXD input are converted by the transmitter into bus signals with optimized slew rate and wave shaping to minimize EME. A LOW level at the TXD input is converted to a LIN dominant level while a HIGH level is converted to a LIN recessive level.

### 7.2.4 Sleep mode

Sleep mode features extremely low power consumption.

The TJA1028 switches to Sleep mode from Normal mode during the mode select window if TXD and EN are both LOW (see [Section 7.2.5](#)), provided RSTN = 1.

The voltage regulator and the LIN physical layer are disabled in Sleep mode. Pin RSTN is forced LOW. Remote wake-up detection is active.

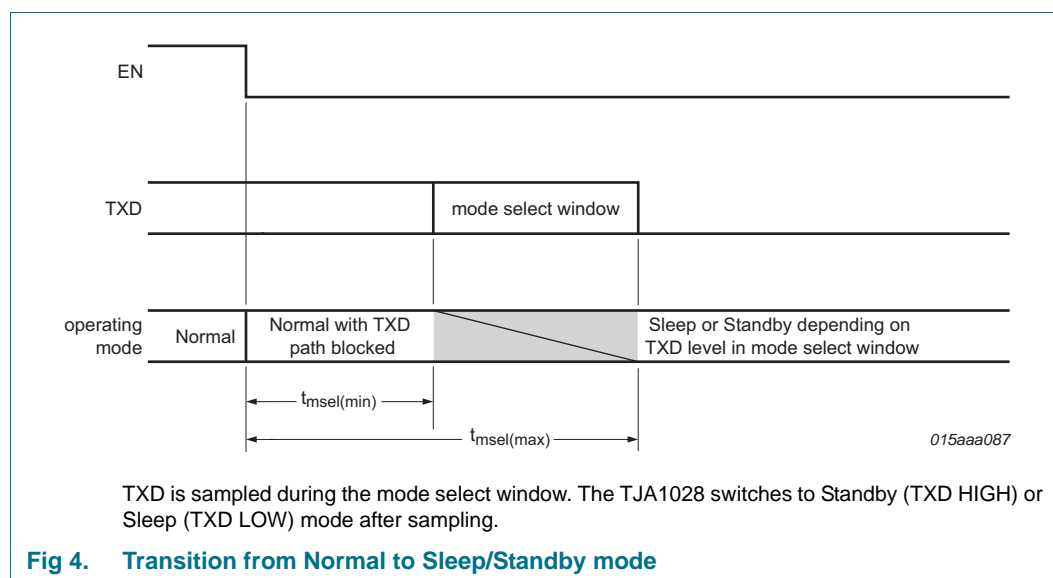
### 7.2.5 Transition from Normal to Sleep or Standby mode

When EN is driven LOW in Normal mode, the TJA1028 disables the transmit path. The mode select window opens  $t_{msel(min)}$  after EN goes LOW, and remains open until  $t_{msel(max)}$  after EN goes LOW (see [Figure 4](#)).

The TXD pin is sampled in the mode select window. A transition to Standby mode is triggered if TXD is HIGH, or to Sleep mode if TXD is LOW.

To avoid complicated timing in the application, EN and TXD can be pulled LOW at the same time without having any effect on the LIN bus. In order to ensure that the remote wake-up time ( $t_{wake(dom)LIN}$ ) is not reset on a transition to Sleep mode, TXD should be pulled LOW at least  $t_{d(EN-TXD)}$  after EN goes LOW. This is guaranteed by design.

The user must ensure the appropriate level is present on pin TXD while the mode select window is open.



**Fig 4. Transition from Normal to Sleep/Standby mode**

## 7.3 Power supplies

### 7.3.1 Battery (pin $V_{BAT}$ )

The TJA1028 contains a single supply pin,  $V_{BAT}$ . An external diode is needed in series to protect the device against negative voltages. The operating range is from 4.5 V to 28 V. The TJA1028 can handle voltages up to 40 V (max). If the voltage on pin  $V_{BAT}$  falls below  $V_{th(det)poff}$ , the TJA1028 switches to Off mode, shutting down the internal logic and the voltage regulator and disabling the LIN transmitter. The TJA1028 exits Off mode as soon as the voltage rises above  $V_{th(det)pon}$ , provided the junction temperature is below  $T_{th(rel)otp}$ .

### 7.3.2 Voltage regulator (pin $V_{CC}$ )

The TJA1028 contains a voltage regulator supplied via pin  $V_{BAT}$ , which delivers up to 70 mA. It is designed to supply the microcontroller and its periphery via pin  $V_{CC}$ .

### 7.3.3 Reset (pin RSTN)

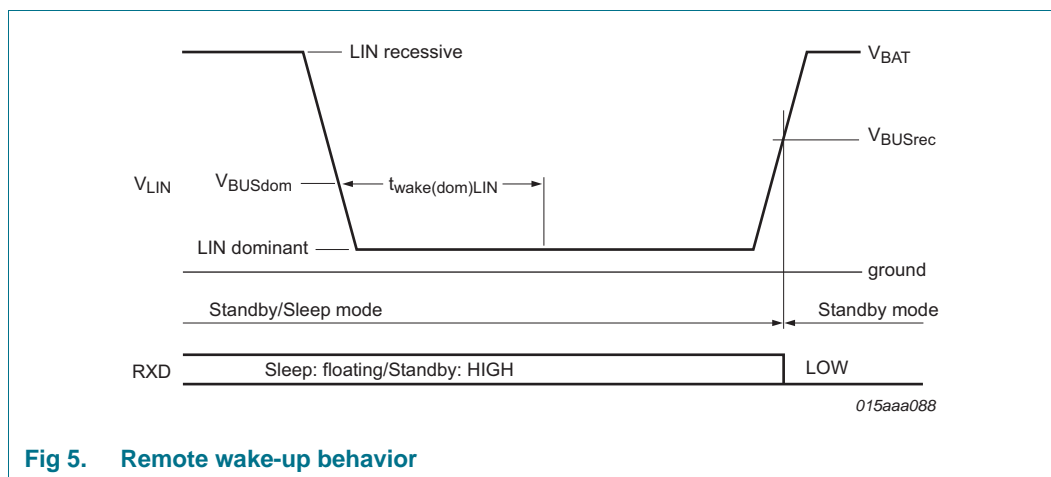
The output voltage on pin  $V_{CC}$  is monitored continuously and a system reset signal is generated (pin RSTN goes LOW) if an undervoltage event is detected ( $V_{CC} < V_{uvd}$  for  $t_{det(uv)(V_{CC})}$ ). Pin RSTN will go HIGH again once the voltage on  $V_{CC}$  exceeds the undervoltage recovery threshold ( $V_{uvr}$ ) for  $t_{rst}$ .

## 7.4 LIN transceiver

The transceiver is the interface between a LIN master/slave protocol controller and the physical bus in a LIN network. It is primarily intended for in-vehicle sub-networks using baud rates from 2.4 kBd up to 20 kBd and is LIN 2.0/LIN 2.1/SAE J2602 compliant.

## 7.5 Remote wake-up

A remote wake-up is triggered by a falling edge on pin LIN, followed by LIN remaining LOW for at least  $t_{wake(dom)LIN}$ , followed by a rising edge on pin LIN (see [Figure 5](#)).



**Fig 5. Remote wake-up behavior**

The remote wake-up request is communicated to the microcontroller in Standby mode by a continuous LOW level on pin RXD.

Note that  $t_{wake(dom)LIN}$  is measured in Sleep and Standby modes, and in Normal mode if TXD is HIGH.

## 7.6 Fail-safe features

### 7.6.1 General fail-safe features

The following general fail-safe features have been implemented:

- An internal pull-up towards  $V_{CC}$  on pin TXD guarantees a recessive bus level if the pin is left floating by a bad solder joint or floating microcontroller port pin.
- The current in the transmitter output stage is limited in order to protect the transmitter against short circuits to pin  $V_{BAT}$ .
- A loss of power (pins  $V_{BAT}$  and GND) has no impact on the bus line or on the microcontroller. There will be no reverse currents from the bus.
- The LIN transmitter is automatically disabled when either EN or RSTN is LOW.



- After a transition to Normal mode, the LIN transmitter is only enabled if a recessive level is present on pin TXD.

### 7.6.2 TXD dominant time-out function

A TXD dominant time-out timer circuit prevents the bus line being driven to a permanent dominant state (blocking all network communications) if TXD is forced permanently LOW by a hardware or software application failure. The timer is triggered by a negative edge on the TXD pin. If the pin remains LOW for longer than the TXD dominant time-out time ( $t_{to(dom)TXD}$ ), the transmitter is disabled, driving the bus line to a recessive state. The timer is reset by a positive edge on TXD.

### 7.6.3 Temperature protection

The temperature of the IC is monitored in Normal, Standby and Off modes. If the temperature is too high ( $T_{vj} > T_{th(act)otp}$ ), the TJA1028 will switch to Off mode (if in Standby or Normal modes). The voltage regulator and the LIN transmitter will be switched off and the RSTN pin driven LOW.

When the temperature falls below the overtemperature protection release threshold ( $T_{vj} < T_{th(rel)otp}$ ), the TJA1028 switches to Standby mode.

## 8. Limiting values

**Table 4. Limiting values**

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

| Symbol    | Parameter                       | Conditions   | Min      | Max            | Unit |
|-----------|---------------------------------|--|----------|----------------|------|
| $V_{BAT}$ | battery supply voltage          | DC; continuous   | -0.3     | +40            | V    |
| $V_x$     | voltage on pin x                | DC value   |          |                |      |
|           |                                 | pin $V_{CC}$   | -0.3     | +7             | V    |
|           |                                 | pins TXD, RXD, RSTN and EN                             | -0.3     | $V_{CC} + 0.3$ | V    |
|           |                                 | pin LIN with respect to GND                            | -40      | +40            | V    |
| $V_{ESD}$ | electrostatic discharge voltage | HBM  | [1]      |                |      |
|           |                                 | at pins LIN and $V_{BAT}$                              | [2] -8   | +8             | kV   |
|           |                                 | at any other pin                                       | -2       | +2             | kV   |
|           |                                 | IEC 61000-4-2  | [3]      |                |      |
|           |                                 | at pins LIN and $V_{BAT}$                              | -8       | +8             | kV   |
|           |                                 | MM   | [4]      |                |      |
|           |                                 | at any pin   | -250     | +250           | V    |
|           |                                 | CDM  | [5]      |                |      |
|           |                                 | at corner pins   | -750     | +750           | V    |
| $V_{trt}$ | transient voltage               | on pin $V_{BAT}$ via reverse polarity diode/capacitor; | [6] -150 | +100           | V    |
|           |                                 | on pin LIN via 1 nF coupling capacitor                 |          |                |      |
| $T_{vj}$  | virtual junction temperature    |  | [7] -40  | +150           | °C   |
| $T_{stg}$ | storage temperature             |  | -55      | +150           | °C   |

[1] Human Body Model (HBM): according to AEC-Q100-002 (100 pF, 1.5 kΩ).

[2]  $V_{CC}$  and  $V_{BAT}$  connected to GND, emulating application circuit.

- [3] ESD performance of pins LIN and V<sub>BAT</sub> according to IEC 61000-4-2 (150 pF, 330 Ω) has been verified by an external test house.
- [4] Machine Model (MM): according to AEC-Q100-003 (200 pF, 0.75 μH, 10 Ω).
- [5] Charged Device Model (CDM): according to AEC-Q100-011 (field induced charge; 4 pF).
- [6] Verified by an external test house to ensure pins can withstand ISO 7637 part 2 automotive transient test pulses 1, 2a, 3a and 3b.
- [7] 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<sub>vj</sub> limits the allowable combinations of power dissipation (P) and ambient temperature (T<sub>amb</sub>).

## 9. Thermal characteristics

**Table 5. Thermal characteristics**

| Symbol               | Parameter                                   | Conditions                 | Typ     | Unit |
|----------------------|---|----------------------------|---------|------|
| R <sub>th(j-a)</sub> | thermal resistance from junction to ambient | SO8; single-layer board    | [1] 132 | K/W  |
|                      |   | SO8; four-layer board      | [2] 93  | K/W  |
|                      |   | HVSON8; single-layer board | [1] 129 | K/W  |
|                      |   | HVSON8; four-layer board   | [3] 67  | K/W  |

- [1] According to JEDEC JESD51-2 and JESD51-3 at natural convection on 1s board.
- [2] According to JEDEC JESD51-2, JESD51-5 and JESD51-7 at natural convection on 2s2p board. Board with two inner copper layers (thickness: 35 μm) and thermal via array under the package connected to the first inner copper layer.
- [3] According to JEDEC JESD51-2, JESD51-5 and JESD51-7 at natural convection on 2s2p board. Board with two inner copper layers (thickness: 35 μm) and thermal via array under the exposed pad connected to the first inner copper layer.

## 10. Static characteristics

**Table 6. Static characteristics**

V<sub>BAT</sub> = 5.5 V to 28 V; T<sub>vj</sub> = -40 °C to +150 °C; R<sub>L(LIN-VBAT)</sub> = 500 Ω; all voltages are defined with respect to ground; positive currents flow into the IC; typical values are given at V<sub>BAT</sub> = 12 V; unless otherwise specified.

| Symbol                             | Parameter                             | Conditions  | Min   | Typ | Max   | Unit |
|------------------------------------|---------------------------------------|---|-------|-----|-------|------|
| <b>Supply; pin V<sub>BAT</sub></b> |                                       |   |       |     |       |      |
| I <sub>BAT</sub>                   | battery supply current                | Standby mode; V <sub>LIN</sub> = V <sub>BAT</sub>   | -     | 45  | 59    | μA   |
|                                    |                                       | Sleep mode; V <sub>LIN</sub> = V <sub>BAT</sub>   | -     | 12  | 18    | μA   |
|                                    |                                       | Normal mode; bus recessive; V <sub>LIN</sub> = V <sub>BAT</sub> ; V <sub>RXD</sub> = V <sub>CC</sub> ; V <sub>RSTN</sub> = HIGH | -     | 850 | 1800  | μA   |
|                                    |                                       | Normal mode; bus dominant; V <sub>BAT</sub> = 12 V; V <sub>TXD</sub> = 0 V; V <sub>RSTN</sub> = HIGH                            | -     | 2.0 | 4.5   | mA   |
| V <sub>th(det)pon</sub>            | power-on detection threshold voltage  |   | -     | -   | 5.25  | V    |
| V <sub>th(det)poff</sub>           | power-off detection threshold voltage |   | 3     | -   | 4.2   | V    |
| V <sub>hys(det)pon</sub>           | power-on detection hysteresis voltage | V <sub>BAT</sub> = 2 V to 28 V  | 50    | -   | -     | mV   |
| <b>Supply; pin V<sub>CC</sub></b>  |                                       |   |       |     |       |      |
| V <sub>CC</sub>                    | supply voltage                        | V <sub>CC(nom)</sub> = 5 V; I <sub>VCC</sub> = -70 mA to 0 mA   | 4.9   | 5   | 5.1   | V    |
|                                    |                                       | V <sub>CC(nom)</sub> = 3.3 V; V <sub>BAT</sub> = 4.5 V to 28 V; I <sub>VCC</sub> = -70 mA to 0 mA                               | 3.234 | 3.3 | 3.366 | V    |
|                                    |                                       |   |       |     |       |      |
| I <sub>olim</sub>                  | output current limit                  | V <sub>CC</sub> = 0 V to 5.5 V  | -250  | -   | -70   | mA   |

**Table 6.** Static characteristics ...continued

$V_{BAT} = 5.5 \text{ V to } 28 \text{ V}$ ;  $T_{vj} = -40 \text{ }^{\circ}\text{C to } +150 \text{ }^{\circ}\text{C}$ ;  $R_{L(LIN-VBAT)} = 500 \text{ }\Omega$ ; 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.

| Symbol                                  | Parameter  | Conditions   | Min                 | Typ | Max                 | Unit          |
|---|--|--|---------------------|-----|---------------------|---------------|
| $V_{uvd}$                               | undervoltage detection voltage                                     | $V_{CC(nom)} = 5 \text{ V}$  | 4.5                 | -   | 4.75                | V             |
|   |  | $V_{CC(nom)} = 3.3 \text{ V}$  | 2.97                | -   | 3.135               | V             |
| $V_{uvr}$                               | undervoltage recovery voltage                                      | $V_{CC(nom)} = 5 \text{ V}$  | 4.6                 | -   | 4.9                 | V             |
|   |  | $V_{CC(nom)} = 3.3 \text{ V}$  | 3.036               | -   | 3.234               | V             |
| $R_{(VBAT-VCC)}$                        | resistance between pin $V_{BAT}$ and pin $V_{CC}$                  | $V_{CC(nom)} = 5 \text{ V}$ ; $V_{BAT} = 4.5 \text{ V to } 5.5 \text{ V}$ ; $I_{VCC} = -70 \text{ mA to } -5 \text{ mA}$ ; regulator in saturation   | [1]                 |     |                     |               |
|   |  | $T_{vj} = 85 \text{ }^{\circ}\text{C}$   | -                   | -   | 7                   | $\Omega$      |
|   |  | $T_{vj} = 150 \text{ }^{\circ}\text{C}$  | -                   | -   | 9                   | $\Omega$      |
| $C_o$                                   | output capacitance   | equivalent series resistance $< 5 \text{ }\Omega$  | [2] 1.8             | 10  | -                   | $\mu\text{F}$ |
| <b>LIN transmit data input; pin TXD</b> |  |  |                     |     |                     |               |
| $V_{th(sw)}$                            | switching threshold voltage  | $V_{CC} = 2.97 \text{ V to } 5.5 \text{ V}$  | $0.3 \times V_{CC}$ | -   | $0.7 \times V_{CC}$ | V             |
| $V_{hys(i)}$                            | input hysteresis voltage   | $V_{CC} = 2.97 \text{ V to } 5.5 \text{ V}$  | 200                 | -   | -                   | mV            |
| $R_{pu}$                                | pull-up resistance   |  | 5                   | 12  | 25                  | k $\Omega$    |
| <b>LIN receive data output; pin RXD</b> |  |  |                     |     |                     |               |
| $I_{OH}$                                | HIGH-level output current  | Normal mode;<br>$V_{LIN} = V_{BAT}$ ; $V_{RXD} = V_{CC} - 0.4 \text{ V}$   | -                   | -   | -0.4                | mA            |
| $I_{OL}$                                | LOW-level output current   | Normal mode;<br>$V_{LIN} = \text{GND}$ ; $V_{RXD} = 0.4 \text{ V}$   | 0.4                 | -   | -                   | mA            |
| <b>Enable input; pin EN</b>             |  |  |                     |     |                     |               |
| $V_{th(sw)}$                            | switching threshold voltage  |  | 0.8                 | -   | 2                   | V             |
| $R_{pd}$                                | pull-down resistance   |  | 50                  | 130 | 400                 | k $\Omega$    |
| <b>Reset output; pin RSTN</b>           |  |  |                     |     |                     |               |
| $R_{pu}$                                | pull-up resistance   | $V_{RSTN} = V_{CC} - 0.4 \text{ V}$ ;<br>$V_{CC} = 2.97 \text{ V to } 5.5 \text{ V}$   | 3                   | -   | 12                  | k $\Omega$    |
| $I_{OL}$                                | LOW-level output current   | $V_{RSTN} = 0.4 \text{ V}$ ; $V_{CC} = 2.97 \text{ V to } 5.5 \text{ V}$ ;<br>$-40 \text{ }^{\circ}\text{C} < T_{vj} < 195 \text{ }^{\circ}\text{C}$ | 3.2                 | -   | 40                  | mA            |
| $V_{OL}$                                | LOW-level output voltage   | $V_{CC} = 2.5 \text{ V to } 5.5 \text{ V}$ ;<br>$-40 \text{ }^{\circ}\text{C} < T_{vj} < 195 \text{ }^{\circ}\text{C}$                               | 0                   | -   | 0.5                 | V             |
| $V_{OH}$                                | HIGH-level output voltage  | $-40 \text{ }^{\circ}\text{C} < T_{vj} < 195 \text{ }^{\circ}\text{C}$   | $0.8 \times V_{CC}$ | -   | $V_{CC} + 0.3$      | V             |
| <b>LIN bus line; pin LIN</b>            |  |  |                     |     |                     |               |
| $I_{BUS\_LIM}$                          | current limitation for driver dominant state                       | $V_{BAT} = V_{LIN} = 18 \text{ V}$ ; $V_{TXD} = 0 \text{ V}$   | 40                  | -   | 100                 | mA            |
| $I_{BUS\_PAS\_rec}$                     | receiver recessive input leakage current                           | $V_{LIN} = 18 \text{ V}$ ; $V_{BAT} = 5.5 \text{ V}$ ; $V_{TXD} = V_{CC}$  | -                   | -   | 2                   | $\mu\text{A}$ |
| $I_{BUS\_PAS\_dom}$                     | receiver dominant input leakage current including pull-up resistor | Normal mode;<br>$V_{TXD} = V_{CC}$ ; $V_{LIN} = 0 \text{ V}$ ; $V_{BAT} = 12 \text{ V}$  | -600                | -   | -                   | $\mu\text{A}$ |
| $I_{BUS\_NO\_GND}$                      | loss-of-ground bus current   | $V_{BAT} = 18 \text{ V}$ ; $V_{LIN} = 0 \text{ V}$   | -750                | -   | +10                 | $\mu\text{A}$ |
| $I_{BUS\_NO\_BAT}$                      | loss-of-battery bus current  | $V_{BAT} = 0 \text{ V}$ ; $V_{LIN} = 18 \text{ V}$   | -                   | -   | 2                   | $\mu\text{A}$ |

**Table 6.** Static characteristics ...continued

$V_{BAT} = 5.5\text{ V to }28\text{ V}$ ;  $T_{vj} = -40\text{ °C to }+150\text{ °C}$ ;  $R_{L(LIN-VBAT)} = 500\text{ }\Omega$ ; 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.

| Symbol                        | Parameter   | Conditions  | Min                        | Typ                   | Max                    | Unit       |
|-------------------------------|---|---|----------------------------|-----------------------|------------------------|------------|
| $V_{BUSrec}$                  | receiver recessive state                                    | $V_{BAT} = 5.5\text{ V to }18\text{ V}$   | $0.6 \times V_{BAT}$       | -                     | -                      | V          |
| $V_{BUSdom}$                  | receiver dominant state                                     | $V_{BAT} = 5.5\text{ V to }18\text{ V}$   | -                          | -                     | $0.4 \times V_{BAT}$   | V          |
| $V_{BUS\_CNT}$                | receiver center voltage                                     | $V_{BAT} = 5.5\text{ V to }18\text{ V}$ ;<br>$V_{BUS\_CNT} = (V_{BUSdom} + V_{BUSrec}) / 2$ | [3] $0.475 \times V_{BAT}$ | $0.5 \times V_{BAT}$  | $0.525 \times V_{BAT}$ | V          |
| $V_{HYS}$                     | receiver hysteresis voltage                                 | $V_{BAT} = 5.5\text{ V to }18\text{ V}$ ;<br>$V_{HYS} = V_{BUSrec} - V_{BUSdom}$            | [3] $0.05 \times V_{BAT}$  | $0.15 \times V_{BAT}$ | $0.175 \times V_{BAT}$ | V          |
| $V_{SerDiode}$                | voltage drop at the serial diode                            | in pull-up path with $R_{slave}$ ;<br>$I_{SerDiode} = 0.9\text{ mA}$                        | [2] 0.4                    | -                     | 1.0                    | V          |
| $C_{LIN}$                     | capacitance on pin LIN                                      | with respect to GND   | [2] -                      | -                     | 30                     | pF         |
| $V_{O(dom)}$                  | dominant output voltage                                     | Normal mode;<br>$V_{TXD} = 0\text{ V}$ ; $V_{BAT} = 7\text{ V}$                             | -                          | -                     | 1.4                    | V          |
|                               |   | Normal mode;<br>$V_{TXD} = 0\text{ V}$ ; $V_{BAT} = 18\text{ V}$                            | -                          | -                     | 2.0                    | V          |
| $R_{slave}$                   | slave resistance  | between pin LIN and $V_{BAT}$ ;<br>$V_{LIN} = 0\text{ V}$ ; $V_{BAT} = 12\text{ V}$         | 20                         | 30                    | 60                     | k $\Omega$ |
| <b>Temperature protection</b> |   |   |                            |                       |                        |            |
| $T_{th(act)otp}$              | overtemperature protection activation threshold temperature |   | 165                        | 180                   | 195                    | °C         |
| $T_{th(rel)otp}$              | overtemperature protection release threshold temperature    |   | 126                        | 138                   | 150                    | °C         |

[1] See [Figure 1](#) and [Figure 6](#).

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

[3] See [Figure 8](#).

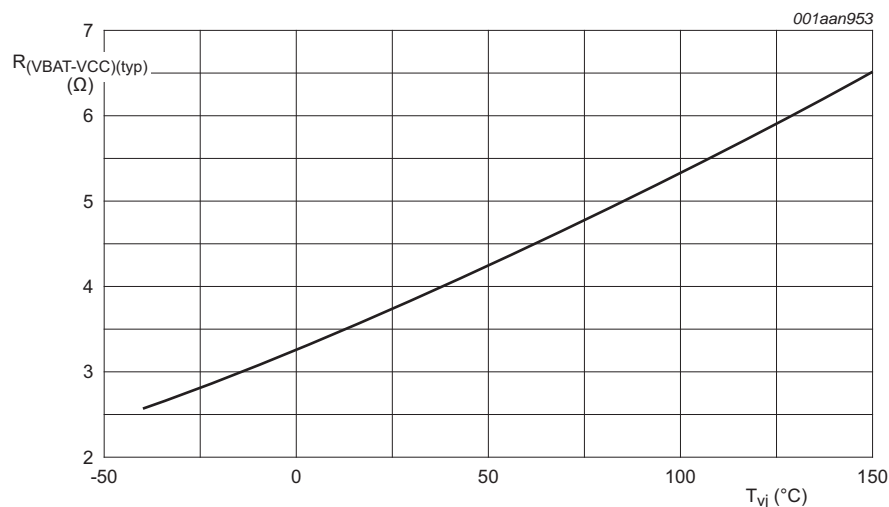


Fig 6. Graph of  $R_{(VBAT-VCC)(typ)}$  as a function of junction temperature ( $T_{vj}$ )

## 11. Dynamic characteristics

Table 7. Dynamic characteristics

$V_{BAT} = 5.5\text{ V to }18\text{ V}$ ;  $T_{vj} = -40\text{ °C to }+150\text{ °C}$ ;  $R_{L(LIN-VBAT)} = 500\text{ }\Omega$ ; 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.<sup>[1]</sup>

| Symbol             | Parameter    | Conditions   | Min  | Typ | Max   | Unit |
|--------------------|--------------|--|--|-----|-------|------|
| <b>Duty cycles</b> |              |  |  |     |       |      |
| $\delta 1$         | duty cycle 1 | $V_{th(rec)(max)} = 0.744V_{BAT}$ ;<br>$V_{th(dom)(max)} = 0.581V_{BAT}$ ;<br>$t_{bit} = 50\text{ }\mu\text{s}$ ;<br>$V_{BAT} = 7\text{ V to }18\text{ V}$   | <sup>[2][3]</sup><br><sup>[4][5]</sup> 0.396 | -   | -     |      |
|                    |              | $V_{th(rec)(max)} = 0.76V_{BAT}$ ;<br>$V_{th(dom)(max)} = 0.593V_{BAT}$ ;<br>$t_{bit} = 50\text{ }\mu\text{s}$ ;<br>$V_{BAT} = 5.5\text{ V to }7.0\text{ V}$ | <sup>[2][3]</sup><br><sup>[4][5]</sup> 0.396 | -   | -     |      |
| $\delta 2$         | duty cycle 2 | $V_{th(rec)(min)} = 0.422V_{BAT}$ ;<br>$V_{th(dom)(min)} = 0.284V_{BAT}$ ;<br>$t_{bit} = 50\text{ }\mu\text{s}$ ;<br>$V_{BAT} = 7.6\text{ V to }18\text{ V}$ | <sup>[2][4]</sup><br><sup>[5][6]</sup> -     | -   | 0.581 |      |
|                    |              | $V_{th(rec)(min)} = 0.41V_{BAT}$ ;<br>$V_{th(dom)(min)} = 0.275V_{BAT}$ ;<br>$t_{bit} = 50\text{ }\mu\text{s}$ ;<br>$V_{BAT} = 6.1\text{ V to }7.6\text{ V}$ | <sup>[2][4]</sup><br><sup>[5][6]</sup> -     | -   | 0.581 |      |
| $\delta 3$         | duty cycle 3 | $V_{th(rec)(max)} = 0.778V_{BAT}$ ;<br>$V_{th(dom)(max)} = 0.616V_{BAT}$ ;<br>$t_{bit} = 96\text{ }\mu\text{s}$ ;<br>$V_{BAT} = 7\text{ V to }18\text{ V}$   | <sup>[3][4]</sup><br><sup>[5]</sup> 0.417    | -   | -     |      |
|                    |              | $V_{th(rec)(max)} = 0.797V_{BAT}$ ;<br>$V_{th(dom)(max)} = 0.630V_{BAT}$ ;<br>$t_{bit} = 96\text{ }\mu\text{s}$ ;<br>$V_{BAT} = 5.5\text{ V to }7\text{ V}$  | <sup>[3][4]</sup><br><sup>[5]</sup> 0.417    | -   | -     |      |

**Table 7. Dynamic characteristics ...continued**

$V_{BAT} = 5.5\text{ V to }18\text{ V}$ ;  $T_{vj} = -40\text{ }^{\circ}\text{C to }+150\text{ }^{\circ}\text{C}$ ;  $R_{L(LIN-VBAT)} = 500\text{ }\Omega$ ; 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.<sup>[1]</sup>

| Symbol     | Parameter    | Conditions  | Min                                   | Typ | Max   | Unit |
|------------|--------------|---|---------------------------------------|-----|-------|------|
| $\delta 4$ | duty cycle 4 | $V_{th(rec)(min)} = 0.389V_{BAT}$<br>$V_{th(dom)(min)} = 0.251V_{BAT}$<br>$t_{bit} = 96\text{ }\mu\text{s}$<br>$V_{BAT} = 7.6\text{ V to }18\text{ V}$        | <sup>[4][5]</sup> -                   | -   | 0.590 |      |
|            |              | $V_{th(rec)(min)} = 0.378V_{BAT}$ ;<br>$V_{th(dom)(min)} = 0.242V_{BAT}$ ;<br>$t_{bit} = 96\text{ }\mu\text{s}$ ;<br>$V_{BAT} = 6.1\text{ V to }7.6\text{ V}$ | <sup>[4][5]</sup> -<br><sup>[6]</sup> | -   | 0.590 |      |

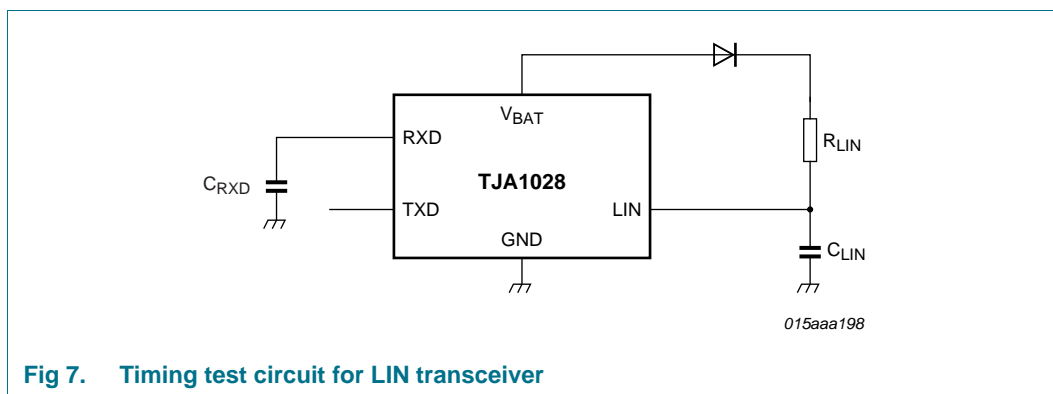
**Timing characteristics**

|                    |   |   |                  |    |     |               |
|--------------------|---|---|------------------|----|-----|---------------|
| $t_{rx\_pd}$       | receiver propagation delay                  | rising and falling;<br>$C_{RXD} = 20\text{ pF}$ | -                | -  | 6   | $\mu\text{s}$ |
| $t_{rx\_sym}$      | receiver propagation delay symmetry         | $C_{RXD} = 20\text{ pF}$                        | -2               | -  | +2  | $\mu\text{s}$ |
| $t_{wake(dom)LIN}$ | LIN dominant wake-up time                   | Sleep mode                                      | 30               | 80 | 150 | $\mu\text{s}$ |
| $t_{to(dom)TXD}$   | TXD dominant time-out time                  | $V_{TXD} = 0\text{ V}$                          | 6                | -  | 20  | ms            |
| $t_{msel}$         | mode select time                            |   | 3                | -  | 20  | $\mu\text{s}$ |
| $t_{d(EN-TXD)}$    | delay time from EN to TXD                   |   | <sup>[7]</sup> 0 | -  | 1   | $\mu\text{s}$ |
| $t_{det(uv)(VCC)}$ | undervoltage detection time on pin $V_{CC}$ | $C_{RSTN} = 20\text{ pF}$                       | 1                | -  | 15  | $\mu\text{s}$ |

**Reset output; pin RSTN**

|           |            |  |   |   |   |    |
|-----------|------------|--|---|---|---|----|
| $t_{rst}$ | reset time |  | 2 | - | 8 | 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 ranges.
- [2] Not applicable to the low slope versions (TJA1028T/xxx/10 and TJA1028TK/xxx/10) of the TJA1028.
- [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 8](#).
- [4] Bus load conditions are:  $C_{BUS} = 1\text{ nF}$  and  $R_{BUS} = 1\text{ k}\Omega$ ;  $C_{BUS} = 6.8\text{ nF}$  and  $R_{BUS} = 660\text{ }\Omega$ ;  $C_{BUS} = 10\text{ nF}$  and  $R_{BUS} = 500\text{ }\Omega$ .
- [5] For  $V_{BAT} > 18\text{ V}$ , the LIN transmitter might be suppressed. If TXD is HIGH then the LIN transmitter output is recessive.
- [6]  $\delta 2, \delta 4 = \frac{t_{bus(rec)(max)}}{2 \times t_{bit}}$ . Variable  $t_{bus(rec)(max)}$  is illustrated in the LIN timing diagram in [Figure 8](#).
- [7] Not tested in production; guaranteed by design.

**Fig 7. Timing test circuit for LIN transceiver**

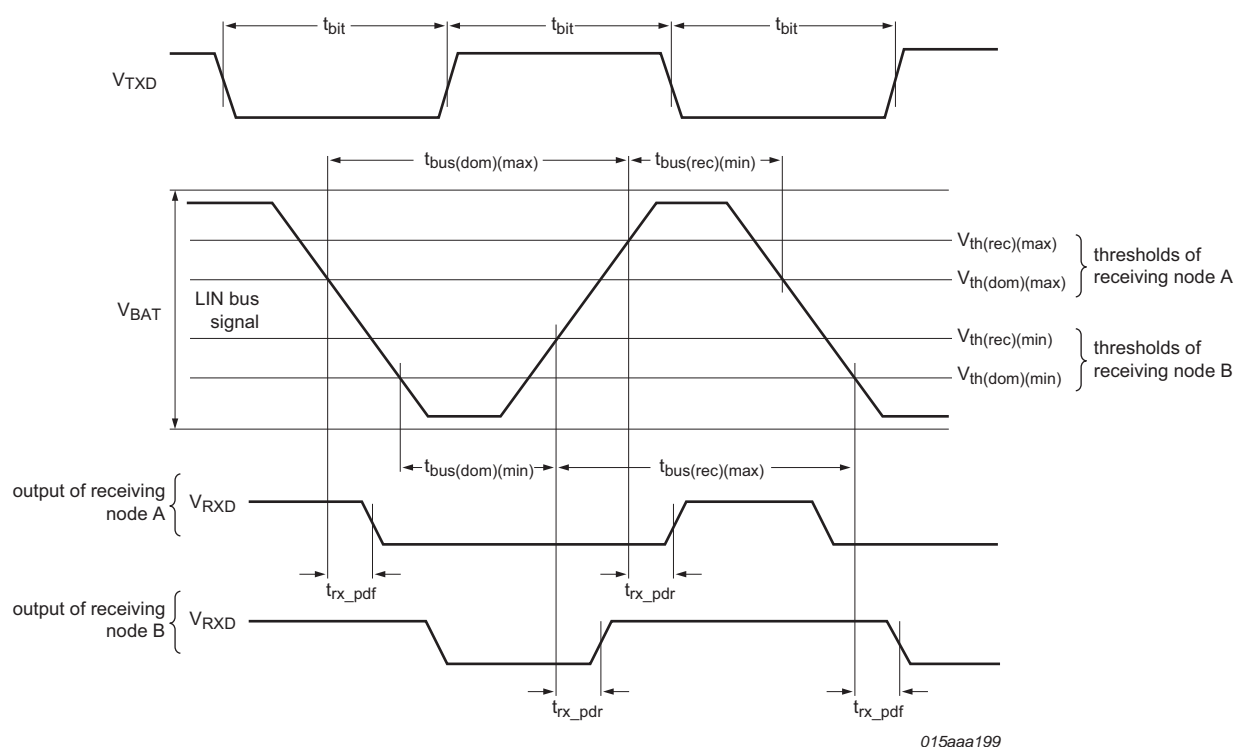


Fig 8. LIN transceiver timing diagram

## 12. Test information

### 12.1 Quality information

This product has been qualified in accordance with the Automotive Electronics Council (AEC) standard Q100 - *Failure mechanism based stress test qualification for integrated circuits*, and is suitable for use in automotive applications.

13. Package outline

SO8: plastic small outline package; 8 leads; body width 3.9 mm SOT96-1

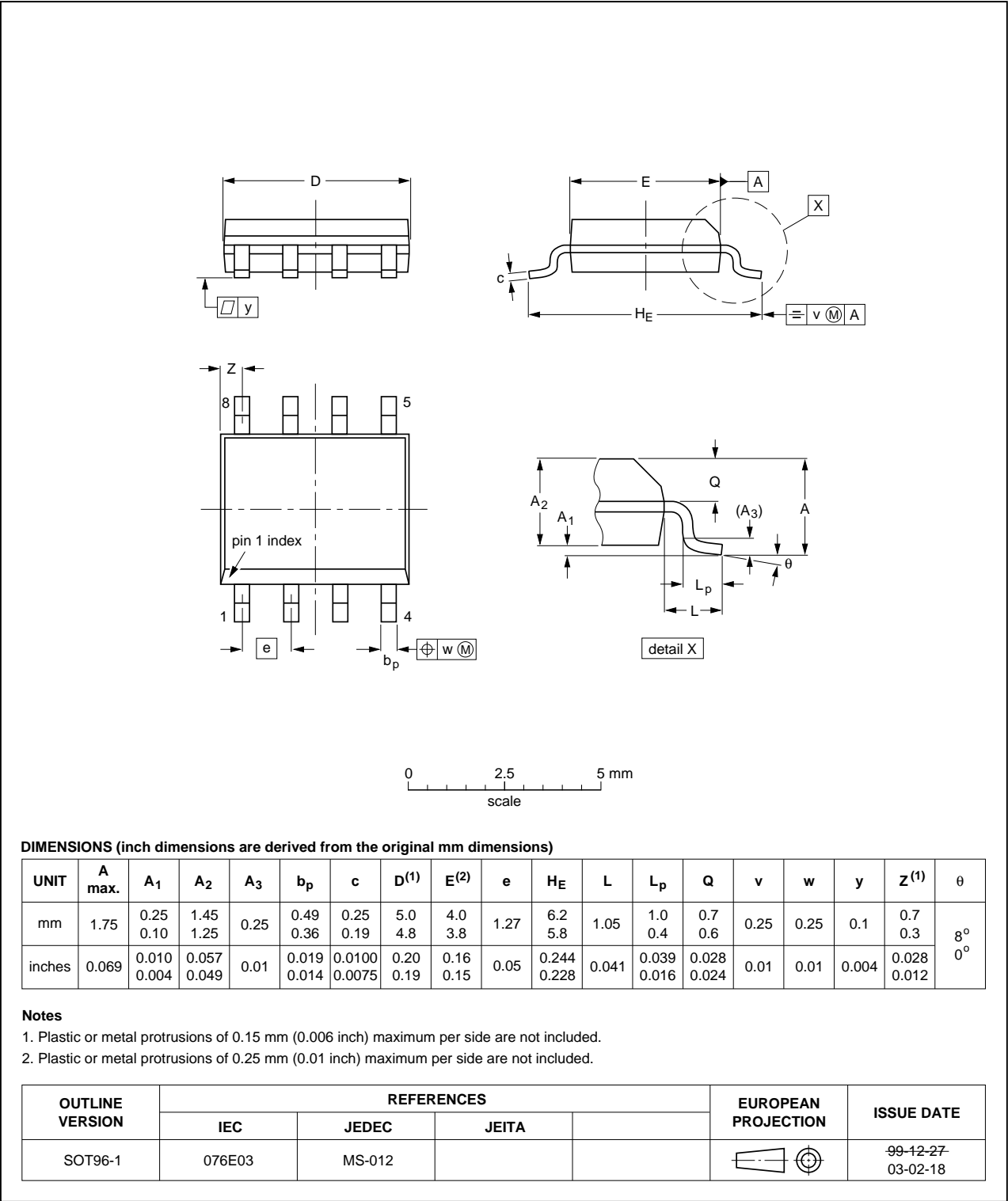


Fig 9. Package outline SOT96-1 (SO8)



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

SOT782-1

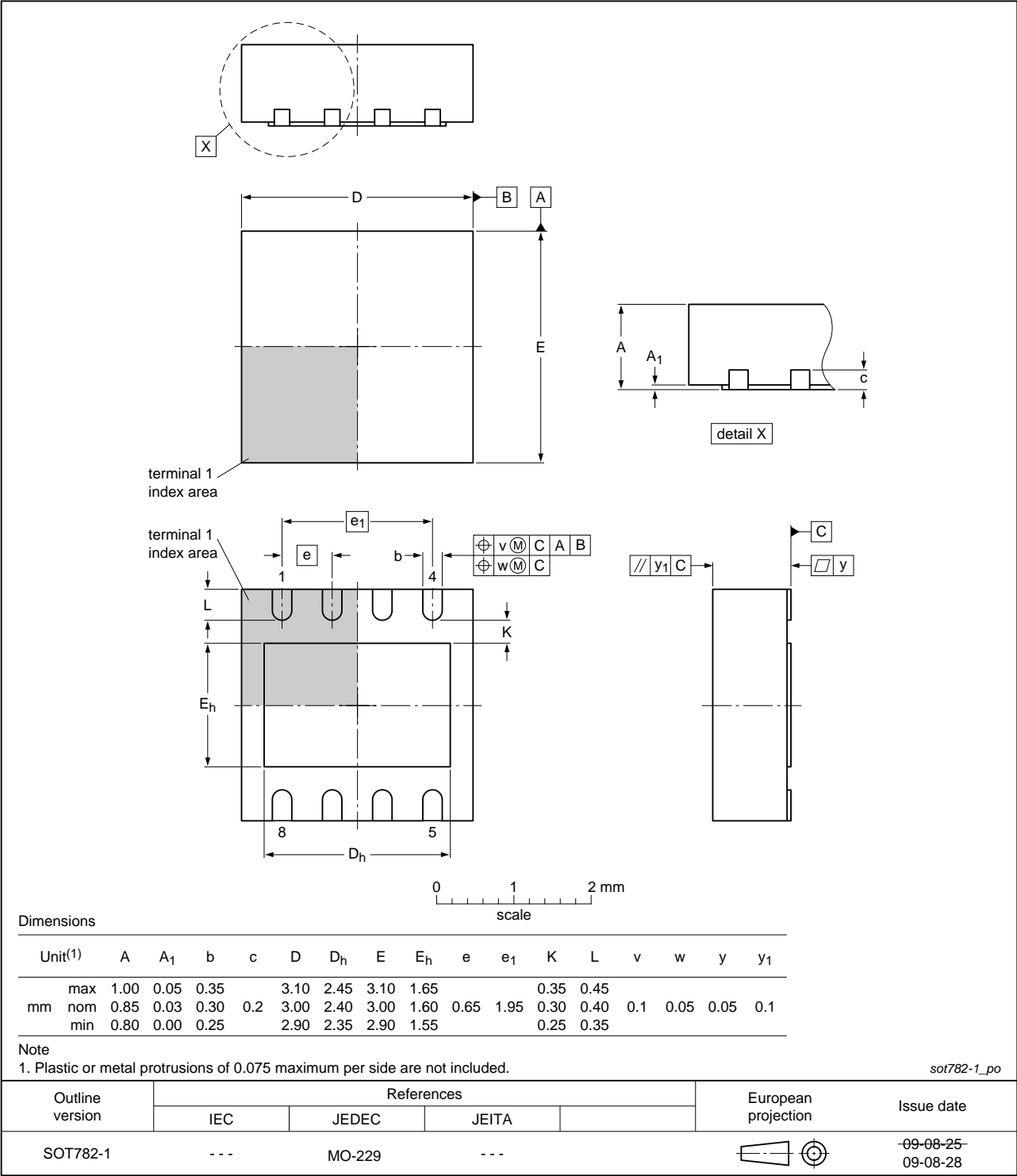


Fig 10. Package outline SOT782-1 (HVSON8)

## 14. 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.

## 15. 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"*.

### 15.1 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.

### 15.2 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

### 15.3 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

## 15.4 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 11](#)) 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 8](#) and [9](#)

**Table 8. SnPb eutectic process (from J-STD-020C)**

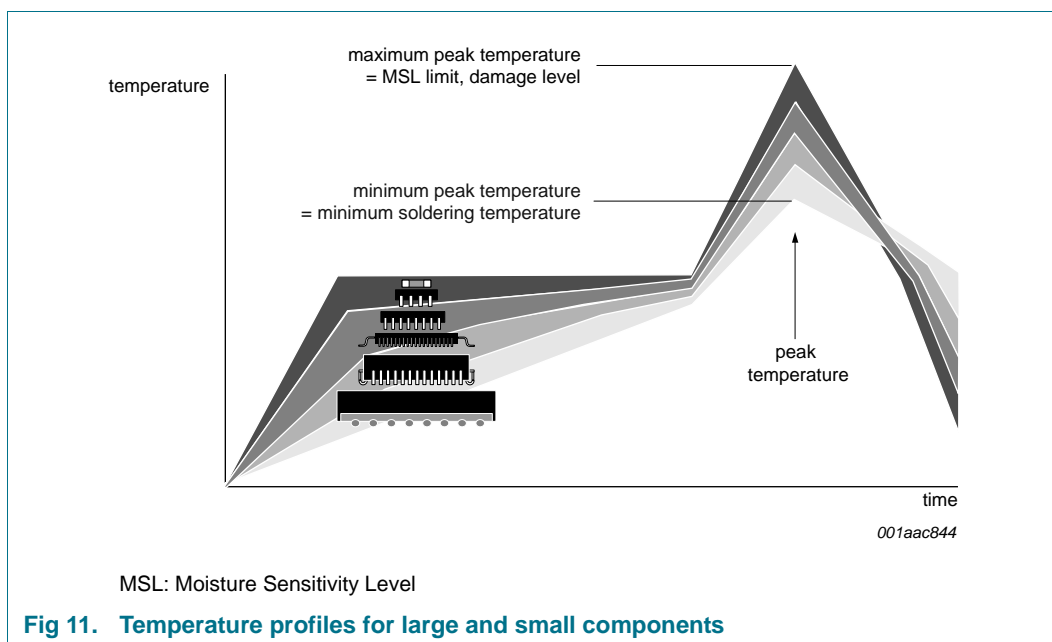
| Package thickness (mm) | Package reflow temperature (°C) |       |
|------------------------|---------------------------------|-------|
|                        | Volume (mm <sup>3</sup> )       |       |
|                        | < 350                           | ≥ 350 |
| < 2.5                 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

**Table 9. Lead-free process (from J-STD-020C)**

| Package thickness (mm) | Package reflow temperature (°C) |             |        |
|------------------------|---------------------------------|-------------|--------|
|                        | Volume (mm <sup>3</sup> )       |             |        |
|                        | < 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 11](#).



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

## 16. Soldering of HVSON packages

[Section 15](#) 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”

## 17. Revision history

**Table 10. Revision history**

| Document ID    | Release date   | Data sheet status  | Change notice | Supersedes  |
|----------------|--|--------------------|---------------|-------------|
| TJA1028 v.4    | 20120725   | Product data sheet | -             | TJA1028 v.3 |
| Modifications: | <ul style="list-style-type: none"><li>• <a href="#">Table 5</a>: text of table note section amended</li><li>• <a href="#">Table 3</a>: text of table note amended</li><li>• <a href="#">Section 2</a>, <a href="#">Section 7</a>, <a href="#">Section 7.3.2</a>: text revised</li><li>• <a href="#">Section 7.1</a>, <a href="#">Section 7.3.3</a>: added</li><li>• <a href="#">Figure 1</a>, <a href="#">Figure 5</a>: amended</li><li>• <a href="#">Table 6</a>: parameters values/conditions changed: <math>V_{th(det)pon}</math>, <math>V_{th(det)poff}</math></li></ul> |                    |               |             |
| TJA1028 v.3    | 20110519   | Product data sheet | -             | TJA1028 v.2 |
| TJA1028 v.2    | 20100225   | Product data sheet | -             | TJA1028 v.1 |
| TJA1028 v.1    | 20100921   | Product data sheet | -             | -           |

## 18. Legal information

### 18.1 Data sheet status

| Document status <sup>[1][2]</sup> | Product status <sup>[3]</sup> | 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".

[3] The product status of device(s) described in this document may have changed since this document was published and may differ in case of multiple devices. The latest product status information is available on the Internet at URL <http://www.nxp.com>.

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