

# NCV7424

## Four Channel LIN Transceiver

NCV7424 is a four channel physical layer device using the Local Interconnect Network (LIN) protocol. It allows interfacing of four independent LIN physical buses and the LIN protocol controllers. The device is compliant to LIN 2.x Protocol Specification package and the SAE J2602 standard.

The NCV7424 LIN device is a member of the in-vehicle networking (IVN) transceiver family. The device is a monolithic solution incorporating 4 times the NCV7321-1 transceiver.

### Features

- TSSOP-16 Package. Pin-out Compatible with One Single LIN NCV7321 Transceiver (Pin Numbers 4 to 7, and 10 to 13)
- Compliant with LIN2.x, Backwards Compatible to Version 1.3 and J2602
- Transmission Rate 1 kbps to 20 kbps
- Indefinite Short-Circuit Protection on LIN towards Supply and Ground
- Bus Pins Protected Against Transients in an Automotive Environment
- Thermal Shutdown
- System ESD on LIN Pin Exceeding 10 kV, No Need for External ESD Protections
- Load Dump Protection (45 V)
- Integrated Slope Control Resulting into Excellent EME Performance also without any Capacitor on LIN Pin
- Excellent EMI Performance
- Remote Wake-up via LIN Bus on all Four Channels
- 3.3 V and 5 V Compatible Digital Inputs

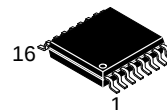
### Quality

- NCV Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements; AEC-Q100 Qualified and PPAP Capable
- These Devices are Pb-Free, Halogen Free/BFR Free and are RoHS Compliant



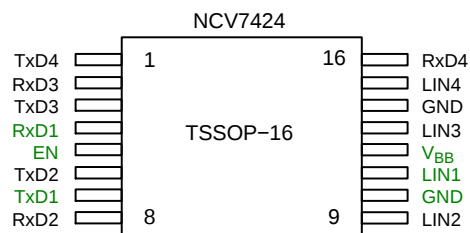
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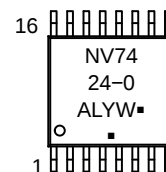


**TSSOP-16  
CASE 948F**

### PACKAGE PICTURE



### MARKING DIAGRAM



NV7424-0 = Specific Device Code  
A = Assembly Location  
L = Wafer Lot  
Y = Year  
W = Work Week  
▪ = Pb-Free Package

(Note: Microdot may be in either location)

### ORDERING INFORMATION

See detailed ordering, marking and shipping information in the package dimensions section on page 11 of this data sheet.

# NCV7424

## BLOCK DIAGRAM

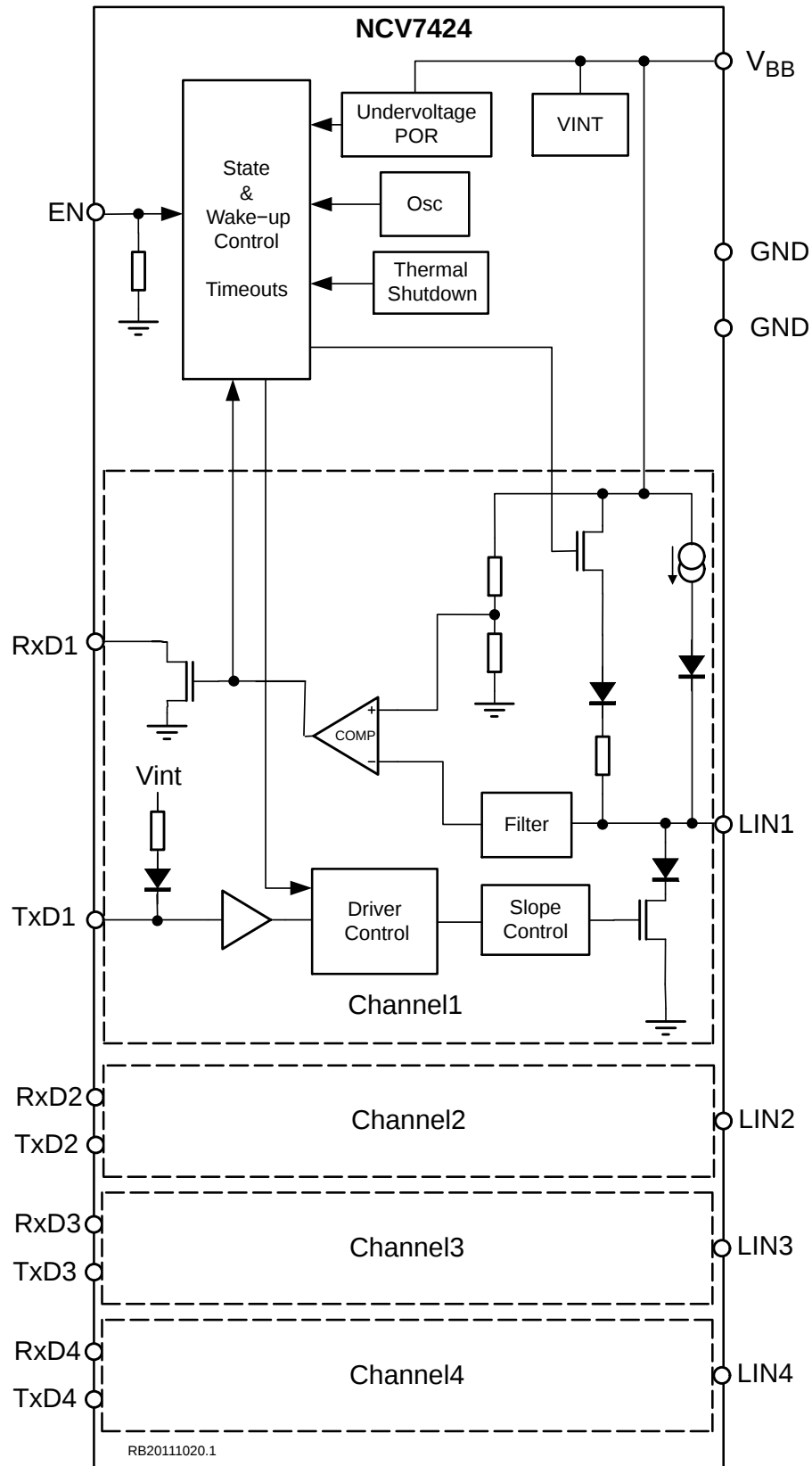


Figure 1. Block Diagram

**Table 1. KEY TECHNICAL CHARACTERISTICS AND OPERATING RANGES**

| Symbol              | Parameter                                                                                                       | Min | Typ | Max | Unit |
|---------------------|-----------------------------------------------------------------------------------------------------------------|-----|-----|-----|------|
| V <sub>BB</sub>     | Nominal Battery Operating Voltage (Note 1)                                                                      | 5   | 12  | 27  | V    |
|                     | Load Dump Protection                                                                                            |     |     | 45  |      |
| I <sub>BB_SLP</sub> | Supply Current in Sleep Mode, V <sub>BB</sub> = 12 V, T <sub>J</sub> < 85°C V <sub>LINx</sub> = V <sub>BB</sub> |     | 10  | 30  | μA   |
| V <sub>LIN</sub>    | LIN Bus Voltage                                                                                                 | -45 |     | 45  | V    |
| V <sub>Dig_IO</sub> | Operating DC Voltage on Digital IO Pins (EN, RxD1-4, TxD1-4)                                                    | 0   |     | 5.5 | V    |
| T <sub>J</sub>      | Junction Thermal Shutdown Temperature                                                                           | 150 | 165 | 185 | °C   |
| T <sub>amb</sub>    | Operating Ambient Temperature                                                                                   | -40 |     | 125 | °C   |
| V <sub>ESD</sub>    | Electrostatic Discharge Voltage (all pins) Human Body Model (Note 2)<br>Conform to EIA-JESD22-A114-B            | -4  |     | 4   | kV   |
|                     | Electrostatic Discharge Voltage (LIN) System Human Body Model (Note 3)<br>Conform to EIC 61000-4-2              | -10 |     | 10  | kV   |

- Below 5 V on V<sub>BB</sub> in normal mode, the bus will either stay recessive or comply with the voltage level specifications and transition time specifications as required by SAE J2602. It is ensured by the battery monitoring circuit. Above 27 V on V<sub>BB</sub>, LIN communication is operational (LIN pin toggling) but parameters cannot be guaranteed. For higher battery voltage operation above 27 V, LIN pull-up resistor must be selected large enough to avoid clamping of LIN pin by voltage drop over external pull-up resistor and LIN pin min current limitation.
- Equivalent to discharging a 100 pF capacitor through a 1.5 kΩ resistor.
- Equivalent to discharging a 150 pF capacitor through a 330 Ω resistor. System HBM levels are verified by an external test-house.

**Table 2. PIN FUNCTION DESCRIPTION**

| Pin | Name            | Description                                                                                                  |
|-----|-----------------|--------------------------------------------------------------------------------------------------------------|
| 1   | TxD4            | Transmit Data Input, Low for Dominant State; Pull-up to internal supply guaranteed above pin input threshold |
| 2   | RxD3            | Receive Data Output; Low in Dominant State                                                                   |
| 3   | TxD3            | Transmit Data Input, Low for Dominant State; Pull-up to internal supply guaranteed above pin input threshold |
| 4   | RxD1            | Receive Data Output; Low in Dominant State                                                                   |
| 5   | EN              | Enable Input, Transceiver in Normal Operation Mode when High, Pull-down Resistor to GND                      |
| 6   | TxD2            | Transmit Data Input, Low for Dominant State; Pull-up to internal supply guaranteed above pin input threshold |
| 7   | TxD1            | Transmit Data Input, Low for Dominant State; Pull-up to internal supply guaranteed above pin input threshold |
| 8   | RxD2            | Receive Data Output; Low in Dominant State                                                                   |
| 9   | LIN2            | LIN Bus Output/Input                                                                                         |
| 10  | GND             | Ground                                                                                                       |
| 11  | LIN1            | LIN Bus Output/Input                                                                                         |
| 12  | V <sub>BB</sub> | Battery Supply Input                                                                                         |
| 13  | LIN3            | LIN Bus Output/Input                                                                                         |
| 14  | GND             | Ground                                                                                                       |
| 15  | LIN4            | LIN Bus Output/Input                                                                                         |
| 16  | RxD4            | Receive Data Output; Low in Dominant State                                                                   |

TYPICAL APPLICATION

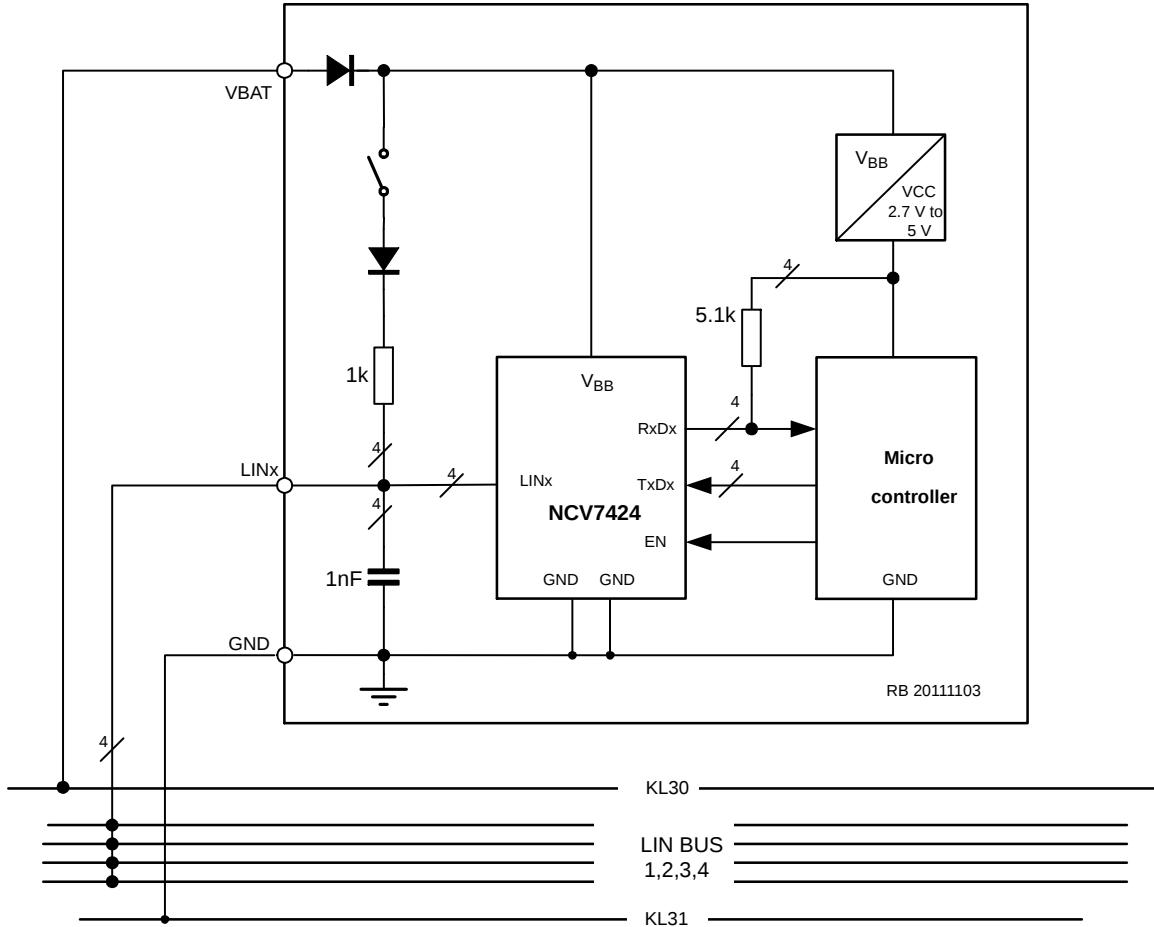


Figure 2. Application Diagram, Four LIN Master Nodes

Table 3. ABSOLUTE MAXIMUM RATINGS

| Symbol              | Parameter                                                                   | Min  | Typ | Max | Unit |
|---------------------|-----------------------------------------------------------------------------|------|-----|-----|------|
| V <sub>BB</sub>     | Voltage on Pin V <sub>BB</sub>                                              | -0.3 |     | 45  | V    |
| V <sub>LINx</sub>   | LINx Bus Voltage (LIN1-4)                                                   | -45  |     | 45  | V    |
| V <sub>Dig_IO</sub> | DC Input Voltage on Pins (EN, RxD1-4, TxD1-4)                               | -0.3 |     | 7   | V    |
| T <sub>J</sub>      | Maximum Junction Temperature                                                | -40  |     | 150 | °C   |
| V <sub>ESD</sub>    | HBM (All Pins) (Note 4)<br>Conform to EIA-JESD22-A114-B                     | -4   |     | 4   | kV   |
|                     | CDM (All Pins)<br>According to ESD STM 5.3.1-1999                           | -750 |     | 750 | V    |
|                     | HBM (LINx and V <sub>BB</sub> ) (Note 4)                                    | -8   |     | 8   | kV   |
|                     | System HBM (LINx and V <sub>BB</sub> ) (Note 5)<br>Conform to EIC 61000-4-2 | -10  |     | 10  | kV   |

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

4. Equivalent to discharging a 100 pF capacitor through a 1.5 kΩ resistor.

5. Equivalent to discharging a 150 pF capacitor through a 330 Ω resistor. System HBM levels are verified by an external test-house.

Table 4. THERMAL CHARACTERISTICS

| Symbol             | Parameter                                             | Conditions | Value | Unit |
|--------------------|-------------------------------------------------------|------------|-------|------|
| R <sub>θJA_1</sub> | Thermal Resistance Junction-to-Air, JESD51-3 1S0P PCB | Free air   | 128   | K/W  |
| R <sub>θJA_2</sub> | Thermal Resistance Junction-to-Air, JESD51-7 2S2P PCB | Free air   | 72    | K/W  |

## FUNCTIONAL DESCRIPTION

### Overall Functional Description

LIN is a serial communication protocol that efficiently supports the control of mechatronic nodes in distributed automotive applications. The domain is class-A multiplex buses with a single master node and a set of slave nodes.

The NCV7424 contains four independent LIN transmitters, LIN receivers plus common battery monitoring, power-on-reset (POR) circuits and thermal shutdown (TSD). The used LIN transmitter is optimized for the maximum specified transmission speed of 20 kbps with

excellent EMC performance due to reduced slew rate of the LIN outputs.

The junction temperature is monitored via a thermal shutdown circuit that switches the LIN transmitters off when temperature exceeds the TSD trigger level.

The NCV7424 has four operating states (unpowered mode, standby mode, normal mode and sleep mode) that are determined by the supply voltage  $V_{BB}$ , input signals EN and activity on the LIN bus. The operating states and principal transitions between them are depicted in Figure 3.

## OPERATING STATES

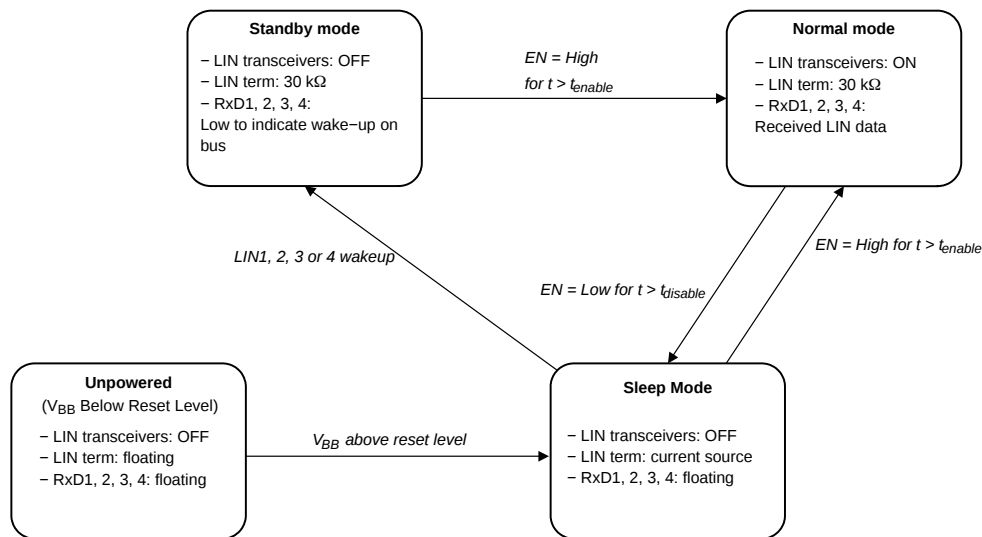


Figure 3. State Diagram

### Unpowered Mode

As long as  $V_{BB}$  remains below its power-on-reset level, the chip is kept in a safe unpowered state. LIN transmitters are inactive, LINx pins are left floating. Pins RxDx remain floating.

The unpowered state will be entered from any other state when  $V_{BB}$  falls below its power-on-reset level.

### Standby Mode

Standby mode is a low-power mode, where the LIN transceivers remain inactive. A 30 kΩ resistor in series with a reverse-protection diode is internally connected between individual LIN pins and pin  $V_{BB}$ . Standby mode is entered after a wake-up event is recognized while the chip was in the

sleep mode, the RxD1,2,3 or 4 pin is pulled low depending on which of the respective pins LIN1,2,3 or 4 the valid LIN wake-up occurred. While staying in standby mode, wake-up signaling by RxDx pins on each LIN channel is fully functional. This is also in case if wake event(s) started in sleep mode but actual transition from sleep to standby was caused by preceding wake-up event on other LIN channel.

### Normal Mode

In normal mode, the full functionality of the LIN transceivers is available. Data are sent to the LINx bus according to the state of TxDx inputs and RxDx pins reflect the logical symbol received on the LINx bus – high-impedant for recessive and Low level for dominant.

A 30 k $\Omega$  resistor in series with a reverse-protection diode is internally connected between LIN and V<sub>BB</sub> pins.

To avoid that, due to a failure of the application (e.g. software error, a short to ground, etc.), the LIN bus is permanently driven dominant and thus blocking all subsequent communication, the signal on each TxDx pin passes through an independent timer per LIN channel, which releases the bus in case TxDx remains

Low for longer than  $t_{\text{TxD\_timeout}}$ . The transmission can continue once the TxDx returns to High logical level. This is independent on each channel, means permanent dominant on one channel is not blocking the other channels from communication.

In case the junction temperature increases above the thermal shutdown threshold, e.g. due to a short of the LIN wiring to the battery and high ambient temperature, all four transmitters are disabled and LIN buses are kept in recessive state independently of TxDx inputs. RxDx pins are kept Low during thermal shutdown.

Once the junction temperature decreases below the thermal shutdown release level, the transmission is enabled again. RxD pins are released from asserted thermal shutdown low level immediately when chip is below thermal shutdown threshold.

As required by SAE J2602, the transceiver behaves safely below its operating range – it either continues to transmit correctly (according to its specification) or remains silent (transmits a recessive state regardless of the TxDx signal). A battery monitoring circuit in NCV7424 deactivates the transmitter in normal mode if the V<sub>BB</sub> level drops below MONL\_VBB. Transmission is enabled again when V<sub>BB</sub> reaches MONH\_VBB. The internal logic remains in normal mode and the reception from the LIN line is still possible even if the battery monitor disables the transmission. Although the specifications of the monitoring and power-on-reset levels are overlapping, it is ensured by the implementation that the monitoring level never falls below the power-on-reset level.

Normal mode can be entered from either standby or sleep mode when EN Pin is High for longer than  $t_{\text{enable}}$ . When the transition is made from standby mode, RxDx is put high-impedant immediately after EN becomes High (before the expiration of  $t_{\text{enable}}$  filtering time). Transmission on each LINx channel is only possible for particular TxDx pin starting from High to Low level (if TxDx pin is Low when entering Normal mode, transmission is not enabled).

### Sleep Mode

Sleep mode provides extremely low current consumption. The LIN transceiver is inactive and the battery consumption is minimized. Only a weak pull-up current source is internally connected between LIN and V<sub>BB</sub> pins, in order to minimize current consumption even in case of LIN short to GND.

Sleep mode can be entered:

- After the voltage level at V<sub>BB</sub> pin rises above its power-on-reset level. RxDx pins are set high-impedant after start-up
- From normal mode by assigning a Low logical level to pin EN for longer than  $t_{\text{disable}}$ . The sleep mode can be entered even if a permanent short occurs on the LINx Pin.

If a wake-up event occurs during the transition between normal and sleep mode (during the  $t_{\text{disable}}$  filtering time), it will be regarded as a valid wake-up and the chip will enter standby mode with the appropriate setting of pins RxDx.

### LIN Wake-up

Remote (or LIN) wake-up can be recognized on all LINx pins on NCV7424 when LINx bus is externally driven dominant for longer than  $t_{\text{LIN\_wake}}$  and a rising edge on LIN occurs afterwards – see Figure 4. Wake-up events can be exclusively detected in sleep mode or during the transition from normal mode to sleep mode. Due to timing tolerances, valid wake-up events beginning shortly before normal-to-sleep mode transition can be also sometimes regarded as valid wake-ups.

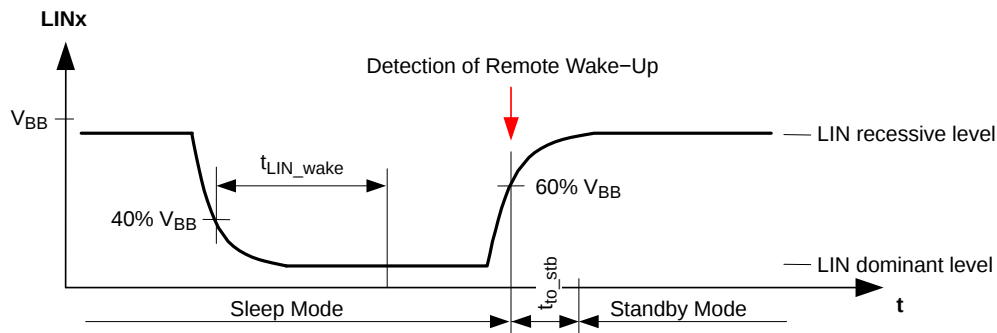


Figure 4. LIN Bus Wake-up Detection

## ELECTRICAL CHARACTERISTICS

## Definitions

All voltages are referenced to GND (Pins 10, 14. These pins are electrically connected inside of the package). Positive currents flow into the IC.

**Table 5. DC CHARACTERISTICS** ( $V_{BB} = 5\text{ V to }27\text{ V}$ ;  $T_J = -40^\circ\text{C to }+150^\circ\text{C}$ ;  $R_{L(LIN-V_{BB})} = 500\ \Omega$ , unless otherwise specified. Typical values are given at  $V(V_{BB}) = 12\text{ V}$  and  $T_J = 25^\circ\text{C}$ , unless otherwise specified.)

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|--------|-----------|------------|-----|-----|-----|------|
|--------|-----------|------------|-----|-----|-----|------|

## CURRENT CONSUMPTION

|                    |                      |                                                                                      |  |      |      |               |
|--------------------|----------------------|--------------------------------------------------------------------------------------|--|------|------|---------------|
| $I_{BB\_ON\_rec}$  | $V_{BB}$ Consumption | Normal Mode; LIN Recessive<br>$V_{LINx} = V_{BB}$                                    |  | 2.3  | 4.7  | mA            |
| $I_{BB\_ON\_dom}$  | $V_{BB}$ Consumption | Normal Mode; LIN Dominant<br>$TxDx = \text{Low}$                                     |  | 16.5 | 28   | mA            |
| $I_{BB\_STB}$      | $V_{BB}$ Consumption | Standby Mode<br>$V_{LINx} = V_{BB}$                                                  |  | 0.22 | 0.45 | mA            |
| $I_{BB\_SLP}$      | $V_{BB}$ Consumption | Sleep Mode<br>$V_{LINx} = V_{BB}$                                                    |  | 11   | 35   | $\mu\text{A}$ |
| $I_{BB\_SLP\_18V}$ | $V_{BB}$ Consumption | Sleep Mode, $V_{BB} < 18\text{ V}$<br>$V_{LINx} = V_{BB}$                            |  | 10   | 33   | $\mu\text{A}$ |
| $I_{BB\_SLP\_12V}$ | $V_{BB}$ Consumption | Sleep Mode, $V_{BB} = 12\text{ V}$ , $T_J < 85^\circ\text{C}$<br>$V_{LINx} = V_{BB}$ |  | 9    | 30   | $\mu\text{A}$ |

POR AND  $V_{BB}$  MONITOR

|                |                                       |                  |     |     |     |   |
|----------------|---------------------------------------|------------------|-----|-----|-----|---|
| $PORH\_V_{BB}$ | Power-on Reset High Level on $V_{BB}$ | $V_{BB}$ Rising  | 2   | 3.3 | 4.5 | V |
| $PORL\_V_{BB}$ | Power-on Reset Low Level on $V_{BB}$  | $V_{BB}$ Falling | 1.7 | 2.9 | 4   | V |
| $MONH\_V_{BB}$ | Battery Monitoring High Level         | $V_{BB}$ Rising  |     | 4.1 | 4.5 | V |
| $MONL\_V_{BB}$ | Battery Monitoring Low Level          | $V_{BB}$ Falling | 3   | 4   |     | V |

## LIN TRANSMITTERS

|                        |                                  |                                                             |                |     |          |            |
|------------------------|----------------------------------|-------------------------------------------------------------|----------------|-----|----------|------------|
| $V_{LINx\_dom\_LoSup}$ | LINx Dominant Output Voltage     | $TxDx = \text{Low}$ ; $V_{BB} = 7.3\text{ V}$               |                | 1   | 1.2      | V          |
| $V_{LINx\_dom\_HiSup}$ | LINx Dominant Output Voltage     | $TxDx = \text{Low}$ ; $V_{BB} = 18\text{ V}$                |                | 1.4 | 2.0      | V          |
| $V_{LINx\_REC}$        | LIN Recessive Output Voltage     | $TxDx = \text{High}$ ; $I_{LIN} = 10\ \mu\text{A}$ (Note 6) | $V_{BB} - 1.5$ |     | $V_{BB}$ | V          |
| $I_{LINx\_lim}$        | Short Circuit Current Limitation | $V_{LINx} = V_{BB} = 18\text{ V}$ ; $TxDx = \text{Low}$     | 70             | 140 | 200      | mA         |
| $RLINx_{slave}$        | Internal Pull-up Resistance      |                                                             | 20             | 33  | 47       | k $\Omega$ |

## LIN RECEIVERS

|                      |                                 |                              |     |      |     |          |
|----------------------|---------------------------------|------------------------------|-----|------|-----|----------|
| $V_{LINx\_bus\_dom}$ | Bus Voltage for Dominant State  |                              |     |      | 0.4 | $V_{BB}$ |
| $V_{LINx\_bus\_rec}$ | Bus Voltage for Recessive State |                              | 0.6 |      |     | $V_{BB}$ |
| $V_{LINx\_rec\_dom}$ | Receiver Threshold              | LIN Bus Recessive – Dominant | 0.4 | 0.45 | 0.6 | $V_{BB}$ |
| $V_{LINx\_rec\_rec}$ | Receiver Threshold              | LIN Bus Dominant – Recessive | 0.4 | 0.55 | 0.6 | $V_{BB}$ |

6. The voltage drop in Normal mode between LIN and  $V_{BB}$  pin is the sum of the diode drop and the drop at serial pull-up resistor. The drop at the switch is negligible. See Figure 1.

**Table 5. DC CHARACTERISTICS** ( $V_{BB} = 5\text{ V}$  to  $27\text{ V}$ ;  $T_J = -40^\circ\text{C}$  to  $+150^\circ\text{C}$ ;  $R_{L(LIN-VBB)} = 500\ \Omega$ , unless otherwise specified. Typical values are given at  $V(V_{BB}) = 12\text{ V}$  and  $T_J = 25^\circ\text{C}$ , unless otherwise specified.)

| Symbol                    | Parameter                                                   | Conditions                                                                                       | Min   | Typ   | Max   | Unit             |
|---------------------------|-------------------------------------------------------------|--------------------------------------------------------------------------------------------------|-------|-------|-------|------------------|
| <b>LIN RECEIVERS</b>      |                                                             |                                                                                                  |       |       |       |                  |
| $V_{LINx\_rec\_cnt}$      | Receiver Centre Voltage                                     | $(V_{LINx\_rec\_dom} + V_{LINx\_rec\_rec}) / 2$                                                  | 0.475 | 0.5   | 0.525 | $V_{BB}$         |
| $V_{LINx\_rec\_hys}$      | Receiver Hysteresis                                         | $(V_{LINx\_rec\_rec} - V_{LINx\_rec\_dom})$                                                      | 0.05  | 0.1   | 0.175 | $V_{BB}$         |
| $I_{LINx\_off\_dom}$      | LIN Output Current, Bus externally driven to dominant state | Normal Mode, Driver Off; $V_{BB} = 12\text{ V}$ ; $TxDx = \text{High}$ ; $V_{LINx} = 0\text{ V}$ | -1    | -0.37 | -0.2  | mA               |
| $I_{LINx\_off\_dom\_slp}$ | LIN Output Current, Bus externally driven to dominant state | Sleep Mode, Driver Off; $V_{BB} = 12\text{ V}$ ; $TxDx = \text{High}$ ; $V_{LINx} = 0\text{ V}$  | -20   | -8    | -2    | $\mu\text{A}$    |
| $I_{LINx\_off\_rec}$      | LIN Output Current, Bus in Recessive State                  | Driver Off; $V_{BB} < 18\text{ V}$ ; $V_{BB} < V_{LINx} < 18\text{ V}$                           |       |       | 2     | $\mu\text{A}$    |
| $I_{LINx\_no\_GND}$       | Communication not Affected                                  | $V_{BB} = GND = 12\text{ V}$ ; $0 < V_{LINx} < 18\text{ V}$                                      | -1    |       | 1     | mA               |
| $I_{LINx\_no\_V_{BB}}$    | LIN Bus Remains Operational                                 | $V_{BB} = GND = 0\text{ V}$ ; $0 < V_{LINx} < 18\text{ V}$                                       |       | 0     | 5     | $\mu\text{A}$    |
| $C_{LINx}$                | Capacitance on LINx pin                                     | Not tested in production, guaranteed by design                                                   |       | 20    | 30    | pF               |
| <b>PIN EN</b>             |                                                             |                                                                                                  |       |       |       |                  |
| $V_{il\_EN}$              | Low Level Input Voltage                                     |                                                                                                  | -0.3  |       | 0.8   | V                |
| $V_{ih\_EN}$              | High Level Input Voltage                                    |                                                                                                  | 2.0   |       | 5.5   | V                |
| $R_{pd\_EN}$              | Pull-down Resistance to Ground                              |                                                                                                  | 150   | 350   | 650   | k $\Omega$       |
| <b>PIN RxDx</b>           |                                                             |                                                                                                  |       |       |       |                  |
| $I_{ol\_RxDx}$            | Low Level Output Current                                    | $V_{RxD} = 0.4\text{ V}$ , Normal Mode, $V_{LINx} = 0\text{ V}$                                  | 1.5   | 4.3   |       | mA               |
| $I_{oh\_RxDx}$            | High Level Output Current                                   | $V_{RxD} = 5\text{ V}$ , Normal Mode, $V_{LINx} = V_{BB}$                                        | -5    | 0     | 5     | $\mu\text{A}$    |
| <b>PIN TxDx</b>           |                                                             |                                                                                                  |       |       |       |                  |
| $V_{il\_TxDx}$            | Low Level Input Voltage                                     |                                                                                                  | -0.3  |       | 0.8   | V                |
| $V_{ih\_TxDx}$            | High Level Input Voltage                                    |                                                                                                  | 2.0   |       | 5.5   | V                |
| $R_{pd\_TxDx}$            | Pull-up on TxDx Pins                                        |                                                                                                  | 60    | 100   | 150   | k $\Omega$       |
| <b>THERMAL SHUTDOWN</b>   |                                                             |                                                                                                  |       |       |       |                  |
| $T_{JSD}$                 | Thermal Shutdown Junction Temperature                       | Temperature Rising                                                                               | 150   | 165   | 185   | $^\circ\text{C}$ |
| $T_{JSD\_HYST}$           | Thermal Shutdown Hysteresis                                 |                                                                                                  |       | 5     |       | $^\circ\text{C}$ |

6. The voltage drop in Normal mode between LIN and  $V_{BB}$  pin is the sum of the diode drop and the drop at serial pull-up resistor. The drop at the switch is negligible. See Figure 1.

**Table 6. AC CHARACTERISTICS** ( $V_{BB} = 5\text{ V to }27\text{ V}$ ;  $T_J = -40^\circ\text{C to }+150^\circ\text{C}$ ;  $R_{L(LIN-V_{BB})} = 500\ \Omega$ , unless otherwise specified.  
For the transmitter parameters, the following bus loads are considered:  $L1 = 1\text{ k}\Omega / 1\text{ nF}$ ;  $L2 = 660\ \Omega / 6.8\text{ nF}$ ;  $L3 = 500\ \Omega / 10\text{ nF}$

| Symbol                  | Parameter                                               | Conditions                                                                                                                                                                 | Min   | Typ  | Max   | Unit          |
|-------------------------|---------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|------|-------|---------------|
| <b>LIN TRANSMITTER</b>  |                                                         |                                                                                                                                                                            |       |      |       |               |
| D1                      | Duty Cycle 1 = $t_{BUS\_REC(min)} / (2 \times t_{BIT})$ | $TH_{REC(max)} = 0.744 \times V_{BB}$<br>$TH_{DOM(max)} = 0.581 \times V_{BB}$<br>$t_{BIT} = 50\ \mu\text{s}$<br>$V(V_{BB}) = 7\text{ V to }18\text{ V}$                   | 0.396 |      | 0.5   |               |
| D2                      | Duty Cycle 2 = $t_{BUS\_REC(max)} / (2 \times t_{BIT})$ | $TH_{REC(min)} = 0.422 \times V_{BB}$<br>$TH_{DOM(min)} = 0.284 \times V_{BB}$<br>$t_{BIT} = 50\ \mu\text{s}$<br>$V(V_{BB}) = 7.6\text{ V to }18\text{ V}$                 | 0.5   |      | 0.581 |               |
| D3                      | Duty Cycle 3 = $t_{BUS\_REC(min)} / (2 \times t_{BIT})$ | $TH_{REC(max)} = 0.778 \times V_{BB}$<br>$TH_{DOM(max)} = 0.616 \times V_{BB}$<br>$t_{BIT} = 96\ \mu\text{s}$<br>$V(V_{BB}) = 7\text{ V to }18\text{ V}$                   | 0.417 |      | 0.5   |               |
| D4                      | Duty Cycle 4 = $t_{BUS\_REC(max)} / (2 \times t_{BIT})$ | $TH_{REC(min)} = 0.389 \times V_{BB}$<br>$TH_{DOM(min)} = 0.251 \times V_{BB}$<br>$t_{BIT} = 96\ \mu\text{s}$<br>$V(V_{BB}) = 7.6\text{ V to }18\text{ V}$                 | 0.5   |      | 0.590 |               |
| D1e                     | Duty Cycle 1 = $t_{BUS\_REC(min)} / (2 \times t_{BIT})$ | $TH_{REC(max)} = 0.744 \times V_{BB}$<br>$TH_{DOM(max)} = 0.581 \times V_{BB}$<br>$t_{BIT} = 50\ \mu\text{s}$<br>$V(V_{BB}) = 5\text{ V to }40\text{ V}$ , (Notes 7 and 8) | 0.39  |      | 0.5   |               |
| D2e                     | Duty Cycle 2 = $t_{BUS\_REC(max)} / (2 \times t_{BIT})$ | $TH_{REC(min)} = 0.422 \times V_{BB}$<br>$TH_{DOM(min)} = 0.284 \times V_{BB}$<br>$t_{BIT} = 50\ \mu\text{s}$<br>$V(V_{BB}) = 5\text{ V to }40\text{ V}$ , (Notes 7 and 8) | 0.5   |      | 0.59  |               |
| D3e                     | Duty Cycle 3 = $t_{BUS\_REC(min)} / (2 \times t_{BIT})$ | $TH_{REC(max)} = 0.778 \times V_{BB}$<br>$TH_{DOM(max)} = 0.616 \times V_{BB}$<br>$t_{BIT} = 96\ \mu\text{s}$<br>$V(V_{BB}) = 5\text{ V to }40\text{ V}$ , (Notes 7 and 8) | 0.41  |      | 0.5   |               |
| D4e                     | Duty Cycle 4 = $t_{BUS\_REC(max)} / (2 \times t_{BIT})$ | $TH_{REC(min)} = 0.389 \times V_{BB}$<br>$TH_{DOM(min)} = 0.251 \times V_{BB}$<br>$t_{BIT} = 96\ \mu\text{s}$<br>$V(V_{BB}) = 5\text{ V to }40\text{ V}$ , (Notes 7 and 8) | 0.5   |      | 0.6   |               |
| $t_{tx\_prop\_down\_x}$ | Propagation Delay of TxDx to LINx. TxD High to Low      |                                                                                                                                                                            | 1.3   | 4.2  | 10    | $\mu\text{s}$ |
| $t_{tx\_prop\_up\_x}$   | Propagation Delay of TxDx to LINx. TxD Low to High      |                                                                                                                                                                            | 1.3   | 4.6  | 10    | $\mu\text{s}$ |
| $t_{tx\_sym\_x}$        | Propagation Delay Symmetry                              | $t_{tx\_prop\_down\_x} - t_{tx\_prop\_up\_x}$                                                                                                                              | -2.5  | -0.4 | 2.5   | $\mu\text{s}$ |
| $t_{fall}$              | LINx Falling Edge                                       | Normal Mode; $V_{BB} = 12\text{ V}$                                                                                                                                        |       | 9    | 22.5  | $\mu\text{s}$ |
| $t_{rise}$              | LINx Rising Edge                                        | Normal Mode; $V_{BB} = 12\text{ V}$                                                                                                                                        |       | 10   | 22.5  | $\mu\text{s}$ |
| $t_{sym}$               | LINx Slope Symmetry                                     | Normal Mode; $V_{BB} = 12\text{ V}$                                                                                                                                        | -4    | 0    | 4     | $\mu\text{s}$ |

**LIN RECEIVERS**

|                          |                                                         |                                                 |     |      |   |               |
|--------------------------|---------------------------------------------------------|-------------------------------------------------|-----|------|---|---------------|
| $t_{rec\_prop\_down\_x}$ | Propagation Delay of LINx to RxDx Receiver Falling Edge |                                                 | 0.1 | 1.6  | 6 | $\mu\text{s}$ |
| $t_{rec\_prop\_up\_x}$   | Propagation Delay of LINx to RxDx Receiver Rising Edge  |                                                 | 0.1 | 1.35 | 6 | $\mu\text{s}$ |
| $t_{rec\_sym\_x}$        | Propagation Delay Symmetry                              | $t_{rec\_prop\_down\_x} - t_{rec\_prop\_up\_x}$ | -2  | 0.25 | 2 | $\mu\text{s}$ |

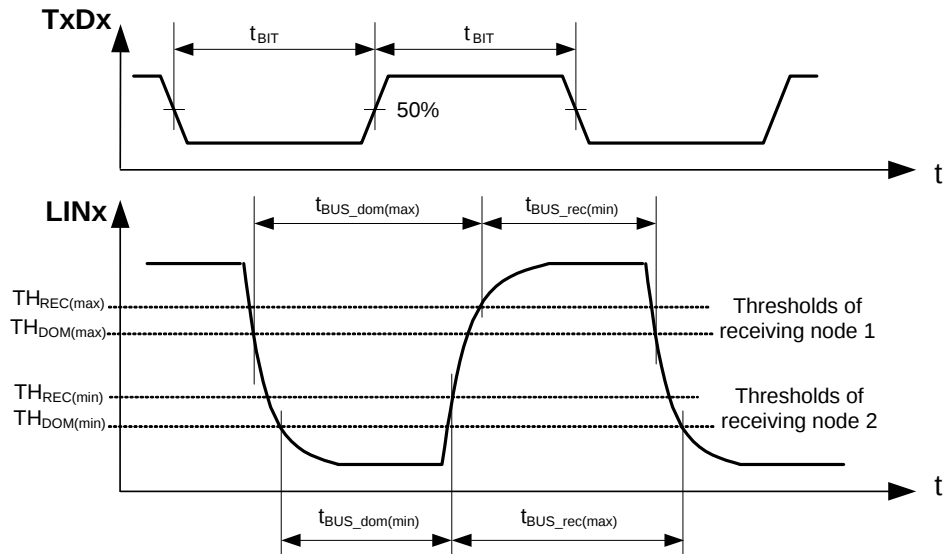
7. The external pull-up resistor for duty cycles on  $V(V_{BB}) = 40\text{ V}$  is  $1\text{ k}\Omega$

8. Not tested in production Extended battery range (5 V; 40 V) is tested on limited sample base only

**Table 6. AC CHARACTERISTICS** ( $V_{BB} = 5\text{ V}$  to  $27\text{ V}$ ;  $T_J = -40^\circ\text{C}$  to  $+150^\circ\text{C}$ ;  $R_{L(LIN-VBB)} = 500\ \Omega$ , unless otherwise specified.  
For the transmitter parameters, the following bus loads are considered: L1 =  $1\text{ k}\Omega / 1\text{ nF}$ ; L2 =  $660\ \Omega / 6.8\text{ nF}$ ; L3 =  $500\ \Omega / 10\text{ nF}$

| Symbol                               | Parameter                                                                                         | Conditions                                                   | Min | Typ | Max  | Unit          |
|--------------------------------------|---------------------------------------------------------------------------------------------------|--------------------------------------------------------------|-----|-----|------|---------------|
| <b>MODE TRANSITIONS AND TIMEOUTS</b> |                                                                                                   |                                                              |     |     |      |               |
| $t_{LINx\_wake}$                     | Duration of LINx Dominant for Detection of Wake-up via LINx bus                                   | Sleep Mode                                                   | 30  | 90  | 150  | $\mu\text{s}$ |
| $t_{to\_stb}$                        | Delay from LIN Bus Dominant to Recessive Edge to Entering of Standby Mode after Valid LIN Wake-up | See Figure 4                                                 | 2   | 2.8 | 18.5 | $\mu\text{s}$ |
| $t_{enable}$                         | Duration of High Level on EN Pin for Transition to Normal Mode                                    |                                                              | 2   | 18  | 47   | $\mu\text{s}$ |
| $t_{disable}$                        | Duration of Low Level on EN Pin for Transition to Sleep Mode                                      |                                                              | 2   | 7.5 | 18.5 | $\mu\text{s}$ |
| $t_{TxD\_timeout}$                   | TxD Dominant Timeout                                                                              | Normal Mode, TxD = Low, Guarantees Baudrate as Low as 1 kbps | 15  | 28  | 50   | ms            |

7. The external pull-up resistor for duty cycles on  $V(V_{BB}) = 40\text{ V}$  is  $1\text{ k}\Omega$   
8. Not tested in production Extended battery range ( $5\text{ V}$ ;  $40\text{ V}$ ) is tested on limited sample base only



**Figure 5. LINx Bus Transmitter Duty Cycle**

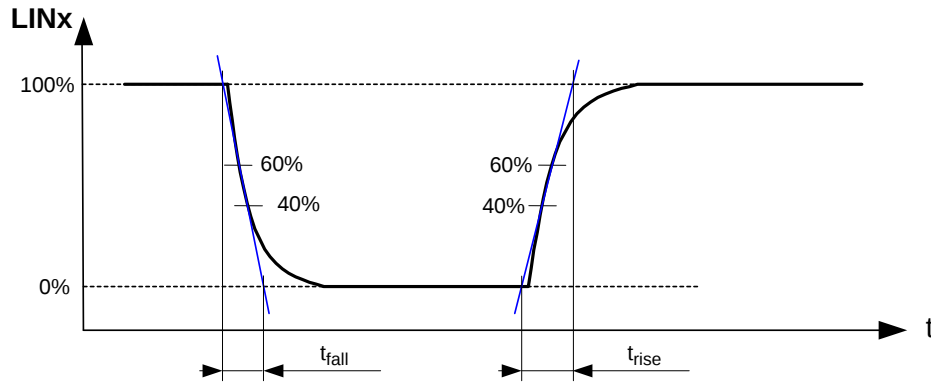


Figure 6. LINx Bus Transmitter Rising and Falling Times

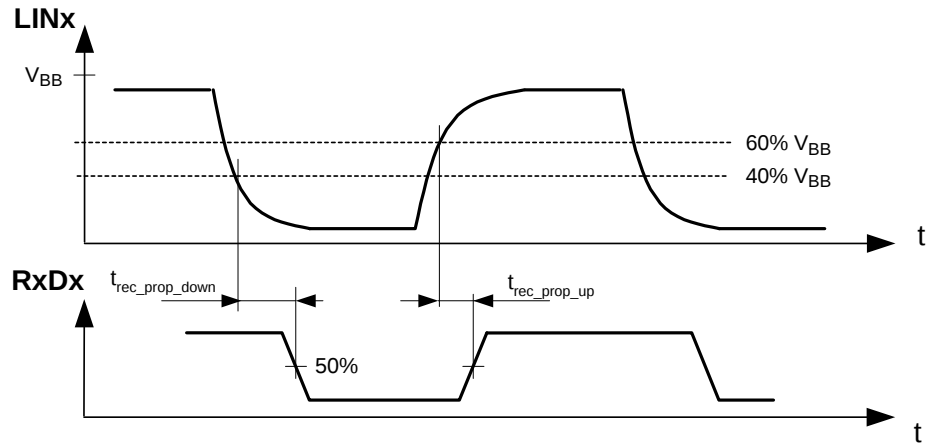


Figure 7. LINx Bus Receiver Timing

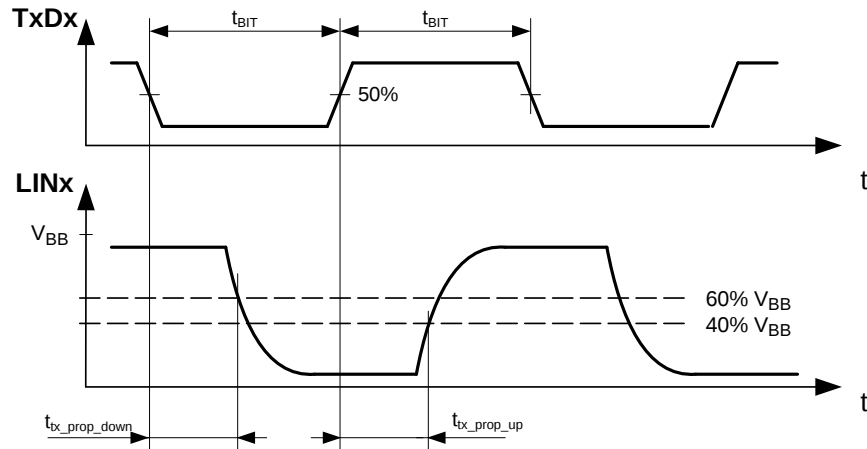


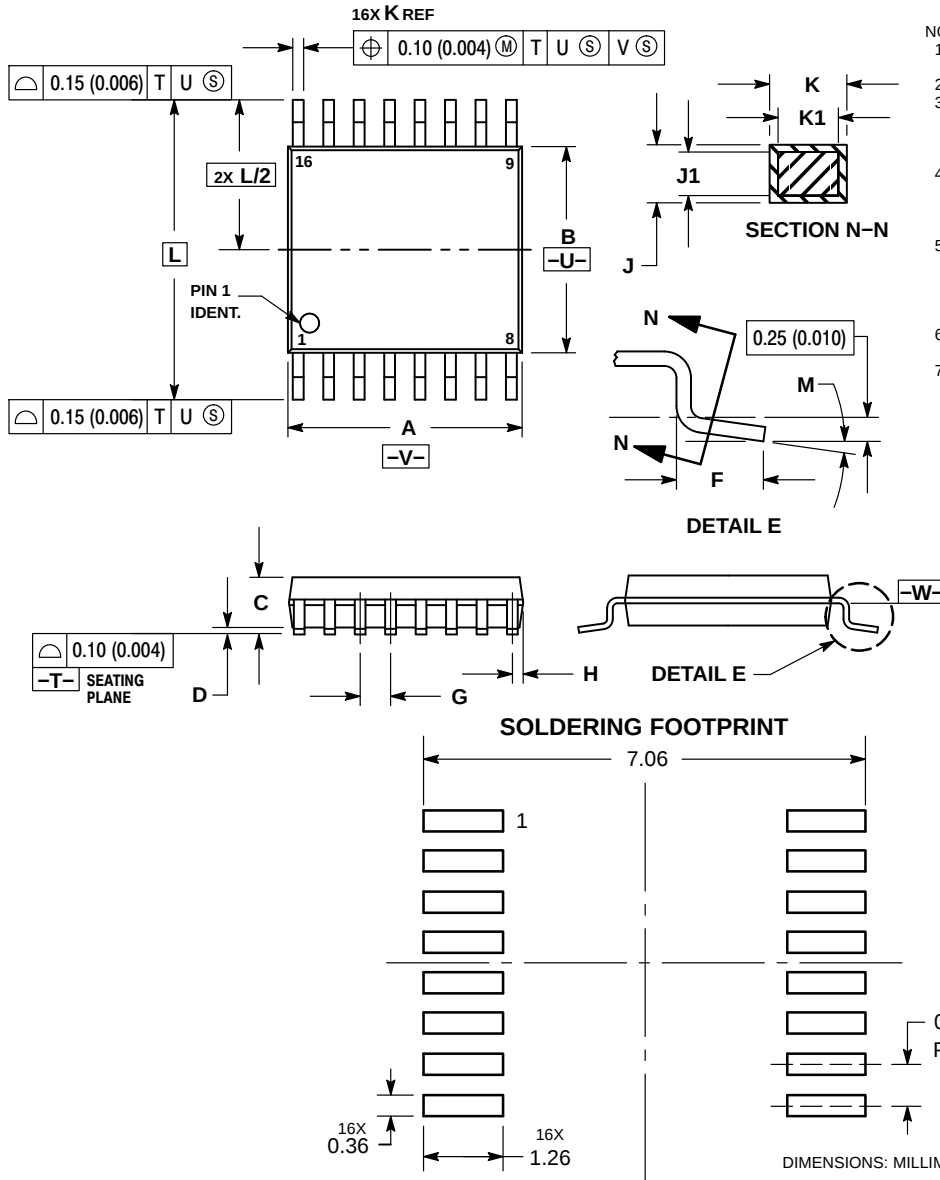
Figure 8. LINx Transmitter Timing

#### ORDERING INFORMATION

| Part Number   | Description          | Temperature Range | Package            | Shipping <sup>†</sup> |
|---------------|----------------------|-------------------|--------------------|-----------------------|
| NCV7424DB0R2G | Quad LIN Transceiver | -40°C to +125°C   | TSSOP-16 (Pb-Free) | 2500 / Tape & Reel    |

<sup>†</sup>For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

## PACKAGE DIMENSIONS

TSSOP-16  
CASE 948F  
ISSUE B

## NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSION A DOES NOT INCLUDE MOLD FLASH. PROTRUSIONS OR GATE BURRS. MOLD FLASH OR GATE BURRS SHALL NOT EXCEED 0.15 (0.006) PER SIDE.
4. DIMENSION B DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION. INTERLEAD FLASH OR PROTRUSION SHALL NOT EXCEED 0.25 (0.010) PER SIDE.
5. DIMENSION K DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.08 (0.003) TOTAL IN EXCESS OF THE K DIMENSION AT MAXIMUM MATERIAL CONDITION.
6. TERMINAL NUMBERS ARE SHOWN FOR REFERENCE ONLY.
7. DIMENSION A AND B ARE TO BE DETERMINED AT DATUM PLANE -W-.

| DIM | MILLIMETERS |      | INCHES    |       |
|-----|-------------|------|-----------|-------|
|     | MIN         | MAX  | MIN       | MAX   |
| A   | 4.90        | 5.10 | 0.193     | 0.200 |
| B   | 4.30        | 4.50 | 0.169     | 0.177 |
| C   | ---         | 1.20 | ---       | 0.047 |
| D   | 0.05        | 0.15 | 0.002     | 0.006 |
| F   | 0.50        | 0.75 | 0.020     | 0.030 |
| G   | 0.65 BSC    |      | 0.026 BSC |       |
| H   | 0.18        | 0.28 | 0.007     | 0.011 |
| J   | 0.09        | 0.20 | 0.004     | 0.008 |
| J1  | 0.09        | 0.16 | 0.004     | 0.006 |
| K   | 0.19        | 0.30 | 0.007     | 0.012 |
| K1  | 0.19        | 0.25 | 0.007     | 0.010 |
| L   | 6.40 BSC    |      | 0.252 BSC |       |
| M   | 0°          | 8°   | 0°        | 8°    |

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