

# TCAN1043xx-Q1 Automotive Low-Power Fault Protected CAN Transceiver with CAN FD and Wake

## 1 Features

- AEC Q100: Qualified for automotive applications
  - Temperature grade 1:  $T_A = -55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$
  - Device HBM classification level:  $\pm 16\text{kV}$
  - Device CDM classification level:  $\pm 1500\text{V}$
- [Functional Safety-Capable](#)
  - [Documentation available to aid functional safety system design](#)
- Meets the requirements of the ISO 11898-2 (2016)
- All devices support classic CAN and 2Mbps CAN FD (flexible data rate) and "G" options support 5Mbps
  - Short and symmetrical propagation delays and fast loop times for enhanced timing margin
  - Higher data rates in loaded CAN networks
- $V_{IO}$  Level shifting supports 2.8V to 5.5V
- Operating modes
  - Normal mode
  - Standby Mode with INH output and local and remote wake up request
  - Low power sleep mode with INH output and local and remote wake up request
- Passive behavior when unpowered
  - Bus and logic terminals are high impedance (no load to operating bus or application)
  - Hot plug capable: power up and down glitch free operation on bus and RXD output
- Meets or exceeds EMC standard requirements
  - IEC 62228-3 – 2007 compliant
  - SAE J2962-2 compliant
- Protection features
  - IEC ESD protection of bus terminals:  $\pm 8\text{kV}$
  - Bus fault protection:  $\pm 58\text{V}$  (non-H variants) and  $\pm 70\text{V}$  (H variants)
  - Undervoltage protection on supply terminals
  - Driver dominant time Out (TXD DTO): data rates down to 9.2kbps
  - Thermal shutdown protection (TSD)
- Receiver common mode input voltage:  $\pm 30\text{V}$
- Typical loop delay: 110ns
- Junction temperatures from  $-55^{\circ}\text{C}$  to  $150^{\circ}\text{C}$

- Available in SOIC (14) package and leadless VSON (14) package (4.5mm x 3mm) with improved automated optical inspection (AOI) capability

## 2 Applications

- 12V or 24V System applications
- Automotive and transportation
  - [Advanced driver assistance system \(ADAS\)](#)
  - [Infotainment](#)
  - [Cluster](#)
  - [Body electronics and lighting](#)

## 3 Description

The TCAN1043xx-Q1 meets the physical layer requirements of the ISO 11898–2 (2016) High Speed Controller Area Network (CAN) specification providing an interface between the CAN bus and the CAN protocol controller. These devices support both classical CAN and CAN FD up to 2 megabits per second (Mbps). Devices with part numbers that include the suffix "G" are designed for CAN FD data rates up to 5Mbps. The TCAN1043xx-Q1 allows for system-level reductions in battery current consumption by selectively enabling (via the INH output pin) the various power supplies that can be present on a node. This allows an ultra-low-current sleep state in which power is gated to all system components except for the TCAN1043xx-Q1, which remains in a low-power state monitoring the CAN bus.

When a wake-up pattern is detected on the bus or when a local wake-up is requested via the WAKE input, the TCAN1043xx-Q1 initiates node start-up by driving INH high. The TCAN1043xx-Q1 includes internal logic level translation via the  $V_{IO}$  terminal to allow for interfacing directly to 3.3V or 5V controllers. The device includes many protection and diagnostic features including CAN bus line short-circuit detection and battery connection detection. The TCAN1043xx-Q1 meets the ESD and EMC requirements of IEC 62228-3 and J2962-2 without the need for additional protection components.

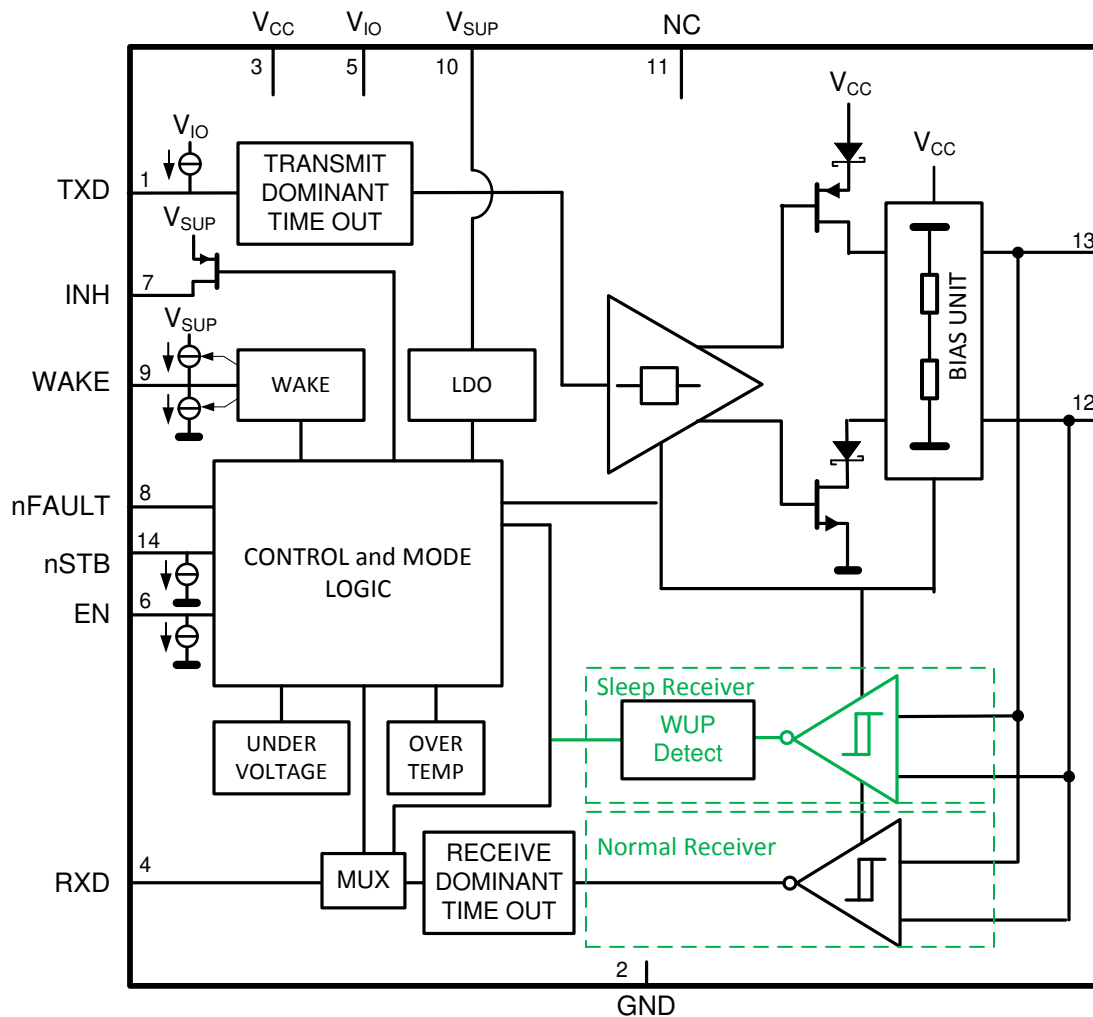


### Package Information

| PART NUMBER   | PACKAGE <sup>(1)</sup> | PACKAGE SIZE <sup>(2)</sup> |
|---------------|------------------------|-----------------------------|
| TCAN1043xx-Q1 | SOIC (14)              | 8.65mm × 6mm                |
|               | VSON (14)              | 4.5mm × 3mm                 |

(1) For more information, see [Section 12](#).

(2) The package size (length × width) is a nominal value and includes pins, where applicable.



Copyright © 2016, Texas Instruments Incorporated

**Functional Block Diagram**

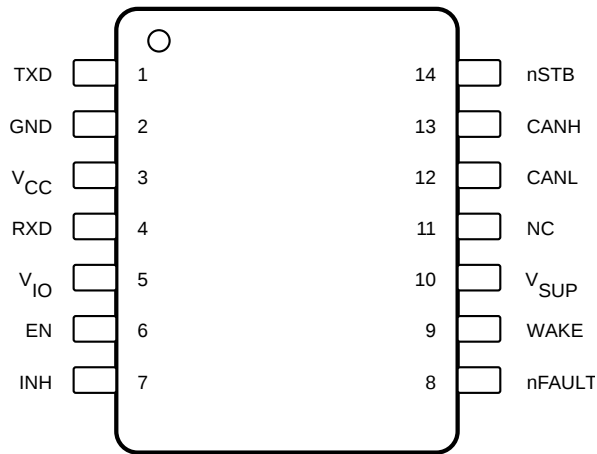
## Table of Contents

|                                                  |           |                                                                  |           |
|--------------------------------------------------|-----------|------------------------------------------------------------------|-----------|
| <b>1 Features</b> .....                          | <b>1</b>  | 8.2 Functional Block Diagram.....                                | <b>18</b> |
| <b>2 Applications</b> .....                      | <b>1</b>  | 8.3 Feature Description.....                                     | <b>19</b> |
| <b>3 Description</b> .....                       | <b>1</b>  | 8.4 Device Functional Modes.....                                 | <b>24</b> |
| <b>4 Device Comparison Table</b> .....           | <b>3</b>  | <b>9 Application Information Disclaimer</b> .....                | <b>34</b> |
| <b>5 Pin Configuration and Functions</b> .....   | <b>4</b>  | 9.1 Application Information.....                                 | <b>34</b> |
| <b>6 Specifications</b> .....                    | <b>5</b>  | 9.2 Typical Application.....                                     | <b>34</b> |
| 6.1 Absolute Maximum Ratings.....                | <b>5</b>  | 9.3 Power Supply Recommendations.....                            | <b>37</b> |
| 6.2 ESD Ratings.....                             | <b>5</b>  | 9.4 Layout.....                                                  | <b>37</b> |
| 6.3 ESD Ratings IEC Specification.....           | <b>6</b>  | <b>10 Device and Documentation Support</b> .....                 | <b>39</b> |
| 6.4 Recommended Operating Conditions.....        | <b>6</b>  | 10.1 Receiving Notification of Documentation Updates..           | <b>39</b> |
| 6.5 Thermal Information.....                     | <b>6</b>  | 10.2 Support Resources.....                                      | <b>39</b> |
| 6.6 Dissipation Ratings.....                     | <b>7</b>  | 10.3 Trademarks.....                                             | <b>39</b> |
| 6.7 Electrical Characteristics.....              | <b>7</b>  | 10.4 Electrostatic Discharge Caution.....                        | <b>39</b> |
| 6.8 Switching Characteristics.....               | <b>10</b> | 10.5 Glossary.....                                               | <b>39</b> |
| 6.9 Typical Characteristics.....                 | <b>12</b> | <b>11 Revision History</b> .....                                 | <b>39</b> |
| <b>7 Parameter Measurement Information</b> ..... | <b>13</b> | <b>12 Mechanical, Packaging, and Orderable Information</b> ..... | <b>40</b> |
| <b>8 Detailed Description</b> .....              | <b>18</b> |                                                                  |           |
| 8.1 Overview.....                                | <b>18</b> |                                                                  |           |

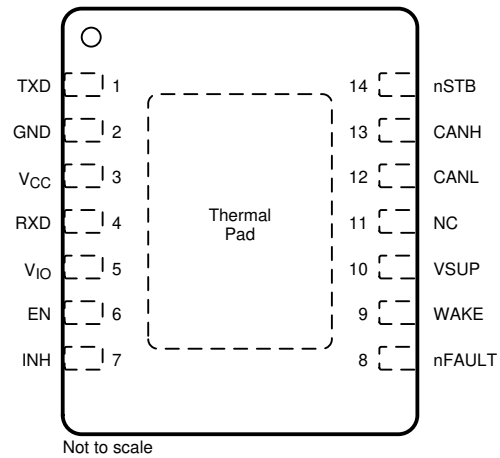
## 4 Device Comparison Table

| DEVICE NUMBER | BUS FAULT PROTECTION | MAXIMUM DATA RATE |
|---------------|----------------------|-------------------|
| TCAN1043-Q1   | ±58V                 | 2Mbps             |
| TCAN1043H-Q1  | ±70V                 | 2Mbps             |
| TCAN1043G-Q1  | ±58V                 | 5Mbps             |
| TCAN1043HG-Q1 | ±70V                 | 5Mbps             |

## 5 Pin Configuration and Functions



**Figure 5-1. D Package, 14 Pin (SOIC)  
 (Top View)**



**Figure 5-2. DMT Package, 14 Pin (VSON)  
 (Top View)**

**Table 5-1. Pin Functions**

| PINS             |    | TYPE                | DESCRIPTION                                                                             |
|------------------|----|---------------------|-----------------------------------------------------------------------------------------|
| NAME             | NO |                     |                                                                                         |
| TXD              | 1  | Digital Input       | CAN transmit data input (low for dominant and high for recessive bus states)            |
| GND              | 2  | GND                 | Ground connection                                                                       |
| V <sub>CC</sub>  | 3  | Supply              | 5V CAN bus supply voltage                                                               |
| RXD              | 4  | Digital Output      | CAN receive data output (low for dominant and high for recessive bus states), tri-state |
| V <sub>IO</sub>  | 5  | Supply              | I/O supply voltage                                                                      |
| EN               | 6  | Digital Input       | Enable input for mode control, integrated pull down                                     |
| INH              | 7  | High Voltage Output | Can be used to control system voltage regulators                                        |
| nFAULT           | 8  | Digital Output      | Fault output, inverted logic                                                            |
| WAKE             | 9  | High Voltage Input  | Wake input terminal, high voltage input                                                 |
| V <sub>SUP</sub> | 10 | Supply              | Reverse-blocked battery supply input                                                    |
| NC               | 11 | —                   | No connect (not internally connected)                                                   |
| CANL             | 12 | Bus I/O             | Low-level CAN bus input/output line                                                     |
| CANH             | 13 | Bus I/O             | High-level CAN bus input/output line                                                    |
| nSTB             | 14 | Digital Input       | Standby input for mode control, integrated pull down                                    |

## 6 Specifications

### 6.1 Absolute Maximum Ratings

See (1) (2)

|                             |                                                                                                                                                                   |                                | MIN  | MAX                                            | UNIT |
|-----------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|------|------------------------------------------------|------|
| V <sub>SUP</sub>            | Battery supply (reverse-blocked) voltage range – standard versions                                                                                                |                                | –0.3 | 58                                             | V    |
|                             | Battery supply (reverse blocked) voltage range – H versions                                                                                                       |                                | –0.3 | 70                                             | V    |
| V <sub>CC</sub>             | 5-V bus supply voltage                                                                                                                                            |                                | –0.3 | 7                                              | V    |
| V <sub>IO</sub>             | I/O level shifting voltage                                                                                                                                        |                                | –0.3 | 7                                              | V    |
| V <sub>BUS</sub>            | CAN bus I/O voltage range (CANH, CANL)                                                                                                                            | Devices without the "H" suffix | –58  | 58                                             | V    |
|                             | CAN bus I/O voltage range (CANH, CANL)                                                                                                                            | Devices with the "H" suffix    | –70  | 70                                             | V    |
| V <sub>(DIFF)</sub>         | Max differential voltage between CANH and CANL                                                                                                                    |                                | –58  | 58                                             | V    |
|                             |                                                                                                                                                                   | Devices with the "H" suffix    | –70  | 70                                             | V    |
| V <sub>(Logic_Input)</sub>  | Logic input terminal voltage range                                                                                                                                |                                | –0.3 | 7                                              | V    |
| V <sub>(Logic_Output)</sub> | Logic output terminal voltage range                                                                                                                               |                                | –0.3 | 7                                              | V    |
| V <sub>INH</sub>            | INH output pin voltage range                                                                                                                                      | Devices without the "H" suffix | –0.3 | 58 and V <sub>O</sub> ≤ V <sub>SUP</sub> + 0.3 | V    |
|                             | INH output pin voltage range                                                                                                                                      | H versions                     | –0.3 | 70 and V <sub>O</sub> ≤ V <sub>SUP</sub> + 0.3 | V    |
| V <sub>(WAKE)</sub>         | WAKE input pin voltage range                                                                                                                                      | Devices without the "H" suffix | –0.3 | 58 and V <sub>I</sub> ≤ V <sub>SUP</sub> + 0.3 | V    |
|                             | WAKE input pin voltage range                                                                                                                                      | H versions                     | –0.3 | 70 and V <sub>I</sub> ≤ V <sub>SUP</sub> + 0.3 | V    |
| I <sub>O(LOGIC)</sub>       | Logic output current                                                                                                                                              | RXD, and nFAULT                |      | 8                                              | mA   |
| I <sub>O(INH)</sub>         | INH output current                                                                                                                                                |                                |      | 4                                              | mA   |
| I <sub>O(WAKE)</sub>        | Wake current if due to ground shifts V <sub>(WAKE)</sub> ≤ V <sub>(GND)</sub> – 0.3 V, thus the current into WAKE must be limited via an external serial resistor |                                |      | 3                                              | mA   |
| T <sub>J</sub>              | Operating virtual junction temperature range                                                                                                                      |                                | –55  | 150                                            | °C   |

- Operation outside the Absolute Maximum Ratings may cause permanent device damage. Absolute Maximum Ratings do not imply functional operation of the device at these or any other conditions beyond those listed under Recommended Operating Conditions. If used outside the Recommended Operating Conditions but within the Absolute Maximum Ratings, the device may not be fully functional, and this may affect device reliability, functionality, performance, and shorten the device lifetime.
- All voltage values, except differential I/O bus voltages, are with respect to ground terminal.

### 6.2 ESD Ratings

|                    |                         |                                          |                                                        | VALUE  | UNIT |
|--------------------|-------------------------|------------------------------------------|--------------------------------------------------------|--------|------|
| V <sub>(ESD)</sub> | Electrostatic discharge | Human body model (HBM), per AEC Q100-002 | V <sub>SUP</sub> , INH <sup>(1)</sup>                  | ±4000  | V    |
|                    |                         |                                          | All pins, except V <sub>SUP</sub> , INH <sup>(1)</sup> | ±6000  | V    |
|                    |                         |                                          | CAN bus terminals (CANH, CANL) <sup>(2)</sup>          | ±16000 | V    |
|                    |                         | Charged device model (CDM) - SOIC        | All terminals <sup>(3)</sup>                           | ±1500  | V    |
|                    |                         | Charged device model (CDM) - DMT         | All terminals <sup>(3)</sup>                           | ±500   | V    |
|                    |                         |                                          | Corner terminals <sup>(3)</sup>                        | ±750   | V    |
|                    |                         | Machine model (MM)                       | All terminals <sup>(4)</sup>                           | ±200   | V    |

- AEC Q100-002 indicates that HBM stressing shall be in accordance with the ANSI/ESDA/JEDEC JS-001 specification.
- Test method based upon AEC-Q100-002, CAN bus terminals stressed with respect to each other and to GND.
- Tested in accordance to AEC-Q100-011.
- Tested in accordance to JEDEC Standard 22, Test Method A115A.

### 6.3 ESD Ratings IEC Specification

|                    |                                                                                         |                                                                |                                                                                           | VALUE  | UNIT |
|--------------------|-----------------------------------------------------------------------------------------|----------------------------------------------------------------|-------------------------------------------------------------------------------------------|--------|------|
| V <sub>(ESD)</sub> | System level electrostatic discharge (ESD)                                              | CAN bus terminals (CANH, CANL) to GND                          | ISO 10605 per SAE J2962-2: Powered Air Discharge <sup>(2)</sup>                           | ±15000 | V    |
|                    |                                                                                         |                                                                | ISO 10605 per SAE J2962-2: Powered Contact Discharge <sup>(2)</sup>                       | ±8000  | V    |
|                    |                                                                                         |                                                                | IEC 61000-4-2 (150 pF, 330 Ω): Unpowered contact discharge                                | ±15000 | V    |
|                    |                                                                                         | V <sub>SUP</sub> and WAKE                                      | IEC 61000-4-2 (150 pF, 330 Ω) Unpowered contact discharge                                 | ±6000  | V    |
|                    | ISO 7637-2 Transients according to GIFT - ICT CAN EMC test specification <sup>(1)</sup> | CAN bus terminals (CANH, CANL) to GND, V <sub>SUP</sub> , WAKE | Pulse 1                                                                                   | –100   | V    |
|                    |                                                                                         |                                                                | Pulse 2                                                                                   | +75    | V    |
|                    |                                                                                         |                                                                | Pulse 3a                                                                                  | –150   | V    |
|                    |                                                                                         |                                                                | Pulse 3b                                                                                  | +100   | V    |
|                    | ISO 7637-3 Transients                                                                   | CAN bus terminals (CANH, CANL) to GND, V <sub>SUP</sub> , WAKE | Direct coupling capacitor "slow transient pulse" with 100-nF coupling capacitor - powered | ±85    | V    |

- (1) ISO 7637 is a system level transient test. Results given here are specific to the IBEE CAN EMC Test specification conditions. Different system level configurations leads to different results.  
(2) Verified by external test facility on SOIC package

### 6.4 Recommended Operating Conditions

|                         |                                                                   | MIN | NOM | MAX | UNIT |
|-------------------------|-------------------------------------------------------------------|-----|-----|-----|------|
| V <sub>SUP</sub>        | Battery supply (reverse-blocked) voltage range - standard version | 4.5 |     | 45  | V    |
|                         | Battery supply (reverse-blocked) voltage range - H version        | 4.5 |     | 60  | V    |
| V <sub>CC</sub>         | 5 V Supply Voltage                                                | 4.5 |     | 5.5 | V    |
| V <sub>IO</sub>         | I/O supply voltage                                                | 2.8 |     | 5.5 | V    |
| I <sub>OH</sub> (LOGIC) | Logic terminal high level output current – RXD and nFAULT         | –2  |     |     | mA   |
| I <sub>OL</sub> (LOGIC) | Logic terminal low level output current – RXD and nFAULT          |     |     | 2   | mA   |
| I <sub>O</sub> (INH)    | INH output current                                                |     |     | 1   | mA   |
| T <sub>A</sub>          | Operational free-air temperature                                  | –55 |     | 125 | °C   |

### 6.5 Thermal Information

| THERMAL METRIC <sup>(1)</sup> |                                              | TCAN1043x-Q1 |            | UNIT |
|-------------------------------|----------------------------------------------|--------------|------------|------|
|                               |                                              | D (SOIC)     | DMT (VSON) |      |
|                               |                                              | 14 PINS      | 14 PINS    |      |
| R <sub>θJA</sub>              | Junction-to-ambient thermal resistance       | 78           | 33.1       | °C/W |
| R <sub>θJC(top)</sub>         | Junction-to-case (top) thermal resistance    | 33.6         | 30.5       | °C/W |
| R <sub>θJB</sub>              | Junction-to-board thermal resistance         | 34.7         | 10.8       | °C/W |
| Ψ <sub>JT</sub>               | Junction-to-top characterization parameter   | 5.7          | 0.4        | °C/W |
| Ψ <sub>JB</sub>               | Junction-to-board characterization parameter | 34.3         | 10.7       | °C/W |
| R <sub>θJC(bot)</sub>         | Junction-to-case (bottom) thermal resistance | n/a          | 1.3        | °C/W |

- (1) For more information about traditional and new thermal metrics, see the [Semiconductor and IC Package Thermal Metrics](#) application report.

## 6.6 Dissipation Ratings

| PARAMETER      |                              | TEST CONDITIONS                                                                                                                                                                                                                                                                                                          | POWER DISSIPATION | UNIT             |
|----------------|------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|------------------|
| $P_D$          | Average power dissipation    | $V_{SUP} = 14\text{ V}$ , $V_{CC} = 5\text{ V}$ , $V_{IO} = 5\text{ V}$ , $T_J = 27^\circ\text{C}$ , $R_L = 60\ \Omega$ , $nSTB = 5\text{ V}$ , $EN = 5\text{ V}$ , $C_{L\_RXD} = 15\text{ pF}$ . Typical CAN operating conditions at 500 kbps with 25% transmission (dominant) rate.                                    | 58                | mW               |
|                |                              | $V_{SUP} = 14\text{ V}$ , $V_{CC} = 5.5\text{ V}$ , $V_{IO} = 5.5\text{ V}$ , $T_J = 150^\circ\text{C}$ , $R_L = 50\ \Omega$ , $nSTB = 5.5\text{ V}$ , $EN = 5.5\text{ V}$ , $C_{L\_RXD} = 15\text{ pF}$ . Typical high load CAN operating conditions at 1Mbps with 50% transmission (dominant) rate and loaded network. | 126               | mW               |
| $T_{TSD}$      | Thermal shutdown temperature |                                                                                                                                                                                                                                                                                                                          | 170               | $^\circ\text{C}$ |
| $T_{TSD\_HYS}$ | Thermal shutdown hysteresis  |                                                                                                                                                                                                                                                                                                                          | 10                | $^\circ\text{C}$ |

## 6.7 Electrical Characteristics

Over recommended operating conditions with  $T_A = -55^\circ\text{C}$  to  $125^\circ\text{C}$  (unless otherwise noted).

| PARAMETER                          |                                                                      |                             | TEST CONDITIONS                                                                                                                                                                                             | MIN                                                                              | TYP <sup>(1)</sup>    | MAX  | UNIT |
|------------------------------------|----------------------------------------------------------------------|-----------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------|-----------------------|------|------|
| SUPPLY CHARACTERISTICS             |                                                                      |                             |                                                                                                                                                                                                             |                                                                                  |                       |      |      |
| I <sub>SUP</sub>                   | Supply current<br>V <sub>SUP</sub>                                   | Normal, Silent, Go-to-Sleep |                                                                                                                                                                                                             |                                                                                  | 40                    | 70   | μA   |
|                                    |                                                                      | Standby mode                | Standby mode, V <sub>CC</sub> > 4.5 V, V <sub>IO</sub> > 2.8 V, V <sub>INH</sub> = V <sub>(WAKE)</sub> = V <sub>SUP</sub>                                                                                   |                                                                                  | 15                    | 45   | μA   |
|                                    |                                                                      | Sleep mode                  | Sleep mode, V <sub>CC</sub> = V <sub>IO</sub> = V <sub>INH</sub> = 0 V<br>V <sub>(WAKE)</sub> = V <sub>SUP</sub>                                                                                            |                                                                                  | 15                    | 30   | μA   |
| I <sub>CC</sub>                    | Supply current<br>Normal mode<br>V <sub>CC</sub>                     | Dominant                    | See <a href="#">Figure 7-2</a> . TXD = 0 V, R <sub>L</sub> = 60 Ω, C <sub>L</sub> = open. Typical bus load.                                                                                                 |                                                                                  |                       | 70   | mA   |
|                                    |                                                                      |                             | See <a href="#">Figure 7-2</a> . TXD = 0 V, R <sub>L</sub> = 50 Ω, C <sub>L</sub> = open. High bus load.                                                                                                    |                                                                                  |                       | 80   | mA   |
|                                    |                                                                      | Dominant with bus fault     | See <a href="#">Figure 7-2</a> . TXD = 0 V, CANH = -25 V, R <sub>L</sub> = open, C <sub>L</sub> = open                                                                                                      |                                                                                  |                       | 110  | mA   |
|                                    |                                                                      | Recessive                   | See <a href="#">Figure 7-2</a> . TXD = V <sub>IO</sub> , R <sub>L</sub> = 50 Ω, C <sub>L</sub> = open, R <sub>CM</sub> = open                                                                               |                                                                                  |                       | 5    | mA   |
|                                    | Supply current Silent and Go-to-Sleep mode                           |                             | See <a href="#">Figure 7-2</a> . TXD = V <sub>IO</sub> , R <sub>L</sub> = 50 Ω, C <sub>L</sub> = open                                                                                                       |                                                                                  |                       | 2.5  | mA   |
|                                    | Supply current Standby mode                                          |                             | See <a href="#">Figure 7-2</a> . EN = L, NSTB = L                                                                                                                                                           |                                                                                  |                       | 5    | μA   |
|                                    | Sleep mode                                                           |                             | See <a href="#">Figure 7-2</a> . EN = H or L, NSTB = L                                                                                                                                                      |                                                                                  |                       | 5    |      |
|                                    | I <sub>IO</sub>                                                      | I/O supply current          | Normal mode                                                                                                                                                                                                 | RXD floating, TXD = 0 V (dominant) nSTB = V <sub>IO</sub> , EN = V <sub>IO</sub> |                       |      | 450  |
| Normal, Silent or Go-to-Sleep mode |                                                                      |                             | RXD floating, TXD = V <sub>IO</sub> recessive                                                                                                                                                               |                                                                                  |                       | 5    | μA   |
|                                    |                                                                      |                             |                                                                                                                                                                                                             |                                                                                  |                       |      |      |
| Sleep mode                         |                                                                      |                             | NSTB = L                                                                                                                                                                                                    |                                                                                  |                       |      | 5    |
| UV <sub>SUP</sub>                  | Undervoltage detection on V <sub>SUP</sub> for protected mode        |                             |                                                                                                                                                                                                             | 3.0                                                                              |                       | 4.2  | V    |
| V <sub>HYS(UVSUP)</sub>            | Hysteresis voltage on UV <sub>SUP</sub>                              |                             |                                                                                                                                                                                                             |                                                                                  | 50                    |      | mV   |
| UV <sub>VCC</sub>                  | Rising undervoltage detection on V <sub>CC</sub> for protected mode  |                             |                                                                                                                                                                                                             |                                                                                  | 4.1                   | 4.4  | V    |
|                                    | Falling undervoltage detection on V <sub>CC</sub> for protected mode |                             |                                                                                                                                                                                                             | 3.5                                                                              | 3.9                   |      | V    |
| V <sub>HYS(UVVCC)</sub>            | Hysteresis voltage on UV <sub>VCC</sub>                              |                             |                                                                                                                                                                                                             |                                                                                  | 200                   |      | mV   |
| UV <sub>VIO</sub>                  | Undervoltage detection on V <sub>IO</sub> for protected mode         |                             |                                                                                                                                                                                                             | 1.3                                                                              |                       | 2.75 | V    |
| V <sub>HYS(UVIO)</sub>             | Hysteresis voltage on UV <sub>IO</sub>                               |                             |                                                                                                                                                                                                             |                                                                                  | 80                    |      | mV   |
| Driver Electrical Characteristics  |                                                                      |                             |                                                                                                                                                                                                             |                                                                                  |                       |      |      |
| V <sub>O(D)</sub>                  | Bus output voltage<br>dominant - normal<br>mode                      | CANH                        | See <a href="#">Figure 7-2</a> and <a href="#">Figure 8-3</a> , TXD = 0 V, Normal mode, 50 ≤ R <sub>L</sub> ≤ 65 Ω, C <sub>L</sub> = open, R <sub>CM</sub> = open                                           | 2.75                                                                             |                       | 4.5  | V    |
|                                    |                                                                      | CANL                        |                                                                                                                                                                                                             | 0.5                                                                              |                       | 2.25 | V    |
| V <sub>O(R)</sub>                  | Bus output voltage<br>recessive                                      | CANH and CANL               | See <a href="#">Figure 7-2</a> and <a href="#">Figure 8-3</a> , TXD = V <sub>CC</sub> , V <sub>IO</sub> = V <sub>CC</sub> , Normal or Silent <sup>(2)</sup> , R <sub>L</sub> = open, R <sub>CM</sub> = open | 2                                                                                | 0.5 × V <sub>CC</sub> | 3    | V    |

## 6.7 Electrical Characteristics (continued)

Over recommended operating conditions with  $T_A = -55^\circ\text{C}$  to  $125^\circ\text{C}$  (unless otherwise noted).

| PARAMETER                           |                                                                                                                             |             | TEST CONDITIONS                                                                                                                                                                                     | MIN  | TYP <sup>(1)</sup> | MAX  | UNIT  |
|-------------------------------------|-----------------------------------------------------------------------------------------------------------------------------|-------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|--------------------|------|-------|
| V <sub>OD(D)</sub>                  | Differential output voltage dominant                                                                                        | CANH - CANL | See <a href="#">Figure 7-2</a> and <a href="#">Figure 8-3</a> , TXD = 0 V, Normal mode, 50 Ω ≤ R <sub>L</sub> ≤ 65 Ω, C <sub>L</sub> = open, R <sub>CM</sub> = open                                 | 1.5  |                    | 3    | V     |
|                                     |                                                                                                                             |             | See <a href="#">Figure 7-2</a> and <a href="#">Figure 8-3</a> , TXD = 0 V, Normal mode, 45 Ω ≤ R <sub>L</sub> ≤ 50 Ω, CL = open, R <sub>CM</sub> = open                                             | 1.4  |                    | 3    | V     |
|                                     |                                                                                                                             |             | See <a href="#">Figure 7-2</a> and <a href="#">Figure 8-3</a> , TXD = 0 V, Normal mode, R <sub>L</sub> = 2240 Ω, C <sub>L</sub> = open, R <sub>CM</sub> = open                                      | 1.5  |                    | 5    | V     |
|                                     |                                                                                                                             |             | See <a href="#">Figure 7-2</a> and <a href="#">Figure 8-3</a> , TXD = 0 V, Normal mode, 45 Ω ≤ R <sub>L</sub> ≤ 70 Ω, C <sub>L</sub> = open, R <sub>CM</sub> = open                                 | 1.4  |                    | 3.3  | V     |
| V <sub>OD(R)</sub>                  | Differential output voltage recessive                                                                                       | CANH - CANL | See <a href="#">Figure 7-2</a> and <a href="#">Figure 8-3</a> , TXD = V <sub>CC</sub> , Normal or Silent mode <sup>(2)</sup> , R <sub>L</sub> = 60 Ω, C <sub>L</sub> = open, R <sub>CM</sub> = open | −120 |                    | 12   | mV    |
|                                     |                                                                                                                             |             | See <a href="#">Figure 7-2</a> and <a href="#">Figure 8-3</a> , TXD = V <sub>CC</sub> , Normal or Silent mode <sup>(2)</sup> , R <sub>L</sub> = open, C <sub>L</sub> = open, R <sub>CM</sub> = open | −50  |                    | 50   | mV    |
| V <sub>SYM</sub>                    | Driver symmetry, dominant or recessive<br>V <sub>SYM</sub> = (V <sub>O(CANH)</sub> + V <sub>O(CANL)</sub> )/V <sub>CC</sub> |             | See <a href="#">Figure 7-2</a> and <a href="#">Figure 9-4</a> , Normal mode, C <sub>L</sub> = open, R <sub>CM</sub> = open, TXD = 1MHz <sup>(3)</sup>                                               | 0.9  |                    | 1.1  | V / V |
| V <sub>SYM_DC</sub>                 | Driver symmetry, dominant<br>V <sub>SYM(DC)</sub> = V <sub>CC</sub> - V <sub>O(CANH)</sub> - V <sub>O(CANL)</sub>           |             | See <a href="#">Figure 7-2</a> and <a href="#">Figure 8-3</a> , Normal or Silent mode, R <sub>L</sub> = 60 Ω, C <sub>L</sub> = open, R <sub>CM</sub> = open                                         | −400 |                    | 400  | mV    |
| I <sub>OS(DOM)</sub>                | Short circuit steady-state output current dominant                                                                          |             | See <a href="#">Figure 7-10</a> and <a href="#">Figure 8-3</a> , V <sub>CANH</sub> = -5 V, CANL = open, TXD = 0 V                                                                                   | −100 |                    |      | mA    |
|                                     |                                                                                                                             |             | See <a href="#">Figure 7-10</a> and <a href="#">Figure 8-3</a> , V <sub>CANL</sub> = 40 V, CANH = open, TXD = 0 V                                                                                   |      |                    | 100  | mA    |
| I <sub>OS(REC)</sub>                | Short circuit steady-state output current recessive                                                                         |             | See <a href="#">Figure 7-10</a> and <a href="#">Figure 8-3</a><br>−27 V ≤ V <sub>BUS</sub> ≤ 32 V, V <sub>BUS</sub> = CANH = CANL, TXD = V <sub>IO</sub>                                            | −5   |                    | 5    | mA    |
| V <sub>O(STB)</sub>                 | Bus output voltage Standby mode                                                                                             | CANH        | STB = V <sub>CC</sub> or V <sub>IO</sub> , R <sub>L</sub> = open, R <sub>CM</sub> = open                                                                                                            | −0.1 | 0                  | 0.1  | V     |
|                                     |                                                                                                                             | CANL        |                                                                                                                                                                                                     | −0.1 | 0                  | 0.1  | V     |
|                                     |                                                                                                                             | CANH - CANL |                                                                                                                                                                                                     | −0.2 | 0                  | 0.2  | V     |
| Receiver Electrical Characteristics |                                                                                                                             |             |                                                                                                                                                                                                     |      |                    |      |       |
| V <sub>CM</sub>                     | Common mode range<br>Normal and Silent modes                                                                                |             | See <a href="#">Figure 7-3</a> and <a href="#">Table 8-5</a>                                                                                                                                        | −30  |                    | 30   | V     |
| V <sub>IT</sub>                     | Input threshold voltage<br>Normal and Silent modes                                                                          |             | See <a href="#">Figure 7-3</a> and <a href="#">Table 8-5</a> , V <sub>CM</sub> ≤ ±20 V                                                                                                              | 500  |                    | 900  | mV    |
|                                     |                                                                                                                             |             | See <a href="#">Figure 7-3</a> and <a href="#">Table 8-5</a> , V <sub>CM</sub> ≤ ±30 V                                                                                                              | 400  |                    | 1000 | mV    |
| V <sub>REC</sub>                    | Receiver recessive voltage                                                                                                  |             | See <a href="#">Figure 7-3</a> and <a href="#">Table 8-5</a>                                                                                                                                        | −3   |                    | 0.5  | V     |
| V <sub>DOM</sub>                    | Receiver dominant voltage                                                                                                   |             | Normal or Silent mode, V <sub>CM</sub> = ±20 V                                                                                                                                                      | 0.9  |                    | 8    | V     |
| V <sub>HYS</sub>                    | Hysteresis voltage for input threshold<br>Normal and Silent modes                                                           |             | See <a href="#">Figure 7-3</a> and <a href="#">Table 8-5</a>                                                                                                                                        |      | 120                |      | mV    |
| V <sub>IT(Sleep)</sub>              | Input threshold<br>Sleep mode                                                                                               |             | See <a href="#">Figure 7-3</a> and <a href="#">Table 8-5</a> ; V <sub>CM</sub> = ± 12 V                                                                                                             | 400  |                    | 1150 | mV    |
| V <sub>REC(Sleep)</sub>             | Receiver recessive voltage<br>Sleep mode                                                                                    |             |                                                                                                                                                                                                     | −3   |                    | 0.4  | V     |
| V <sub>DOM(Sleep)</sub>             | Receiver dominant voltage<br>Sleep mode                                                                                     |             |                                                                                                                                                                                                     | 1.15 |                    | 8    | V     |
| V <sub>CM</sub>                     | Common mode range<br>Standby, Go-to-Sleep and Sleep modes                                                                   |             | See <a href="#">Figure 7-3</a> and <a href="#">Table 8-5</a>                                                                                                                                        | −12  |                    | 12   | V     |
| I <sub>IOFF(LKG)</sub>              | Power-off (unpowered) bus input leakage current                                                                             |             | CANH = CANL = 5 V, V <sub>CC</sub> = GND, V <sub>IO</sub> = GND, V <sub>SUP</sub> = 0 V                                                                                                             |      |                    | 4.8  | μA    |
| C <sub>I</sub>                      | Input capacitance to ground (CANH or CANL)                                                                                  |             | TXD = V <sub>CC</sub> , V <sub>IO</sub> = V <sub>CC</sub> <sup>(4)</sup>                                                                                                                            |      | 24                 | 30   | pF    |
| C <sub>ID</sub>                     | Differential input capacitance (CANH or CANL)                                                                               |             |                                                                                                                                                                                                     |      | 12                 | 15   | pF    |
| R <sub>ID</sub>                     | Differential input resistance                                                                                               |             | TXD = V <sub>CC</sub> = V <sub>IO</sub> = 5 V, Normal mode; −30 ≤ V <sub>CM</sub> ≤ +30V                                                                                                            | 30   |                    | 80   | kΩ    |
| R <sub>IN</sub>                     | Input resistance (CANH or CANL)                                                                                             |             |                                                                                                                                                                                                     | 15   |                    | 40   | kΩ    |

## 6.7 Electrical Characteristics (continued)

Over recommended operating conditions with  $T_A = -55^\circ\text{C}$  to  $125^\circ\text{C}$  (unless otherwise noted).

| PARAMETER                                        |                                                                           | TEST CONDITIONS                                                                       | MIN             | TYP <sup>(1)</sup> | MAX             | UNIT          |
|--------------------------------------------------|---------------------------------------------------------------------------|---------------------------------------------------------------------------------------|-----------------|--------------------|-----------------|---------------|
| $R_{IN(M)}$                                      | Input resistance matching:<br>[1 – $R_{IN(CANH)} / R_{IN(CANL)}$ ] × 100% | $V_{(CANH)} = V_{(CANL)} = 5\text{ V}$                                                | –2%             |                    | 2%              |               |
| $R_{CBF}$                                        | Valid differential load impedance range for bus fault circuitry           | $R_{CM} = R_L$ , $C_L$ = open                                                         | 45              |                    | 70              | $\Omega$      |
| <b>TXD TERMINAL (CAN TRANSMIT DATA INPUT)</b>    |                                                                           |                                                                                       |                 |                    |                 |               |
| $V_{IH}$                                         | High level input voltage                                                  |                                                                                       | 0.7 $V_{IO}$    |                    |                 | V             |
| $V_{IL}$                                         | Low level input voltage                                                   |                                                                                       |                 |                    | 0.3 $V_{IO}$    | V             |
| $I_{IH}$                                         | High level input leakage current                                          | TXD = $V_{CC} = V_{IO} = 5.5\text{ V}$                                                | –2.5            | 0                  | 1               | $\mu\text{A}$ |
| $I_{IL}$                                         | Low level input leakage current                                           | TXD = 0 V, $V_{CC} = V_{IO} = 5.5\text{ V}$                                           | –100            |                    | –2.5            | $\mu\text{A}$ |
| $I_{LKG(OFF)}$                                   | Unpowered leakage current                                                 | TXD = 5.5 V, $V_{CC} = V_{IO} = 0\text{ V}$                                           | –1              | 0                  | 1               | $\mu\text{A}$ |
| $C_I$                                            | Input capacitance                                                         | $V_{IN} = 0.4 \times \sin(2 \times \pi \times 2 \times 10^6 \times t) + 2.5\text{ V}$ |                 | 5                  |                 | pF            |
| <b>RXD TERMINAL (CAN RECEIVE DATA OUTPUT)</b>    |                                                                           |                                                                                       |                 |                    |                 |               |
| $V_{OH}$                                         | High level output voltage                                                 | See Figure 7-3, $I_O = -2\text{ mA}$ .                                                | 0.8 $V_{IO}$    |                    |                 | V             |
| $V_{OL}$                                         | Low level output voltage                                                  | See Figure 7-3, $I_O = -2\text{ mA}$ .                                                |                 |                    | 0.2 $V_{IO}$    | V             |
| <b>nFAULT TERMINAL (FAULT AND STATUS OUTPUT)</b> |                                                                           |                                                                                       |                 |                    |                 |               |
| $V_{OH}$                                         | High level output voltage                                                 | See Figure 7-1, $I_O = -2\text{ mA}$ .                                                | 0.8 $V_{IO}$    |                    |                 | V             |
| $V_{OL}$                                         | Low level output voltage                                                  | See Figure 7-1 $I_O = 2\text{ mA}$ .                                                  |                 |                    | 0.2 $V_{IO}$    | V             |
| <b>nSTB TERMINAL (STANDBY MODE INPUT)</b>        |                                                                           |                                                                                       |                 |                    |                 |               |
| $V_{IH}$                                         | High level input voltage                                                  |                                                                                       | 0.7 $V_{IO}$    |                    |                 | V             |
| $V_{IL}$                                         | Low level input voltage                                                   |                                                                                       |                 |                    | 0.3 $V_{IO}$    | V             |
| $I_{IH}$                                         | High level input leakage current                                          | nSTB = $V_{CC} = V_{IO} = 5.5\text{ V}$                                               | 0.5             |                    | 10              | $\mu\text{A}$ |
| $I_{IL}$                                         | Low level input leakage current                                           | nSTB = 0 V, $V_{CC} = V_{IO} = 5.5\text{ V}$                                          | –1              |                    | 1               | $\mu\text{A}$ |
| $I_{LKG(OFF)}$                                   | Unpowered leakage current                                                 | nSTB = 5.5 V, $V_{CC} = 0\text{ V}$ , $V_{IO} = 0\text{ V}$                           | –1              | 0                  | 1               | $\mu\text{A}$ |
| <b>EN TERMINAL (ENABLE MODE INPUT)</b>           |                                                                           |                                                                                       |                 |                    |                 |               |
| $V_{IH}$                                         | High level input voltage                                                  |                                                                                       | 0.7 $V_{IO}$    |                    |                 | V             |
| $V_{IL}$                                         | Low level input voltage                                                   |                                                                                       |                 |                    | 0.3 $V_{IO}$    | V             |
| $I_{IH}$                                         | High level input leakage current                                          | EN = $V_{CC} = V_{IO} = 5.5\text{ V}$                                                 | 0.5             |                    | 10              | $\mu\text{A}$ |
| $I_{IL}$                                         | Low level input leakage current                                           | EN = 0 V, $V_{CC} = V_{IO} = 5.5\text{ V}$                                            | –1              |                    | 1               | $\mu\text{A}$ |
| $I_{LKG(OFF)}$                                   | Unpowered leakage current                                                 | EN = 5.5 V, $V_{CC} = 0\text{ V}$ , $V_{IO} = 0\text{ V}$                             | –1              | 0                  | 1               | $\mu\text{A}$ |
| <b>INH TERMINAL (INHIBIT OUTPUT)</b>             |                                                                           |                                                                                       |                 |                    |                 |               |
| $\Delta V_H$                                     | High level voltage drop INH with respect to $V_{SUP}$                     | $I_{INH} = -0.5\text{ mA}$                                                            |                 | 0.5                | 1               | V             |
| $I_{LKG(INH)}$                                   | Leakage current                                                           | INH = 0 V, Sleep Mode                                                                 | –5              |                    | 5               | $\mu\text{A}$ |
| <b>Wake TERMINAL (WAKE INPUT)</b>                |                                                                           |                                                                                       |                 |                    |                 |               |
| $V_{IH}$                                         | High level input voltage                                                  | Standby and Sleep Mode                                                                | $V_{SUP} - 1.9$ |                    |                 | V             |
| $V_{IL}$                                         | Low level input voltage                                                   | Standby and Sleep Mode                                                                |                 |                    | $V_{SUP} - 3.5$ | V             |
| $I_{IH}$                                         | High level input current <sup>(5)</sup>                                   | WAKE = $V_{SUP} - 1\text{ V}$                                                         | –25             | –15                |                 | $\mu\text{A}$ |
| $I_{IL}$                                         | Low level input current <sup>(5)</sup>                                    | WAKE = 1 V                                                                            |                 | 15                 | 25              | $\mu\text{A}$ |

- (1) All typical values are at  $25^\circ\text{C}$  and supply voltages of  $V_{CC} = 5\text{ V}$ ,  $V_{IO} = 3.3\text{ V}$ , and  $R_L = 60\ \Omega$ . Unless otherwise noted.
- (2) The recessive bus voltage is the same if the device is in Normal mode with the nSTB and EN terminals high or if the device is in Silent mode with the nSTB terminal high and EN terminal low.
- (3) The bus output voltage symmetry,  $V_{SYM}$ , is measured using  $R_{TERM} / 2 = 30\ \Omega$  and  $C_{SPLIT} = 4.7\text{ nF}$  as shown in Figure 9-4
- (4) Specified by design and verified during product validation using the ISO 11898-2 method.
- (5) To minimize system level current consumption, the WAKE automatically configures itself based on the applied voltage to have either an internal pull-up or pull-down current source. A high level input results in an internal pull-up and a low level input results in an internal pull-down. For more information, refer to Section 8.4.6.2.

## 6.8 Switching Characteristics

Over recommended operating conditions with  $T_A = -55^\circ\text{C}$  to  $125^\circ\text{C}$  (unless otherwise noted)

| PARAMETER                                 |                                                                                      | TEST CONDITIONS                                                                                                                                                  | MIN | TYP <sup>(1)</sup> | MAX | UNIT          |
|-------------------------------------------|--------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|--------------------|-----|---------------|
| <b>DRIVER SWITCHING CHARACTERISTICS</b>   |                                                                                      |                                                                                                                                                                  |     |                    |     |               |
| $t_{pHR}$                                 | Propagation delay time, high TXD to driver recessive                                 | See Figure 7-2, Normal mode.<br>$R_L = 60\ \Omega$ , $C_L = 100\ \text{pF}$ , $R_{CM} = \text{open}$                                                             |     | 50                 |     | ns            |
| $t_{pLD}$                                 | Propagation delay time, low TXD to driver dominant                                   |                                                                                                                                                                  |     | 40                 |     | ns            |
| $t_{sk(p)}$                               | Pulse skew ( $ t_{pHR} - t_{pLD} $ )                                                 |                                                                                                                                                                  |     | 10                 |     | ns            |
| $t_R$                                     | Differential output signal rise time                                                 |                                                                                                                                                                  |     | 45                 |     | ns            |
| $t_F$                                     | Differential output signal fall time                                                 |                                                                                                                                                                  |     | 45                 |     | ns            |
| $t_{TXD\_DTO}$                            | Dominant time out                                                                    | See Figure 7-9, $R_L = 60\ \Omega$ , $C_L = \text{open}$                                                                                                         | 1.2 |                    | 3.8 | ms            |
| <b>RECEIVER SWITCHING CHARACTERISTICS</b> |                                                                                      |                                                                                                                                                                  |     |                    |     |               |
| $t_{pRH}$                                 | Propagation delay time, bus recessive input to high RXD                              | See Figure 7-3<br>$C_{L(RXD)} = 15\ \text{pF}$                                                                                                                   |     | 50                 |     | ns            |
| $t_{pDL}$                                 | Propagation delay time, bus dominant input to RXD low output                         |                                                                                                                                                                  |     | 50                 |     | ns            |
| $t_R$                                     | Output signal rise time (RXD)                                                        |                                                                                                                                                                  |     | 8                  |     | ns            |
| $t_F$                                     | Output signal fall time (RXD)                                                        |                                                                                                                                                                  |     | 8                  |     | ns            |
| $t_{BUS\_DOM}$                            | Dominant time out                                                                    | See Figure 17, $R_L = 60\ \Omega$ , $C_L = \text{open}$                                                                                                          | 1.3 |                    | 3.8 | ms            |
| $t_{CBF}$                                 | Bus fault detection time                                                             | $45\ \Omega \leq R_{CM} \leq 70\ \Omega$ , $C_L = \text{open}$                                                                                                   | 1.9 |                    |     | $\mu\text{s}$ |
| <b>Wake Terminal (Wake input)</b>         |                                                                                      |                                                                                                                                                                  |     |                    |     |               |
| $t_{WAKE\_HT}$                            | WAKE hold time                                                                       | See Figure 7-12 and Figure 7-13<br>Time required for LWU from a high to low or low to high on WAKE                                                               | 5   |                    | 50  | $\mu\text{s}$ |
| <b>Device Switching Characteristics</b>   |                                                                                      |                                                                                                                                                                  |     |                    |     |               |
| $t_{PROP(LOOP1)}$                         | Total loop delay, driver input (TXD) to receiver output (RXD), recessive to dominant | See Figure 7-5, Normal mode,<br>$R_L = 60\ \Omega$ , $C_L = 100\ \text{pF}$ ,<br>$C_{L(RXD)} = 15\ \text{pF}$                                                    | 100 | 160                |     | ns            |
| $t_{PROP(LOOP2)}$                         | Total loop delay, driver input (TXD) to receiver output (RXD), dominant to recessive |                                                                                                                                                                  | 110 | 175                |     | ns            |
| $t_{MODE1}$                               | Mode change time                                                                     | See Figure 7-4 and Figure 7-5, Mode change time for leaving Sleep mode to entering normal and silent mode after $V_{CC}$ and $V_{IO}$ have crossed UV thresholds |     | 20                 |     | $\mu\text{s}$ |
| $t_{MODE2}$                               | Mode change time                                                                     | Mode changes between Normal, Silent and Standby modes, and Sleep to Standby mode transition                                                                      |     | 10                 |     | $\mu\text{s}$ |
| $t_{UV\_RE-ENABLE}$                       | Re-enable time after under voltage event                                             | Time for device to return to normal operation from $UV_{VCC}$ or $UV_{VIO}$ under voltage event                                                                  |     | 200                |     | $\mu\text{s}$ |
| $t_{Power\_Up}$                           | Power up time on $V_{SUP}$                                                           | See Figure 7-11                                                                                                                                                  |     | 250                |     | $\mu\text{s}$ |
| $t_{WK\_FILTER}$                          | Bus time to meet filtered bus requirements for wake up request                       | See Figure 8-5                                                                                                                                                   | 0.5 |                    | 1.8 | $\mu\text{s}$ |
| $t_{WK\_TIMEOUT}$                         | Bus Wake-up timeout value                                                            | See Figure 8-5                                                                                                                                                   | 0.5 |                    | 2   | ms            |
| $t_{UV}$                                  | Undervoltage filter time for $V_{IO}$ and $V_{CC}$                                   | $V_{IO} \leq UV_{VIO}$ or $V_{CC} < UV_{VCC}$                                                                                                                    | 159 |                    | 340 | ms            |
| $t_{Go\_To\_Sleep}$                       | Minimum hold time for transition to sleep mode                                       | $EN = H$ and $nSTB = L$                                                                                                                                          | 5   |                    | 50  | $\mu\text{s}$ |
| <b>FD Timing Parameters</b>               |                                                                                      |                                                                                                                                                                  |     |                    |     |               |

## 6.8 Switching Characteristics (continued)

Over recommended operating conditions with  $T_A = -55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$  (unless otherwise noted)

| PARAMETER               |                                                                                             | TEST CONDITIONS                                                                                                                                          | MIN | TYP <sup>(1)</sup> | MAX | UNIT |
|-------------------------|---------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|-----|--------------------|-----|------|
| $t_{\text{BIT(BUS)}}$   | Bit time on CAN bus output pins with $t_{\text{BIT(TXD)}} = 500$ ns, all devices            | Normal mode, $R_L = 60\ \Omega$ , $C_L = 100$ pF,<br>$C_{L(\text{RXD})} = 15$ pF,<br>$\Delta t_{\text{REC}} = t_{\text{BIT(RXD)}} - t_{\text{BIT(BUS)}}$ | 435 |                    | 530 | ns   |
|                         | Bit time on CAN bus output pins with $t_{\text{BIT(TXD)}} = 200$ ns, G device variants only |                                                                                                                                                          | 155 |                    | 210 | ns   |
| $t_{\text{BIT(RXD)}}$   | Bit time on RXD output pins with $t_{\text{BIT(TXD)}} = 500$ ns, all devices                |                                                                                                                                                          | 400 |                    | 550 | ns   |
|                         | Bit time on RXD output pins with $t_{\text{BIT(TXD)}} = 200$ ns, G device variants only     |                                                                                                                                                          | 120 |                    | 220 | ns   |
| $\Delta t_{\text{REC}}$ | Receiver timing symmetry with $t_{\text{BIT(TXD)}} = 500$ ns, all devices                   |                                                                                                                                                          | -65 |                    | 40  | ns   |
|                         | Receiver timing symmetry with $t_{\text{BIT(TXD)}} = 200$ ns, G device variants only        |                                                                                                                                                          | -45 |                    | 15  | ns   |

## 6.9 Typical Characteristics

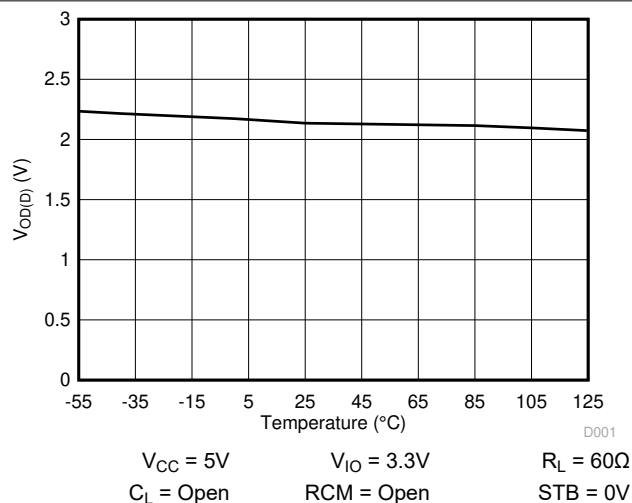


Figure 6-1.  $V_{OD(D)}$  Over Temperature

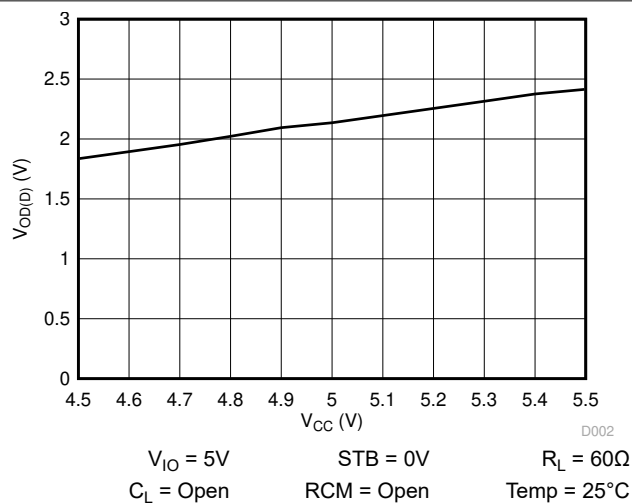


Figure 6-2.  $V_{OD(D)}$  Over  $V_{CC}$

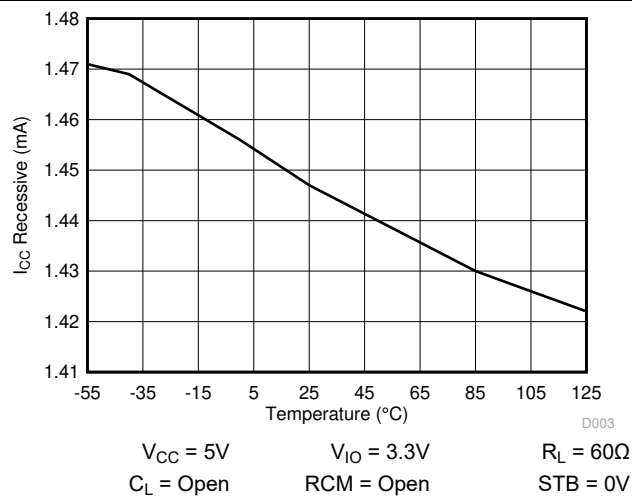


Figure 6-3.  $I_{CC}$  Recessive Over Temperature

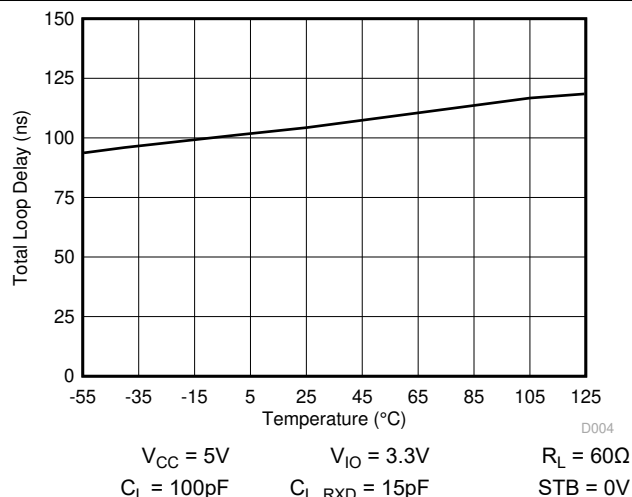
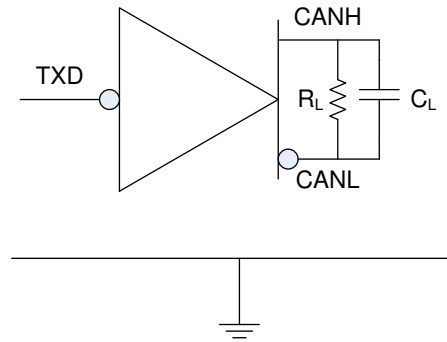


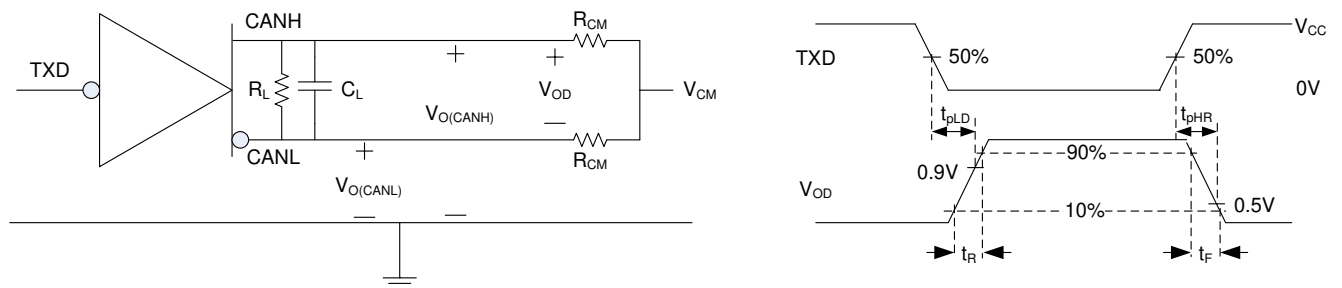
Figure 6-4. Total Loop Delay Over Temperature

## 7 Parameter Measurement Information



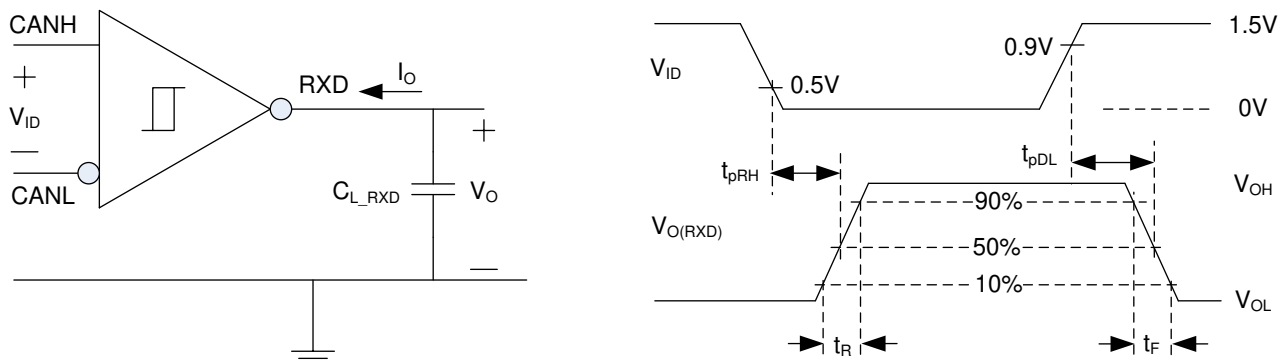
Copyright © 2016, Texas Instruments Incorporated

**Figure 7-1. Supply Test Circuit**



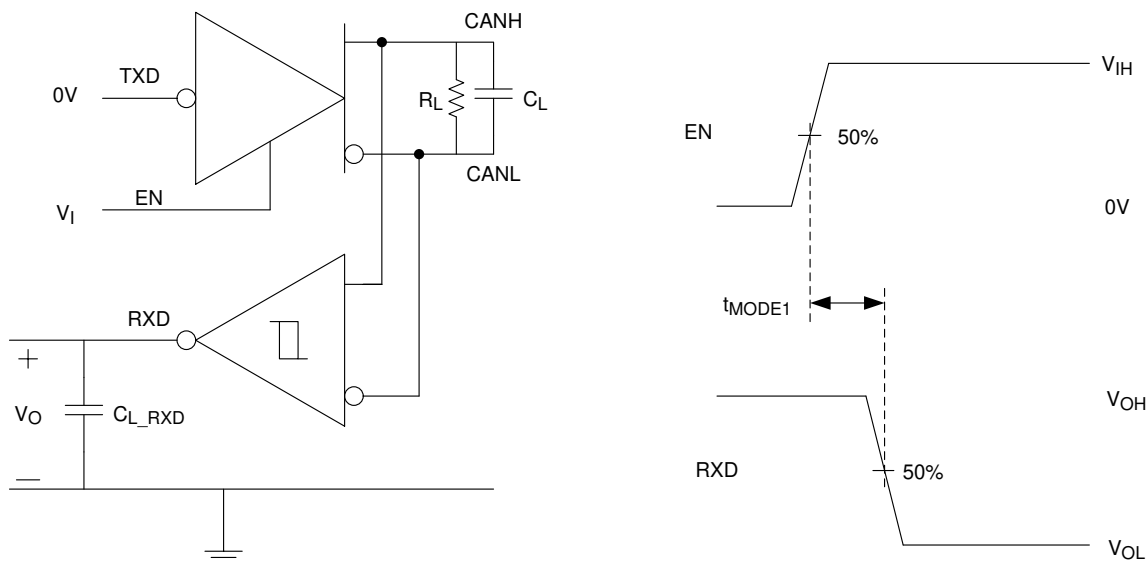
Copyright © 2016, Texas Instruments Incorporated

**Figure 7-2. Driver Test Circuit and Measurement**



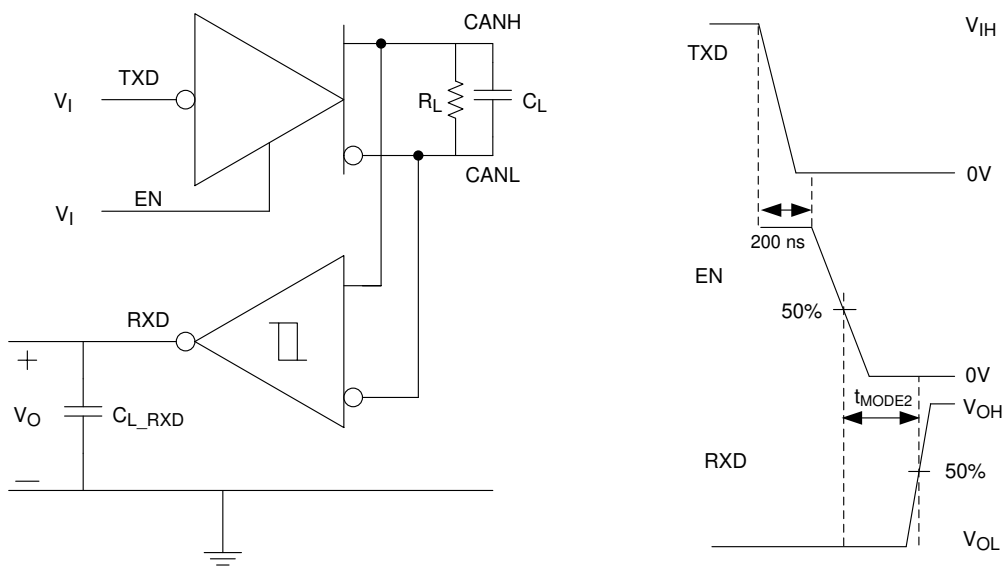
Copyright © 2016, Texas Instruments Incorporated

**Figure 7-3. Receiver Test Circuit and Measurement**



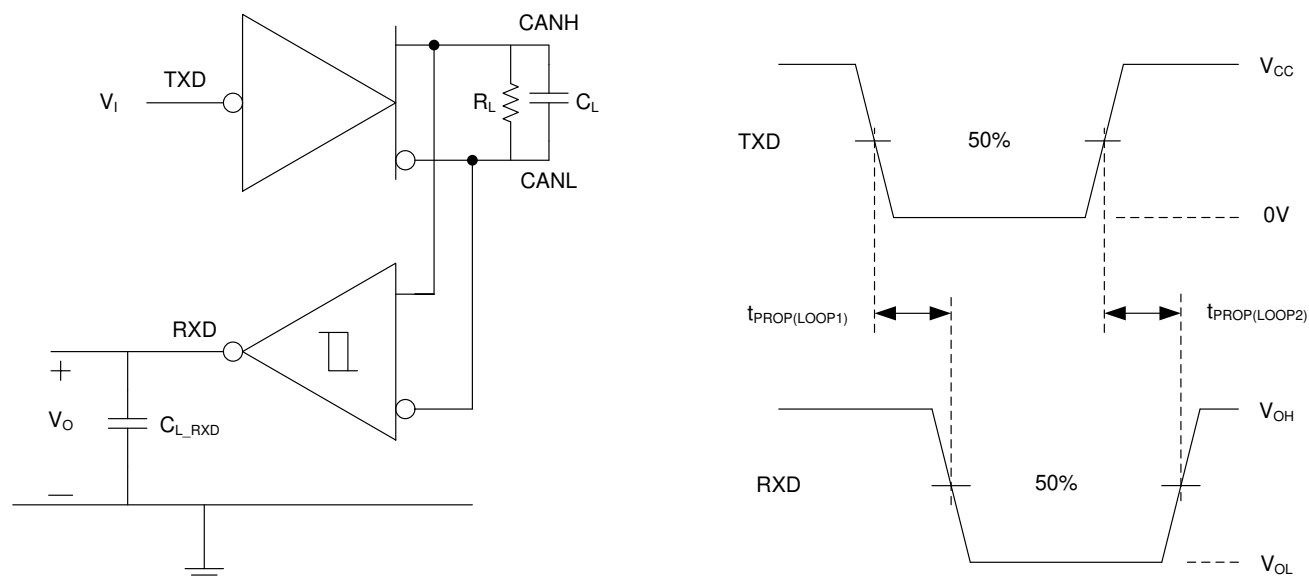
Copyright © 2017, Texas Instruments Incorporated

**Figure 7-4.  $t_{MODE1}$  Test Circuit and Measurement, Silent Mode to Normal Mode**



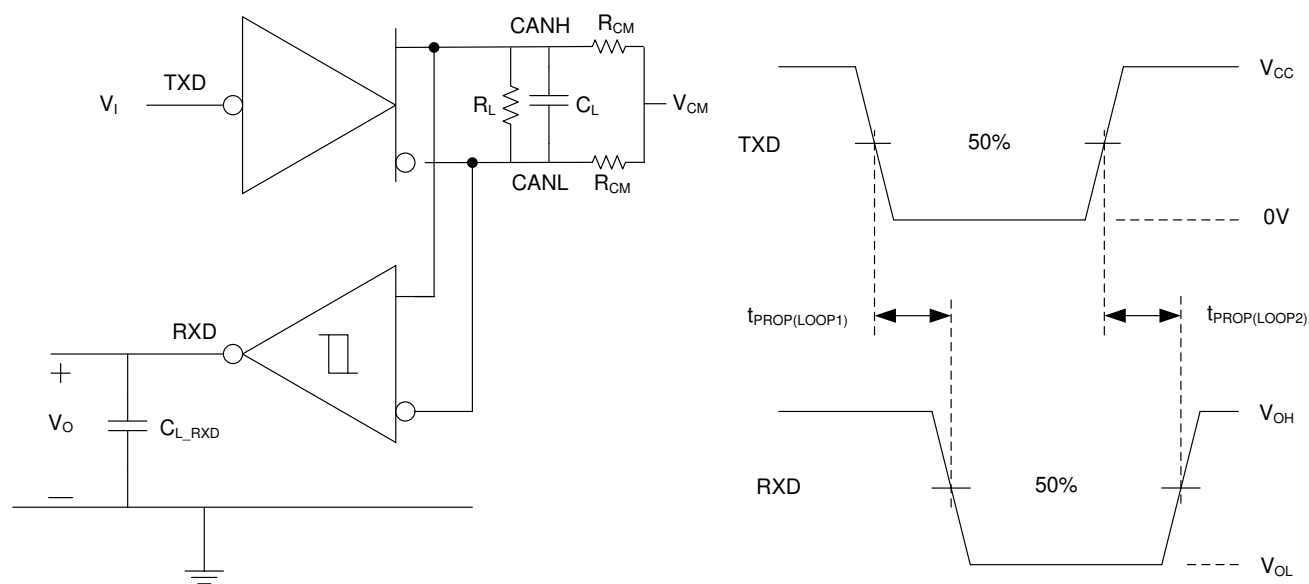
Copyright © 2017, Texas Instruments Incorporated

**Figure 7-5.  $t_{MODE2}$  Test Circuit and Measurement, Normal Mode to Silent Mode**



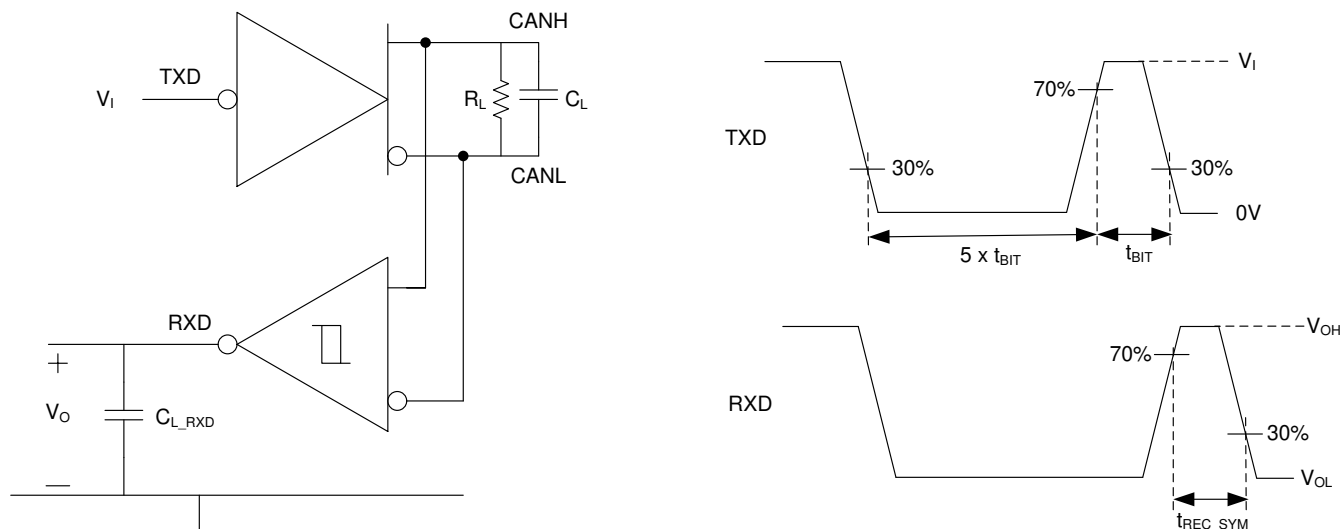
Copyright © 2016, Texas Instruments Incorporated

**Figure 7-6.  $t_{PROP(LOOP)}$  Test Circuit and Measurement**



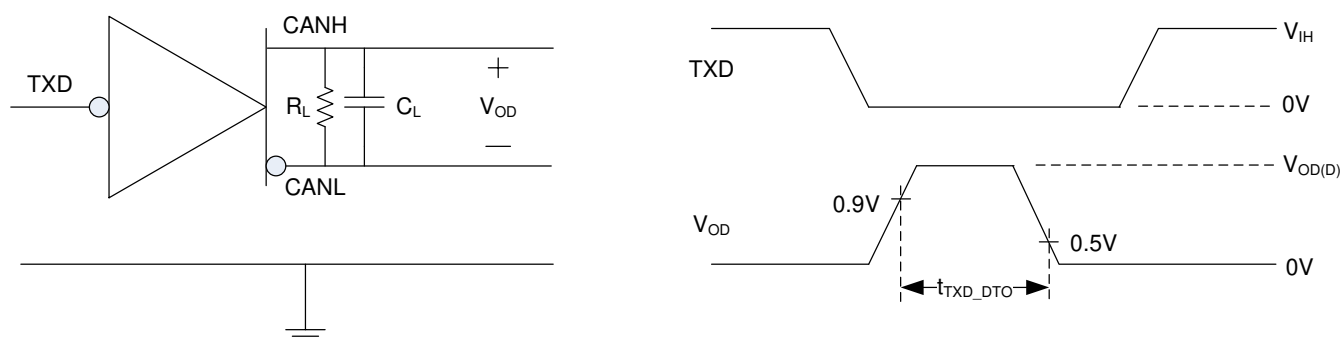
Copyright © 2016, Texas Instruments Incorporated

**Figure 7-7.  $t_{PROP(LOOP)}$  Test Circuit and Measurement with CM Range**



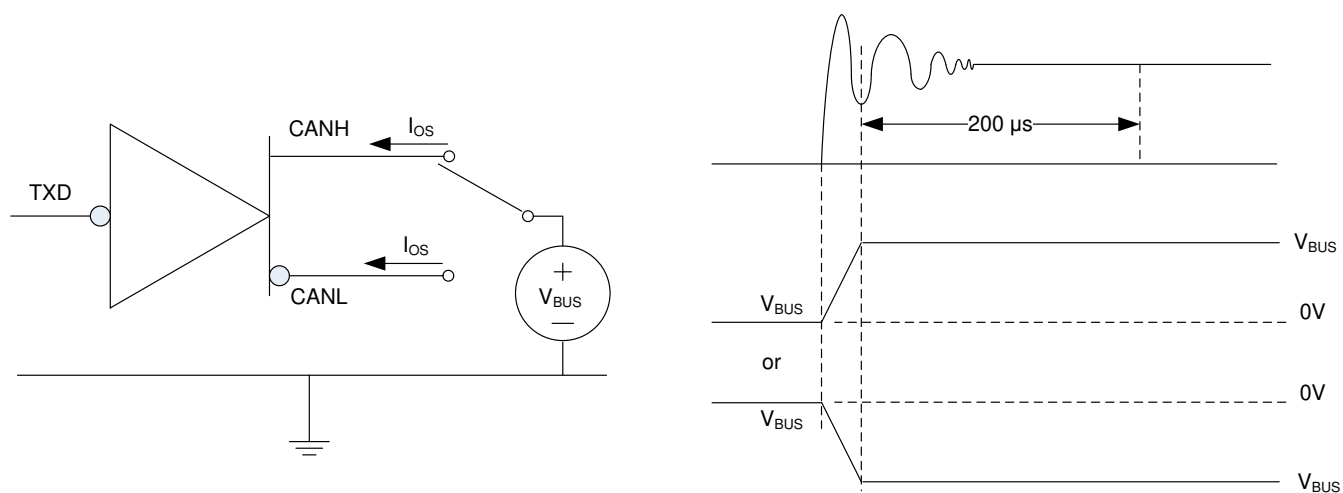
Copyright © 2016, Texas Instruments Incorporated

**Figure 7-8. Loop Delay Symmetry Test Circuit and Measurement**



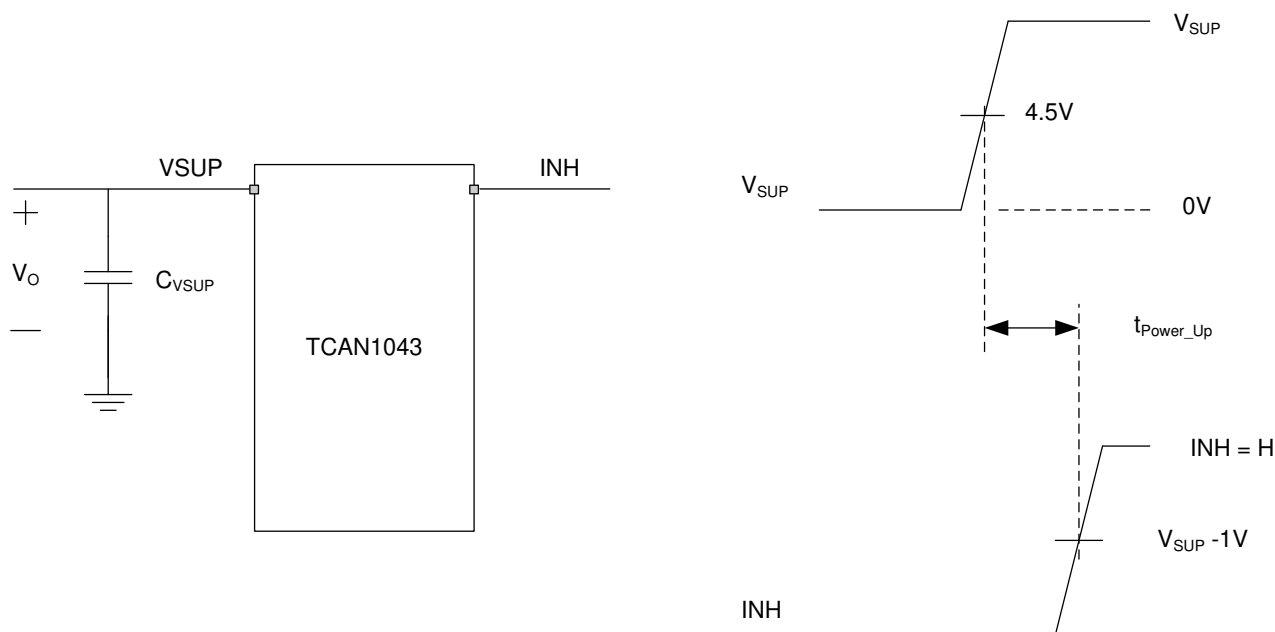
Copyright © 2016, Texas Instruments Incorporated

**Figure 7-9. TXD Dominant Timeout Test Circuit and Measurement**



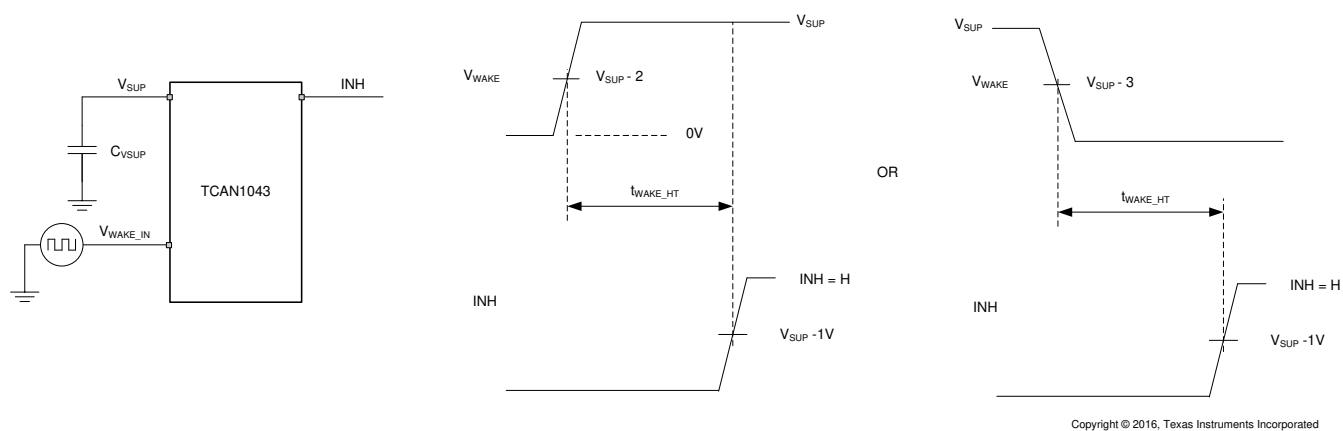
Copyright © 2016, Texas Instruments Incorporated

**Figure 7-10. Driver Short-Circuit Current Test and Measurement**



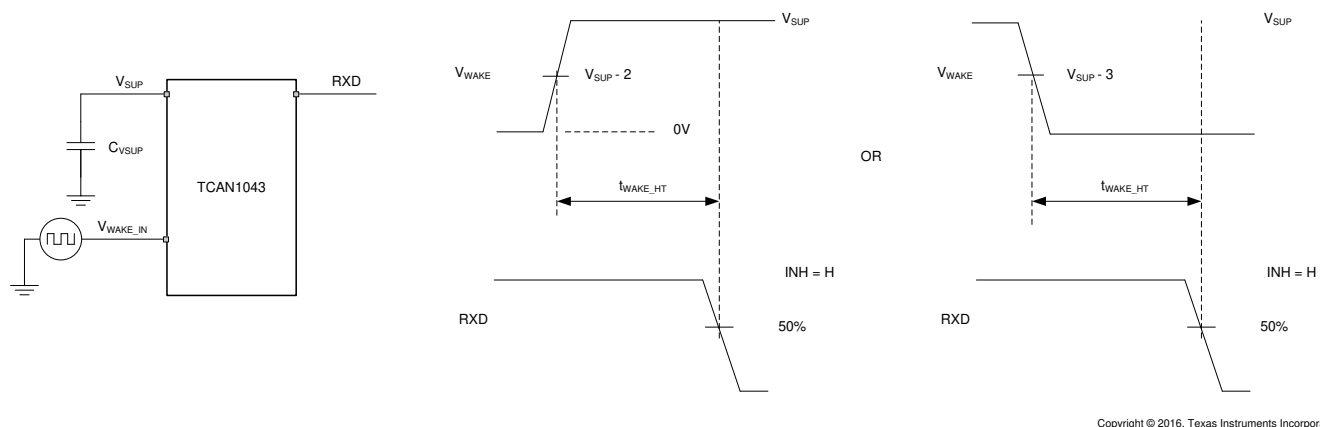
Copyright © 2016, Texas Instruments Incorporated

**Figure 7-11.  $t_{Power\_Up}$  Timing Measurement**



Copyright © 2016, Texas Instruments Incorporated

**Figure 7-12.  $t_{Wake\_HT}$  While Monitoring INH Output**



Copyright © 2016, Texas Instruments Incorporated

**Figure 7-13.  $t_{Wake\_HT}$  While Monitoring RXD Output**

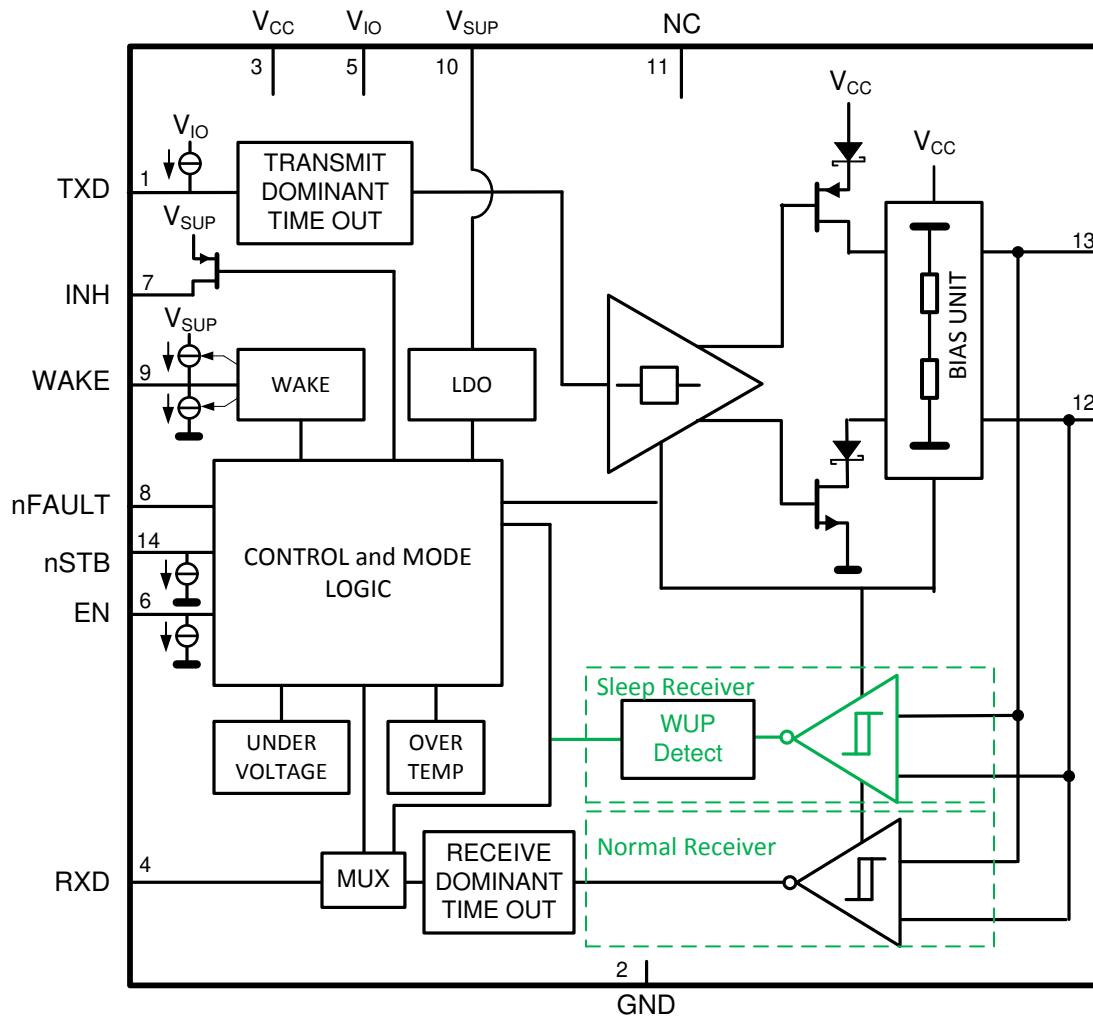
## 8 Detailed Description

### 8.1 Overview

The TCAN1043xx-Q1 meets or exceeds the specifications of the ISO 11898-2 (2016) High Speed CAN (Controller Area Network) physical layer standard. The device has been certified to the requirements of ISO11898-2/5 according to the GIFT/ICT High Speed CAN test specification.

This device provides CAN transceiver differential transmit capability to the bus and differential receive capability from the bus. The device includes many protection features providing device and CAN bus robustness. All of the devices are available to support CAN and CAN FD (Flexible Data Rate) up to 2Mbps while the G version of the device support CAN and CAN FD data rates up to 5Mbps.

### 8.2 Functional Block Diagram



Copyright © 2016, Texas Instruments Incorporated

## 8.3 Feature Description

### 8.3.1 Internal and External Indicator Flags (nFAULT and RXD)

The following device status indicator flags are implemented to allow for the MCU to determine the status of the device and the system. In addition to faults, the nFAULT terminal also signals wake up requests and a cold power-up sequence on the V<sub>SUP</sub> battery terminal so the system can do any diagnostics or cold booting sequence necessary. The RXD terminal indicates wake up request and the faults are multiplexed (ORed) to the nFAULT output.

**Table 8-1. Device Status Indicator Flags**

| EVENT                                     | FLAG NAME             | CAUSE                                                                                                              | INDICATORS <sup>(1)</sup>                                                                                                                 | FLAG IS CLEARED                                                                                                                                          | COMMENT                                                                                                                            |
|-------------------------------------------|-----------------------|--------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------|
| Power-up                                  | PWRON                 | Power up on VSUP and any return of VSUP after it has been below UV <sub>VSUP</sub>                                 | nFAULT = L upon entering Silent mode from Standby, Go-to-Sleep, or Sleep mode                                                             | After transition to normal mode                                                                                                                          |                                                                                                                                    |
| Wake-up Request                           | WAKERQ <sup>(2)</sup> | Wake up event on CAN bus, state transition on WAKE pin, or initial power up                                        | nFAULT = RXD = L after wake up in standby mode, go-to-sleep mode, and sleep mode                                                          | After transition to normal mode, or either a UV <sub>VCC</sub> or UV <sub>VIO</sub> event                                                                | Wake up request can only be set from standby, Go-to-sleep, or sleep mode. Resets timers for UV <sub>VCC</sub> or UV <sub>VIO</sub> |
| Wake-up Source Recognition <sup>(3)</sup> | WAKESR                | Wake up event on CAN bus, state transition on WAKE pin, initial power up                                           | Available upon entering normal mode <sup>(4)</sup> , nFAULT = L indicates wake from WAKE terminal, nFAULT = H indicates wake from CAN bus | After four recessive to dominant edges on TXD in normal mode, leaving normal mode, or either a UV <sub>VCC</sub> or UV <sub>VIO</sub> event              | A LWU source flag is set on initial power up                                                                                       |
| Under voltage                             | UVVCC                 | Under voltage V <sub>CC</sub>                                                                                      | Not externally indicated                                                                                                                  | V <sub>CC</sub> returns, or Wake-up request occurs                                                                                                       |                                                                                                                                    |
|                                           | UVVIO                 | Under voltage V <sub>IO</sub>                                                                                      | Not externally indicated                                                                                                                  | V <sub>IO</sub> returns, or Wake-up request occurs                                                                                                       |                                                                                                                                    |
|                                           | UVVSUP                | Under voltage V <sub>SUP</sub>                                                                                     | Not externally indicated                                                                                                                  | V <sub>SUP</sub> returns                                                                                                                                 | V <sub>SUP</sub> undervoltage event triggers the PWRON and WAKERQ flags upon return of VSUP                                        |
| CAN Bus Failures                          | CBF                   | CANH shorted to GND, V <sub>CC</sub> , V <sub>SUP</sub> or CANL shorted to GND, V <sub>CC</sub> , V <sub>SUP</sub> | nFAULT = L in Normal mode only <sup>(5)</sup>                                                                                             | Upon leaving Normal mode, or if no CAN bus fault is detected for four consecutive dominant to recessive transitions of the TXD pin while in normal mode. | Failure must persist for four consecutive dominant to recessive transitions                                                        |
| Local Faults                              | TXDDTO                | TXD Dominant Time Out, dominant (low) signal for $t \geq t_{TXD\_DTO}$                                             | nFAULT = L upon entering Silent mode from Normal mode                                                                                     | RXD = L and TXD = H, or upon transitioning into Normal, Standby, Go-to-Sleep, or Sleep modes                                                             | CAN driver remains disabled until the TXDDTO is cleared                                                                            |
|                                           | TXDRXD                | TXD and RXD pins are shorted together for $t \geq t_{TXD\_DTO}$                                                    |                                                                                                                                           |                                                                                                                                                          | CAN driver remains disabled until the TXDRXD is cleared                                                                            |
|                                           | CANDOM                | CAN bus dominant fault, when dominant bus signal received for $t \geq t_{BUS\_DOM}$                                |                                                                                                                                           | RXD = H, or upon transitioning into Normal, Standby, Go-to-Sleep, or Sleep modes                                                                         | Driver remains enabled                                                                                                             |
|                                           | TSD                   | Thermal Shutdown, junction temperature $\geq T_{TSD}$                                                              |                                                                                                                                           | T <sub>J</sub> drops below t <sub>TSD</sub> and either RXD = L and TXD = H, or upon transitioning into Normal, Standby, Go-to-Sleep, or Sleep modes      | CAN driver remains disabled until the TSD is cleared                                                                               |

(1) V<sub>IO</sub> and V<sub>SUP</sub> are present.

(2) Transitions to Go-to-sleep mode is blocked until WAKERQ flag is cleared.

(3) Wake-up source recognition reflects the first wake up source. If additional wake-up. events occur the source still indicates the original wake up source.

(4) Indicator is only available in normal mode until the flag is cleared.

(5) CAN Bus failure flag is indicated after four recessive-to-dominant edges on TXD.

### 8.3.2 Power-Up Flag (PWRON)

This is an internal and external flag that is set and controls the power up state of the device. The device powers on to standby mode with the PWRON flag set after  $V_{SUP}$  has cleared the under voltage lock out for  $V_{SUP}$ ,  $UV_{VSUP}$ .

### 8.3.3 Wake-Up Request Flag (WAKERQ)

This is an internal and external flag that can be set in standby, go-to-sleep, or sleep mode. This flag is set when either a valid local wake up (LWU) request occurs, or a valid remote wake request occurs, or on power up on  $V_{SUP}$ . The setting of this flag clears  $t_{UV}$  timer for the  $UV_{VCC}$  or  $UV_{VIO}$ . This flag is cleared upon entering normal mode or during a under voltage event on  $V_{CC}$  or  $V_{IO}$ .

### 8.3.4 Wake-Up Source Recognition Flag (WAKESR)

This flag is an internal and external flag that is set high or low after a valid local wake up (LWU) request occurs, or a valid remote wake request occurs. This flag is only available in Normal mode before four recessive to dominant transitions occur on TXD. If the nFAULT pin is high after entering normal mode, this indicates that a remote wake request was received. If the nFAULT output is low after entering Normal mode, this indicates that a local wake up event occurred. Upon power up on  $V_{SUP}$ , or after and under voltage event on  $V_{SUP}$ , the local wake up request is indicated on nFAULT.

### 8.3.5 Undervoltage Fault Flags

The TCAN1043xx-Q1 device comes with undervoltage detection circuits on all three supply terminals:  $V_{SUP}$ ,  $V_{CC}$ , and  $V_{IO}$ . These flags are internal flags and are not indicated on the nFAULT terminal.

#### 8.3.5.1 Undervoltage on $V_{CC}$ Fault

This internal flag is set when the voltage on  $V_{CC}$  drops below the undervoltage detection voltage threshold,  $UV_{VCC}$ , for longer than the undervoltage filter time,  $t_{UV}$ .

#### 8.3.5.2 Undervoltage on $V_{IO}$ Fault

This internal flag is set when the voltage on  $V_{IO}$  drops below the undervoltage detection voltage threshold,  $UV_{VIO}$ , for longer than the undervoltage filter time,  $t_{UV}$ .

#### 8.3.5.3 Undervoltage on $V_{SUP}$ Fault

This internal flag is set when the voltage on  $V_{SUP}$  drops below the undervoltage detection voltage threshold,  $UV_{VSUP}$ . While this flag is not externally indicated, the PWRON and WAKERQ flags are set once the  $V_{SUP}$  supply returns.

### 8.3.6 CAN Bus Failure Fault Flag

The TCAN1043xx-Q1 devices are able to detect the following six faults that can occur on the CANH and CANL bus terminals. These faults are only detected in Normal mode, and are only indicated via the nFAULT terminal while in Normal mode.

1. CANH bus pin shorted  $V_{SUP}$
2. CANH bus pin shorted  $V_{CC}$
3. CANH bus pin shorted GND
4. CANL bus pin shorted  $V_{SUP}$
5. CANL bus pin shorted  $V_{CC}$
6. CANL bus pin shorted GND

These failures are detected while transmitting a dominant signal on the CAN bus. If one of these fault conditions persists for four consecutive dominant bit transmissions, the nFAULT indicates a CAN bus failure flag in Normal mode by driving the nFAULT pin low. The CAN bus driver remains active.

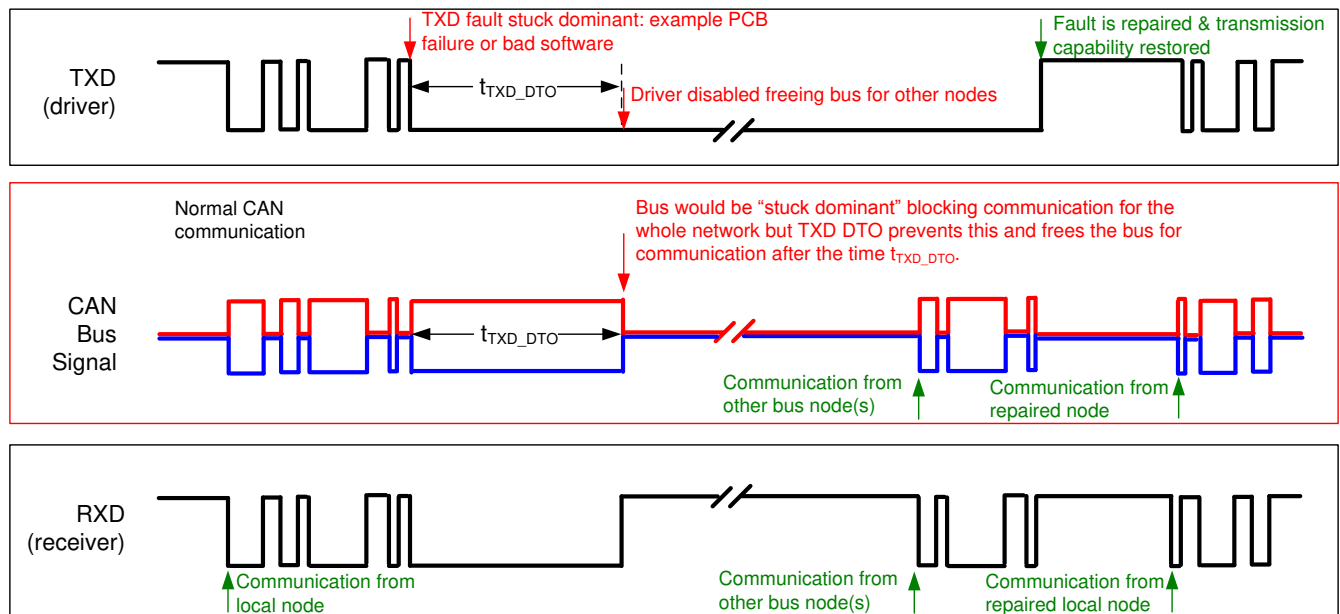
The bus fault failure circuitry is able to detect bus faults for a range of differential resistance loads ( $R_{CBF}$ ), and for data rates from 250kbps to 1Mbps. If a data rate lower than 250kbps is used, the CAN bus fault detection circuitry can falsely report bus faults.

### 8.3.7 Local Faults

Local faults are detected in both Normal mode and Silent mode, but are only indicated via the nFAULT pin when transitioned from Normal mode to Silent mode. All other mode transitions clear the local fault flag indicators.

#### 8.3.7.1 TXD Dominant Timeout (TXD DTO)

During Normal mode, the only mode where the CAN driver is active, the TXD DTO circuit prevents the local node from blocking network communication in event of a hardware or software failure where TXD is held dominant longer than the time out period  $t_{TXD\_DTO}$ . The TXD DTO circuit is triggered by a falling edge on TXD. If no rising edge is seen before the time out constant of the circuit,  $t_{TXD\_DTO}$ , expires, the CAN driver is disabled. This keeps the bus free for communication between other nodes on the network. The CAN driver is re-activated when a recessive signal is seen on the TXD terminal, thus clearing the dominant time out. The receiver and RXD terminal reflects what is on the CAN bus and the bus terminals is biased to recessive level during a TXD DTO. This fault is indicated via the TXDDTO flag shown on the nFAULT terminal.



**Figure 8-1. Example Timing Diagram for TXD DTO**

#### Note

The minimum dominant TXD time allowed by the TXD DTO circuit limits the minimum possible transmitted data rate of the device. The CAN protocol allows a maximum of eleven successive dominant bits (on TXD) for the worst case, where five successive dominant bits are followed immediately by an error frame. The minimum transmitted data rate may be calculated by: Minimum Data Rate = 11 bits /  $t_{TXD\_DTO}$  = 11 bits / 1.2ms = 9.2kbps.

#### 8.3.7.2 TXD Shorted to RXD Fault

The TXDRXD flag is set if the device detects that the TXD and RXD lines have been shorted together for  $t_{TXD\_DTO}$ . This fault is then indicated via the nFAULT terminal. The CAN driver is disabled until the TXDRXD fault is cleared.

This fault is only indicated in Normal mode and Silent mode.

#### 8.3.7.3 CAN Bus Dominant Fault

The CAN bus dominant fault detects if the CAN bus is stuck in a permanent dominant (low) state. This fault is detected when the device detects a dominant on the bus for time  $\geq t_{\text{BUS\_DOM}}$ . This fault is then indicated via the CANDOM flag shown on the nFAULT terminal.

This fault is only indicated on the nFAULT pin in Silent mode. This fault can also be seen on the RXD pin as a dominant pulse for a time  $\geq t_{\text{BUS\_DOM}}$ .

#### 8.3.7.4 Thermal Shutdown (TSD)

If the junction temperature of the device exceeds the thermal shut down threshold, the device turns off the CAN driver circuits thus blocking the TXD to the bus transmission path. The shutdown condition is cleared when the junction temperature of the device drops below the thermal shutdown temperature of the device. If the fault condition that caused the thermal shutdown is still present, the temperature may rise again causing the device to reenter thermal shut down. Prolonged operation with thermal shutdown conditions may affect device reliability. The thermal shutdown circuit includes hysteresis to avoid oscillation of the driver output. This fault is indicated via the TSD flag shown on the nFAULT terminal.

#### 8.3.7.5 RXD Recessive Fault

The RXD recessive fault detects if the RXD terminal is stuck (clamped) in a permanent recessive state. This fault is detected when the device transmits four dominant bits to the bus via TXD but the RXD output does not follow. This fault is then indicated via the RXDREC flag shown on the nFAULT terminal.

#### 8.3.7.6 Undervoltage Lockout (UVLO)

The supply terminals have under voltage detection which puts the device in protected mode if one of the supply rails drop below the threshold voltage. This protects the bus and system during an under voltage event on either  $V_{\text{SUP}}$ ,  $V_{\text{CC}}$  or  $V_{\text{IO}}$  supply terminals. These faults are internal fault flags and are not indicated via the nFAULT terminal.

During an undervoltage event on  $V_{\text{CC}}$  or  $V_{\text{IO}}$  the device goes into protected mode and the driver is disabled. After the UV timer expires, the device transitions into sleep mode and the INH pin goes into a high impedance state. In the event of a UV on  $V_{\text{IO}}$  where the mode pins are no longer driven, the device transitions into standby mode (due to internal fail safe biasing on the NSTB and EN pins) until the UV timer expires and the device transitions into sleep mode.

The  $V_{\text{CC}}$  and  $V_{\text{IO}}$  undervoltage detection circuits share the same timer. Therefore, if an undervoltage on one supply occurs and the timers starts, and then during the undervoltage the other supply has an undervoltage event before the first supply recovers the timer does not reset.

Once an under voltage condition is cleared and the supplies have returned to valid levels the device typically needs 200 $\mu$ s to transition to normal operation.

#### 8.3.7.7 Unpowered Device

The device is designed to be an "ideal passive" or "no load" to the CAN bus when unpowered. The bus terminals (CANH, CANL) have low leakage currents when the device is un-powered so the terminals do not load down the bus. This is critical if some nodes of the network are unpowered while the rest of the of network remains in operation.

Logic terminals also have low leakage currents when the device is un-powered, so the terminals do not load down other circuits which can remain powered.

### 8.3.7.8 Floating Terminals

These devices have internal pull ups on critical terminals to place the device into known states if the terminals float. See [Table 8-2](#) for details on terminal bias conditions.

**Table 8-2. Terminal Failsafe Biasing**

| TERMINAL | PULL UP or PULL DOWN | COMMENT                                                                                      |
|----------|----------------------|----------------------------------------------------------------------------------------------|
| TXD      | Pull up              | Weakly biases TXD toward recessive to prevent bus blockage or TXD DTO triggering             |
| nSTB     | Pull down            | Weakly biases nSTB terminal towards low power Standby mode to prevent excessive system power |
| EN       | Pull down            | Weakly biases EN terminal towards low power mode to prevent excessive system power           |

#### Note

The internal bias should not be relied on by design, especially in noisy environments but should be considered a fall back protection. Special care needs to be taken when the device is used with MCUs using open drain outputs. TXD is weakly internally pulled up. The TXD pull up strength and CAN bit timing require special consideration when this device is used with an open drain TXD output on the microprocessor CAN controller. An adequate external pull up resistor must be used to make sure the TXD output of the microprocessor maintains adequate bit timing input to the CAN transceiver.

### 8.3.7.9 CAN Bus Short Circuit Current Limiting

The TCAN1043xx-Q1 has several protection features that limit the short circuit current when a CAN bus line is shorted. These include CAN driver current limiting (dominant and recessive). The device has TXD dominant time out which prevents permanently having the higher short circuit current of dominant state in case of a system fault. During CAN communication the bus switches between dominant and recessive states, thus the short circuit current can be viewed either as the current during each bus state or as a DC average current. For system current and power considerations in the termination resistors and common mode choke ratings, the average short circuit current is typically used. The percentage dominant is limited by the TXD dominant time out and CAN protocol which has forced state changes and recessive bits such as bit stuffing, control fields, and interframe space. These make sure there is a minimum recessive amount of time on the bus even if the data field contains a high percentage of dominant bits.

The short circuit current of the bus depends on the ratio of recessive to dominant bits and their respective short circuit currents. The average short circuit current can be calculated with [Equation 1](#).

$$I_{OS(AVG)} = \%Transmit \times [(\%REC\_Bits \times I_{OS(SS)\_REC}) + (\%DOM\_Bits \times I_{OS(SS)\_DOM})] + [\%Receive \times I_{OS(SS)\_REC}] \quad (1)$$

Where:

- $I_{OS(AVG)}$  is the average short circuit current
- $\%Transmit$  is the percentage the node is transmitting CAN messages
- $\%Receive$  is the percentage the node is receiving CAN messages
- $\%REC\_Bits$  is the percentage of recessive bits in the transmitted CAN messages
- $\%DOM\_Bits$  is the percentage of dominant bits in the transmitted CAN messages
- $I_{OS(SS)\_REC}$  is the recessive steady state short circuit current
- $I_{OS(SS)\_DOM}$  is the dominant steady state short circuit current

#### Note

The short circuit current and possible fault cases of the network can be taken into consideration when sizing the power ratings of the termination resistance and other network components.

## 8.4 Device Functional Modes

The device has four main operating modes: Normal mode, Standby mode, Silent mode and Sleep mode, and one transitional mode called Go-to-Sleep mode. Operating mode selection is made via the nSTB and EN input terminals in conjunction with supply conditions and wake events.

**Table 8-3. Operating Modes**

| V <sub>CC</sub> and V <sub>IO</sub>         | V <sub>SUP</sub>     | EN | nSTB | WAKERQ Flag | Mode                       | Driver         | Receiver                           | RXD                                  | Bus Bias           | INH               |
|---------------------------------------------|----------------------|----|------|-------------|----------------------------|----------------|------------------------------------|--------------------------------------|--------------------|-------------------|
| > UV <sub>VCC</sub> and > UV <sub>VIO</sub> | > UV <sub>VSUP</sub> | H  | H    | X           | Normal                     | Enabled        | Enabled                            | Mirrors Bus State                    | V <sub>CC</sub> /2 | ON                |
| > UV <sub>VCC</sub> and > UV <sub>VIO</sub> | > UV <sub>VSUP</sub> | L  | H    | X           | Silent                     | Disabled (OFF) | Enabled                            | Mirrors Bus State                    | V <sub>CC</sub> /2 | ON                |
| > UV <sub>VCC</sub> and > UV <sub>VIO</sub> | > UV <sub>VSUP</sub> | H  | L    | Cleared     | Go-to-Sleep <sup>(1)</sup> | Disabled (OFF) | Low Power Bus Monitor Enabled (ON) | High or High Z (no V <sub>IO</sub> ) | Weak pull to GND   | ON <sup>(2)</sup> |
|                                             |                      |    |      | Cleared     | Sleep <sup>(3)</sup>       | Disabled (OFF) | Low Power Bus Monitor Enabled (ON) | High or High Z (no V <sub>IO</sub> ) | Weak pull to GND   | OFF               |
|                                             |                      |    |      | Set         | Standby                    | Disabled (OFF) | Low Power Bus Monitor Enabled (ON) | LOW signals wake up                  | Weak pull to GND   | ON                |
| > UV <sub>VCC</sub> and > UV <sub>VIO</sub> | > UV <sub>VSUP</sub> | L  | L    | X           | Standby                    | Disabled (OFF) | Low Power Bus Monitor Enabled (ON) | LOW signals wake up                  | Weak pull to GND   | ON                |
| < UV <sub>VCC</sub> and < V <sub>VIO</sub>  | > UV <sub>VSUP</sub> | X  | X    | X           | Sleep                      | Disabled (OFF) | Low Power Bus Monitor Enabled (ON) | High or High Z (no V <sub>IO</sub> ) | Weak pull to GND   | OFF (High Z)      |
| X                                           | < UV <sub>VSUP</sub> | X  | X    | X           | Protected                  | Disabled (OFF) | Disabled (OFF)                     | High Z                               | High Z             | OFF (High Z)      |

(1) Go-to-sleep: Transitional mode for EN = H, nSTB = L until t<sub>go\_to\_sleep</sub> timer has expired

(2) The INH pin transitions to high Z (off) after t<sub>go\_to\_sleep</sub> timer has expired

(3) Mode change from Go-to-Sleep mode to sleep mode once t<sub>go\_to\_sleep</sub> timer has expired

### 8.4.1 CAN Bus States

The CAN bus has two logical states during operation: recessive and dominant. See [Figure 8-2](#) and [Figure 8-3](#).

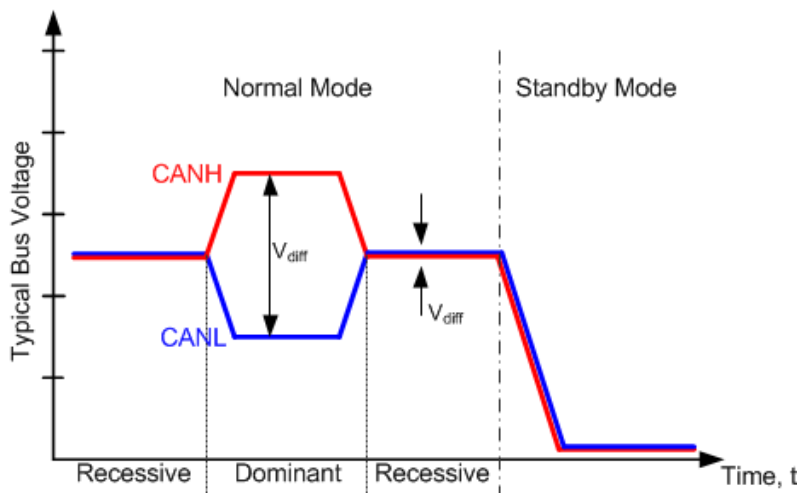
In the recessive bus state the bus is biased to a common mode of approximately V<sub>CC</sub>/2 (2.5V) via the high resistance internal input resistors of the receiver of each node on the bus. Recessive is equivalent to a logic high and is typically a differential voltage on the bus of approximately 0V.

The dominant bus state is when the bus is driven differentially by one or more drivers. Current flows through the termination resistors and generates a differential voltage on the bus. Dominant is equivalent to a logic low and is a differential voltage on the bus greater than the minimum threshold for a CAN dominant. A dominant state overwrites the recessive state.

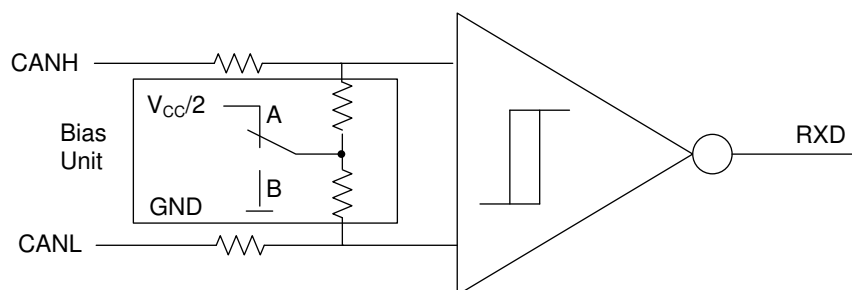
During arbitration, multiple CAN nodes may transmit a dominant bit at the same time. In this case, the differential voltage of the bus is greater than the differential voltage of a single driver.

The host microprocessor of the CAN node uses the TXD terminal to drive the bus and receives data from the bus on the RXD terminal.

The TCAN1043xx-Q1 transceivers has a third bus state in low power standby mode where the bus terminals are weakly biased to ground via the high resistance internal resistors of the receiver. See [Figure 8-2](#) and [Figure 8-3](#).

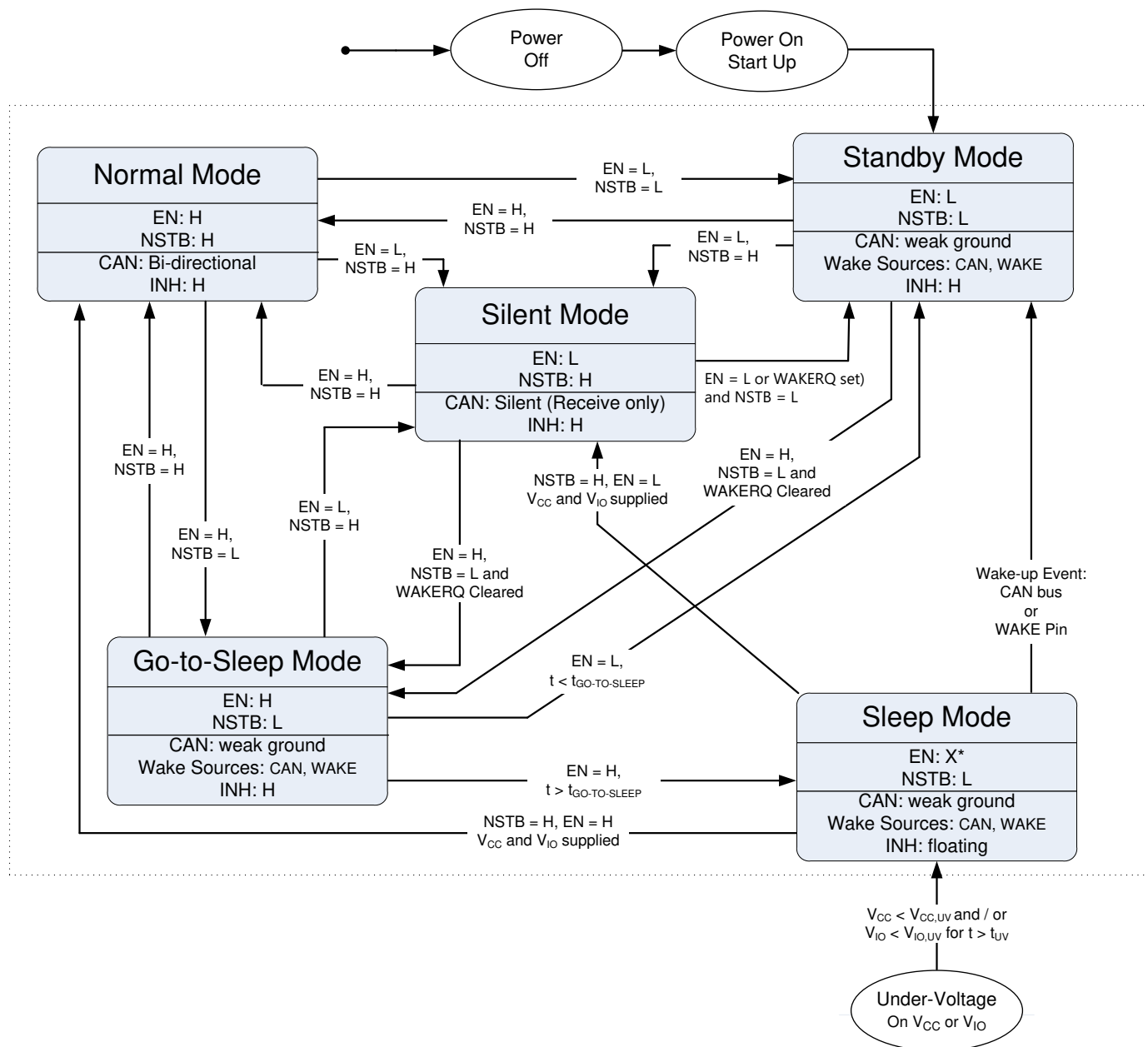


**Figure 8-2. Bus States (Physical Bit Representation)**



- A. Normal and Silent Modes
- B. Sleep and Standby Modes

**Figure 8-3. Bias Unit (Recessive Common Mode Bias) and Receiver**



\*The enable pin can be in a logical high or low state while in sleep mode. However, due to an internal pull-down, the lowest possible power consumption occurs when the pin is left either floating or pulled low externally.

**Figure 8-4. State Diagram**

#### 8.4.2 Normal Mode

This is the normal operating mode of the device. The CAN driver and receiver are fully operational and CAN communication is bi-directional. The driver is translating a digital input on TXD to a differential output on CANH and CANL. The receiver is translating the differential signal from CANH and CANL to a digital output on RXD.

Entering Normal mode clears both the WAKERQ and PWRON flags.

#### 8.4.3 Silent Mode

Silent mode is commonly referred to as listen only and receive only mode. In this mode, the CAN driver is disabled but the receiver is fully operational and CAN communication is unidirectional into the device. The receiver is translating the differential signal from CANH and CANL to a digital output on the RXD terminal.

In Silent mode, the PWRON, and Local Failure Flags can be polled.

#### 8.4.4 Standby Mode

Standby mode is a low power mode where the driver and receiver are disabled, reducing current consumption. However, this is not the lowest power mode of the device since the INH terminal is on, allowing the rest of the system to resume normal operation.

During standby mode, a wake up request (WAKERQ) is indicated by the RXD terminal being low. The wake up source is identified via the nFAULT pin after the device is returned to normal mode.

#### 8.4.5 Go-to-Sleep Mode

Go-to-Sleep mode is the transitional mode of the device from any state to sleep. In this state, the driver and receiver are disabled, reducing the current consumption. However, the INH terminal is on allowing the rest of the system to resume normal operation. If the device is held in this state for time  $\geq t_{go\_to\_sleep}$ , the device transitions to sleep mode, and the INH is turned off (high Z).

Entering Go-to-Sleep Mode from standby mode is gated if the WAKERQ flag is set. Once this flag is cleared, the transition is no longer gated.

#### 8.4.6 Sleep Mode with Remote Wake and Local Wake Up Requests

Sleep mode is the lowest power mode of the device. The CAN driver and main receiver are turned off and bi-directional CAN communication is not possible.

The low power receiver with bus monitor and WAKE circuits are supplied via the  $V_{SUP}$  supply terminal. The low power receiver is able to monitor the bus for any activity that validates the wake up pattern (WUP) requirements, and the WAKE monitoring circuit monitors for state changes on the WAKE terminal for a local wake up (LWU) event. The  $V_{CC}$  and  $V_{IO}$  supplies can be turned off or be controlled via the INH output for additional system level current savings.

The valid wake up sources in sleep mode are:

- Remote wake request: CAN bus activity that validates the WUP requirements
- Local wake up (LWU) request: state change on WAKE terminal

Additionally, EN and nSTB can be used to change modes if both  $V_{CC}$  and  $V_{IO}$  are powered.

If a bus wake up pattern (WUP) or local wake up (LWU) event occurs, the internal WAKERQ flag is set and the device transitions to standby mode which in turn sets the INH output high. The wake up source recognition flag (WAKESR) is set either high or low to identify which wake event occurred. This flag can be polled via the nFAULT pin after the device is returned to normal mode and only until there have been four recessive to dominant transitions on the TXD pin.

The wake source (WAKESR) flag has two states:

- Low: This indicates that the wake up source was via the WAKE pin.
- High: This indicates that a remote wake request via the CAN bus occurred.

If both a local wake and a remote wake request occur, the device indicates whichever event was completed first.

The device transitions into sleep mode if at any time either or both the  $V_{CC}$  or  $V_{IO}$  supplies have an under voltage condition that lasts longer than timer  $t_{UV}$ . If  $V_{IO}$  remains active in sleep mode, the recommendation is to drive the EN pin low once the device has transitioned into sleep mode to reduce the current consumption due to the internal pull-down on the EN terminal.

#### 8.4.6.1 Remote Wake Request via Wake Up Pattern (WUP)

The TCAN1043xx-Q1 use the multiple filtered dominant wake up pattern (WUP) from ISO 11898-2 (2016) to qualify bus activity. The WUP is active for both sleep and standby modes, and results in the RXD terminal being driven low after a valid pattern is received.

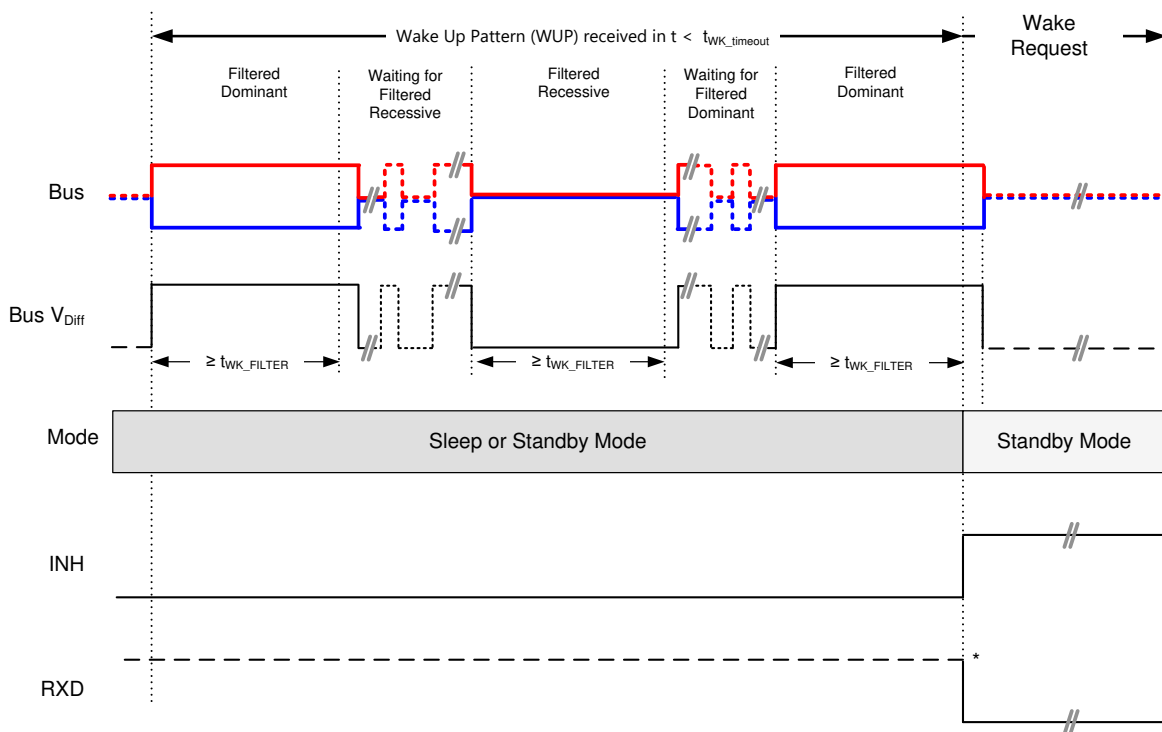
The WUP consists of a filtered dominant pulse, followed by a filtered recessive pulse, and finally by a second filtered dominant pulse. The first filtered dominant initiates the WUP, and the bus monitor then waits on a filtered recessive. Other bus traffic does not reset the bus monitor. Once a filtered recessive is received, the bus monitor is waiting for a filtered dominant and again. Other bus traffic does not reset the bus monitor. Immediately upon reception of the second filtered dominant, the bus monitor recognizes the WUP and transition to standby mode, and drives the INH output high and sets the RXD terminal low (if  $V_{IO}$  is present) to signal the wake up request.

For a dominant or recessive to be considered “filtered”, the bus must be in that state for more than the  $t_{WK\_FILTER}$  time. Due to variability in  $t_{WK\_FILTER}$  the following scenarios are applicable. Bus state times less than  $t_{WK\_FILTER(MIN)}$  are never detected as part of a WUP; thus, no wake request is generated. Bus state times between  $t_{WK\_FILTER(MIN)}$  and  $t_{WK\_FILTER(MAX)}$  may be detected as part of a WUP and a wake request may be generated. Bus state times greater than  $t_{WK\_FILTER(MAX)}$  are always detected as part of a WUP; thus, a wake request is always generated. See [Figure 8-5](#) for the timing diagram of the WUP.

The pattern and  $t_{WK\_FILTER}$  time, used for the WUP and wake request, prevents noise and bus stuck dominant faults from causing false wake requests while allowing any CAN or CAN FD message to initiate a wake request.

If the device is switched to normal mode or an under voltage event occurs on either the  $V_{CC}$  or  $V_{IO}$  supplies, the wake request is lost.

ISO 11898-2 (2016) has two sets of times for a short and long wake up filter times. The  $t_{WK\_FILTER}$  timing for the TCAN1043xx-Q1 devices have been picked to be within the min and max values of both filter ranges. This timing has been chosen such that a single bit time at 500kbps, or two back to back bit times at 1Mbps triggers the filter in either bus state.



The RXD pin is only driven once V<sub>IO</sub> is present.

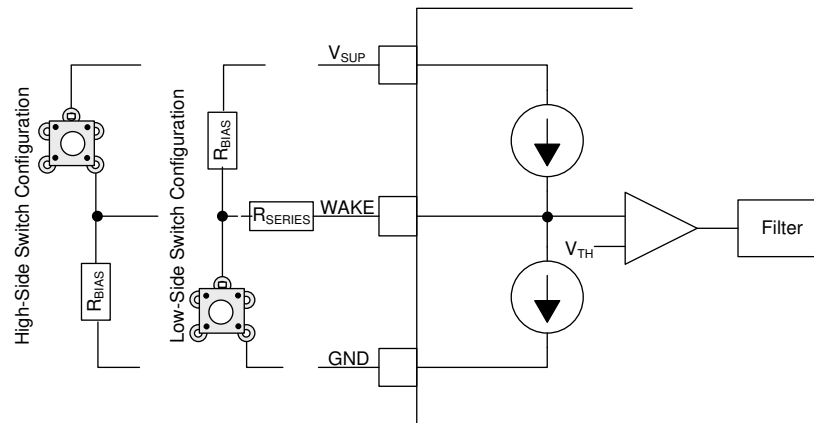
**Figure 8-5. Wake Up Pattern (WUP)**

For an additional layer of robustness and to prevent false wake-ups, the devices implement a timeout feature. For a remote wake up event to successfully occur, the entire WUP must be received within the timeout value  $t < t_{WK\_timeout}$  (see Figure 8-5). If not, the internal logic is reset, and the part remains in the current state without waking up. The full pattern must then be retransmitted, conforming to the constraints mentioned in this section and shown in figure Figure 8-5.

#### 8.4.6.2 Local Wake Up (LWU) via WAKE Input Terminal

The WAKE terminal is a high voltage input terminal which can be used for local wake up (LWU) requests via a voltage transition. The terminal triggers a local wake up (LWU) event on either a low-to-high, or a high-to-low transition since it has a bi-directional input threshold (falling or rising edge).

This terminal may be used with a switch to V<sub>SUP</sub> or to ground. If the terminal is unused it should be pulled to ground or V<sub>SUP</sub> to avoid unwanted parasitic wake up events.



Copyright © 2017, Texas Instruments Incorporated

**Figure 8-6. TCAN1043xx-Q1 WAKE Circuit Example**

Figure 8-6 shows two possible configurations for the WAKE terminal, the low-side and high side switch configurations. The objective of the series resistor,  $R_{SERIES}$ , is to protect the WAKE pin of the transceiver from over current conditions that may occur in the event of a ground shift or ground loss. The minimum value of  $R_{SERIES}$  can be calculated using the maximum supply voltage,  $V_{SUPMAX}$  and the maximum allowable current of the WAKE pin,  $I_{IO(WAKE)}$ .  $R_{SERIES}$  is calculated using:

$$R_{SERIES} = V_{SUPMAX} / I_{IO(WAKE)} \quad (2)$$

If the battery voltage never exceeds 58V DC, then the  $R_{SERIES}$  value is approximately 20kΩ.

The  $R_{BIAS}$  resistor is used to set the static voltage level of the WAKE pin when the switch is not in use. When the switch is in use in a high-side switch configuration, the  $R_{BIAS}$  resistor in combination with the  $R_{SERIES}$  resistor sets the WAKE pin voltage appropriately above the  $V_{IH}$  threshold. The maximum value of  $R_{BIAS}$  can be calculated using the maximum supply voltage,  $V_{SUPMAX}$ , the maximum WAKE threshold voltage  $V_{IH}$ , the maximum WAKE input current  $I_{IH}$  and the series resistor value  $R_{SERIES}$ .  $R_{BIAS}$  is calculated using:

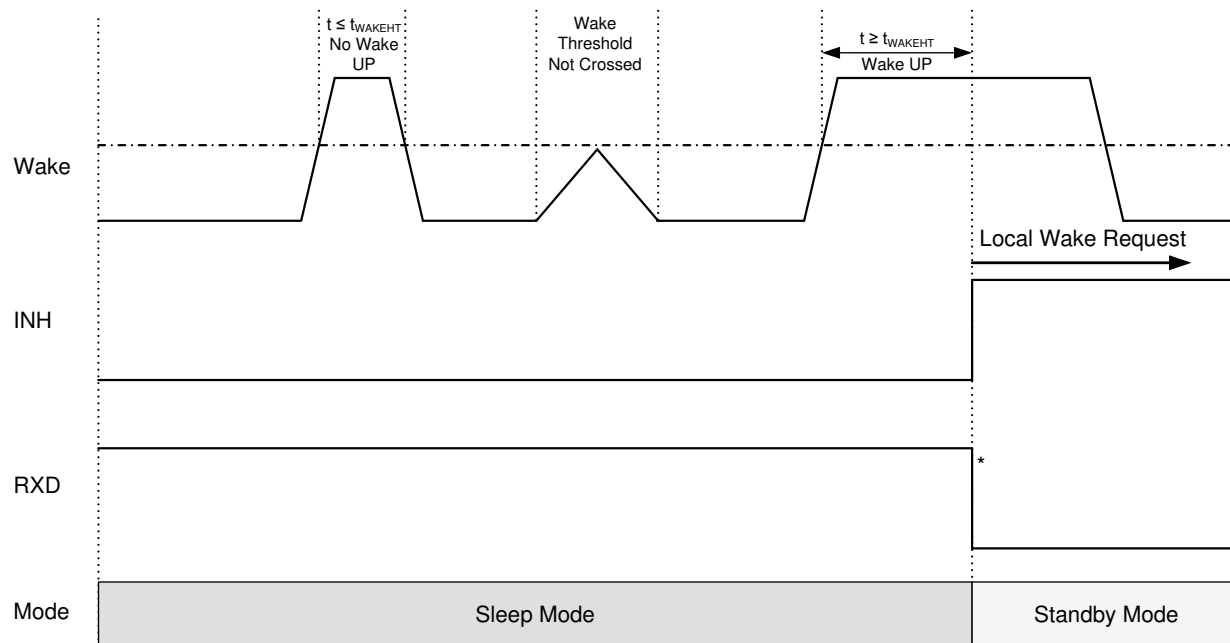
$$R_{BIAS} < ((V_{SUP} - V_{IH}) / I_{IH}) - R_{SERIES} \quad (3)$$

If the battery voltage never exceed 58V DC, then the  $R_{BIAS}$  resistor value must be less than 60kΩ.

For lower current consumption, the low-side switch configuration is the ideal architecture.

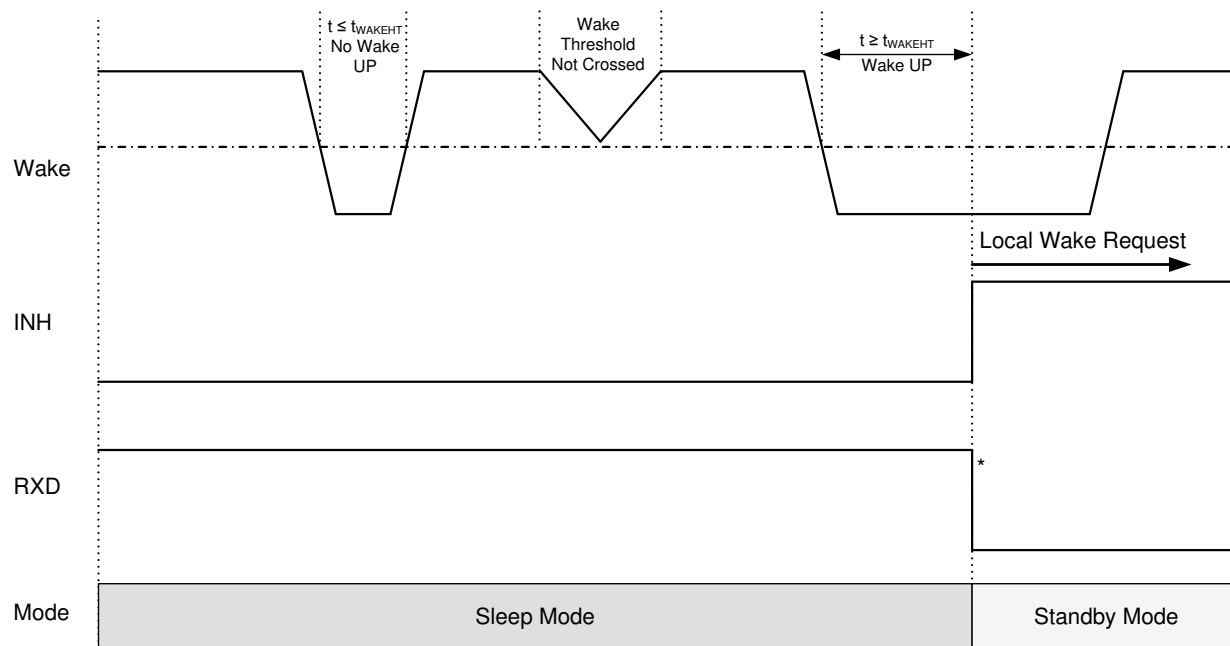
The LWU circuitry is active in [Section 8.4.6](#), [Section 8.4.4](#) and [Section 8.4.5](#). If a valid LWU event occurs the device transitions to standby mode. The LWU circuitry is not active in Normal mode or Silent mode.

To minimize system level current consumption, the internal bias voltages of the terminal follows the state on the terminal with a delay of  $t_{WAKE(min)}$ . A constant high level on WAKE has an internal pull-up to  $V_{SUP}$  and a constant low level on WAKE has an internal pull-down to GND. This minimizes the current flowing into the WAKE pin under these steady-state conditions, and so does not need to be factored into calculations of the total draw from  $V_{SUP}$ .



The RXD pin is only driven once  $V_{IO}$  is present.

**Figure 8-7. Local Wake Up – Rising Edge**



The RXD pin is only driven once  $V_{IO}$  is present.

**Figure 8-8. Local Wake Up – Falling Edge**

## 8.4.7 Driver and Receiver Function Tables

**Table 8-4. Driver Function Table**

| DEVICE MODE | TXD INPUTS <sup>(1)</sup> | BUS OUTPUTS <sup>(2)</sup> |      | DRIVEN BUS STATE <sup>(3)</sup>  |
|-------------|---------------------------|----------------------------|------|----------------------------------|
|             |                           | CANH                       | CANL |                                  |
| Normal      | L                         | H                          | L    | Dominant                         |
|             | H or Open                 | Z                          | Z    | Common Mode Biased to $V_{CC}/2$ |
| Silent      | X                         | Z                          | Z    | Common Mode Biased to $V_{CC}/2$ |
| Standby     | X                         | Z                          | Z    | Common Mode Biased to GND        |
| Go-to-Sleep | X                         | Z                          | Z    | Common Mode Biased to GND        |
| Sleep       | X                         | Z                          | Z    | Common Mode Biased to GND        |

(1) H = high level, L = low level, X = irrelevant.

(2) H = high level, L = low level, Z = high Z receiver bias.

(3) For Bus state and bias see Figure 3 and Figure 4.

**Table 8-5. Receiver Function Table**

| DEVICE MODE                         | CAN DIFFERENTIAL INPUTS<br>$V_{ID} = V_{CANH} - V_{CANL}$ | BUS STATE     | RXD TERMINAL <sup>(1)</sup>                                                                                                                        |
|-------------------------------------|-----------------------------------------------------------|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------|
| Normal                              | $V_{ID} \geq 0.9V$                                        | Dominant      | L                                                                                                                                                  |
|                                     | $0.5V < V_{ID} < 0.9V$                                    | Indeterminate | Indeterminate                                                                                                                                      |
|                                     | $V_{ID} \leq 0.5V$                                        | Recessive     | H                                                                                                                                                  |
|                                     | Open ( $V_{ID} \approx 0V$ )                              | Open          | H                                                                                                                                                  |
| Standby                             | $V_{ID} \geq 1.15V$                                       | Dominant      | H<br>L if either remote or local<br>wake events have occurred                                                                                      |
|                                     | $V_{ID} \leq 0.4V$                                        | Indeterminate |                                                                                                                                                    |
|                                     | $0.5V < V_{ID} < 1.15V$                                   | Recessive     |                                                                                                                                                    |
|                                     | Open ( $V_{ID} \approx 0V$ )                              | Open          |                                                                                                                                                    |
| Sleep and Go-to-Sleep (WUP Monitor) | $V_{ID} \geq 1.15V$                                       | Dominant      | H<br>L if either remote or local<br>wake events have occurred<br>and $V_{IO}$ is present.<br>Tri-State if $V_{IO}$ or $V_{SUP}$ are<br>not present |
|                                     | $0.4V, V_{IO} < 1.15V$                                    | Indeterminate |                                                                                                                                                    |
|                                     | $V_{ID} \leq 0.4V$                                        | Recessive     |                                                                                                                                                    |
|                                     | Open ( $V_{ID} \approx 0V$ )                              | Open          |                                                                                                                                                    |

(1) H = high level, L = low level

## 8.4.8 Digital Inputs and Outputs

All devices have a  $V_{IO}$  supply that is used to set the digital input thresholds and digital output levels. The input thresholds are ratio metric to the  $V_{IO}$  supply using CMOS input levels, making them scalable for  $\mu$ Ps with digital IOs from 2.8V to 5V. The high level output voltages for the RXD and nFAULT output pins are driven to  $V_{IO}$  level for logic high output.

#### **8.4.9 INH (Inhibit) Output**

The inhibit output terminal is used to control system power management devices allowing for extremely low system current consumption in sleep mode. This terminal can be used to enable and disable local power supplies. The pin has two states: driven high and high impedance (High Z).

When high (on), the terminal shows  $V_{SUP}$  minus a diode voltage drop. In the high impedance state, the output is left floating. The INH pin is high for normal, silent, Go-to-Sleep, and standby modes. INH is low when in sleep mode.

---

#### **Note**

This terminal is considered a “high voltage logic” terminal, not a power output. Thus, can be used to drive the EN terminal of the system power management device and not used as a switch for the power management supply. This terminal is not reverse battery protected and can not be connected outside the system module.

---

## 9 Application Information Disclaimer

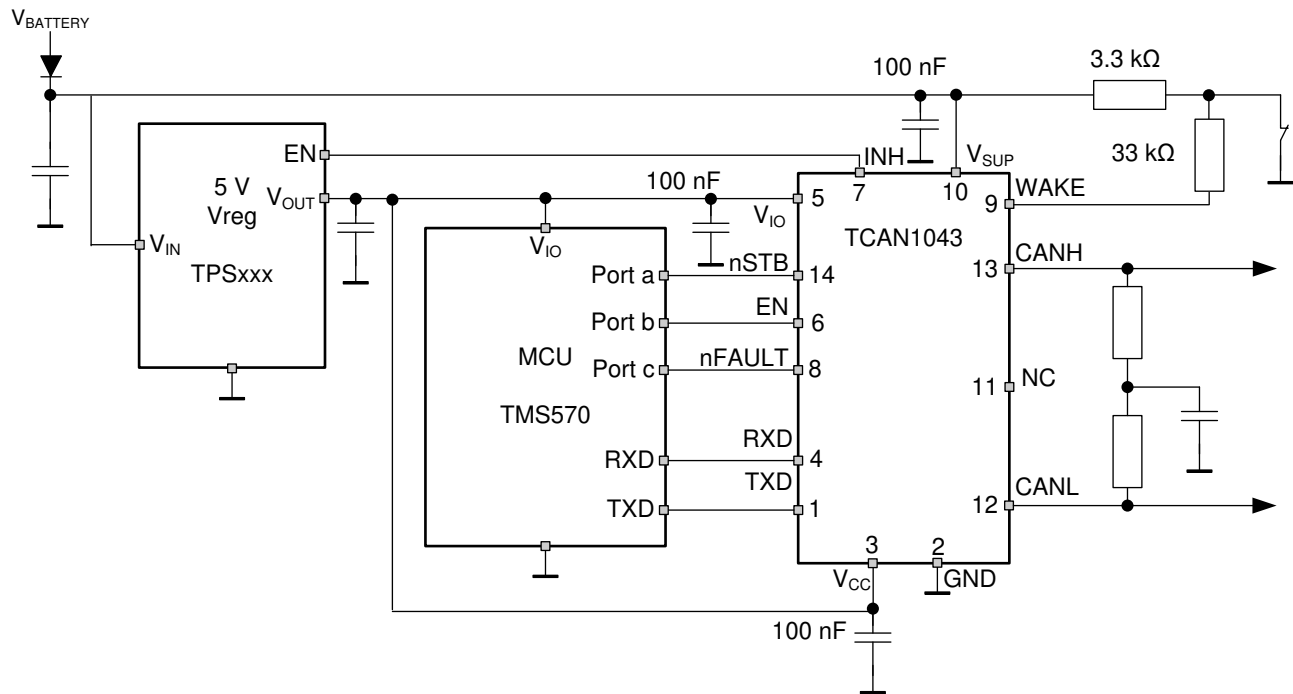
### Note

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes, as well as validating and testing their design implementation to confirm system functionality.

## 9.1 Application Information

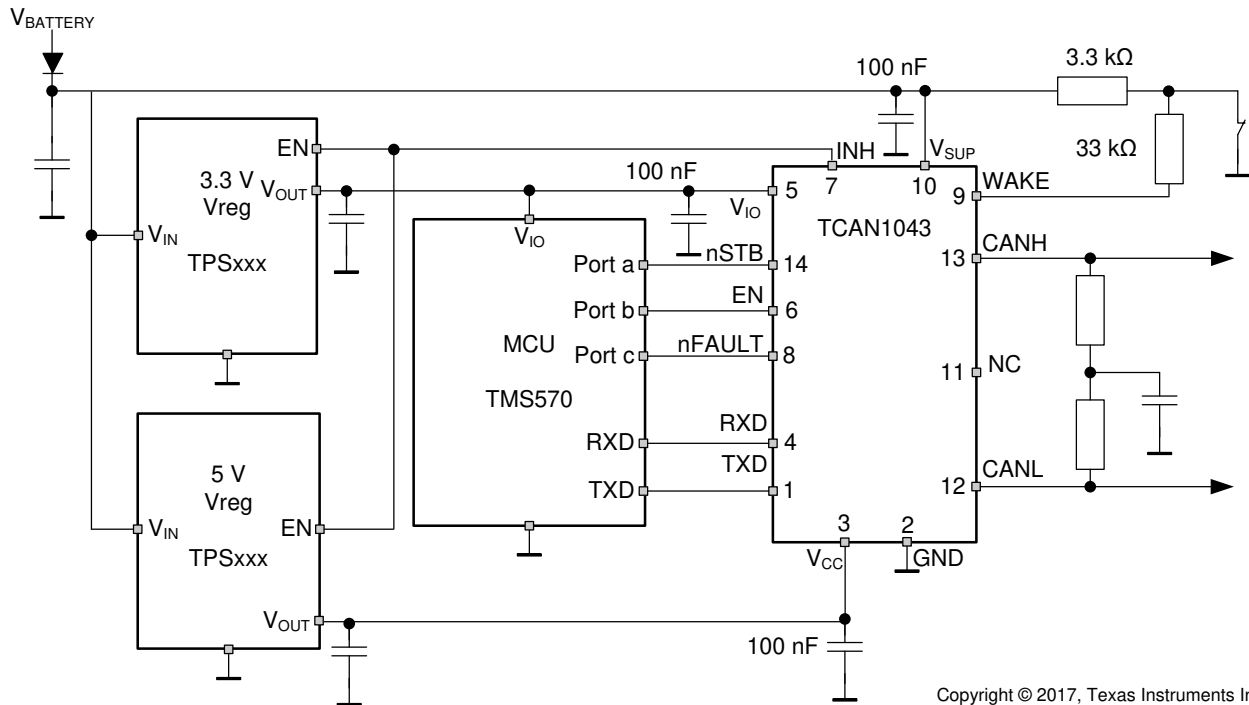
The TCAN1043xx-Q1 transceivers are typically used in applications with a host microprocessor or FPGA that includes the data link layer portion of the CAN protocol. These types of applications usually also include power management technology that allows for power to be gated to the application via an enable (EN) or inhibit (INH) pin. A single 5V regulator can be used to drive both  $V_{CC}$  and  $V_{IO}$  as shown in [Figure 9-1](#), or independent 5V and 3.3V regulators can be used to drive  $V_{CC}$  and  $V_{IO}$  separately as shown in [Figure 9-2](#). The bus termination is shown for illustrative purposes.

## 9.2 Typical Application



Copyright © 2017, Texas Instruments Incorporated

**Figure 9-1. Typical CAN Bus Application Using TCAN1043xx-Q1 With 5V  $\mu$ C**



### Figure 9-2. Typical CAN Bus Application Using TCAN1043xx-Q1 With 3.3V $\mu$ C

### 9.2.1 Design Requirements

### 9.2.1.1 Bus Loading, Length and Number of Nodes

A typical CAN application can have a maximum bus length of 40 meters and maximum stub length of 0.3m. However, with careful design, users can have longer cables, longer stub lengths, and many more nodes to a bus. A high number of nodes requires a transceiver with high input impedance such as the TCAN1043xx-Q1 family.

Many CAN organizations and standards have scaled the use of CAN for applications outside the original ISO 11898-2 standard. They made system level trade off decisions for data rate, cable length, and parasitic loading of the bus. Examples of these CAN systems level specifications are ARINC 825, CANopen, DeviceNet, SAE J2284, SAE J1939, and NMEA 2000.

A CAN network system design is a series of tradeoffs. In ISO 11898-2 the driver differential output is specified with a bus load that can range from  $50\Omega$  to  $65\Omega$  where the differential output must be greater than 1.5V. The TCAN1043xx-Q1 family is specified to meet the 1.5V requirement down to  $50\Omega$  and is specified to meet 1.4V differential output at  $45\Omega$  bus load. The differential input resistance of the TCAN1043xx-Q1 is a minimum of  $30k\Omega$ . If 100 TCAN1043xx-Q1 transceivers are in parallel on a bus, this is equivalent to a  $300\Omega$  differential load in parallel with the nominal  $60\Omega$  bus termination which gives a total bus load of  $50\Omega$ . Therefore, the TCAN1043xx-Q1 family theoretically supports over 100 transceivers on a single bus segment. However for CAN network design margin must be given for signal loss across the system and cabling, parasitic loadings, timing, network imbalances, ground offsets and signal integrity thus a practical maximum number of nodes is much lower. Bus length can also be extended beyond 40 meters by careful system design and data rate tradeoffs. For example, CANopen network design guidelines allow the network to be up to 1km with changes in the termination resistance, cabling, less than 64 nodes and significantly lowered data rate.

This flexibility in CAN network design is one of the key strengths of the various extensions and additional standards that have been built on the original ISO 11898-2 CAN standard. However, when using this flexibility the CAN network system designer must take the responsibility of good network design to for robust network operation.

## 9.2.2 Detailed Design Procedures

### 9.2.2.1 CAN Termination

The ISO11898-2 standard specifies the interconnect to be a single twisted pair cable (shielded or unshielded) with 120Ω characteristic impedance ( $Z_0$ ). Resistors equal to the characteristic impedance of the line can be used to terminate both ends of the cable to prevent signal reflections. Unterminated drop-lines (stubs) connecting nodes to the bus must be kept as short as possible to minimize signal reflections. The termination can be in a node but is generally not recommended, especially if the node can be removed from the bus. Termination must be carefully placed so that it is not removed from the bus. System level CAN implementations such as CANopen allow for different termination and cabling concepts for example to add cable length.

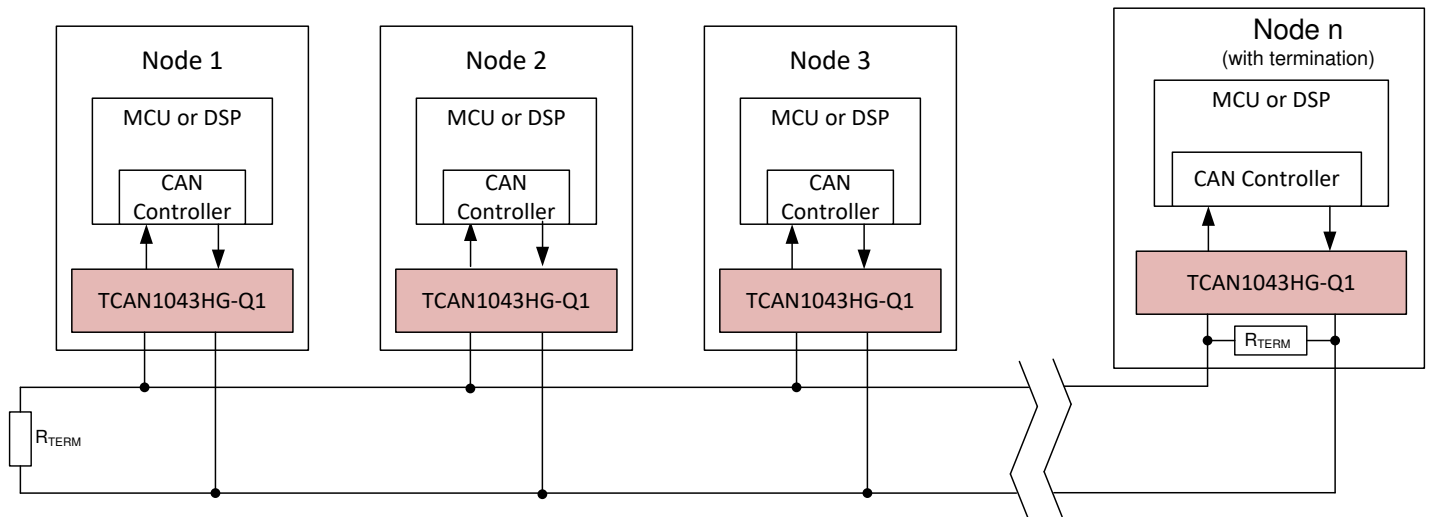
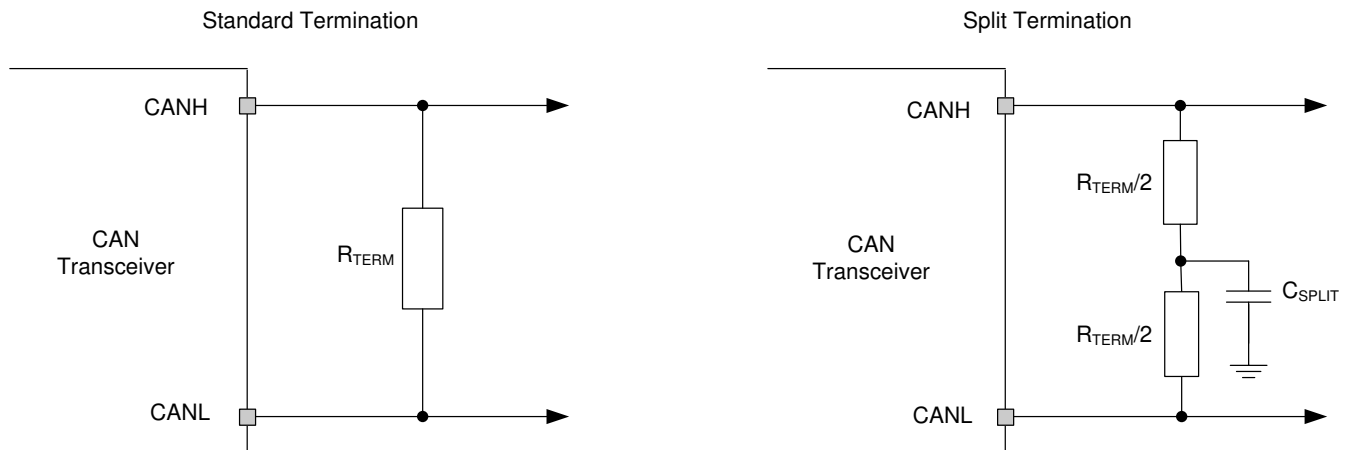


Figure 9-3. Typical CAN Bus Application

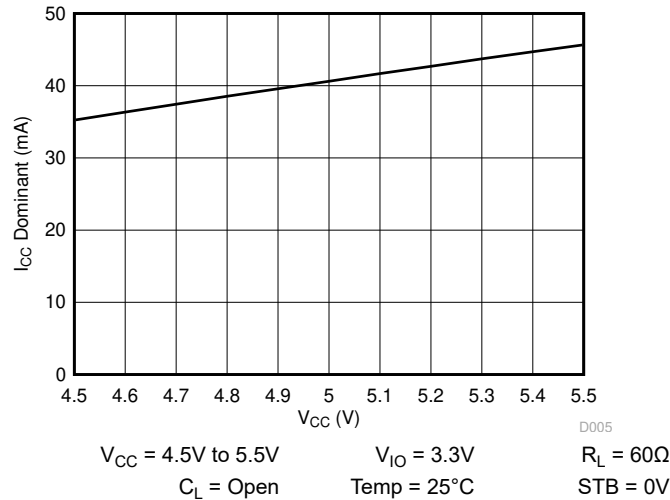
Termination can be a single 120Ω resistor at the ends of the bus, either on the cable or in a terminating node. If filtering and stabilization of the common mode voltage of the bus is desired then “split termination” can be used, see Figure 9-4. Split termination improves the electromagnetic emissions behavior of the network by eliminating fluctuations in the bus common mode voltage levels at the start and end of message transmissions.



Copyright © 2016, Texas Instruments Incorporated

Figure 9-4. CAN Bus Termination Concepts

### 9.2.3 Application Curves



**Figure 9-5. I<sub>CC</sub> Dominant Current over V<sub>CC</sub> Supply Voltage**

## 9.3 Power Supply Recommendations

The TCAN1043xx-Q1 device is designed to operate with a main V<sub>CC</sub> input voltage supply range between 4.5V and 5.5V. The device also has an IO level shifting supply input, V<sub>IO</sub>, designed for a range between 2.8V and 5.5V. For reliable operation at all data rates and supply voltages, each supply can be decoupled with a 100nF ceramic capacitor located as close to the supply pins as possible. Helping to reduce the supply voltage ripple present on the outputs of switched-mode power supplies, and also helps to compensate for the resistance and inductance of the PCB power planes.

## 9.4 Layout

Robust and reliable bus node design often requires the use of external transient protection devices to protect against transients that can occur in industrial environments. Since these transients have a wide frequency bandwidth (from approximately 3MHz to 300MHz), high-frequency layout techniques can be applied during PCB design.

### 9.4.1 Layout Guidelines

- Place the protection and filtering circuitry close to the bus connector to prevent transients, ESD, and noise from propagating onto the board. In this layout example a transient voltage suppression (TVS) device, D1, has been shown as added protection. The production solution can be either bi-directional TVS diode or varistor with ratings matching the application requirements. This example also shows optional bus filter capacitors C6 and C8, typical values range from 10pF to 100pF, depending on how many nodes are on the CAN bus. Additionally (not shown) a series common mode choke (CMC) can be placed on the CANH and CANL lines between the TCAN1043xx-Q1 transceiver and the connector.
- Design the bus protection components in the direction of the signal path. Do not force the transient current to divert from the signal path to reach the protection device.
- Use supply (V<sub>CC</sub>) and ground planes to provide low inductance as high-frequency current will follow the path of least impedance and not the path of least resistance.
- Use at least two vias for supply (V<sub>CC</sub>, V<sub>IO</sub>, V<sub>SUP</sub>) and ground connections of bypass capacitors and protection devices to minimize trace and via inductance.
- Bypass and bulk capacitors must be placed as close as possible to the supply terminals of transceiver, examples are C4 on the V<sub>CC</sub> supply net, C5 on the V<sub>IO</sub> supply net and C9 on the V<sub>SUP</sub> supply net, all of which are typically chosen as 100nF.
- Bus termination: this layout example shows split termination. This is where the termination is split into two resistors, R6 and R7 (both 60Ω), with the center or split tap of the termination connected to ground via

capacitor C7 (typically 4.7nF, but can go up to 100nF). Split termination provides common mode filtering for the bus. When bus termination is placed on the board instead of directly on the bus, additional care must be taken to make sure the terminating node is not removed from the bus thus also removing the termination. See the application section for information on power ratings needed for the termination resistor(s).

- To limit current of digital lines, series resistors can be used as in R2, R3 and R5, but are not required.
- Terminal 1: R1 is shown optionally for the TXD input of the device. If an open drain host processor is used, this is mandatory to make sure the bit timing into the device is met. R1 is typically 10kΩ.
- Terminal 9: SW1 is oriented in a low-side configuration which is used to implement a local WAKE event. The series resistor R10 is needed for protection against over current conditions to limit the current into the WAKE pin when the ECU has lost the ground connection. The pull-up resistor R9 is required to provide sufficient current during stimulation of a WAKE event. See the application section for more information on calculating both the R9 and R10 values.
- Terminal 14: Is shown assuming the mode terminal, nSTB, is used. If the device is only be used in normal mode, R5 is not needed and R4 can be used for the pull-up resistor to  $V_{IO}$ , R5 is typically 10kΩ.

### 9.4.2 Layout Example

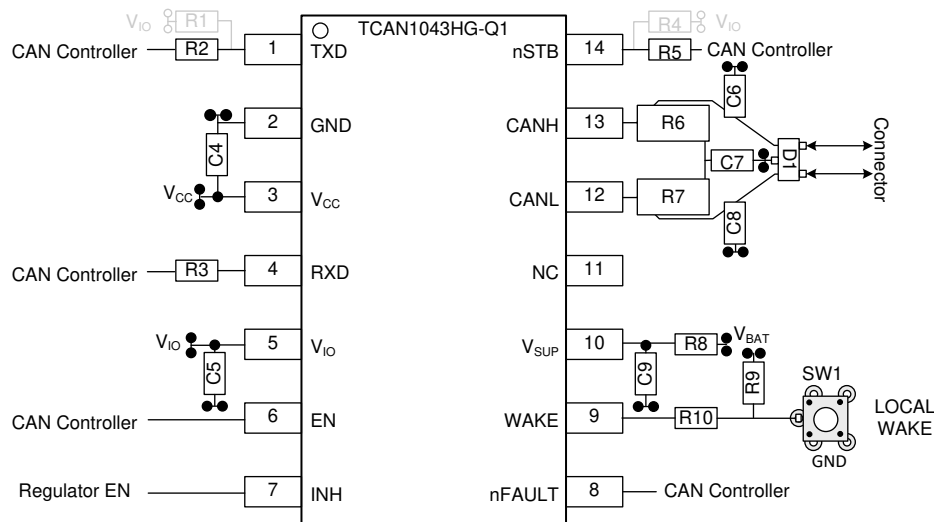


Figure 9-6. TCAN1043xx-Q1 Layout Example

## 10 Device and Documentation Support

### 10.1 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. In the upper right corner, click on *Alert me* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

### 10.2 Support Resources

TI E2E™ support forums are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

Linked content is provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's [Terms of Use](#).

### 10.3 Trademarks

TI E2E™ is a trademark of Texas Instruments.  
All trademarks are the property of their respective owners.

### 10.4 Electrostatic Discharge Caution



This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

### 10.5 Glossary

[TI Glossary](#) This glossary lists and explains terms, acronyms, and definitions.

## 11 Revision History

| Changes from Revision F (November 2023) to Revision G (December 2024)              | Page               |
|------------------------------------------------------------------------------------|--------------------|
| • Changed the last paragraph of the <i>CAN Bus Failure Fault Flag</i> section..... | <a href="#">20</a> |

| Changes from Revision E (January 2021) to Revision F (November 2023)                         | Page               |
|----------------------------------------------------------------------------------------------|--------------------|
| • Changed the <i>Device Information</i> table to the <i>Packaging Information</i> table..... | <a href="#">1</a>  |
| • Deleted the <i>Description (continued)</i> section.....                                    | <a href="#">1</a>  |
| • Changed the last sentence of the <i>CAN Bus Failure Fault Flag</i> section.....            | <a href="#">20</a> |

| Changes from Revision D (July 2019) to Revision E (January 2021) | Page              |
|------------------------------------------------------------------|-------------------|
| • Added Functional Safety to the <i>Features</i> list.....       | <a href="#">1</a> |

| Changes from Revision C (October 2018) to Revision D (July 2019)                | Page               |
|---------------------------------------------------------------------------------|--------------------|
| • Changed the second sentence in the <i>CAN Bus Dominant Fault</i> section..... | <a href="#">22</a> |

| <b>Changes from Revision B (May 2018) to Revision C (October 2018)</b>                                                                                        | <b>Page</b>        |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|
| • Updated $I_{CC}$ dominant with bus fault .....                                                                                                              | <a href="#">7</a>  |
| • Added footnote for $I_{IH}$ and $I_{IL}$ .....                                                                                                              | <a href="#">7</a>  |
| • Changed the Under-Voltage call out in <a href="#">Figure 8-4</a> .....                                                                                      | <a href="#">24</a> |
| • Added sentence: "This minimizes the current flowing into the WAKE pin..." to the last paragraph in <i>Local Wake Up (LWU) via WAKE Input Terminal</i> ..... | <a href="#">29</a> |

| <b>Changes from Revision A (December 2017) to Revision B (May 2018)</b>                                                                 | <b>Page</b>        |
|-----------------------------------------------------------------------------------------------------------------------------------------|--------------------|
| • Updated note 1 to: AEC Q100-002 indicates that HBM stressing shall be in accordance with the ANSI/ESDA/JEDEC JS-01 specification..... | <a href="#">5</a>  |
| • Added Note 2 To ESD Specification Table.....                                                                                          | <a href="#">6</a>  |
| • Updated IEC 61000-4-2 Unpowered Contact Discharge to $\pm 15\text{kV}$ .....                                                          | <a href="#">6</a>  |
| • Changed Max $t_{WK\_FILTER}$ to $1.8\mu\text{s}$ .....                                                                                | <a href="#">10</a> |

| <b>Changes from Revision * (November 2017) to Revision A (December 2017)</b>     | <b>Page</b>       |
|----------------------------------------------------------------------------------|-------------------|
| • Changed status from <i>Advance Information</i> to <i>Production Data</i> ..... | <a href="#">1</a> |

## 12 Mechanical, Packaging, and Orderable Information

The following pages include mechanical packaging and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

## PACKAGING INFORMATION

| Orderable part number           | Status<br>(1) | Material type<br>(2) | Package   Pins  | Package qty   Carrier | RoHS<br>(3) | Lead finish/<br>Ball material<br>(4) | MSL rating/<br>Peak reflow<br>(5) | Op temp (°C) | Part marking<br>(6) |
|---------------------------------|---------------|----------------------|-----------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|---------------------|
| <a href="#">TCAN1043DMTRQ1</a>  | Active        | Production           | VSON (DMT)   14 | 3000   LARGE T&R      | Yes         | NIPDAU   SN                          | Level-2-260C-1 YEAR               | -55 to 125   | 1043                |
| TCAN1043DMTRQ1.A                | Active        | Production           | VSON (DMT)   14 | 3000   LARGE T&R      | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -55 to 125   | 1043                |
| TCAN1043DMTRQ1.B                | Active        | Production           | VSON (DMT)   14 | 3000   LARGE T&R      | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -55 to 125   | 1043                |
| <a href="#">TCAN1043DMTTQ1</a>  | Active        | Production           | VSON (DMT)   14 | 250   SMALL T&R       | Yes         | NIPDAU   SN                          | Level-2-260C-1 YEAR               | -55 to 125   | 1043                |
| TCAN1043DMTTQ1.A                | Active        | Production           | VSON (DMT)   14 | 250   SMALL T&R       | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -55 to 125   | 1043                |
| TCAN1043DMTTQ1.B                | Active        | Production           | VSON (DMT)   14 | 250   SMALL T&R       | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -55 to 125   | 1043                |
| <a href="#">TCAN1043DQ1</a>     | Active        | Production           | SOIC (D)   14   | 50   TUBE             | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -55 to 125   | 1043                |
| TCAN1043DQ1.A                   | Active        | Production           | SOIC (D)   14   | 50   TUBE             | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -55 to 125   | 1043                |
| TCAN1043DQ1.B                   | Active        | Production           | SOIC (D)   14   | 50   TUBE             | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -55 to 125   | 1043                |
| <a href="#">TCAN1043DRQ1</a>    | Active        | Production           | SOIC (D)   14   | 2500   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -55 to 125   | 1043                |
| TCAN1043DRQ1.A                  | Active        | Production           | SOIC (D)   14   | 2500   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -55 to 125   | 1043                |
| TCAN1043DRQ1.B                  | Active        | Production           | SOIC (D)   14   | 2500   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -55 to 125   | 1043                |
| <a href="#">TCAN1043GDMTRQ1</a> | Active        | Production           | VSON (DMT)   14 | 3000   LARGE T&R      | Yes         | NIPDAU   SN                          | Level-2-260C-1 YEAR               | -55 to 125   | 1043                |
| TCAN1043GDMTRQ1.A               | Active        | Production           | VSON (DMT)   14 | 3000   LARGE T&R      | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -55 to 125   | 1043                |
| TCAN1043GDMTRQ1.B               | Active        | Production           | VSON (DMT)   14 | 3000   LARGE T&R      | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -55 to 125   | 1043                |
| <a href="#">TCAN1043GDMTTQ1</a> | Active        | Production           | VSON (DMT)   14 | 250   SMALL T&R       | Yes         | NIPDAU   SN                          | Level-2-260C-1 YEAR               | -55 to 125   | 1043                |
| TCAN1043GDMTTQ1.A               | Active        | Production           | VSON (DMT)   14 | 250   SMALL T&R       | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -55 to 125   | 1043                |
| TCAN1043GDMTTQ1.B               | Active        | Production           | VSON (DMT)   14 | 250   SMALL T&R       | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -55 to 125   | 1043                |
| <a href="#">TCAN1043GDQ1</a>    | Active        | Production           | SOIC (D)   14   | 50   TUBE             | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -55 to 125   | 1043                |
| TCAN1043GDQ1.A                  | Active        | Production           | SOIC (D)   14   | 50   TUBE             | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -55 to 125   | 1043                |
| TCAN1043GDQ1.B                  | Active        | Production           | SOIC (D)   14   | 50   TUBE             | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -55 to 125   | 1043                |
| <a href="#">TCAN1043GDRQ1</a>   | Active        | Production           | SOIC (D)   14   | 2500   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -55 to 125   | 1043                |
| TCAN1043GDRQ1.A                 | Active        | Production           | SOIC (D)   14   | 2500   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -55 to 125   | 1043                |
| TCAN1043GDRQ1.B                 | Active        | Production           | SOIC (D)   14   | 2500   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -55 to 125   | 1043                |
| <a href="#">TCAN1043HDMTRQ1</a> | Active        | Production           | VSON (DMT)   14 | 3000   LARGE T&R      | Yes         | NIPDAU   SN                          | Level-2-260C-1 YEAR               | -55 to 125   | 1043                |
| TCAN1043HDMTRQ1.A               | Active        | Production           | VSON (DMT)   14 | 3000   LARGE T&R      | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -55 to 125   | 1043                |
| TCAN1043HDMTRQ1.B               | Active        | Production           | VSON (DMT)   14 | 3000   LARGE T&R      | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -55 to 125   | 1043                |
| <a href="#">TCAN1043HDMTTQ1</a> | Active        | Production           | VSON (DMT)   14 | 250   SMALL T&R       | Yes         | NIPDAU   SN                          | Level-2-260C-1 YEAR               | -55 to 125   | 1043                |
| TCAN1043HDMTTQ1.A               | Active        | Production           | VSON (DMT)   14 | 250   SMALL T&R       | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -55 to 125   | 1043                |

| Orderable part number            | Status<br>(1) | Material type<br>(2) | Package   Pins  | Package qty   Carrier | RoHS<br>(3) | Lead finish/<br>Ball material<br>(4) | MSL rating/<br>Peak reflow<br>(5) | Op temp (°C) | Part marking<br>(6) |
|----------------------------------|---------------|----------------------|-----------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|---------------------|
| TCAN1043HDMTTQ1.B                | Active        | Production           | VSON (DMT)   14 | 250   SMALL T&R       | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -55 to 125   | 1043                |
| <a href="#">TCAN1043HDQ1</a>     | Active        | Production           | SOIC (D)   14   | 50   TUBE             | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -55 to 125   | 1043                |
| TCAN1043HDQ1.A                   | Active        | Production           | SOIC (D)   14   | 50   TUBE             | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -55 to 125   | 1043                |
| TCAN1043HDQ1.B                   | Active        | Production           | SOIC (D)   14   | 50   TUBE             | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -55 to 125   | 1043                |
| <a href="#">TCAN1043HDRQ1</a>    | Active        | Production           | SOIC (D)   14   | 2500   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -55 to 125   | 1043                |
| TCAN1043HDRQ1.A                  | Active        | Production           | SOIC (D)   14   | 2500   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -55 to 125   | 1043                |
| TCAN1043HDRQ1.B                  | Active        | Production           | SOIC (D)   14   | 2500   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -55 to 125   | 1043                |
| <a href="#">TCAN1043HGDMTRQ1</a> | Active        | Production           | VSON (DMT)   14 | 3000   LARGE T&R      | Yes         | NIPDAU   SN                          | Level-2-260C-1 YEAR               | -55 to 125   | 1043                |
| TCAN1043HGDMTRQ1.A               | Active        | Production           | VSON (DMT)   14 | 3000   LARGE T&R      | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -55 to 125   | 1043                |
| TCAN1043HGDMTRQ1.B               | Active        | Production           | VSON (DMT)   14 | 3000   LARGE T&R      | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -55 to 125   | 1043                |
| <a href="#">TCAN1043HGDMTTQ1</a> | Active        | Production           | VSON (DMT)   14 | 250   SMALL T&R       | Yes         | NIPDAU   SN                          | Level-2-260C-1 YEAR               | -55 to 125   | 1043                |
| TCAN1043HGDMTTQ1.A               | Active        | Production           | VSON (DMT)   14 | 250   SMALL T&R       | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -55 to 125   | 1043                |
| TCAN1043HGDMTTQ1.B               | Active        | Production           | VSON (DMT)   14 | 250   SMALL T&R       | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -55 to 125   | 1043                |
| <a href="#">TCAN1043HGDQ1</a>    | Active        | Production           | SOIC (D)   14   | 50   TUBE             | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -55 to 125   | 1043                |
| TCAN1043HGDQ1.A                  | Active        | Production           | SOIC (D)   14   | 50   TUBE             | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -55 to 125   | 1043                |
| TCAN1043HGDQ1.B                  | Active        | Production           | SOIC (D)   14   | 50   TUBE             | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -55 to 125   | 1043                |
| <a href="#">TCAN1043HGDRQ1</a>   | Active        | Production           | SOIC (D)   14   | 2500   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -55 to 125   | 1043                |
| TCAN1043HGDRQ1.A                 | Active        | Production           | SOIC (D)   14   | 2500   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -55 to 125   | 1043                |
| TCAN1043HGDRQ1.B                 | Active        | Production           | SOIC (D)   14   | 2500   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -55 to 125   | 1043                |

<sup>(1)</sup> **Status:** For more details on status, see our [product life cycle](#).

<sup>(2)</sup> **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

<sup>(3)</sup> **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

<sup>(4)</sup> **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

<sup>(5)</sup> **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

<sup>(6)</sup> **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

**Important Information and Disclaimer:** The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

## TAPE AND REEL INFORMATION



\*All dimensions are nominal

| Device           | Package Type | Package Drawing | Pins | SPQ  | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|------------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| TCAN1043DMTRQ1   | VSON         | DMT             | 14   | 3000 | 330.0              | 12.4               | 3.3     | 4.8     | 1.2     | 8.0     | 12.0   | Q1            |
| TCAN1043DMTTQ1   | VSON         | DMT             | 14   | 250  | 180.0              | 12.4               | 3.3     | 4.8     | 1.2     | 8.0     | 12.0   | Q1            |
| TCAN1043DRQ1     | SOIC         | D               | 14   | 2500 | 330.0              | 16.4               | 6.5     | 9.0     | 2.1     | 8.0     | 16.0   | Q1            |
| TCAN1043GDMTRQ1  | VSON         | DMT             | 14   | 3000 | 330.0              | 12.4               | 3.3     | 4.8     | 1.2     | 8.0     | 12.0   | Q1            |
| TCAN1043GDMTTQ1  | VSON         | DMT             | 14   | 250  | 180.0              | 12.4               | 3.3     | 4.8     | 1.2     | 8.0     | 12.0   | Q1            |
| TCAN1043GDRQ1    | SOIC         | D               | 14   | 2500 | 330.0              | 16.4               | 6.5     | 9.0     | 2.1     | 8.0     | 16.0   | Q1            |
| TCAN1043HDMTRQ1  | VSON         | DMT             | 14   | 3000 | 330.0              | 12.4               | 3.3     | 4.8     | 1.2     | 8.0     | 12.0   | Q1            |
| TCAN1043HDMTTQ1  | VSON         | DMT             | 14   | 250  | 180.0              | 12.4               | 3.3     | 4.8     | 1.2     | 8.0     | 12.0   | Q1            |
| TCAN1043HDRQ1    | SOIC         | D               | 14   | 2500 | 330.0              | 16.4               | 6.5     | 9.0     | 2.1     | 8.0     | 16.0   | Q1            |
| TCAN1043HGDMTRQ1 | VSON         | DMT             | 14   | 3000 | 330.0              | 12.4               | 3.3     | 4.8     | 1.2     | 8.0     | 12.0   | Q1            |
| TCAN1043HGDMTTQ1 | VSON         | DMT             | 14   | 250  | 180.0              | 12.4               | 3.3     | 4.8     | 1.2     | 8.0     | 12.0   | Q1            |
| TCAN1043HGDRQ1   | SOIC         | D               | 14   | 2500 | 330.0              | 16.4               | 6.5     | 9.0     | 2.1     | 8.0     | 16.0   | Q1            |

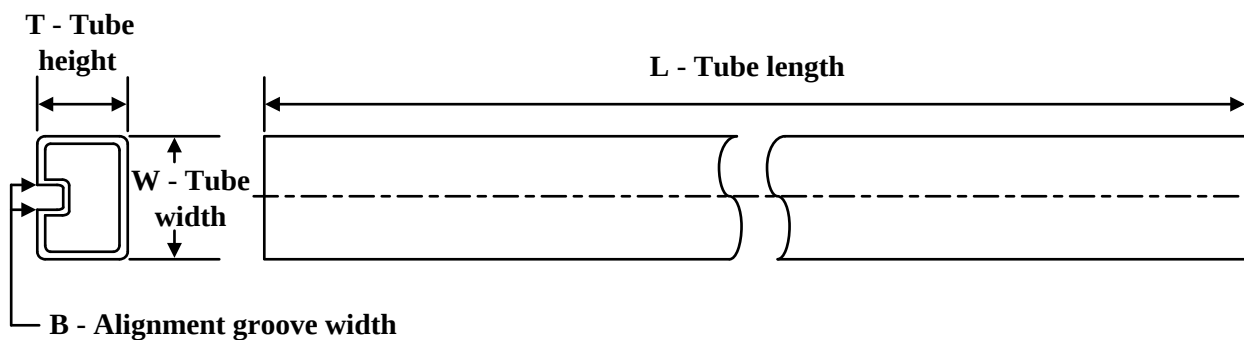
## TAPE AND REEL BOX DIMENSIONS



\*All dimensions are nominal

| Device           | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|------------------|--------------|-----------------|------|------|-------------|------------|-------------|
| TCAN1043DMTRQ1   | VSON         | DMT             | 14   | 3000 | 367.0       | 367.0      | 35.0        |
| TCAN1043DMTTQ1   | VSON         | DMT             | 14   | 250  | 210.0       | 185.0      | 35.0        |
| TCAN1043DRQ1     | SOIC         | D               | 14   | 2500 | 353.0       | 353.0      | 32.0        |
| TCAN1043GDMTRQ1  | VSON         | DMT             | 14   | 3000 | 367.0       | 367.0      | 35.0        |
| TCAN1043GDMTTQ1  | VSON         | DMT             | 14   | 250  | 210.0       | 185.0      | 35.0        |
| TCAN1043GDRQ1    | SOIC         | D               | 14   | 2500 | 353.0       | 353.0      | 32.0        |
| TCAN1043HDMTRQ1  | VSON         | DMT             | 14   | 3000 | 367.0       | 367.0      | 35.0        |
| TCAN1043HDMTTQ1  | VSON         | DMT             | 14   | 250  | 210.0       | 185.0      | 35.0        |
| TCAN1043HDRQ1    | SOIC         | D               | 14   | 2500 | 353.0       | 353.0      | 32.0        |
| TCAN1043HGDMTRQ1 | VSON         | DMT             | 14   | 3000 | 367.0       | 367.0      | 35.0        |
| TCAN1043HGDMTTQ1 | VSON         | DMT             | 14   | 250  | 210.0       | 185.0      | 35.0        |
| TCAN1043HGDRQ1   | SOIC         | D               | 14   | 2500 | 353.0       | 353.0      | 32.0        |

## TUBE

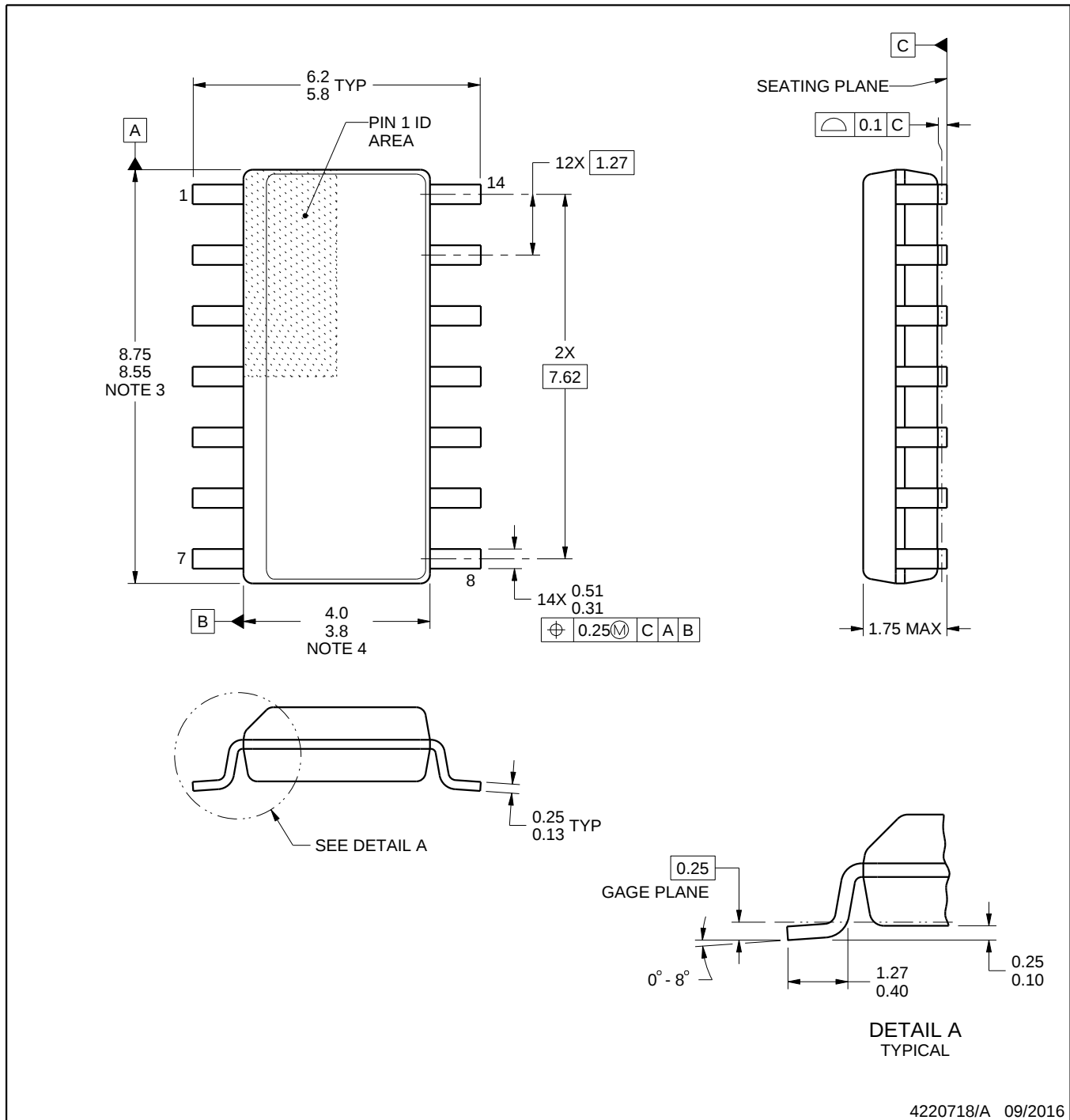


\*All dimensions are nominal

| Device          | Package Name | Package Type | Pins | SPQ | L (mm) | W (mm) | T (μm) | B (mm) |
|-----------------|--------------|--------------|------|-----|--------|--------|--------|--------|
| TCAN1043DQ1     | D            | SOIC         | 14   | 50  | 507    | 8      | 3940   | 4.32   |
| TCAN1043DQ1.A   | D            | SOIC         | 14   | 50  | 507    | 8      | 3940   | 4.32   |
| TCAN1043DQ1.B   | D            | SOIC         | 14   | 50  | 507    | 8      | 3940   | 4.32   |
| TCAN1043GDQ1    | D            | SOIC         | 14   | 50  | 507    | 8      | 3940   | 4.32   |
| TCAN1043GDQ1.A  | D            | SOIC         | 14   | 50  | 507    | 8      | 3940   | 4.32   |
| TCAN1043GDQ1.B  | D            | SOIC         | 14   | 50  | 507    | 8      | 3940   | 4.32   |
| TCAN1043HDQ1    | D            | SOIC         | 14   | 50  | 507    | 8      | 3940   | 4.32   |
| TCAN1043HDQ1.A  | D            | SOIC         | 14   | 50  | 507    | 8      | 3940   | 4.32   |
| TCAN1043HDQ1.B  | D            | SOIC         | 14   | 50  | 507    | 8      | 3940   | 4.32   |
| TCAN1043HGDQ1   | D            | SOIC         | 14   | 50  | 507    | 8      | 3940   | 4.32   |
| TCAN1043HGDQ1.A | D            | SOIC         | 14   | 50  | 507    | 8      | 3940   | 4.32   |
| TCAN1043HGDQ1.B | D            | SOIC         | 14   | 50  | 507    | 8      | 3940   | 4.32   |

**D0014A****PACKAGE OUTLINE****SOIC - 1.75 mm max height**

SMALL OUTLINE INTEGRATED CIRCUIT



4220718/A 09/2016

**NOTES:**

1. All linear dimensions are in millimeters. Dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm, per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.43 mm, per side.
5. Reference JEDEC registration MS-012, variation AB.

# EXAMPLE BOARD LAYOUT

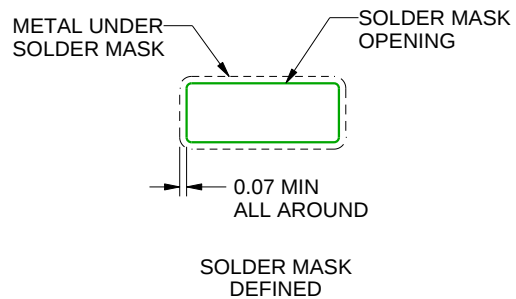
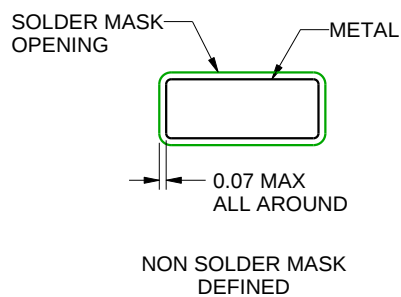
D0014A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



LAND PATTERN EXAMPLE  
SCALE:8X



SOLDER MASK DETAILS

4220718/A 09/2016

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.

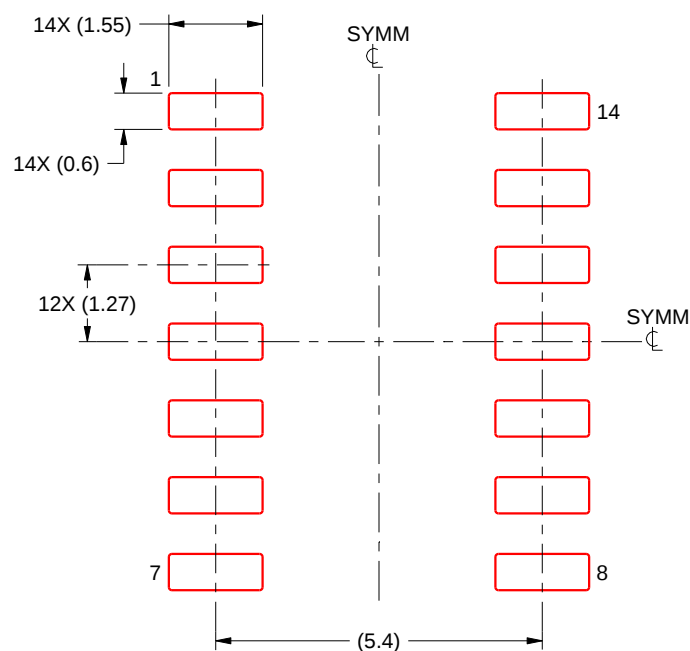
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

## EXAMPLE STENCIL DESIGN

D0014A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



SOLDER PASTE EXAMPLE  
BASED ON 0.125 mm THICK STENCIL  
SCALE:8X

4220718/A 09/2016

NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

## GENERIC PACKAGE VIEW

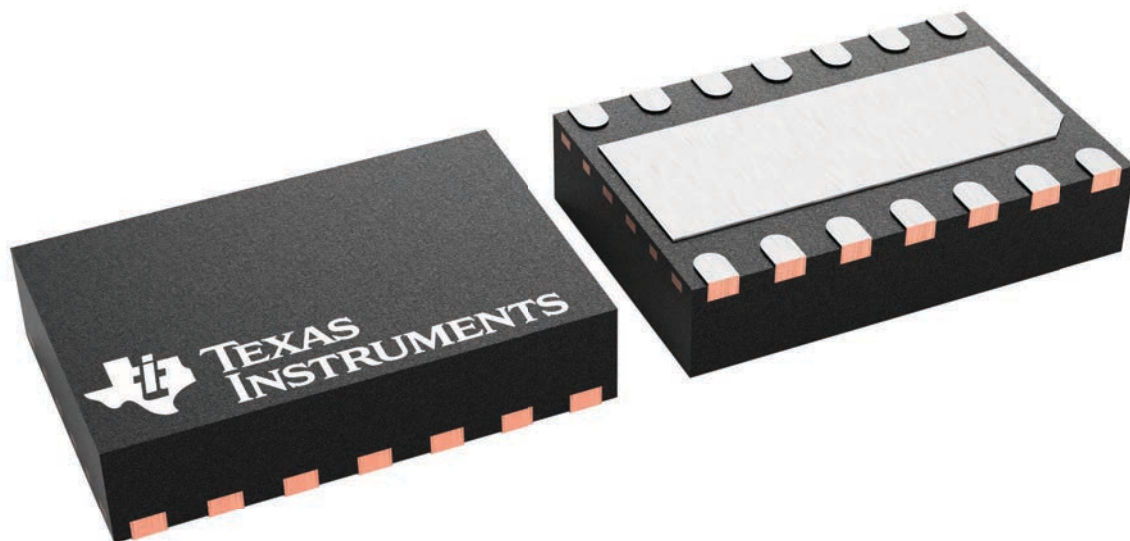
**DMT 14**

**VSON - 0.9 mm max height**

3 x 4.5, 0.65 mm pitch

PLASTIC SMALL OUTLINE - NO LEAD

This image is a representation of the package family, actual package may vary.  
Refer to the product data sheet for package details.



4225088/A

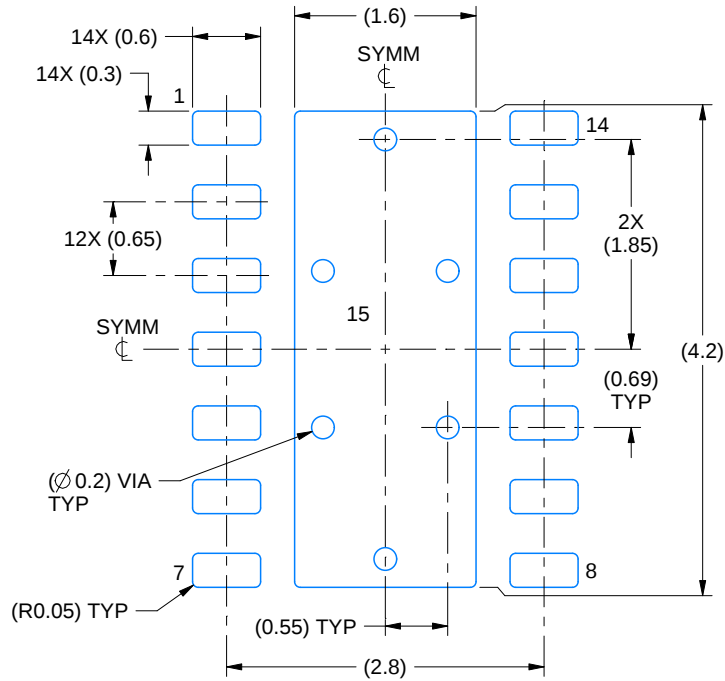


# EXAMPLE BOARD LAYOUT

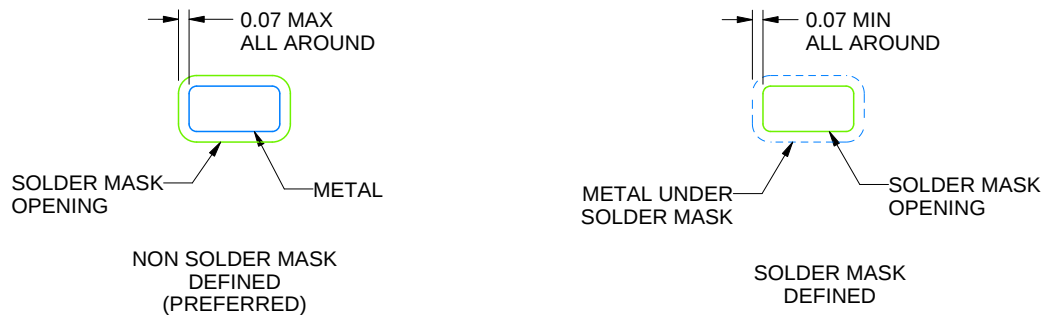
DMT0014A

VSON - 0.9 mm max height

PLASTIC SMALL OUTLINE - NO LEAD



LAND PATTERN EXAMPLE  
SCALE:15X



SOLDER MASK DETAILS

4223033/B 10/2016

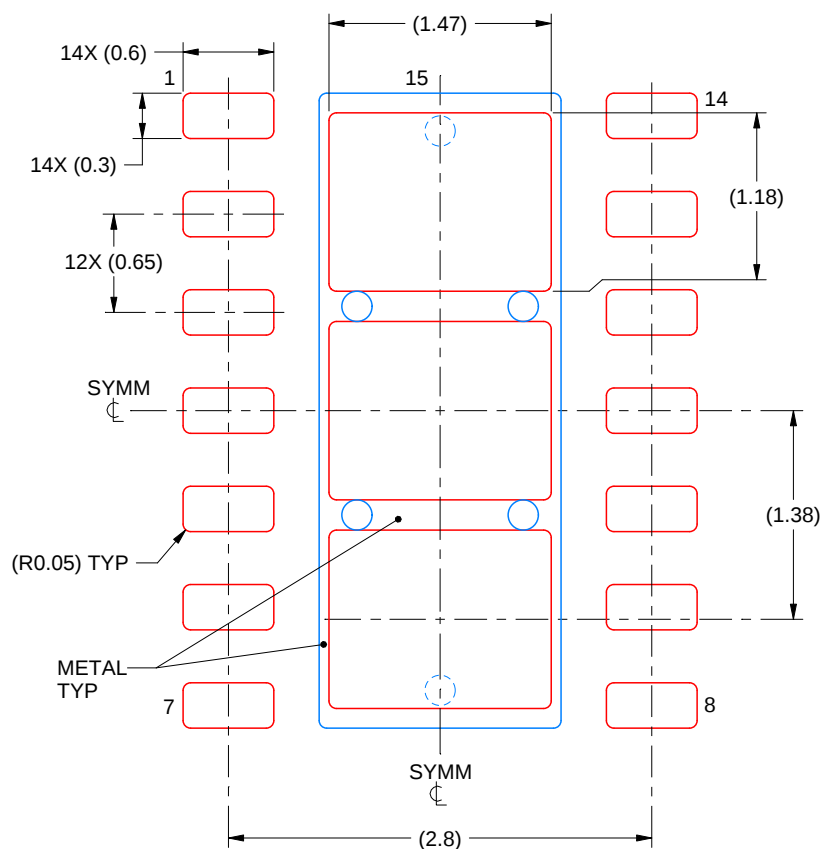
NOTES: (continued)

4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 ([www.ti.com/lit/sluea271](http://www.ti.com/lit/sluea271)).
5. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.

**DMT0014A**

**VSON - 0.9 mm max height**

PLASTIC SMALL OUTLINE - NO LEAD



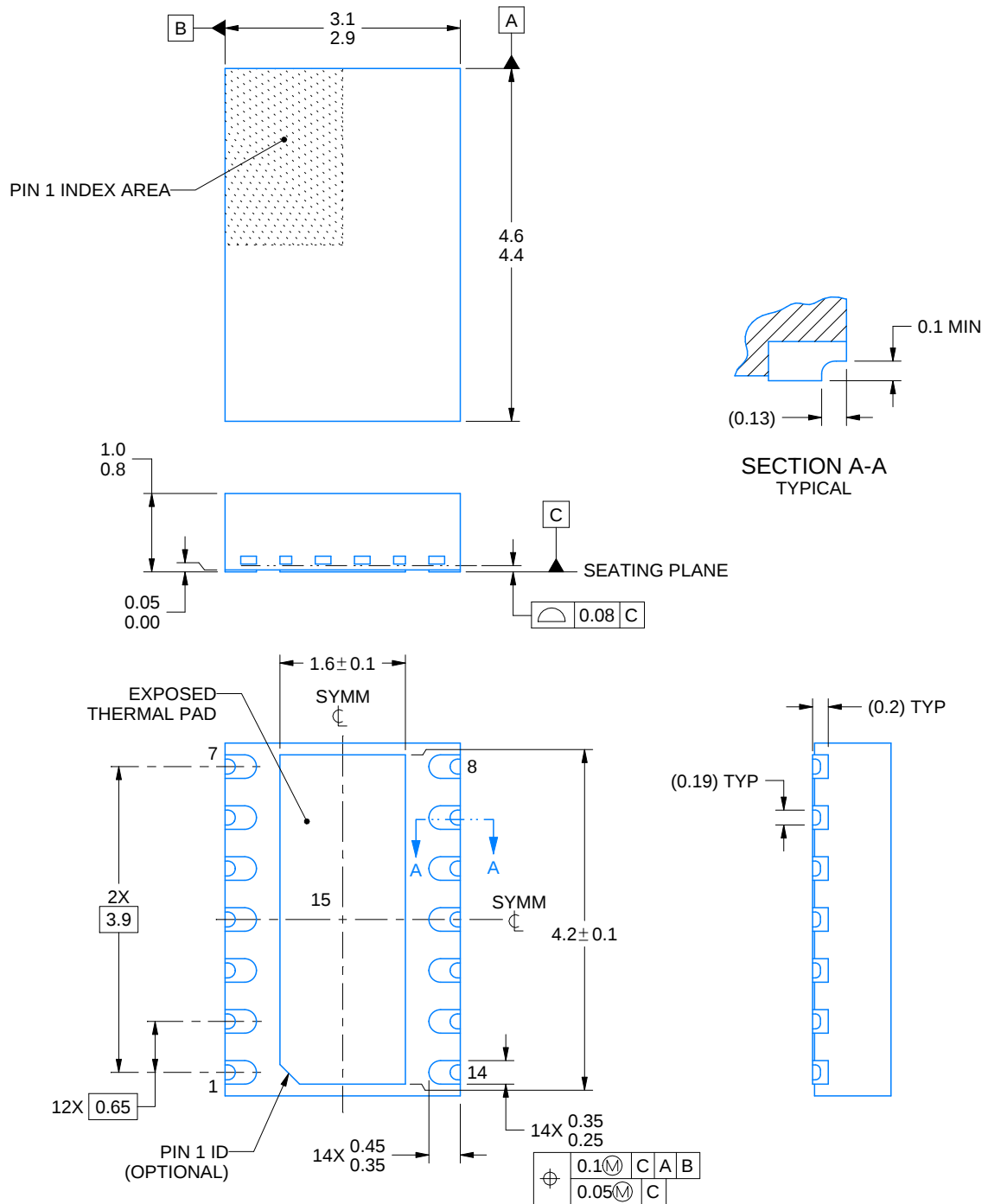
## SOLDER PASTE EXAMPLE BASED ON 0.125 mm THICK STENCIL

EXPOSED PAD 15  
77.4% PRINTED SOLDER COVERAGE BY AREA  
SCALE:20X

4223033/B 10/2016

NOTES: (continued)

6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.



4225087/B 01/2021

## NOTES:

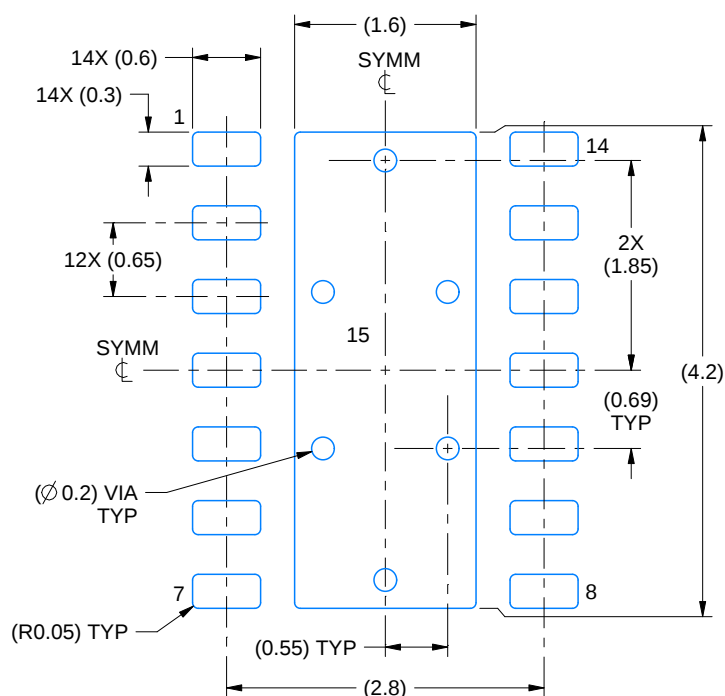
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. The package thermal pad must be soldered to the printed circuit board for thermal and mechanical performance.

# EXAMPLE BOARD LAYOUT

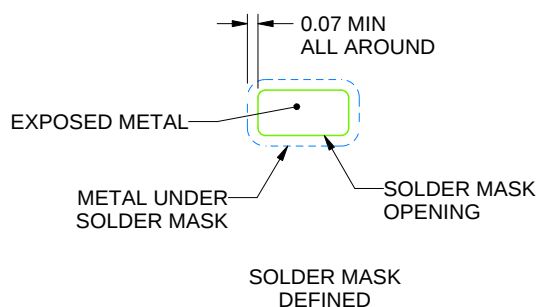
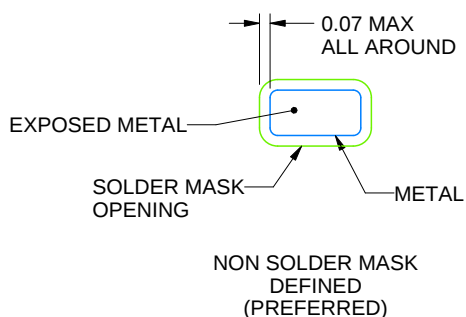
DMT0014B

VSON - 1 mm max height

PLASTIC SMALL OUTLINE - NO LEAD



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE:15X



SOLDER MASK DETAILS

4225087/B 01/2021

NOTES: (continued)

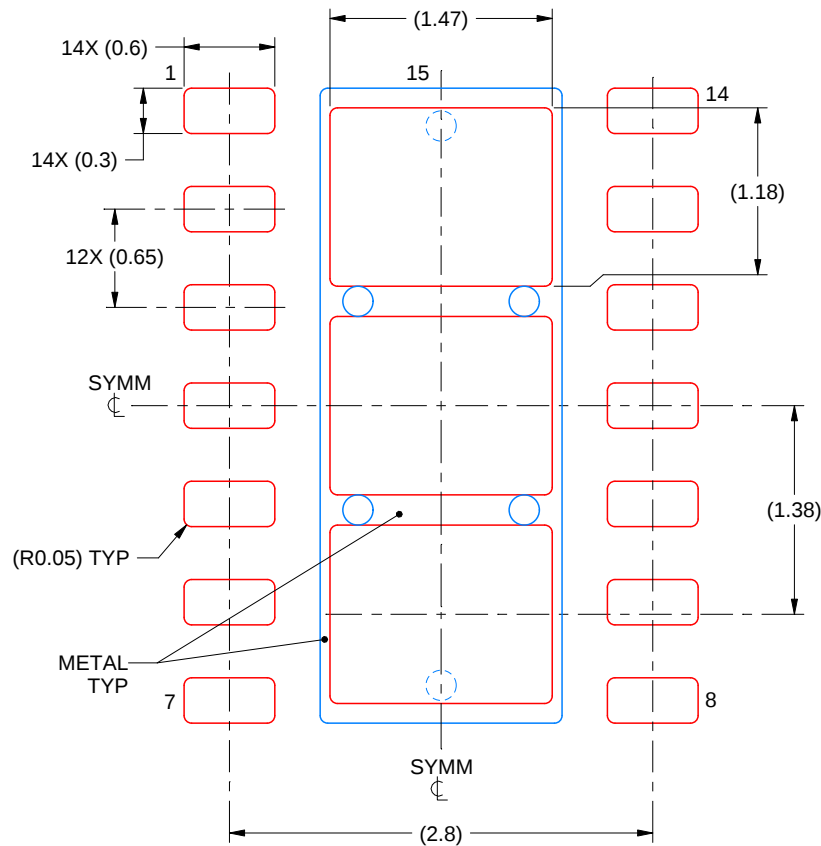
- This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 ([www.ti.com/lit/slua271](http://www.ti.com/lit/slua271)).
- Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.

# EXAMPLE STENCIL DESIGN

DMT0014B

VSON - 1 mm max height

PLASTIC SMALL OUTLINE - NO LEAD



SOLDER PASTE EXAMPLE  
BASED ON 0.125 mm THICK STENCIL

EXPOSED PAD 15  
77.4% PRINTED SOLDER COVERAGE BY AREA  
SCALE:20X

4225087/B 01/2021

NOTES: (continued)

6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

## IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to [TI's Terms of Sale](#) or other applicable terms available either on [ti.com](https://www.ti.com) or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products.

TI objects to and rejects any additional or different terms you may have proposed.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
Copyright © 2025, Texas Instruments Incorporated