

# TCAN340x-Q1 3.3V 車載用 CAN FD トランシーバ、スタンバイモードおよび ±58V バス スタンドオフ付き

## 1 特長

- 車載アプリケーション向けに AEC-Q100 認定済み
- 3.3V 単一電源動作
  - 5V レギュレータが不要、BOM コストと PCB 面積の削減を実現
- 同種および異種ネットワークにおける優れた EMC 動作
- ISO 11898-2:2016 物理層規格要件に適合
- 機能安全対応
  - 機能安全システムの設計に役立つ資料を利用可能
- Classical CAN のサポートと最適化された CAN FD 性能 (2、5、8Mbps)
  - 短く対称的な伝搬遅延時間によりタイミング マージンを強化
- TCAN3403-Q1: I/O 電圧範囲のサポート: 1.7V~3.6V
- レシーバの同相入力電圧: ±30V
- 保護機能:
  - バスフォルト保護: ±58V
  - バスピンの ISO 10605 ESD: ±8kV
  - 低電圧保護
  - TXD ドミナント タイムアウト (DTO)
  - サーマル シャットダウン保護 (TSD)
- 動作モード:
  - 通常モード
  - リモート ウェイクアップ要求をサポートする、低消費電力スタンバイモード
  - 超消費電力シャットダウン モード: TCAN3404-Q1 のみ
- 電源非接続時の最適化された挙動
  - バスおよびロジックピンは高インピーダンス (動作中のバス、アプリケーションに対して無負荷)
  - ホットプラグ対応: 電源オン / オフ時のバスおよび RXD 出力のグリッチフリー動作
- 8ピン SOIC、小型フットプリント SOT-23、自動光学検査 (AOI) に適したウェットプル フランク付きリードレス VSON-8 パッケージ

## 2 アプリケーション

- オートモーティブ (車載) / 交通システム
  - 車体制御モジュール
  - 車載ゲートウェイ
  - 先進運転支援システム (ADAS)
  - インフォテインメント

## 3 概要

TCAN3403-Q1 および TCAN3404-Q1 は、ISO 11898-2:2016 高速 CAN (Controller Area Network) 仕様の物理層要件を満たす 3.3V CAN FD トランシーバです。

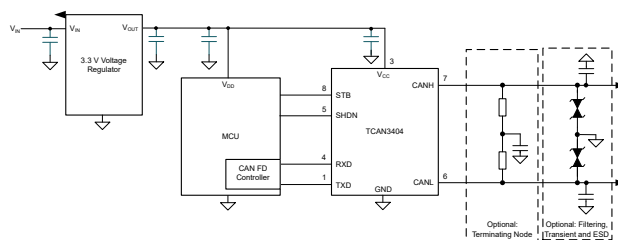
このトランシーバは、電磁両立性 (EMC) 認証済みであり、最高 5 メガビット/秒 (Mbps) の Classical CAN および CAN FD ネットワークに使用できます。これらのデバイスを使用すると、シンプルなネットワークで最大 8Mbps の動作を実現できます。TCAN3403-Q1 には V<sub>IO</sub> ピンによる内部ロジック レベル変換が搭載されているため、トランシーバの I/O を 1.8V、2.5V、3.3V のロジックレベルに直接接続できます。TCAN3404-Q1 にはシャットダウン機能があり、すべてのブロックの電源がオフになり、デバイスは超低消費電力モードに移行します。このトランシーバは、低消費電力スタンバイモードと、ISO 11898-2:2016 に規定されたウェイクアップパターン (WUP) に準拠した「CAN によるウェイク」をサポートしています。

このトランシーバには、サーマル シャットダウン (TSD)、TXD ドミナント タイムアウト (DTO)、および電源低電圧検出機能が備わっています。これらのデバイスには、電源電圧低下またはフローティングピン発生時のフェイルセーフ動作が定義されています。これらのデバイスは、業界標準の SOIC-8、VSON-8、および省スペースの小型 SOT-23 パッケージで提供されています。

### パッケージ情報

部品番号	パッケージ (1)	パッケージ サイズ (2)
TCAN3403-Q1	SOIC (D)	4.9mm × 6mm
	VSON (DRB)	3mm × 3mm
TCAN3404-Q1	SOT-23 (DDF)	2.9mm x 2.8mm

- (1) 詳細については、セクション 12 を参照してください。
- (2) パッケージ サイズ (長さ × 幅) は公称値であり、該当する場合はピンも含まれます。



概略回路図



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## 4 Device Comparison

Part Number	Pin 5	Pin 8
TCAN3404-Q1	Ultra-low power shutdown mode	Low Power Standby Mode with Remote Wake
TCAN3403-Q1	Low voltage I/O support	

## 5 Pin Configuration and Functions

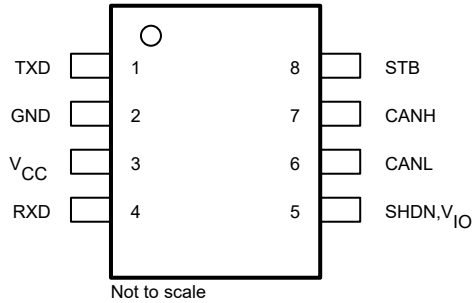


図 5-1. DDF Package, 8-Pin SOT-23 (Top View)

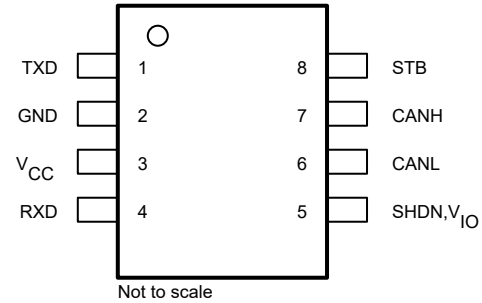


図 5-2. D Package, 8-Pin SOIC (Top View)

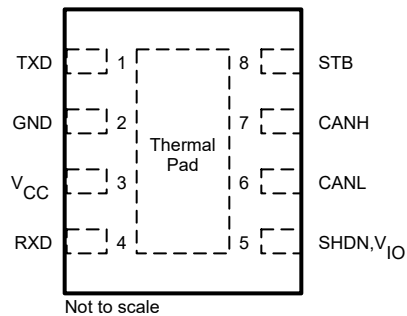


図 5-3. DRB Package, 8-Pin VSON (Top View)

表 5-1. Pin Functions

PINS		TYPE <sup>(1)</sup>	DESCRIPTION
NAME	NO.		
TXD	1	Digital Input	CAN transmit data input; integrated pull-up
GND	2	G	Ground connection
V <sub>CC</sub>	3	Supply	3.3V supply voltage
RXD	4	Digital Output	CAN receive data output, tri-stated when device powered off
SHDN	5	Digital Input	Device in ultra-low power shutdown mode if pin is high; integrated pull-down (TCAN3404-Q1 only)
V <sub>IO</sub>		Supply	I/O supply voltage (TCAN3403-Q1 only)
CANL	6	Bus I/O	Low-level CAN bus input/output line
CANH	7	Bus I/O	High-level CAN bus input/output line
STB	8	Digital Input	Standby input for mode control; integrated pull-up
Thermal Pad (VSON only)		—	Connect the thermal pad to any internal PCB ground plane using multiple vias for optimal thermal performance.

(1) I = Input, O = Output, I/O = Input or Output, G = Ground.

## 6 Specifications

### 6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)<sup>(1) (2)</sup>

		MIN	MAX	UNIT
V <sub>CC</sub>	Supply voltage	-0.3	6	V
V <sub>IO</sub>	Supply voltage I/O level shifter (only for TCAN3403)	-0.3	6	V
V <sub>BUS</sub>	CAN bus I/O voltage range on CANH and CANL	-58	58	V
V <sub>DIFF</sub>	Max differential voltage between CANH and CANL V <sub>DIFF</sub> = (CANH - CANL)	-58	58	V
V <sub>Logic_Input</sub>	Logic pin input voltage (TXD, STB, SHDN)	-0.3	6	V
V <sub>RXD</sub>	Logic output voltage range (RXD)	-0.3	6	V
I <sub>O(RXD)</sub>	RXD output current	-8	8	mA
T <sub>J</sub>	Junction temperature	-40	165	°C
T <sub>STG</sub>	Storage temperature	-65	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 <sup>(1)</sup>	±4000	V
			HBM classification level 3A for all pins	
			HBM classification level 3B for global pins CANH and CANL with respect to GND	±10000
		Charged-device model (CDM), per AEC Q100-011 CDM classification level C5 for all pins	±750	V

- AEC Q100-002 indicates that HBM stressing shall be in accordance with the ANSI/ESDA/JEDEC JS-001 specification.

### 6.3 ESD Ratings, IEC Transients

			VALUE	UNIT	
V <sub>ESD</sub>	System level electrostatic discharge	CAN bus terminals (CANH, CANL) to GND	SAE J2962-2 per ISO 10605 Powered contact discharge	±8000	V
			SAE J2962-2 per ISO 10605 Powered air discharge	±15000	V
			IEC 62228-3 per ISO 10605	±8000	V
V <sub>Tran</sub>	ISO 7637-2 Transient immunity <sup>(1)</sup>	CAN bus terminals (CANH, CANL) to GND	Pulse 1	-100	V
			Pulse 2a	75	V
			Pulse 3a	-150	V
			Pulse 3b	100	V
	Direct capacitor coupling, SAE J2962-2 per ISO 7637-3 <sup>(2)</sup>	CAN bus terminals (CANH, CANL) to GND	DCC slow transient pulse	±30	V

- Tested according to IEC 62228-3:2019 CAN Transceivers, Section 6.3; standard pulses parameters defined in ISO 7637-2 (2011)
- Tested according to SAE J2962-2

### 6.4 Recommended Operating Conditions

		MIN	NOM	MAX	UNIT
V <sub>CC</sub>	Supply voltage	3	3.3	3.6	V
V <sub>IO</sub>	Supply voltage for I/O level shifter (only for TCAN3403)	1.7		3.6	V

## 6.4 Recommended Operating Conditions (続き)

		MIN	NOM	MAX	UNIT
$I_{OH(RXD)}$	RXD terminal high-level output current	-2			mA
$I_{OL(RXD)}$	RXD terminal low-level output current			2	mA
$I_{OH(RXD)}$	RXD terminal high-level output current (only for TCAN3403)	-1.5			mA
$I_{OL(RXD)}$	RXD terminal low-level output current (only for TCAN3403)			1.5	mA
$T_J$	Junction temperature	-40		150	°C

## 6.5 Thermal Characteristics

THERMAL METRIC <sup>(1)</sup>		TCAN3403/3404-Q1			UNIT
		D (SOIC)	DDF (SOT)	DRB (VSON)	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	114.4	122.9	50.9	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	49.0	51.7	55.8	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	58.0	45.7	23.2	°C/W
$\Psi_{JT}$	Junction-to-top characterization parameter	7.0	1.3	1.4	°C/W
$\Psi_{JB}$	Junction-to-board characterization parameter	57.1	45.4	23.2	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	N/A	N/A	7.7	°C/W

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

## 6.6 Supply Characteristics

parameters valid over recommended operating conditions with  $-40^{\circ}\text{C} \leq T_J \leq 150^{\circ}\text{C}$  (Typical values are at  $V_{CC} = 3.3\text{ V}$ ;  $V_{IO} = 3.3\text{ V}$  for TCAN3403, Device ambient maintained at  $27^{\circ}\text{C}$ ) unless otherwise noted

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT	
$I_{CC}$	Supply current normal mode	Dominant	TXD = 0 V, STB = 0 V $R_L = 60\ \Omega$ , $C_L = \text{open}$ See <a href="#">7-1</a>		42	55	mA	
		Dominant	TXD = 0 V, STB = 0 V $R_L = 50\ \Omega$ , $C_L = \text{open}$ See <a href="#">7-1</a>		50	60	mA	
		Recessive	TXD = $V_{CC}$ , STB = 0 V $R_L = 50\ \Omega$ , $C_L = \text{open}$ See <a href="#">7-1</a>		7	8.2	mA	
$I_{CC}$	Supply current normal mode	Dominant with bus fault	TXD = 0 V, STB = 0 V CANH = CANL = $\pm 25\text{ V}$ $R_L = \text{open}$ , $C_L = \text{open}$ See <a href="#">7-1</a>			130	mA	
			TXD = STB = $V_{IO}$ , $R_L = 50\ \Omega$ , $C_L = \text{open}$ , $T_J \leq 85^{\circ}\text{C}$ , See <a href="#">7-1</a>		1	2	$\mu\text{A}$	
	TXD = STB = $V_{IO}$ , $R_L = 50\ \Omega$ , $C_L = \text{open}$ , $T_J \leq 125^{\circ}\text{C}$ , See <a href="#">7-1</a>		1	3				
	TXD = STB = $V_{IO}$ , $R_L = 50\ \Omega$ , $C_L = \text{open}$ , $T_J \leq 150^{\circ}\text{C}$ , See <a href="#">7-1</a>		1	4				
	Supply current standby mode (TCAN3404)			TXD = STB = $V_{CC}$ , $R_L = 50\ \Omega$ , $C_L = \text{open}$ , $T_J \leq 85^{\circ}\text{C}$ , See <a href="#">7-1</a>		10	15	$\mu\text{A}$
				TXD = STB = $V_{CC}$ , $R_L = 50\ \Omega$ , $C_L = \text{open}$ , $T_J \leq 125^{\circ}\text{C}$ , See <a href="#">7-1</a>		10	16	
TXD = STB = $V_{CC}$ , $R_L = 50\ \Omega$ , $C_L = \text{open}$ , $T_J \leq 150^{\circ}\text{C}$ , See <a href="#">7-1</a>					10	17		

## 6.6 Supply Characteristics (続き)

parameters valid over recommended operating conditions with  $-40^{\circ}\text{C} \leq T_J \leq 150^{\circ}\text{C}$  (Typical values are at  $V_{CC} = 3.3\text{ V}$ ;  $V_{IO} = 3.3\text{ V}$  for TCAN3403, Device ambient maintained at  $27^{\circ}\text{C}$ ) unless otherwise noted

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
$I_{IO}$ (only for TCAN3403)	I/O supply current normal mode	Dominant	TXD = 0 V, STB = 0 V $R_L = 60\ \Omega$ , $C_L = \text{open}$ RXD floating		125	300	$\mu\text{A}$
		recessive	TXD = $V_{IO}$ , STB = 0 V $R_L = 60\ \Omega$ , $C_L = \text{open}$ RXD floating		19	48	
	I/O supply current standby mode		TXD = $V_{IO}$ , STB = $V_{IO}$ $R_L = 60\ \Omega$ , $C_L = \text{open}$ RXD floating, $T_J \leq 85^{\circ}\text{C}$		9	13	
			TXD = $V_{IO}$ , STB = $V_{IO}$ $R_L = 60\ \Omega$ , $C_L = \text{open}$ RXD floating, $T_J \leq 125^{\circ}\text{C}$		9	14	
		TXD = $V_{IO}$ , STB = $V_{IO}$ $R_L = 60\ \Omega$ , $C_L = \text{open}$ RXD floating, $T_J \leq 150^{\circ}\text{C}$		9	15		
$I_{CC}$	Supply current ( $V_{CC}$ pin current), shutdown mode (TCAN3404)		SHDN = $V_{CC}$ , RXD floating, TXD = $V_{CC}$ , $T_J \leq 85^{\circ}\text{C}$			2	$\mu\text{A}$
			SHDN = $V_{CC}$ , RXD floating, TXD = $V_{CC}$ , $T_J \leq 150^{\circ}\text{C}$			5	
$UV_{CC(R)}$	Undervoltage detection $V_{CC}$ rising		Ramp up		2.75	2.9	V
$UV_{CC(F)}$	Undervoltage detection on $V_{CC}$ falling		Ramp down	2.5	2.65		
$V_{HYS(UVCC)}$	Hysteresis voltage on $UV_{CC}$				120		mV
$UV_{IO(R)}$	Undervoltage detection $V_{IO}$ rising (TCAN3403)		Ramp up		1.6	1.65	V
$UV_{IO(F)}$	Undervoltage detection on $V_{IO}$ falling (TCAN3403)		Ramp down	1.4	1.5		
$V_{HYS(UVIO)}$	Hysteresis voltage on $UV_{IO}$				50		mV

## 6.7 Dissipation Ratings

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
$P_D$	Average power dissipation Normal mode		$V_{CC} = 3.3\text{ V}$ , $T_J = 27^{\circ}\text{C}$ , $R_L = 60\ \Omega$ , $C_{L\_RXD} = 15\text{ pF}$ TXD input = 250 kHz 50% duty cycle square wave		50		mW
			$V_{CC} = 3.6\text{ V}$ , $T_J = 150^{\circ}\text{C}$ , $R_L = 50\ \Omega$ , $C_{L\_RXD} = 15\text{ pF}$ TXD input = 2.5 MHz 50% duty cycle square wave		60		mW
$T_{TSD}$	Thermal shutdown temperature				192		$^{\circ}\text{C}$
$T_{TSD\_HYS}$	Thermal shutdown hysteresis				10		

## 6.8 Electrical Characteristics

parameters valid over recommended operating conditions with  $-40^{\circ}\text{C} \leq T_J \leq 150^{\circ}\text{C}$  (Typical values are at  $V_{CC} = 3.3\text{ V}$ ,  $V_{IO} = 3.3\text{ V}$  for TCAN3403, Device ambient maintained at  $27^{\circ}\text{C}$ ) unless otherwise noted

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
<b>Driver Electrical Characteristics</b>							
$V_{O(DOM)}$	Dominant output voltage normal mode	CANH	TXD = 0 V, STB, SHDN = 0 V $50\ \Omega \leq R_L \leq 65\ \Omega$ , $C_L = \text{open}$ See <a href="#">7-2</a> and <a href="#">8-3</a>	2.25		$V_{CC}$	V
		CANL		0.5		1.25	V
$V_{O(REC)}$	Recessive output voltage normal mode	CANH and CANL	TXD = $V_{IO}$ or $V_{CC}$ , STB, SHDN = 0 V $R_L = \text{open}$ (no load), $C_L = \text{open}$ See <a href="#">7-2</a> and <a href="#">8-3</a>	1.5	1.9	2.25	V

## 6.8 Electrical Characteristics (続き)

parameters valid over recommended operating conditions with  $-40^{\circ}\text{C} \leq T_J \leq 150^{\circ}\text{C}$  (Typical values are at  $V_{CC} = 3.3\text{ V}$ ,  $V_{IO} = 3.3\text{ V}$  for TCAN3403, Device ambient maintained at  $27^{\circ}\text{C}$ ) unless otherwise noted

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$V_{SYM}$	Driver symmetry $\{(V_{O(CANH)} + V_{O(CANL)}) / (V_{O(REC\_CANH)} + V_{O(REC\_CANL)})\}$	TXD = 250 kHz, 1 MHz, 2.5 MHz, STB, SHDN = 0 V $R_L = 60\ \Omega$ , $C_{SPLIT} = 4.7\ \text{nF}$ , $C_L = \text{open}$ See <a href="#">7-2</a> and <a href="#">9-2</a>	0.9		1.1	V/V
$V_{SYM\_DC}$	DC output symmetry ( $CANH_{REC} + CANL_{REC} - CANH_{DOM} - CANL_{DOM}$ )	STB, SHDN = 0 V $R_L = 60\ \Omega$ , $C_L = \text{open}$ See <a href="#">7-2</a> and <a href="#">8-3</a>	-400		400	mV
$V_{OD(DOM)}$	Differential output voltage normal mode Dominant	CANH - CANL TXD = 0 V, STB, SHDN = 0 V $50\ \Omega \leq R_L \leq 65\ \Omega$ , $C_L = \text{open}$ See <a href="#">7-2</a> and <a href="#">8-3</a>	1.5		3	V
		CANH - CANL TXD = 0 V, STB, SHDN = 0 V $45\ \Omega \leq R_L \leq 70\ \Omega$ , $C_L = \text{open}$ See <a href="#">7-2</a> and <a href="#">8-3</a>	1.4		3	V
		CANH - CANL TXD = 0 V, STB, SHDN = 0 V $R_L = 2240\ \Omega$ , $C_L = \text{open}$ See <a href="#">7-2</a> and <a href="#">8-3</a>	1.5		3.4	V
$V_{OD(REC)}$	Differential output voltage normal mode Recessive	CANH - CANL TXD = $V_{IO}$ or $V_{CC}$ , STB, SHDN = 0 V $R_L = 60\ \Omega$ , $C_L = \text{open}$ See <a href="#">7-2</a> and <a href="#">8-3</a>	-120		12	mV
		CANH - CANL TXD = $V_{IO}$ or $V_{CC}$ , STB, SHDN = 0 V $R_L = \text{open}$ , $C_L = \text{open}$ See <a href="#">7-2</a> and <a href="#">8-3</a>	-50		50	mV
$V_{O(STB)}$	Bus output voltage standby mode	CANH TXD = STB = $V_{IO}$ or $V_{CC}$ , $R_L = \text{open}$ , $C_L = \text{open}$ See <a href="#">7-2</a> and <a href="#">8-3</a>	-0.1		0.1	V
		CANL TXD = STB = $V_{IO}$ or $V_{CC}$ , $R_L = \text{open}$ , $C_L = \text{open}$ See <a href="#">7-2</a> and <a href="#">8-3</a>	-0.1		0.1	V
		CANH - CANL TXD = STB = $V_{IO}$ or $V_{CC}$ , $R_L = \text{open}$ , $C_L = \text{open}$ See <a href="#">7-2</a> and <a href="#">8-3</a>	-0.2		0.2	V
$I_{OS(DOM)}$	Short-circuit bus output current, dominant, normal mode	See <a href="#">7-7</a> and <a href="#">8-3</a> , $V_{(CANH)} = -15\text{ V}$ to $40\text{ V}$ , CANL = open, TXD = 0 V	-115		115	mA
		See <a href="#">7-7</a> and <a href="#">8-3</a> , $V_{(CANL)} = -15\text{ V}$ to $40\text{ V}$ , CANH = open, TXD = 0 V	-115		115	mA
$I_{OS(REC)}$	Short-circuit steady-state output current, recessive, normal mode	See <a href="#">7-7</a> and <a href="#">8-3</a> , $V_{(CANH)} = -27\text{ V}$ to $32\text{ V}$ , CANL = open, STB=0, TXD = $V_{IO}$ or $V_{CC}$ ,	-7		7	mA
		See <a href="#">7-7</a> and <a href="#">8-3</a> , $V_{(CANL)} = -27\text{ V}$ to $32\text{ V}$ , CANH = open, STB = 0, TXD = $V_{IO}$ or $V_{CC}$ ,	-7		7	mA
<b>Receiver Electrical Characteristics</b>						
$V_{IT}$	Input threshold voltage normal mode	See <a href="#">7-3</a> and <a href="#">8-6</a> $-30\text{ V} \leq V_{CM} \leq 30\text{ V}$ , STB, SHDN= 0 V	500		900	mV
$V_{IT(STB)}$	Input threshold standby mode, TCAN3404	See <a href="#">7-3</a> and <a href="#">8-6</a> $-30\text{ V} \leq V_{CM} \leq 30\text{ V}$ , SHDN= 0 V, STB= $V_{CC}$	400		1150	mV
		See <a href="#">7-3</a> and <a href="#">8-6</a> $V_{IO} = 3\text{ V}$ to $3.6\text{ V}$ , $-30\text{ V} \leq V_{CM} \leq 30\text{ V}$ , STB= $V_{IO}$	400		1150	mV
	Input threshold standby mode, TCAN3403	See <a href="#">7-3</a> and <a href="#">8-6</a> $V_{IO} = 1.7\text{ V}$ to $1.9\text{ V}$ , $2.25\text{ V}$ to $2.75\text{ V}$ , $-12\text{ V} \leq V_{CM} \leq 12\text{ V}$ , STB= $V_{IO}$	400		1150	mV
$V_{DOM}$	Normal mode dominant state differential input voltage range	See <a href="#">7-3</a> and <a href="#">8-6</a> $-30\text{ V} \leq V_{CM} \leq 30\text{ V}$ , STB, SHDN= 0 V	0.9		9	V
$V_{REC}$	Normal mode recessive state differential input voltage range	See <a href="#">7-3</a> and <a href="#">8-6</a> $-30\text{ V} \leq V_{CM} \leq 30\text{ V}$ , STB, SHDN= 0 V	-4		0.5	V
$V_{DOM(STB)}$	Standby mode dominant state differential input voltage range	See <a href="#">7-3</a> and <a href="#">8-6</a> SHDN= 0 V, STB = $V_{IO}$ , $-30\text{ V} \leq V_{CM} \leq 30\text{ V}$	1.15		9	V
$V_{REC(STB)}$	Standby mode recessive state differential input voltage range	See <a href="#">7-3</a> and <a href="#">8-6</a> SHDN = 0 V, STB = $V_{IO}$ , $-30\text{ V} \leq V_{CM} \leq 30\text{ V}$	-4		0.4	V

## 6.8 Electrical Characteristics (続き)

parameters valid over recommended operating conditions with  $-40^{\circ}\text{C} \leq T_J \leq 150^{\circ}\text{C}$  (Typical values are at  $V_{CC} = 3.3\text{ V}$ ,  $V_{IO} = 3.3\text{ V}$  for TCAN3403, Device ambient maintained at  $27^{\circ}\text{C}$ ) unless otherwise noted

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$V_{HYS}$	Hysteresis voltage for input threshold normal mode	See 図 7-3 and 表 8-6 $-30\text{ V} \leq V_{CM} \leq 30\text{ V}$ , STB, SHDN = 0 V		50		mV
$V_{CM}$	Common mode range normal and standby modes	See 図 7-3 and 表 8-6	-30		30	V
$I_{LKG(OFF)}$	Unpowered bus input leakage current	CANH = CANL = 5 V, $V_{CC} = V_{IO} = \text{GND}$			5	$\mu\text{A}$
$C_1$	Input capacitance to ground (CANH or CANL)	TXD = $V_{IO}$ ,			40	pF
$C_{ID}$	Differential input capacitance				20	pF
$R_{ID}$	Differential input resistance	TXD = $V_{IO}$ , STB = 0 V $-30\text{ V} \leq V_{CM} \leq 30\text{ V}$	25		50	k $\Omega$
$R_{IN}$	Single ended input resistance (CANH or CANL)		13		25	k $\Omega$
$R_{IN(M)}$	Input resistance matching $[1 - (R_{IN(CANH)} / R_{IN(CANL)})] \times 100\%$	$V_{(CAN\_H)} = V_{(CAN\_L)} = 5\text{ V}$	-3		3	%
<b>TXD Terminal (CAN Transmit Data Input)</b>						
$V_{IH}$	High-level input voltage	TCAN3404	0.7 $V_{CC}$			V
$V_{IH}$	High-level input voltage	TCAN3403	0.7 $V_{IO}$			V
$V_{IL}$	Low-level input voltage	TCAN3404			0.3 $V_{CC}$	V
$V_{IL}$	Low-level input voltage	TCAN3403			0.3 $V_{IO}$	V
$I_{IH}$	High-level input leakage current	TXD = $V_{CC} = V_{IO} = 3.6\text{ V}$	-2.5	0	1	$\mu\text{A}$
$I_{IL}$	Low-level input leakage current	TXD = 0 V, $V_{CC} = V_{IO} = 3.6\text{ V}$	-200	-100	-20	$\mu\text{A}$
$I_{LKG(OFF)}$	Unpowered leakage current	TXD = 3.6 V, $V_{CC} = V_{IO} = 0\text{ V}$	-1	0	1	$\mu\text{A}$
$C_1$	Input capacitance			4		pF
<b>RXD Terminal (CAN Receive Data Output)</b>						
$V_{OH}$	High-level output voltage	TCAN3404 See 図 7-3, $I_O = -2\text{ mA}$	0.8 $V_{CC}$			V
$V_{OH}$	High-level output voltage	See 図 7-3, $I_O = -1.5\text{ mA}$ , TCAN3403	0.8 $V_{IO}$			V
$V_{OL}$	Low-level output voltage	TCAN3404 See 図 7-3, $I_O = 2\text{ mA}$			0.2 $V_{CC}$	V
$V_{OL}$	Low-level output voltage	TCAN3403 See 図 7-3, $I_O = 1.5\text{ mA}$			0.2 $V_{IO}$	V
$I_{LKG(OFF)}$	Unpowered leakage current	RXD = 3.6 V, $V_{CC} = V_{IO} = 0\text{ V}$	-1	0	1	$\mu\text{A}$
<b>STB Terminal (Standby Mode Input)</b>						
$V_{IH}$	High-level input voltage	TCAN3404	0.7 $V_{CC}$			V
$V_{IH}$	High-level input voltage	TCAN3403	0.7 $V_{IO}$			V
$V_{IL}$	Low-level input voltage	TCAN3404			0.3 $V_{CC}$	V
$V_{IL}$	Low-level input voltage	TCAN3403			0.3 $V_{IO}$	V
$I_{IH}$	High-level input leakage current	$V_{CC} = V_{IO} = \text{STB} = 3.6\text{ V}$	-2		2	$\mu\text{A}$
$I_{IL}$	Low-level input leakage current	$V_{CC} = V_{IO} = 3.6\text{ V}$ , STB = 0 V	-20		-2	$\mu\text{A}$
$I_{LKG(OFF)}$	Unpowered leakage current	STB = 3.6V, $V_{CC} = V_{IO} = 0\text{ V}$	-1	0	1	$\mu\text{A}$
<b>SHDN Terminal (Shutdown mode input)</b>						
$V_{IH}$	High-level input voltage	TCAN3404	0.7 $V_{CC}$			V
$V_{IL}$	Low-level input voltage	TCAN3404			0.3 $V_{CC}$	V
$I_{IH}$	High-level input leakage current	$V_{CC} = V_{IO} = \text{SHDN} = 3.6\text{ V}$	2		5.5	$\mu\text{A}$
$I_{IL}$	Low-level input leakage current	$V_{CC} = V_{IO} = 3.6\text{ V}$ , SHDN = 0 V	-2		2	$\mu\text{A}$
$I_{LKG(OFF)}$	Unpowered leakage current	SHDN = 3.6 V, $V_{CC} = V_{IO} = 0\text{ V}$	-1	0	1	$\mu\text{A}$



## 6.9 Switching Characteristics

parameters valid over recommended operating conditions with  $-40^{\circ}\text{C} \leq T_J \leq 150^{\circ}\text{C}$  (Typical values are at  $V_{CC} = 3.3\text{ V}$ ,  $V_{IO} = 3.3\text{ V}$  for TCAN3403, Device ambient maintained at  $27^{\circ}\text{C}$ ) unless otherwise noted

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
<b>Device Switching Characteristics</b>						
$t_{\text{PROP(LOOP1)}}$	Total loop delay, driver input (TXD) to receiver output (RXD), recessive to dominant	See <a href="#">7-4</a> , normal mode, $V_{CC} = V_{IO} = 3\text{ V}$ to $3.6\text{ V}$ , $R_L = 60\ \Omega$ , $C_L = 100\text{ pF}$ , $C_{L(\text{RXD})} = 15\text{ pF}$ TCAN3404, TCAN3403		95	180	ns
		See <a href="#">7-4</a> , normal mode, $V_{CC} = 3$ to $3.6\text{ V}$ , $V_{IO} = 2.25\text{ V}$ to $2.75\text{ V}$ , $R_L = 60\ \Omega$ , $C_L = 100\text{ pF}$ , $C_{L(\text{RXD})} = 15\text{ pF}$ TCAN3403		102	190	ns
		See <a href="#">7-4</a> , normal mode, $V_{CC} = 3$ to $3.6\text{ V}$ , $V_{IO} = 1.71\text{ V}$ to $1.89\text{ V}$ , $R_L = 60\ \Omega$ , $C_L = 100\text{ pF}$ , $C_{L(\text{RXD})} = 15\text{ pF}$ TCAN3403		115	210	ns
$t_{\text{PROP(LOOP2)}}$	Total loop delay, driver input (TXD) to receiver output (RXD), dominant to recessive	See <a href="#">7-4</a> , normal mode, $V_{CC} = V_{IO} = 3\text{ V}$ to $3.6\text{ V}$ , $R_L = 60\ \Omega$ , $C_L = 100\text{ pF}$ , $C_{L(\text{RXD})} = 15\text{ pF}$ TCAN3404, TCAN3403		120	180	ns
		See <a href="#">7-4</a> , normal mode, $V_{CC} = 3$ to $3.6\text{ V}$ , $V_{IO} = 2.25\text{ V}$ to $2.75\text{ V}$ , $R_L = 60\ \Omega$ , $C_L = 100\text{ pF}$ , $C_{L(\text{RXD})} = 15\text{ pF}$ TCAN3403		125	190	ns
		See <a href="#">7-4</a> , normal mode, $V_{CC} = 3$ to $3.6\text{ V}$ , $V_{IO} = 1.71\text{ V}$ to $1.89\text{ V}$ , $R_L = 60\ \Omega$ , $C_L = 100\text{ pF}$ , $C_{L(\text{RXD})} = 15\text{ pF}$ TCAN3403		140	210	ns
$t_{\text{MODE}}$	Mode change time, from normal to standby or from standby to normal	See Figure 8-5 in TCAN1044A datasheet See <a href="#">7-5</a>			30	$\mu\text{s}$
$t_{\text{SHDN1}}$	Mode change time from normal mode to shutdown mode	With TXD = High, Time from SHDN pin (low to high edge 50%) to CANH going from recessive level $V_{o(\text{rec})}$ to $0.5\text{ V}$			40	$\mu\text{s}$
$t_{\text{SHDN2}}$	Mode change time from shutdown mode to normal mode	With TXD high, time from SHDN pin (high to low edge 50%) to CANH going from $0.5\text{ V}$ to $V_{o(\text{rec})}$			200	$\mu\text{s}$
$t_{\text{WK\_FILTER}}$	Filter time for a valid wake-up pattern	See <a href="#">8-5</a>	0.5		1.8	$\mu\text{s}$
$t_{\text{WK\_TIMEOUT}}$	Bus wake-up timeout value		0.8		6	ms
Tstartup	Time duration after $V_{CC}$ or $V_{IO}$ has cleared UV+, and device can resume normal operation				1.5	ms
$T_{\text{filter(STB)}}$	Filter on STB pin to filter out any glitches		0.5	1	2	$\mu\text{s}$
$T_{\text{filter(SHDN)}}$	Filter on SHDN pin to filter out any glitches		0.5	1	2	$\mu\text{s}$
<b>Driver Switching Characteristics</b>						
$t_{\text{prop(TxD-busrec)}}$	Propagation delay time, low-to-high TXD edge to driver recessive (dominant to recessive)	See <a href="#">7-2</a> , STB, SHDN = $0\text{ V}$ , $R_L = 60\ \Omega$ , $C_L = 100\text{ pF}$ , $V_{CC} = V_{IO} = 3\text{ V}$ to $3.6\text{ V}$ TCAN3404, TCAN3403		65	100	ns
		See <a href="#">7-2</a> , STB, SHDN = $0\text{ V}$ , $R_L = 60\ \Omega$ , $C_L = 100\text{ pF}$ , $V_{CC} = 3$ to $3.6\text{ V}$ , $V_{IO} = 2.25\text{ V}$ to $2.75\text{ V}$ TCAN3403		67	110	ns
		See <a href="#">7-2</a> , STB, SHDN = $0\text{ V}$ , $R_L = 60\ \Omega$ , $C_L = 100\text{ pF}$ , $V_{CC} = 3$ to $3.6\text{ V}$ , $V_{IO} = 1.71\text{ V}$ to $1.89\text{ V}$ TCAN3403		71	110	ns

## 6.9 Switching Characteristics (続き)

parameters valid over recommended operating conditions with  $-40^{\circ}\text{C} \leq T_J \leq 150^{\circ}\text{C}$  (Typical values are at  $V_{CC} = 3.3\text{ V}$ ,  $V_{IO} = 3.3\text{ V}$  for TCAN3403, Device ambient maintained at  $27^{\circ}\text{C}$ ) unless otherwise noted

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$t_{\text{prop(TxD-busdom)}}$	Propagation delay time, high-to-low TXD edge to driver dominant (recessive to dominant)	See <a href="#">7-2</a> , STB, SHDN = 0 V, $R_L = 60\ \Omega$ , $C_L = 100\ \text{pF}$ , $V_{CC} = V_{IO} = 3\text{ V}$ to $3.6\text{ V}$ TCAN3404, TCAN3403		46	100	ns
		See <a href="#">7-2</a> , STB, SHDN = 0 V, $R_L = 60\ \Omega$ , $C_L = 100\ \text{pF}$ , $V_{CC} = 3$ to $3.6\text{ V}$ , $V_{IO} = 2.25\text{ V}$ to $2.75\text{ V}$ TCAN3403		48	110	ns
		See <a href="#">7-2</a> , STB, SHDN = 0 V, $R_L = 60\ \Omega$ , $C_L = 100\ \text{pF}$ , $V_{CC} = 3$ to $3.6\text{ V}$ , $V_{IO} = 1.71\text{ V}$ to $1.89\text{ V}$ TCAN3403		53	110	ns
$t_{\text{sk(p)}}$	Pulse skew ( $ t_{\text{prop(TxD-busrec)}} - t_{\text{prop(TxD-busdom)}} $ )	, STB, SHDN = 0 V, $R_L = 60\ \Omega$ , $C_L = 100\ \text{pF}$ , See <a href="#">7-2</a>		18	28	ns
$t_R$	Differential output signal rise time	See <a href="#">7-2</a> , STB, SHDN = 0 V, $R_L = 60\ \Omega$ , $C_L = 100\ \text{pF}$		32	57	ns
$t_F$	Differential output signal fall time			30	50	ns
$t_{\text{TxD\_DTO}}$	Dominant timeout	See <a href="#">7-6</a> , STB, SHDN = 0 V, $R_L = 60\ \Omega$ , $C_L = 100\ \text{pF}$	1.2		4.0	ms
<b>Receiver Switching Characteristics</b>						
$t_{\text{prop(busrec-RXD)}}$	Propagation delay time, bus recessive input to RXD high output (dominant to recessive)	See <a href="#">7-3</a> , STB, SHDN = 0 V, $C_{L(\text{RXD})} = 15\ \text{pF}$ , $V_{CC} = V_{IO} = 3\text{ V}$ to $3.6\text{ V}$ TCAN3404, TCAN3403		55	90	ns
		See <a href="#">7-3</a> , STB, SHDN = 0 V, $C_{L(\text{RXD})} = 15\ \text{pF}$ , $V_{CC} = 3$ to $3.6\text{ V}$ , $V_{IO} = 2.25\text{ V}$ to $2.75\text{ V}$ TCAN3403		60	90	ns
		See <a href="#">7-3</a> , STB, SHDN = 0 V, $C_{L(\text{RXD})} = 15\ \text{pF}$ , $V_{CC} = 3$ to $3.6\text{ V}$ , $V_{IO} = 1.71\text{ V}$ to $1.89\text{ V}$ TCAN3403		70	102	ns
$t_{\text{prop(busdom-RXD)}}$	Propagation delay time, bus dominant input to RXD low output (recessive to dominant)	See <a href="#">7-3</a> , STB, SHDN = 0 V, $C_{L(\text{RXD})} = 15\ \text{pF}$ , $V_{CC} = V_{IO} = 3\text{ V}$ to $3.6\text{ V}$ TCAN3404, TCAN3403		45	90	ns
		See <a href="#">7-3</a> , STB, SHDN = 0 V, $C_{L(\text{RXD})} = 15\ \text{pF}$ , $V_{CC} = 3$ to $3.6\text{ V}$ , $V_{IO} = 2.25\text{ V}$ to $2.75\text{ V}$ TCAN3403		51	90	ns
		See <a href="#">7-3</a> , STB, SHDN = 0 V, $C_{L(\text{RXD})} = 15\ \text{pF}$ , $V_{CC} = 3$ to $3.6\text{ V}$ , $V_{IO} = 1.71\text{ V}$ to $1.89\text{ V}$ TCAN3403		60	100	ns
$t_R$	RXD output signal rise time	See <a href="#">7-3</a> , STB, SHDN = 0 V		10	25	ns
$t_F$	RXD output signal fall time	$C_{L(\text{RXD})} = 15\ \text{pF}$		10	28	ns
<b>FD Timing Characteristics</b>						
$t_{\text{BIT(BUS)}}$	Bit time on CAN bus output pins with $t_{\text{BIT(TXD)}} = 500\ \text{ns}$	See <a href="#">7-4</a> , STB, SHDN = 0 V, $R_L = 60\ \Omega$ , $C_L = 100\ \text{pF}$ , $C_{L(\text{RXD})} = 15\ \text{pF}$		450	525	ns
	Bit time on CAN bus output pins with $t_{\text{BIT(TXD)}} = 200\ \text{ns}$			160	205	ns
	Bit time on CAN bus output pins with $t_{\text{BIT(TXD)}} = 125\ \text{ns}^{(1)}$			85	130	ns
$t_{\text{BIT(RXD)}}$	Bit time on RXD output pins with $t_{\text{BIT(TXD)}} = 500\ \text{ns}$	See <a href="#">7-4</a> , STB, SHDN = 0 V, $R_L = 60\ \Omega$ , $C_L = 100\ \text{pF}$ , $C_{L(\text{RXD})} = 15\ \text{pF}$		410	540	ns
	Bit time on RXD output pins with $t_{\text{BIT(TXD)}} = 200\ \text{ns}$			130	210	ns
	Bit time on RXD output pins with $t_{\text{BIT(TXD)}} = 125\ \text{ns}^{(1)}$			75	135	ns

## 6.9 Switching Characteristics (続き)

parameters valid over recommended operating conditions with  $-40^{\circ}\text{C} \leq T_J \leq 150^{\circ}\text{C}$  (Typical values are at  $V_{CC} = 3.3\text{ V}$ ,  $V_{IO} = 3.3\text{ V}$  for TCAN3403, Device ambient maintained at  $27^{\circ}\text{C}$ ) unless otherwise noted

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$\Delta t_{\text{REC}}$	Receiver timing symmetry with $t_{\text{BIT(TXD)}} = 500\text{ ns}$	See <a href="#">Fig 7-4</a> , STB, SHDN = 0 V, $R_L = 60\ \Omega$ , $C_L = 100\text{ pF}$ , $C_{L(\text{RXD})} = 15\text{ pF}$ $\Delta t_{\text{REC}} = t_{\text{BIT(RXD)}} - t_{\text{BIT(BUS)}}$	-50		20	ns
	Receiver timing symmetry with $t_{\text{BIT(TXD)}} = 200\text{ ns}$		-40		10	ns
	Receiver timing symmetry with $t_{\text{BIT(TXD)}} = 125\text{ ns}^{(1)}$		-40		10	ns

(1) Min/Max limits based on characterization.

## 6.10 Typical Characteristics

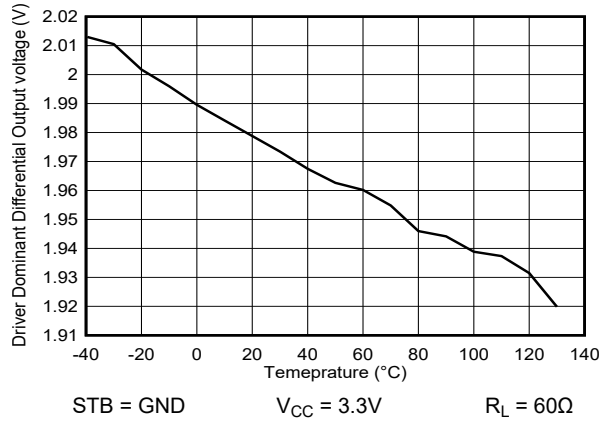


Figure 6-1. V<sub>OD(DOM)</sub> vs Temperature

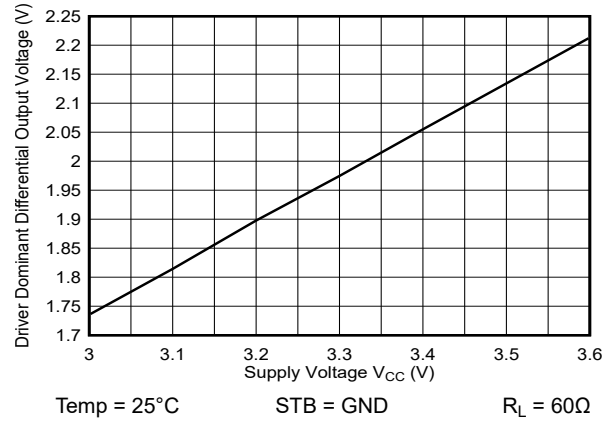


Figure 6-2. V<sub>OD(DOM)</sub> vs V<sub>CC</sub>

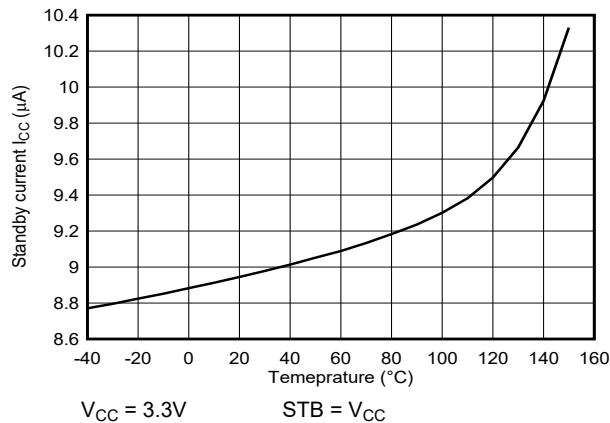


Figure 6-3. I<sub>CC</sub> Standby vs Temperature

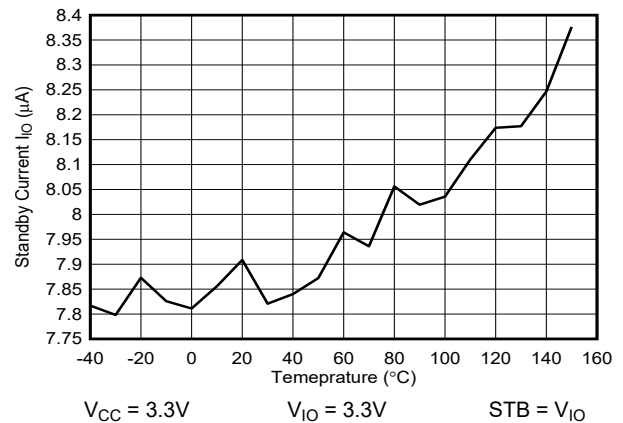


Figure 6-4. I<sub>IO</sub> Standby vs Temperature

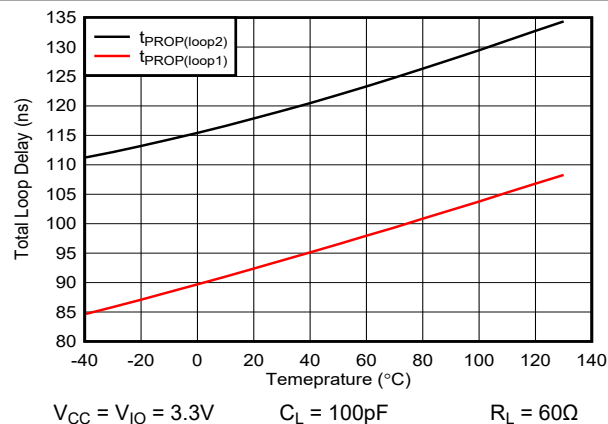


Figure 6-5. Total Loop Delay vs Temperature

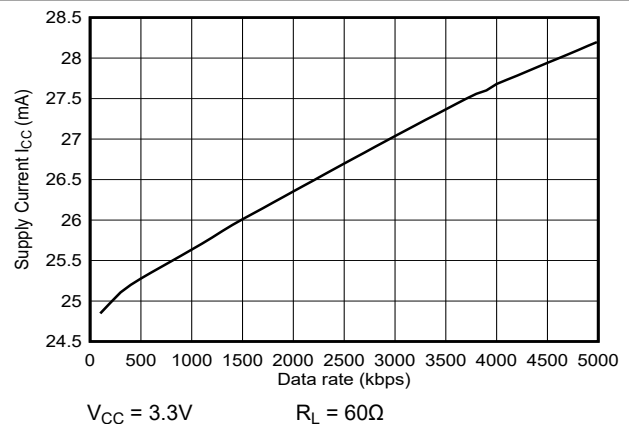
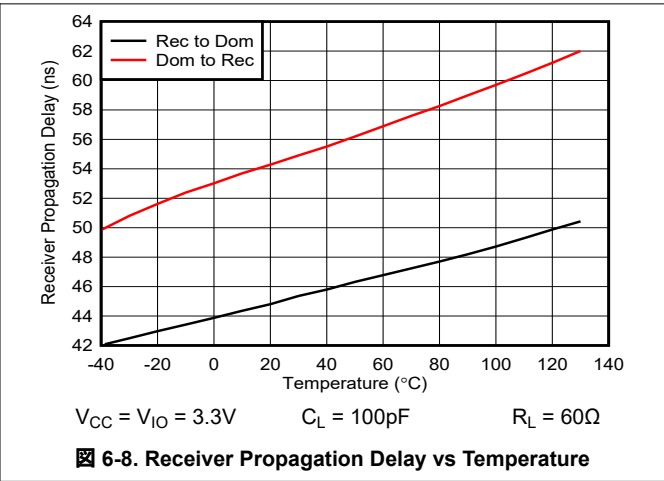
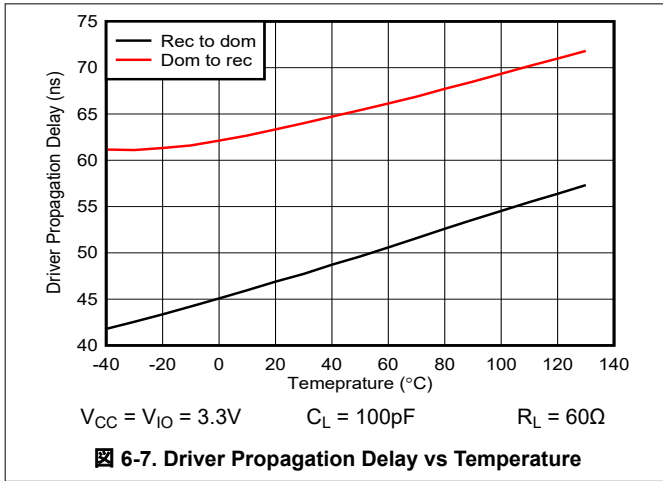


Figure 6-6. I<sub>CC</sub> vs Data Rate

## 6.10 Typical Characteristics (continued)



## 7 Parameter Measurement Information

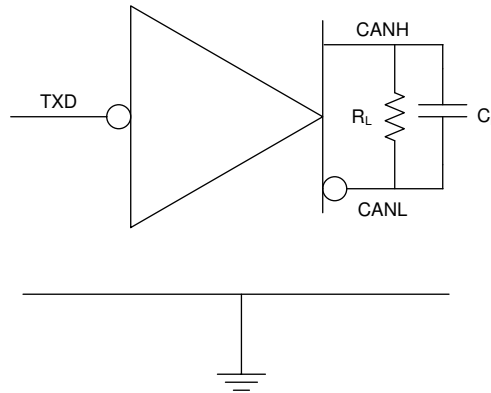


図 7-1.  $I_{CC}$  Test Circuit

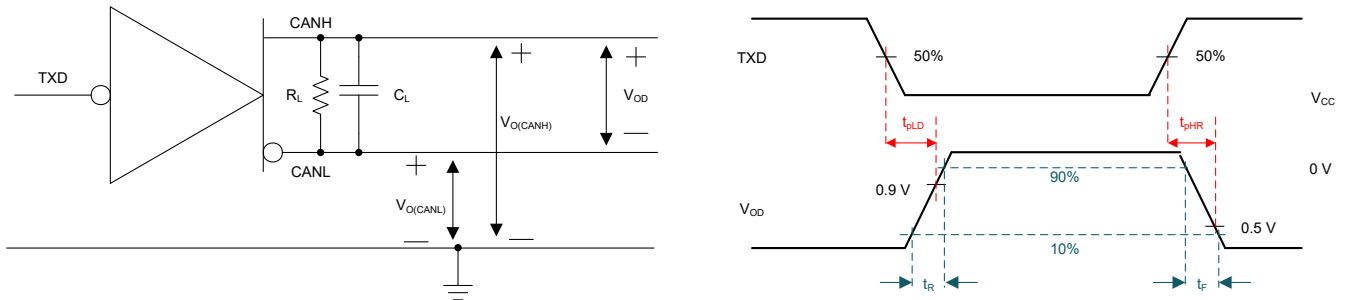


図 7-2. Driver Test Circuit and Measurement

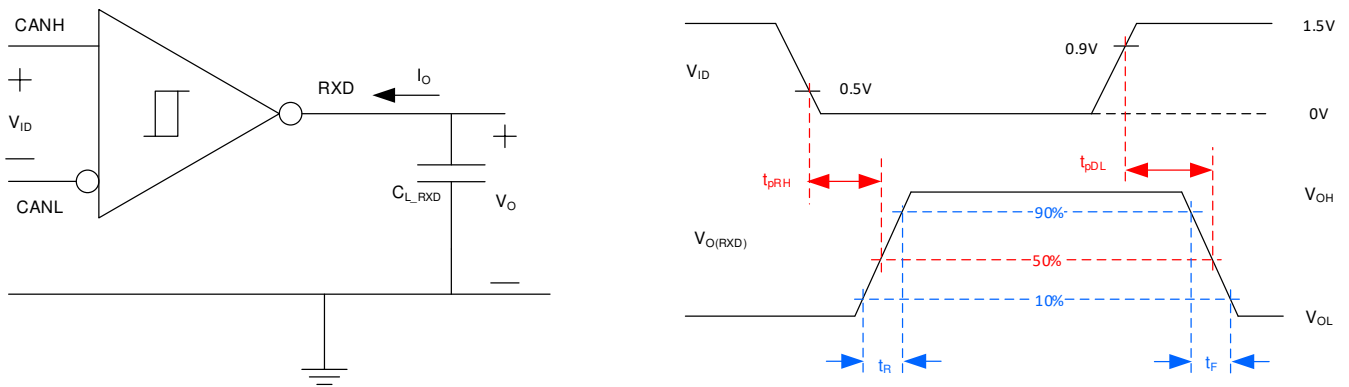


図 7-3. Receiver Test Circuit and Measurement

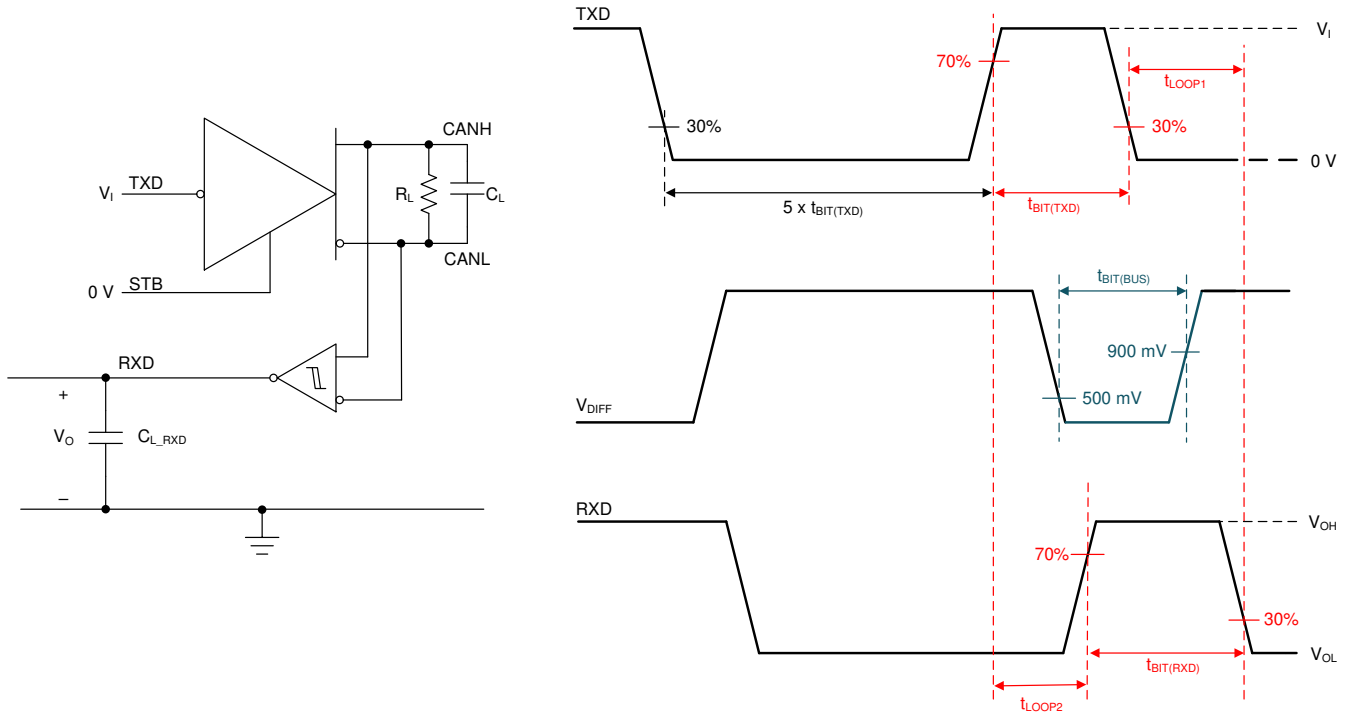


図 7-4. Transmitter and Receiver Timing Test Circuit and Measurement

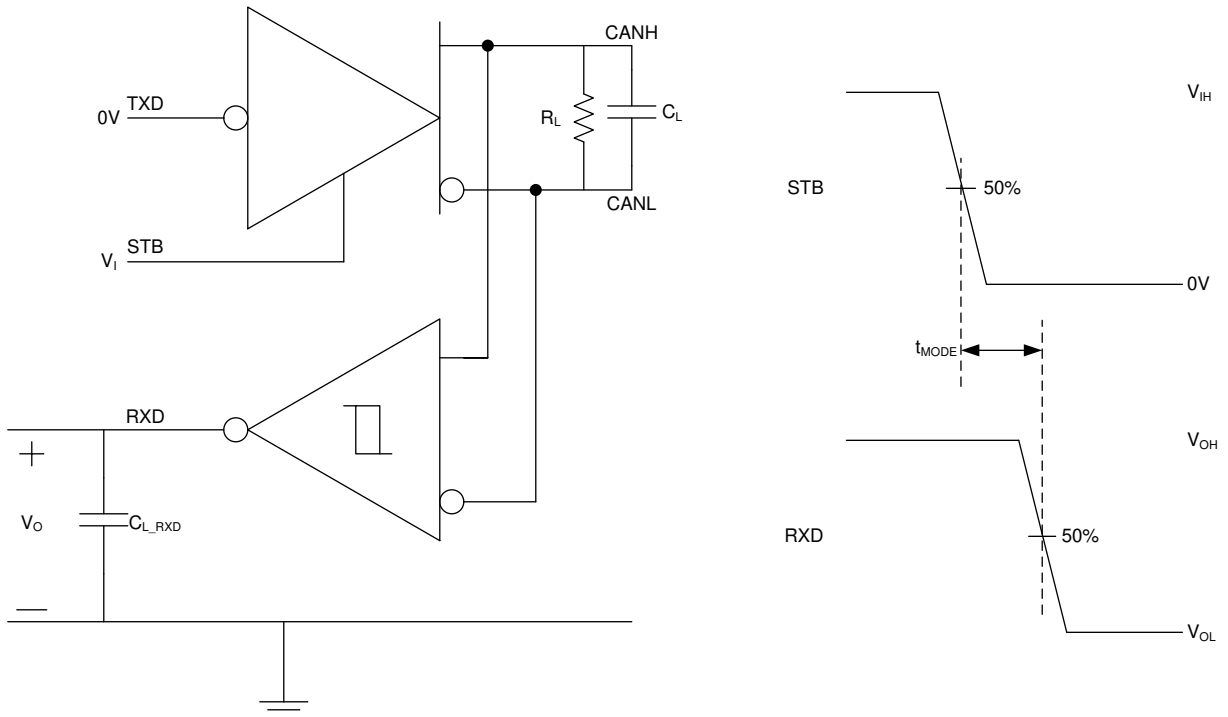
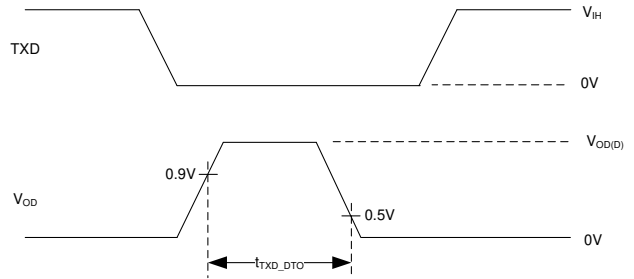
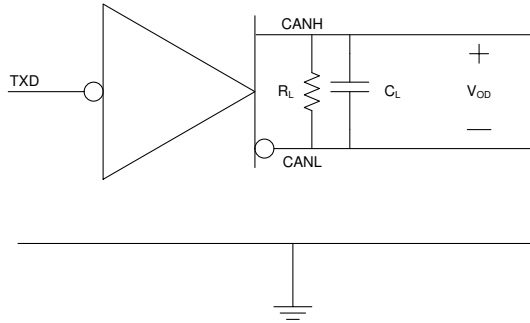
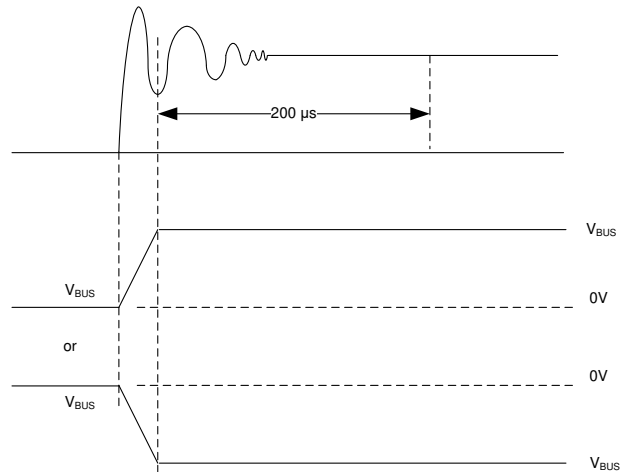
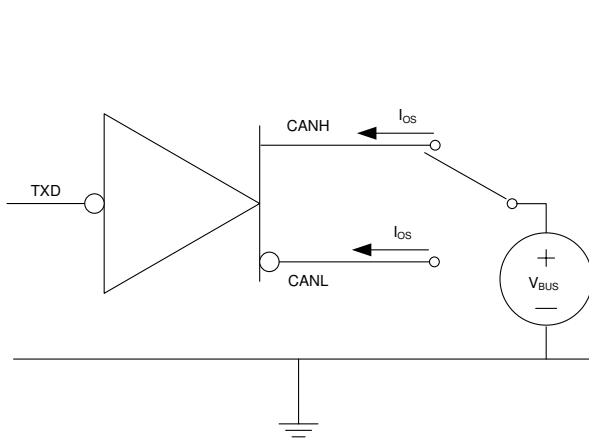


図 7-5.  $t_{MODE}$  Test Circuit and Measurement



**7-6. TXD Dominant Timeout Test Circuit and Measurement**



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



## 8 Detailed Description

### 8.1 Overview

The TCAN340x-Q1 devices are automotive EMC compliant 3.3V CAN FD transceivers. The devices are data rate agnostic making them backward compatible for supporting classical CAN applications while also supporting CAN FD networks up to 8Mbps. These devices have standby mode support which puts the transceiver in low current consumption mode. Upon receiving valid wake-up pattern on CAN bus, the device signals to the microcontroller through the RXD pin. The MCU can then place the device in normal mode using STB pin.

TCAN3404-Q1 supports ultra-low power shutdown mode where most of the internal blocks are disabled. This feature is optimized for battery-powered applications. TCAN3403-Q1 supports  $V_{IO}$  pin for low voltage logic level interface. The device can be interfaced to 1.8V, 2.5V or 3.3V micro controllers.

### 8.2 Functional Block Diagram

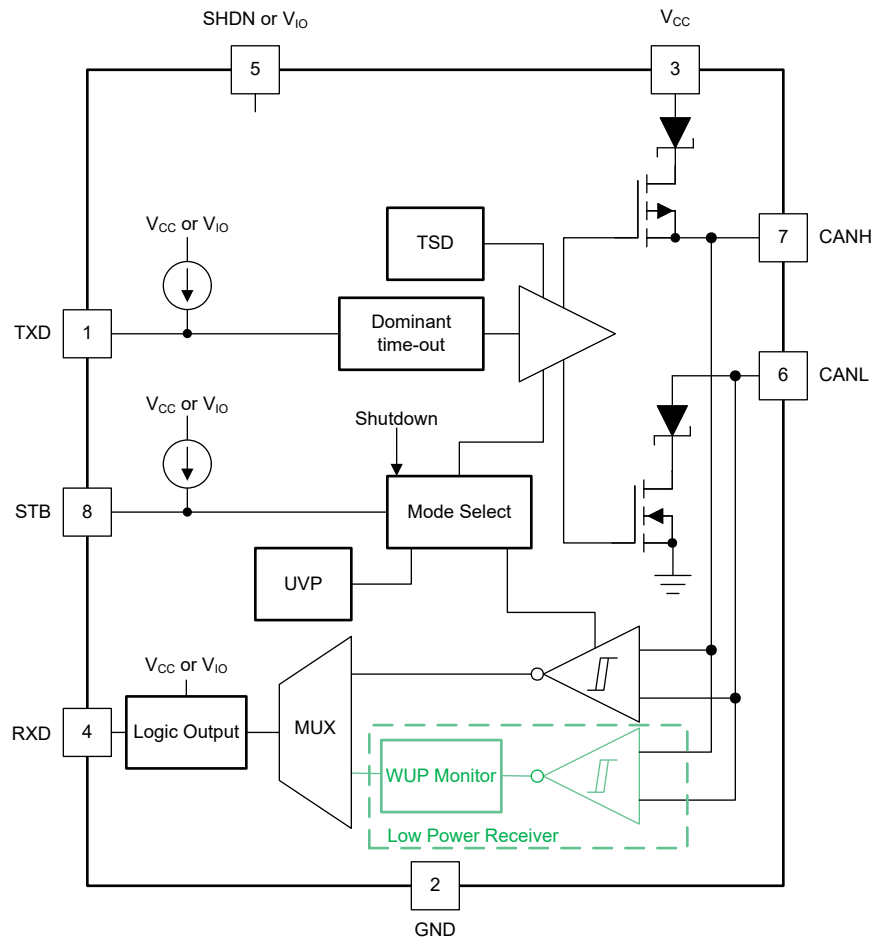


図 8-1. Block Diagram

### 8.3 Feature Description

#### 8.3.1 Pin Description

##### 8.3.1.1 TXD

The TXD input is a logic-level signal from a CAN controller to the transceiver. It is referenced to  $V_{CC}$  for TCAN3404-Q1 or to  $V_{IO}$  for TCAN3403-Q1 device.

### 8.3.1.2 GND

GND is the ground pin of the transceiver. The pin must be connected to the PCB ground.

### 8.3.1.3 V<sub>CC</sub>

V<sub>CC</sub> provides the 3.3 V power supply to the CAN transceiver.

### 8.3.1.4 RXD

The RXD output is a logic-level signal from the CAN transceiver to the CAN controller. It is referenced to V<sub>CC</sub> for TCAN3404-Q1 and V<sub>IO</sub> for TCAN3403-Q1. For TCAN3403-Q1, this pin is only driven once V<sub>IO</sub> is present.

When a CAN bus wakeup event takes place, RXD is driven low

### 8.3.1.5 V<sub>IO</sub> (TCAN3403-Q1 only)

The V<sub>IO</sub> pin provides the digital I/O voltage to match the CAN controller voltage thus avoiding the requirement for a level shifter. It supports voltages from 1.7V to 3.6V providing a wide range of controller support.

### 8.3.1.6 CANH and CANL

The CANH and CANL pins are the CAN high and CAN low differential bus pins. These pins are internally connected to the CAN transmitter, receiver and the low-power wake-up receiver.

### 8.3.1.7 STB (Standby)

The STB pin is an input pin used for mode control of the transceiver. The STB pin can be supplied from either the system processor or from a static system voltage source. STB pin has default pull-up resistor on-chip. So if the pin is left floating or pulled high externally, device is in standby mode. If normal mode is the only intended mode of operation, the STB pin can be tied directly to GND.

### 8.3.1.8 SHDN (Shutdown)

The SHDN pin is only applicable to TCAN3404-Q1 and is used to put the device in ultra-low power mode. SHDN pin has an internal pull-down resistor on-chip, so if the pin is left floating, the device is in normal mode or standby mode depending on the state of STB pin. Pulling SHDN pin high externally puts the device in shutdown. All blocks (including low power wakeup receiver) are disabled in this mode. SHDN pin has higher priority compared to STB pin.

## 8.3.2 CAN Bus States

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

A dominant bus state occurs when the bus is driven differentially and corresponds to a logic low on the TXD and RXD pins. A recessive bus state occurs when the bus is biased to roughly V<sub>CC</sub>/2 via the high-resistance internal input resistors (R<sub>IN</sub>) of the receiver and corresponds to a logic high on the TXD and RXD pins.

A dominant state overwrites the recessive state during arbitration. Multiple CAN nodes may be transmitting a dominant bit at the same time during arbitration, and in this case the differential voltage of the bus is greater than the differential voltage of a single driver.

The TCAN340x-Q1 transceivers implement a low-power standby (STB) mode which enables a third bus state where the bus pins are weakly biased to ground via the high resistance internal resistors of the receiver. See [8-2](#) and [8-3](#).

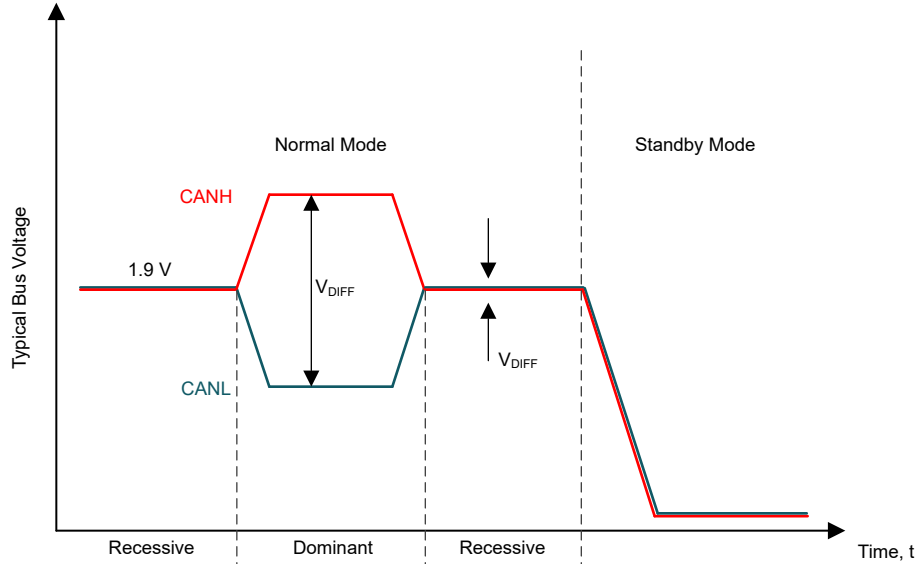
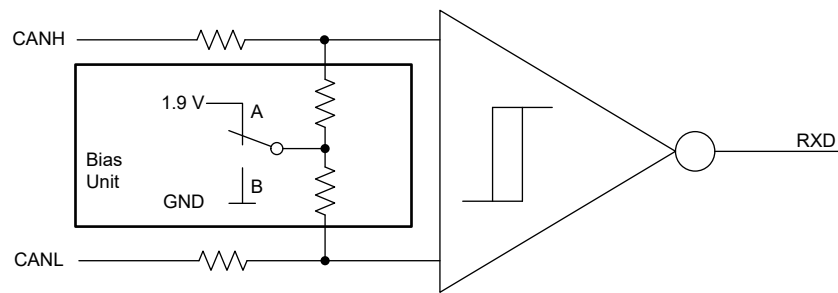


図 8-2. Bus States



A - Normal Mode B - Standby Mode

図 8-3. Simplified Recessive Common Mode Bias Unit and Receiver

### 8.3.3 TXD Dominant Timeout (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 the event of a hardware or software failure where TXD is held dominant longer than the timeout period  $t_{TXD\_DTO}$ . The TXD DTO circuit is triggered by a falling edge on TXD. If no rising edge is seen before the timeout period of the circuit,  $t_{TXD\_DTO}$ , the CAN driver is disabled. This frees the bus for communication between other nodes on the network. The CAN driver is reactivated when a recessive signal is seen on the TXD pin; thus, clearing the dominant time out. The receiver remains active and biased to approximately 1.9V and the RXD output reflects the activity on the CAN bus during the TXD DTO fault.

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 using 式 1.

$$\text{Minimum Data Rate} = 11 \text{ bits} / t_{TXD\_DTO} = 11 \text{ bits} / 1.2\text{ms} = 9.2\text{kbps} \quad (1)$$

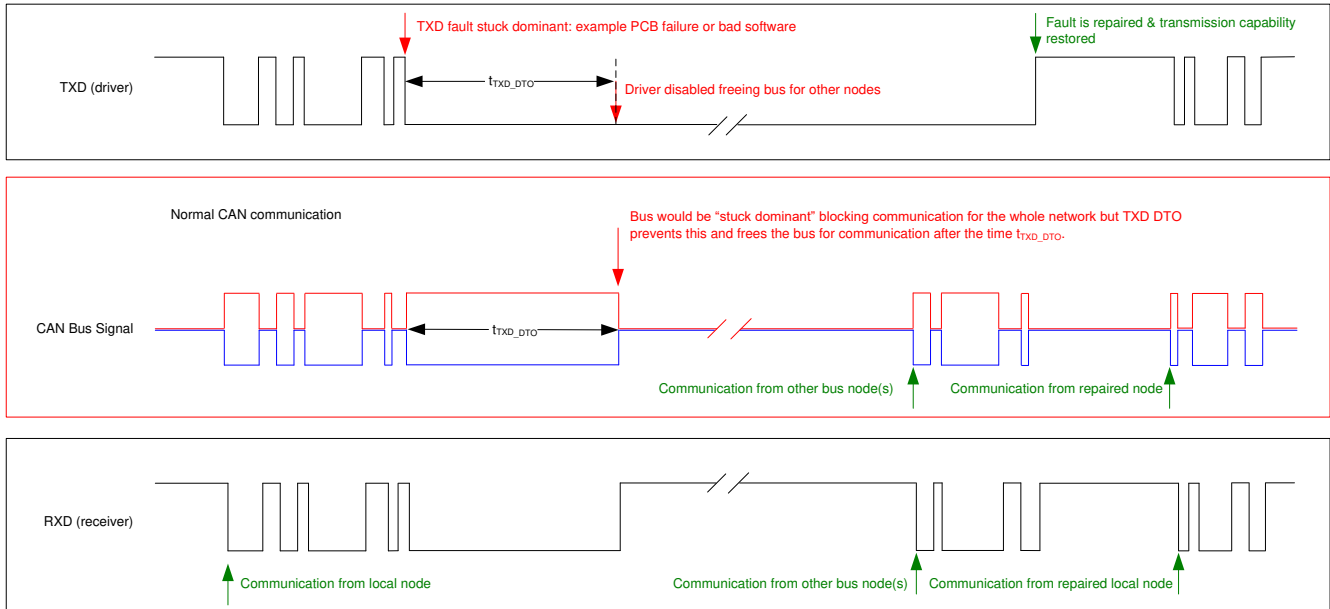


図 8-4. Example Timing Diagram for TXD Dominant Timeout

### 8.3.4 CAN Bus short-circuit current limiting

The devices have several protection features that limit the short-circuit current when a CAN bus line is shorted. These include CAN driver current limiting in the dominant and recessive states and TXD dominant state timeout which prevents permanently having the higher short-circuit current of a dominant state in case of a system fault. During CAN communication the bus switches between the dominant and recessive states, thus the short-circuit current may be viewed as either the current during each bus state or as a DC average current. When selecting termination resistors or a common-mode choke for the CAN design the average power rating,  $I_{OS(AVG)}$ , should be used. The percentage dominant is limited by the TXD DTO and the CAN protocol which has forced state changes and recessive bits due to bit stuffing, control fields, and interframe space. making sure there is a minimum amount of recessive time on the bus even if the data field contains a high percentage of dominant bits.

The average short-circuit current of the bus depends on the ratio of recessive to dominant bits and the respective short-circuit currents. The average short-circuit current may be calculated using 式 2.

$$I_{OS(AVG)} = \% \text{ Transmit} \times [(\% \text{ REC\_Bits} \times I_{OS(SS)\_REC}) + (\% \text{ DOM\_Bits} \times I_{OS(SS)\_DOM})] + [\% \text{ Receive} \times I_{OS(SS)\_REC}] \quad (2)$$

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

This short circuit current and the possible fault cases of the network should be taken into consideration when sizing the power supply used to generate the transceivers  $V_{CC}$  supply.

### 8.3.5 Thermal Shutdown (TSD)

If the junction temperature of the devices exceed the thermal shutdown threshold,  $T_{TSD}$ , the device turns off the CAN driver circuitry and blocks the TXD to bus transmission path. The shutdown condition is cleared when the junction temperature of the device drops below  $T_{TSD}$ . The CAN bus pins are biased to approximately 1.9V during

a TSD fault and the receiver to RXD path remains operational. The TCAN340x-Q1 TSD circuit includes hysteresis which prevents the CAN driver output from oscillating during a TSD fault.

### 8.3.6 Undervoltage Lockout

The supply pins,  $V_{CC}$  and  $V_{IO}$ , have undervoltage detection that places the device into a protected state. This protects the bus during an undervoltage event on either supply pin.

**表 8-1. Undervoltage Lockout - TCAN3404-Q1**

$V_{CC}$	DEVICE STATE	BUS	RXD PIN
$> UV_{VCC}$	Normal if STB = GND and SHDN = GND	Per TXD	Mirrors bus
$> UV_{VCC}$	Standby mode if STB = High and SHDN = GND	Weak biased to GND	$V_{CC}$ , Remote wake request See <a href="#">Remote Wake Request via Wake-Up Pattern (WUP) in Standby Mode</a>
$> UV_{VCC}$	Shutdown mode if SHDN = High	Weak biased to GND	$V_{CC}$
$< UV_{VCC}$	Protected	High impedance	High impedance

**表 8-2. Undervoltage Lockout - TCAN3403-Q1**

$V_{CC}$	$V_{IO}$	DEVICE STATE	BUS	RXD PIN
$> UV_{VCC}$	$> UV_{VIO}$	Normal	Per TXD	Mirrors bus
$< UV_{VCC}$	$> UV_{VIO}$	STB = High: Standby Mode	Weak biased to GND	$V_{IO}$ : Remote wake request See <a href="#">Remote Wake Request via Wake-Up Pattern (WUP) in Standby Mode</a>
		STB = Low: Protected Mode	High impedance	Recessive
$> UV_{VCC}$	$< UV_{VIO}$	Protected	High impedance	High impedance
$< UV_{VCC}$	$< UV_{VIO}$	Protected	High impedance	High impedance

Once the undervoltage condition is cleared, and  $t_{MODE}$  or  $t_{SHDN2}$  has expired, the TCAN340x-Q1 transitions to normal mode and the host controller can again send and receive CAN traffic.

### 8.3.7 Unpowered Device

For unpowered condition, the TCAN340x-Q1 is designed to be a passive or no load to the CAN bus. This is because the bus pins were designed to have low leakage currents to not load the bus. This design consideration is critical if some nodes of the network are unpowered while the rest of the network remains operational.

For unpowered scenario, the logic pins also have low leakage currents. The pins do not load other circuits which may remain powered.

### 8.3.8 Floating pins

The TCAN340x-Q1 devices have internal pull-up/pull-down resistors on critical pins which place the device into known states if the pin floats. This internal bias should not be relied upon by design though, especially in noisy environments, but instead should be considered a failsafe protection feature.

When a CAN controller supporting open-drain outputs is used an adequate external pull-up resistor must be chosen. This makes sure the TXD output of the CAN controller maintains acceptable bit time to the input of the CAN transceiver. See [表 8-3](#) for details on pin bias conditions.

**表 8-3. Pin Bias**

Pin	Pull-up or Pull-down	Comment
TXD	Pull-up	Weakly biases TXD towards recessive to prevent bus blockage or TXD DTO triggering
STB	Pull-up	Weakly biases STB towards low-power standby mode to prevent excessive system power

表 8-3. Pin Bias (続き)

Pin	Pull-up or Pull-down	Comment
SHDN	Pull-down	Weakly biases SHDN towards normal mode to allow normal communication. SHDN pin has higher priority than STB for TCAN3404.

## 8.4 Device Functional Modes

### 8.4.1 Operating Modes

The TCAN340x-Q1 has two main operating modes; normal mode and standby mode. Operating mode selection is made by applying a high or low level to the STB pin. TCAN3404-Q1 has a third mode: shutdown activated through SHDN pin. Pulling SHDN pin high disables most internal blocks and puts the device in lowest power consumption mode.

表 8-4. Operating Modes for STB pin

STB	Device Mode	Driver	Receiver	RXD Pin
High	Low current standby mode with bus wake-up	Disabled	Low-power receiver and bus monitor enable	High (recessive) until valid WUP is received See <a href="#">Remote Wake Request via Wake-Up Pattern (WUP) in Standby Mode</a>
Low	Normal Mode	Enabled	Enabled	Mirrors bus state

### 8.4.2 Normal Mode

This is the normal operating mode of the TCAN340x-Q1. The CAN driver and receiver are fully operational and CAN communication is bi-directional. The driver is translating a digital input on the TXD input to a differential output on the CANH and CANL bus pins. The receiver is translating the differential signal from CANH and CANL to a digital output on the RXD output.

### 8.4.3 Standby Mode

This is the low-power mode of the TCAN340x-Q1. The CAN driver and main receiver are switched off and bi-directional CAN communication is not possible. The low-power receiver and bus monitor circuits are enabled to allow for RXD wake-up requests via the CAN bus. A wake-up request is output to RXD as shown in [Figure 8-5](#). The local CAN protocol controller should monitor RXD for transitions (high-to-low) and reactivate the device to normal mode by pulling the STB pin low. The CAN bus pins are weakly pulled to GND in this mode; see [Figure 8-2](#) and [Figure 8-3](#).

For TCAN3403-Q1 in standby mode, only the  $V_{IO}$  supply is required; therefore, the  $V_{CC}$  may be switched off for additional system level current savings.

#### 8.4.3.1 Remote Wake Request via Wake-Up Pattern (WUP) in Standby Mode

The TCAN340x-Q1 devices support a remote wake-up request that is used to indicate to the host controller that the bus is active and the node should return to normal operation.

The device uses the multiple filtered dominant wake-up pattern (WUP) from the ISO 11898-2:2016 standard to qualify bus activity. Once a valid WUP has been received, the wake request is indicated to the controller by a falling edge and low period corresponding to a filtered dominant on the RXD output of the device.

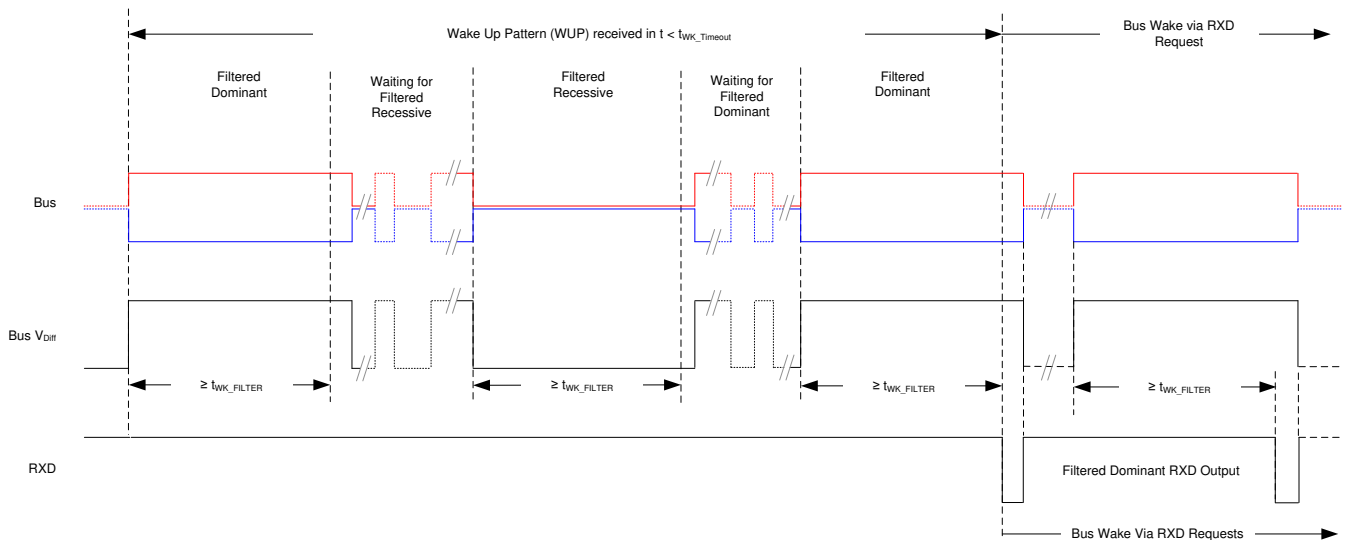
The WUP consists of a filtered dominant pulse, followed by a filtered recessive pulse, and finally by a second filtered dominant pulse. The first filtered dominant initiates the WUP, and the bus monitor then waits on a filtered recessive; other bus traffic does not reset the bus monitor. Once a filtered 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 drives the RXD output low every time an additional filtered dominant signal is received from the bus.

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 and 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-up request may be generated. Bus state times greater than  $t_{WK\_FILTER(MAX)}$  are always detected as part of a WUP; therefore, a wake request is always generated. See [Figure 8-5](#) for the timing diagram of the wake-up pattern.

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

The ISO 11898-2:2016 standard has defined times for a short and long wake-up filter time. The  $t_{WK\_FILTER}$  timing for the device has been picked to be within the minimum and maximum 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. Any CAN frame at 500kbps or less would contain a valid WUP.

For an additional layer of robustness and to prevent false wake-ups, the device implements a wake-up timeout feature. For a remote wake-up event to successfully occur, the entire WUP must be received within the timeout value  $t \leq t_{WK\_TIMEOUT}$ . If not, the internal logic is reset and the transceiver remains in the current state without waking up. The full pattern must then be transmitted again, conforming to the constraints mentioned in this section. See [Figure 8-5](#) for the timing diagram of the wake-up pattern with wake timeout feature.



**Figure 8-5. Wake-Up Pattern (WUP) with  $t_{WK\_TIMEOUT}$**

#### 8.4.4 Shutdown Mode

This is the lowest power state of TCAN3404-Q1. All internal blocks including CAN driver, main receiver and low power wake-up receiver are switched off and bi-directional CAN communication is not possible. Wakeup over CAN bus is also not possible in this mode. CAN bus pins are weakly biased towards GND and RXD is high in this state,

### 8.4.5 Driver and Receiver Function

The TCAN340x-Q1 logic I/Os support CMOS levels with respect to either  $V_{CC}$  for 3.3V systems (TCAN3404-Q1) or  $V_{IO}$  (TCAN3403-Q1) for compatibility with MCUs that support 1.8V, 2.5V, or 3.3V systems.

**表 8-5. Driver Function Table**

Device Mode	TXD Input <sup>(1)</sup>	Bus Outputs		Driven Bus State <sup>(2)</sup>
		CANH	CANL	
Normal	Low	High	Low	Dominant
	High or open	High impedance	High impedance	Biased recessive
Standby	X	High impedance	High impedance	Biased to ground
Shutdown	X	High impedance	High impedance	Biased to ground

(1) X = irrelevant

(2) For bus state and bias see [図 8-2](#) and [図 8-3](#)

**表 8-6. Receiver Function Table Normal and Standby Mode**

Device Mode	CAN Differential Inputs $V_{ID} = V_{CANH} - V_{CANL}$	Bus State	RXD Pin
Normal	$V_{ID} \geq 0.9V$	Dominant	Low
	$0.5V < V_{ID} < 0.9V$	Undefined	Undefined
	$V_{ID} \leq 0.5V$	Recessive	High
Standby	$V_{ID} \geq 1.15V$	Dominant	High Low if a remote wake event occurred See <a href="#">図 8-5</a>
	$0.4V < V_{ID} < 1.15V$	Undefined	
	$V_{ID} \leq 0.4V$	Recessive	
Any	Open ( $V_{ID} \approx 0V$ )	Open	High



## 9 Application Information Disclaimer

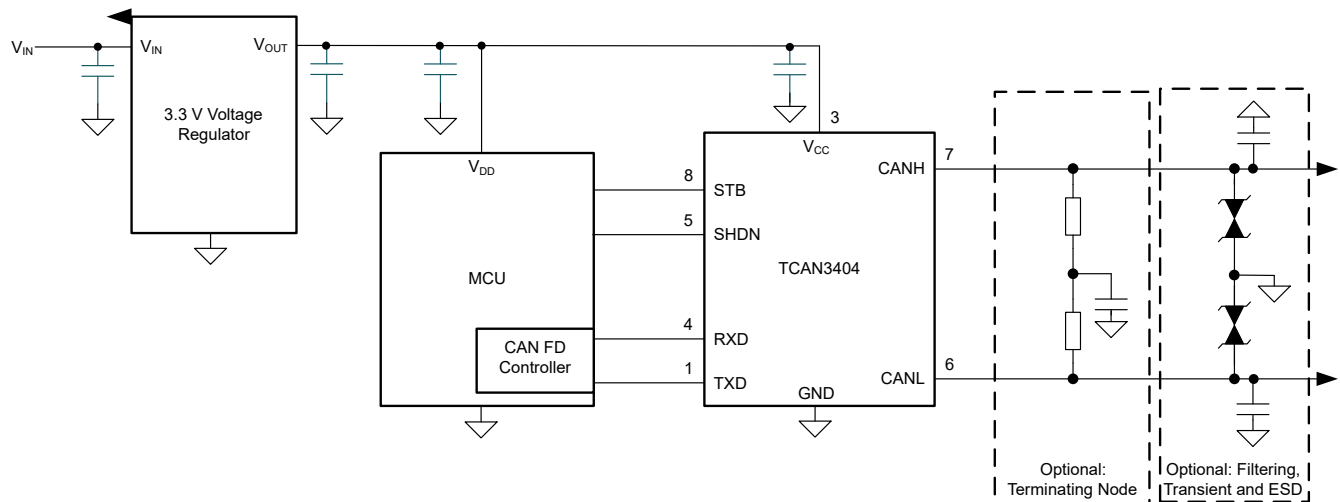
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Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes, as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

### 9.1 Application Information

#### 9.2 Typical Application

The TCAN340x-Q1 transceiver can be used in applications with a host controller or FPGA that includes the link layer portion of the CAN protocol. [Figure 9-1](#) shows a typical configuration for 3.3V controller applications. The bus termination is shown for illustrative purposes.



**Figure 9-1. Transceiver Application Using 3.3V I/O Connections**

#### 9.2.1 Design Requirements

##### 9.2.1.1 CAN Termination

Termination may be a single 120Ω resistor at each end 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 9-2](#). Split termination improves the electromagnetic emissions behavior of the network by filtering higher-frequency common-mode noise that may be present on the differential signal lines.

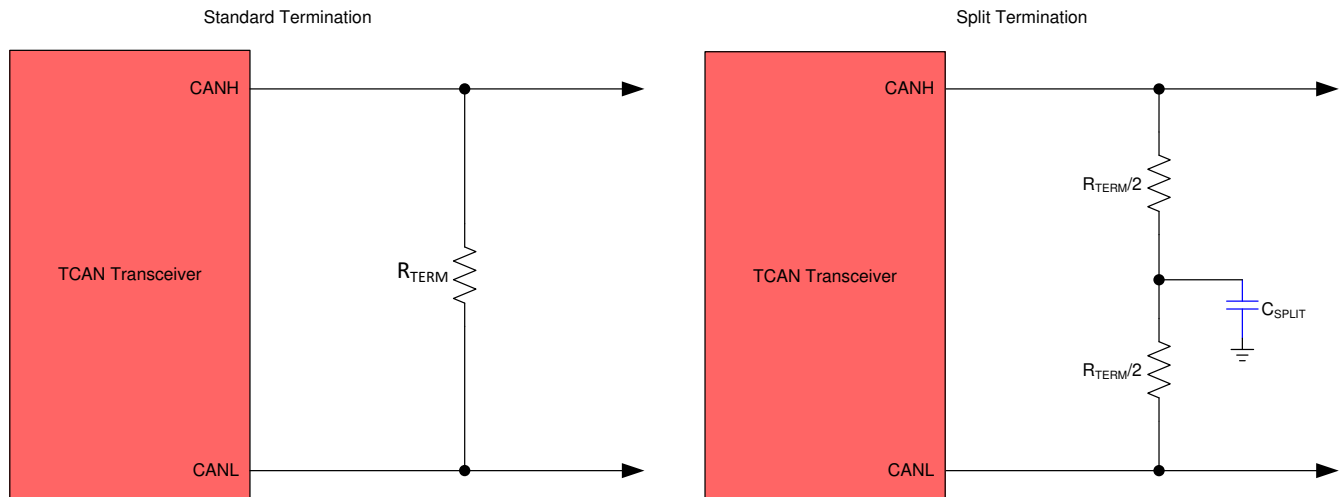


图 9-2. CAN Bus Termination Concepts

## 9.2.2 Detailed Design Procedures

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

A typical CAN application may 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 TCAN340x-Q1.

Many CAN organizations and standards have scaled the use of CAN for applications outside the original ISO 11898-2 standard. There are many 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 the ISO 11898-2:2016 specification, the driver differential output is specified with a bus load that can range from 50Ω to 65Ω where the differential output must be greater than 1.5V. The TCAN340x-Q1 family is specified to meet the 1.5V requirement down to 50Ω and is specified to meet 1.4V differential output at 45-Ω bus load. The differential input resistance of the TCAN340x-Q1 is a minimum of 22kΩ. If 55 TCAN340x-Q1 transceivers are in parallel on a bus, this is equivalent to a 400Ω differential load in parallel with the nominal 60-Ω bus termination which gives a total bus load of approximately 52Ω. Therefore, the TCAN340x-Q1 family theoretically supports over 50 transceivers on a single bus segment. However, for a 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 often lower. Bus length may 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 1 km 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 for robust network operation.

See the application report [SLLA270: Controller Area Network Physical layer requirements](#). This document discusses in detail all system design physical layer parameters.

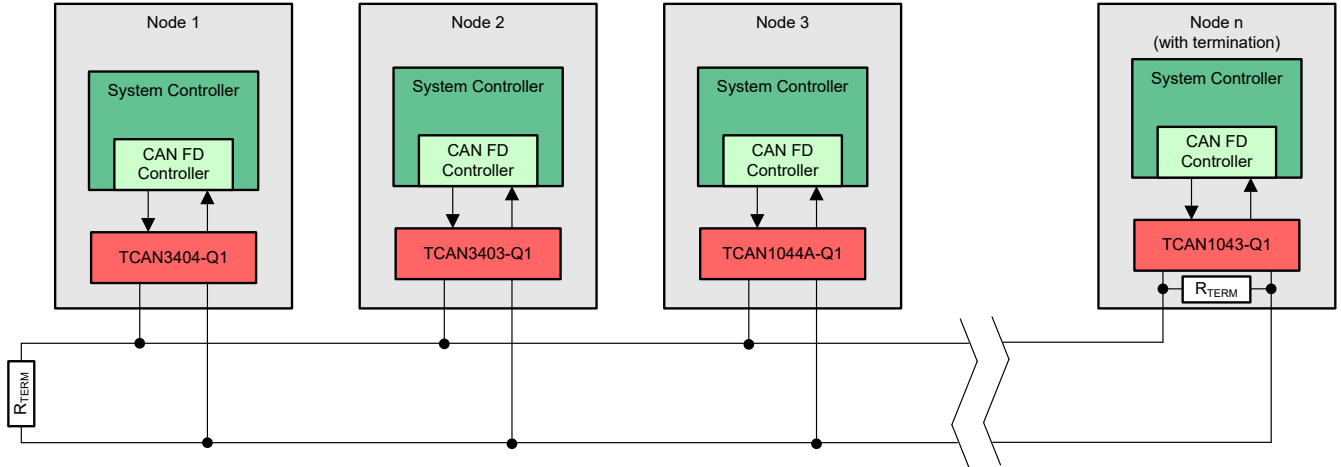


図 9-3. Typical CAN Bus

### 9.2.3 Application Curves

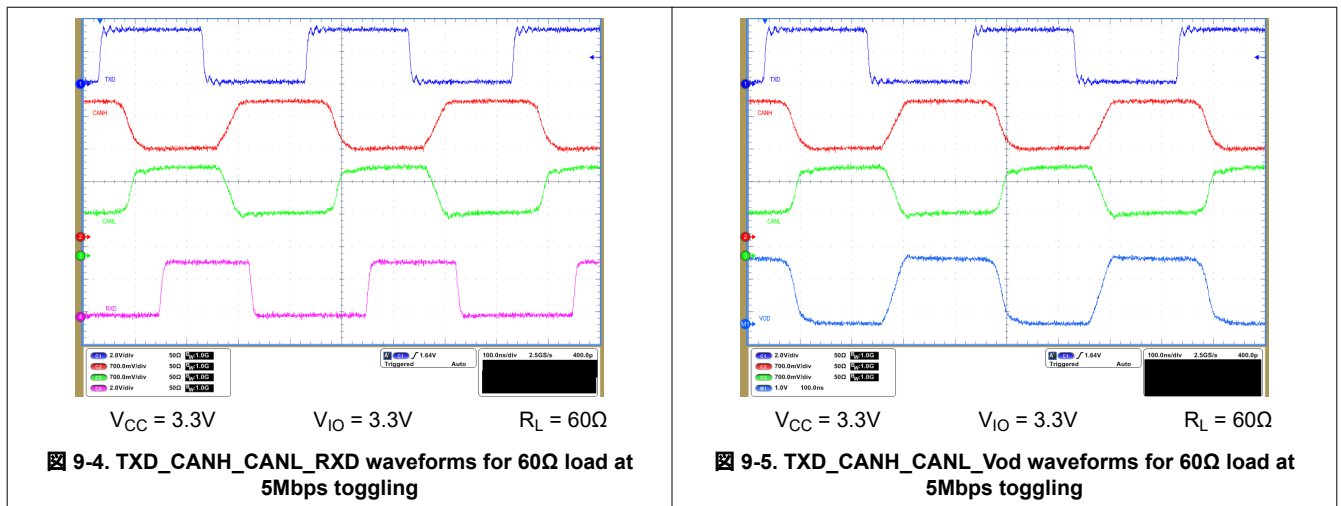


図 9-4. TXD\_CANH\_CANL\_RXD waveforms for 60Ω load at 5Mbps toggling

図 9-5. TXD\_CANH\_CANL\_Vod waveforms for 60Ω load at 5Mbps toggling

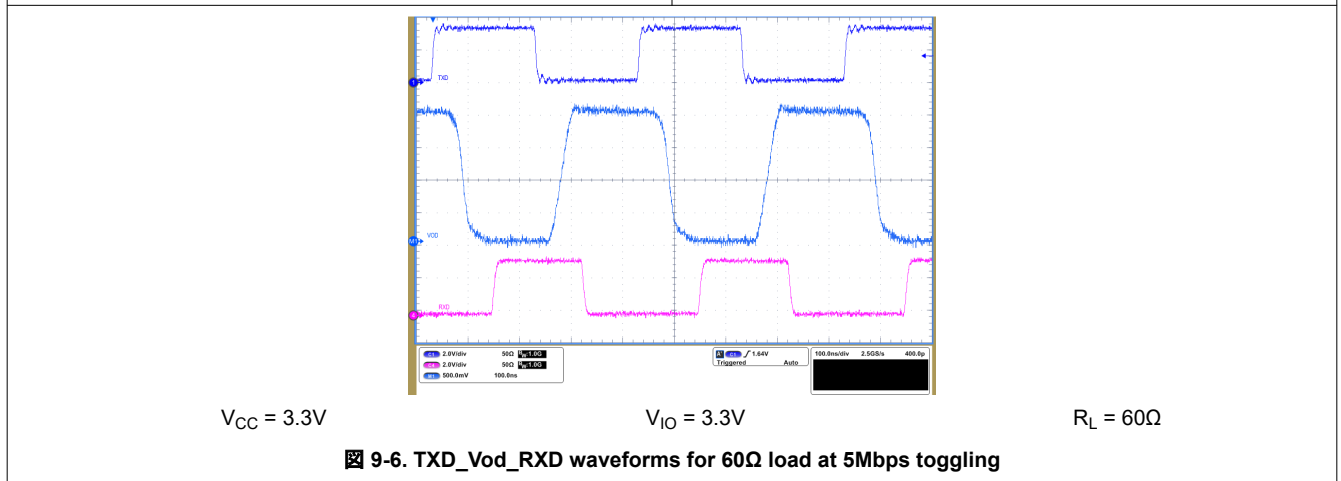
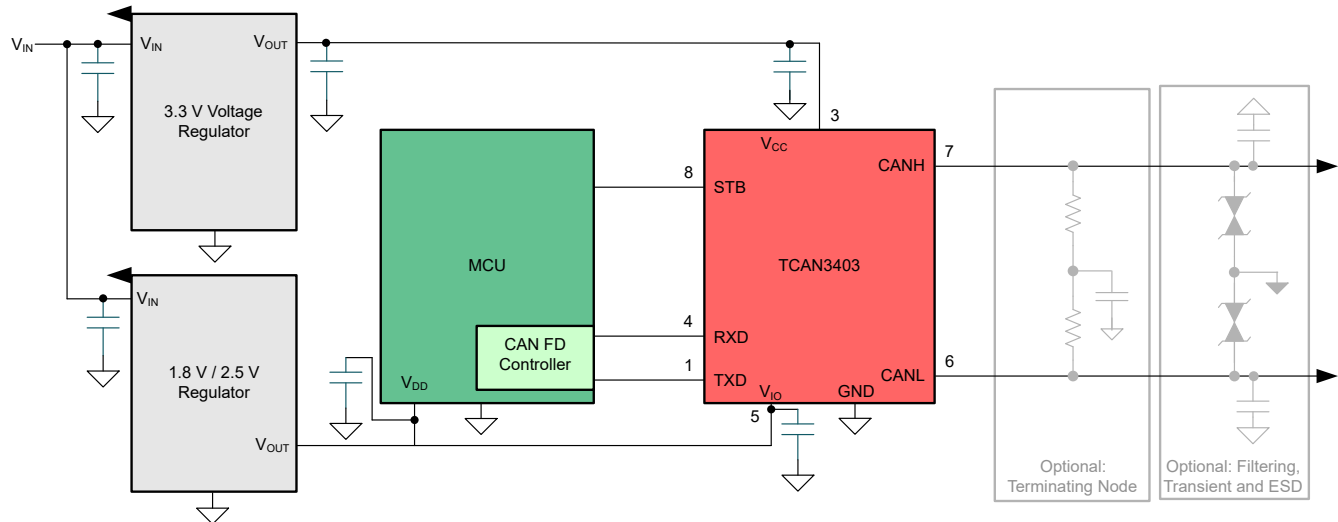


図 9-6. TXD\_Vod\_RXD waveforms for 60Ω load at 5Mbps toggling

## 9.3 System Examples

The TCAN340x-Q1 CAN transceiver is typically used in applications with a host controller or FPGA that includes the link layer portion of the CAN protocol. A 1.8V or 2.5V application is shown in [Figure 9-7](#). The bus termination is shown for illustrative purposes.



**Figure 9-7. Typical Transceiver Application Using 1.8V, 2.5V I/O Connections**

### 9.3.1 ISO 11898-2 Compatibility of TCAN340x-Q1 Family of 3.3V CAN Transceivers

#### 9.3.1.1 Introduction

Many users value the low power consumption of operating their CAN transceivers from a 3.3V supply. However, some are concerned about the interoperability with 5V supplied transceivers on the same bus. This section tries to address those concerns.

#### 9.3.1.2 Differential Signal

CAN is a differential bus where complementary signals are sent over two wires and the voltage difference between the two wires defines the logical state of the bus. The differential CAN receiver monitors this voltage difference and outputs the bus state with a single ended logic level output signal.

The CAN driver creates the differential voltage between CANH and CANL in the dominant state. The dominant differential output of the TCAN340x-Q1 is greater than 1.5V and less than 3V across a 60Ω load as defined by the ISO 11898-2 standard. These are the same limiting values for 5V supplied CAN transceivers. The bus termination resistors drive the recessive bus state and not the CAN driver.

A CAN receiver is required to output a recessive state when less than 500mV of differential voltage exists on the bus, and a dominant state when more than 900mV of differential voltage exists on the bus. The CAN receiver must do this with common-mode input voltages from -12V to 12V. The TCAN340x-Q1 device receivers meet and exceed these receiver input specifications.

#### 9.3.1.3 Common-Mode Signal

A common-mode signal is an average voltage of the two signal wires that the differential receiver rejects. The common-mode signal comes from the CAN driver, ground noise, and coupled bus noise. The TCAN340x-Q1 family has the recessive bias voltage set to 1.9V. This is intentional to match the common mode of recessive output with the common mode of dominant output signal from TCAN340x-Q1. Furthermore, TCAN340x-Q1 has special design techniques for optimum EMC performance in a heterogeneous bus consisting of TCAN340x-Q1 and 5V CAN transceivers.

#### 9.3.1.4 Interoperability of 3.3V CAN in 5V CAN Systems

The 3.3V supplied TCAN340x-Q1 family of CAN transceivers are fully compatible with 5V CAN transceivers. The minimum differential output voltage is the same, and the receivers have the same input threshold specifications. The only difference is in the recessive common mode output voltage which is little lower for 3.3V CAN transceiver than 5V supplied transceiver. But this does not impact regular functionality. Furthermore, special design techniques in TCAN340x-Q1 provide optimum EMC performance in heterogeneous network consisting of TCAN340x-Q1 and 5V supplied CAN transceivers on same CAN bus.

#### 9.4 Power Supply Recommendations

The TCAN3404-Q1 transceiver is designed to operate with a main  $V_{CC}$  input voltage supply range between 3V and 3.6V.

The TCAN3403-Q1 implements an I/O level shifting supply input,  $V_{IO}$ , designed for a range between 1.8V and 3.6V.

Both the  $V_{CC}$  and  $V_{IO}$  inputs must be well regulated. In addition to the power supply filtering, a decoupling capacitance, typically 100nF, should be placed near the CAN transceiver main  $V_{CC}$  and  $V_{IO}$  supply pins.

## 9.5 Layout

Robust and reliable CAN node designs may require special layout techniques depending on the application and design requirements. Since transient disturbances have high frequency content and a wide bandwidth, high-frequency layout techniques should be applied during PCB design.

### 9.5.1 Layout Guidelines

- Place the protection and filtering circuitry close to the bus connector, J1, to prevent transients, ESD, and noise from propagating onto the board. This layout example shows an optional transient voltage suppression (TVS) diode, D1, which may be implemented if the system-level requirements exceed the specified rating of the transceiver. This example also shows optional bus filter capacitors C4 and C5.
- 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.
- Decoupling capacitors should be placed as close as possible to the supply pins  $V_{CC}$  and  $V_{IO}$  of transceiver.
- Use at least two vias for supply and ground connections of bypass capacitors and protection devices to minimize trace and via inductance.

注

High-frequency current follows the path of least impedance and not the path of least resistance.

- This layout example shows how split termination could be implemented on the CAN node. The termination is split into two resistors, R2 and R3, with the center or split tap of the termination connected to ground via capacitor C3. Split termination provides common mode filtering for the bus. See [CAN Termination](#), [CAN Bus short-circuit limiting](#), and [式 2](#) for information on termination concepts and power ratings needed for the termination resistor(s).

### 9.5.2 Layout Example

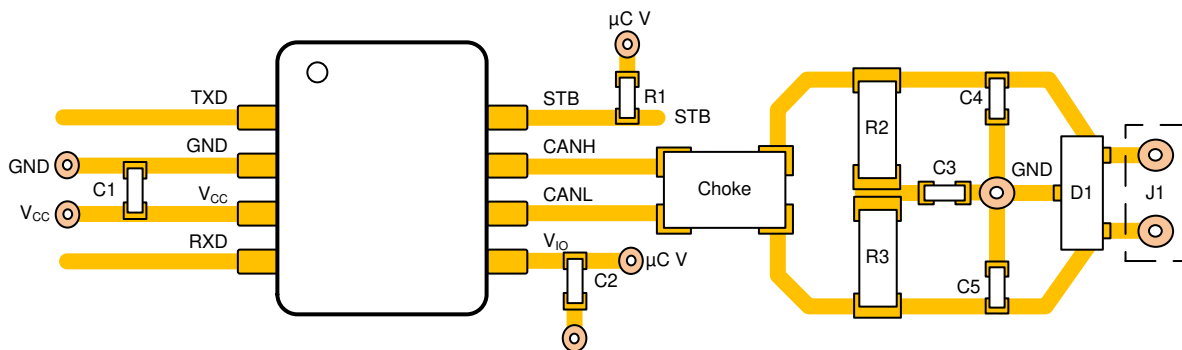


图 9-8. Layout Example

## 10 Device and Documentation Support

### 10.1 ドキュメントの更新通知を受け取る方法

ドキュメントの更新についての通知を受け取るには、[www.tij.co.jp](http://www.tij.co.jp) のデバイス製品フォルダを開いてください。[通知] をクリックして登録すると、変更されたすべての製品情報に関するダイジェストを毎週受け取ることができます。変更の詳細については、改訂されたドキュメントに含まれている改訂履歴をご覧ください。

### 10.2 サポート・リソース

[テキサス・インスツルメンツ E2E™ サポート・フォーラム](#)は、エンジニアが検証済みの回答と設計に関するヒントをエキスパートから迅速かつ直接得ることができる場所です。既存の回答を検索したり、独自の質問をしたりすることで、設計に必要な支援を迅速に得ることができます。

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### 10.3 Trademarks

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### 10.4 静電気放電に関する注意事項



この IC は、ESD によって破損する可能性があります。テキサス・インスツルメンツは、IC を取り扱う際には常に適切な注意を払うことを推奨します。正しい取り扱いおよび設置手順に従わない場合、デバイスを破損するおそれがあります。

ESD による破損は、わずかな性能低下からデバイスの完全な故障まで多岐にわたります。精密な IC の場合、パラメータがわずかに変化するだけで公表されている仕様から外れる可能性があるため、破損が発生しやすくなっています。

### 10.5 用語集

[テキサス・インスツルメンツ用語集](#) この用語集には、用語や略語の一覧および定義が記載されています。

## 11 Revision History

資料番号末尾の英字は改訂を表しています。その改訂履歴は英語版に準じています。

Changes from Revision * (December 2022) to Revision A (June 2024)	Page
• ドキュメントのステータスを「事前情報」から「量産データ」に変更.....	1

## 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.

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**PACKAGING INFORMATION**

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
TCAN3403DDFRQ1	ACTIVE	SOT-23-THIN	DDF	8	3000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 150	2THF	<a href="#">Samples</a>
TCAN3403DRBRQ1	ACTIVE	SON	DRB	8	3000	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 150	3403	<a href="#">Samples</a>
TCAN3403DRQ1	ACTIVE	SOIC	D	8	2500	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 150	3403	<a href="#">Samples</a>
TCAN3404DDFRQ1	ACTIVE	SOT-23-THIN	DDF	8	3000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 150	2TIF	<a href="#">Samples</a>
TCAN3404DRBRQ1	ACTIVE	SON	DRB	8	3000	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 150	3404	<a href="#">Samples</a>
TCAN3404DRQ1	ACTIVE	SOIC	D	8	2500	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 150	3404	<a href="#">Samples</a>

(1) The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBSOLETE:** TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

**RoHS Exempt:** TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

**Green:** TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead finish/Ball material - Orderable Devices 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.

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