TCAN1044V Fault-Protected CAN FD Transceiver with Standby Mode and 1.8-V IO Support

1 Features

- Meets the requirements of ISO 11898-2:2016 and ISO 11898-5:2007 physical layer standards
- Support of classical CAN and optimized CAN FD performance at 2, 5, and 8 Mbps
  - Short and symmetrical propagation delays and fast loop times for enhanced timing margin
  - Higher data rates in loaded CAN networks
- IO voltage range supports 1.7 V to 5.5 V
  - Support for 1.8-V, 2.5-V, 3.3-V, and 5-V applications
- Total loop delay ≤ 210 ns
- Small footprint SOT-23 package (2.9 mm x 1.60 mm)
- Receiver common mode input voltage: ±12 V
- Protection features:
  - Bus fault protection: ±58 V
  - Under-voltage protection
  - Current limiting on bus pins
  - TXD-dominant time-out (DTO)
    - Data rates down to 9.2 kbps
  - Thermal-shutdown protection (TSD)
- Operating modes:
  - Normal mode
  - Low power standby mode supporting remote wake-up request
- Optimized behavior when unpowered
  - Bus and logic pins are high impedance (no load to operating bus or application)
  - Hot-plug capable: power up/down glitch free operation on bus and RXD output
- Junction temperatures from: –40°C to 150°C

2 Applications

- Grid infrastructure
- Industrial transport (non-car & non-light truck)
- Factory automation & control
- Appliances

3 Description

The TCAN1044V is a high speed controller area network (CAN) transceiver that meets the physical layer requirements of the ISO 11898-2:2016 high-speed CAN specification.

The TCAN1044V transceiver supports both classical CAN and CAN FD networks up to 8 megabits per second (Mbps). The TCAN1044V includes internal logic level translation via the V_{IO} terminal to allow for interfacing the transceiver IOs directly to 1.8-V, 2.5-V, 3.3-V, or 5-V logic IOs. The transceiver has a low-power standby mode which supports remote wake-up via the ISO 11898-2:2016 defined wake-up pattern (WUP). The TCAN1044V transceiver also include many protection and diagnostic features including thermal-shutdown (TSD), TXD-dominant time-out (DTO), supply under-voltage detection, and bus fault protection up to ±58 V.

Device Information(1)

PART NUMBER	PACKAGE	BODY SIZE (NOM)
TCAN1044V	SOT (8)	2.90 mm x 1.60 mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.

Simplified Schematic

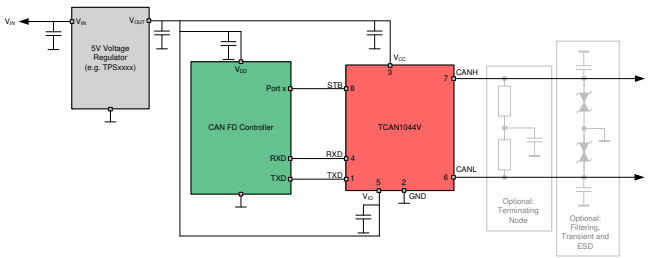


Table of Contents

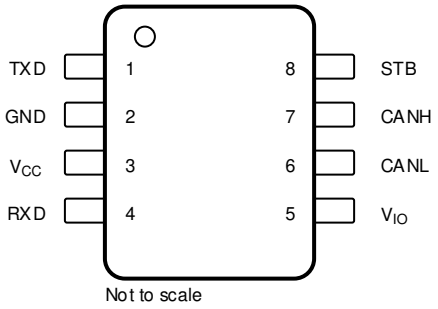
4 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

DATE	REVISION	NOTES
December 2019	*	Advanced Information

5 Pin Configuration and Functions

DDF Package
8-Pin SOT
Top View



Not to scale

Pin Functions

Pins		Type	Description
Name	No.		
TXD	1	Digital Input	CAN transmit data input, integrated pull-up
GND	2	GND	Ground connection
V_{CC}	3	Supply	5-V supply voltage
RXD	4	Digital Output	CAN receive data output, tri-state when powered off
V_{IO}	5	Supply	IO supply voltage
CANL	6	Bus IO	Low-level CAN bus input/output line
CANH	7	Bus IO	High-level CAN bus input/output line
STB	8	Digital Input	Standby input for mode control, integrated pull-up

6 Specifications

6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)(1)(2)

		MIN	MAX	UNIT
V_{CC}	Supply voltage	–0.3	6	V
V_{IO}	Supply voltage IO level shifter	–0.3	6	V
V_{BUS}	CAN Bus IO voltage CANH and CANL	–58	58	V
V_{DIFF}	Max differential voltage between CANH and CANL	–45	45	V
V_{Logic_Input}	Logic input terminal voltage	–0.3	6	V
V_{RXD}	RXD output terminal voltage range	–0.3	6	V
$I_{O(RXD)}$	RXD output current	–8	8	mA
T_J	Operating virtual junction temperature range	–40	150	°C
T_{STG}	Storage temperature	–65	150	°C

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
(2) All voltage values, except differential IO bus voltages, are with respect to ground terminal.

6.2 ESD Ratings

				VALUE	UNIT
V_{ESD}	Electrostatic discharge	Human-body model (HBM), per AEC Q100-002(1)	HBM classification level 3A for all pins	±3000	V
			HBM classifiifation level 3B for global pins CANH & CANL	±10000	V
		Charged-device model (CDM), per AEC Q100-011 CDM classification level C5 for all pins		±750	V

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

6.3 ESD Ratings

				VALUE	UNIT
V_{ESD}	System Level Electro-Static Discharge (ESD)(1)	CAN bus terminals (CANH, CANL) to GND	SAE J2962-2 per ISO 10650 Powered Contact Discharge	±8000	V
			SAE J2962-2 per ISO 10650 Powered Air Discharge	±15000	V
V_{Tran}	ISO 7637 ISO Pulse Transients(2)	CAN bus terminals (CANH, CANL)	Pulse 1	–100	V
			Pulse 2a	75	V
			Pulse 3a	–150	V
			Pulse 3b	100	V
	ISO 7637 Slow transients pulse(3)	CAN bus terminals (CANH, CANL) to GND	DCC slow transient pulse	±85	V

(1) Results given here are specific to the SAE J2962-2 Communication Transceivers Qualification Requirements - CAN. Testing performed by OEM approved independent 3rd party, EMC report available upon request.
(2) Tested according to IEC 62228-3:2019 CAN Transcievers, Section 6.3; standard pulses parameters defined in ISO 7637-2 (2011)
(3) Tested according to ISO 7637-3 (2017); Electrical transient transmission by capacitive and inductive coupling via lines other than supply lines

6.4 Recommended Operating Conditions

		MIN	NOM	MAX	UNIT
V_{CC}	Supply voltage	4.5	5	5.5	V
V_{IO}	Supply voltage for IO level shifter	1.7		5.5	V
$I_{OH(RXD)}$	RXD terminal high level output current	–2			mA
$I_{OL(RXD)}$	RXD terminal low level output current			2	mA
T_A	Operating ambient temperature	–40		125	℃

6.5 Thermal Characteristics

THERMAL METRIC		TCAN1044V	UNIT
		DDF (SOT)	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	128.1	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	68.3	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	71.6	°C/W
Ψ_{JT}	Junction-to-top characterization parameter	19.7	°C/W
Ψ_{JB}	Junction-to-board characterization parameter	70.8	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	–	°C/W

6.6 Supply Characteristics

Over recommended operating conditions with T_A = -40°C to 125°C (unless otherwise noted)

PARAMETER			TEST CONDITIONS	MIN	TYP	MAX	UNIT
I_{CC}	Supply current normal mode	Dominant	See Figure 5,TXD = 0 V, STB = 0 V, R_L = 60 Ω, C_L = open		45	70	mA
			See Figure 5, TXD = 0 V, STB = 0 V, R_L = 50 Ω, C_L = open		49	80	mA
		Recessive	See Figure 5, TXD = V_{CC}, STB = 0 V, R_L = 50 Ω, C_L = open, RCM = open		4.5	7.5	mA
		Dominant with bus fault	See Figure 5, TXD = 0 V, STB = 0 V, CANH = CANL = ±25 V, R_L = open, C_L = open			130	mA
I_{CC}	Supply current standby mode		TXD = STB = V_{IO} R_L = 50 Ω, C_L = open See Figure 5		0.2	1	µA
I_{IO}	IO supply current normal mode	Dominant	TXD = 0 V, STB= 0 V RXD floating		125	300	µA
I_{IO}	IO supply current normal mode	Recessive	TXD = 0 V, STB = 0 V RXD floating		25	48	µA
I_{IO}	IO supply current standby mode		TXD = 0 V, STB = V_{IO} RXD floating		8.5	13.5	µA
UV_{VCC}	Rising under voltage detection on V_{CC} for protected mode				4.2	4.4	V
UV_{VCC}	Falling under voltage detection on V_{CC} for protected mode			3.5	4	4.25	V
UV_{VIO}	Rising under voltage detection on V_{IO}				1.56	1.65	V
UV_{VIO}	Falling under voltage detection on V_{IO}			1.4	1.51	1.59	V

6.7 Dissipation Ratings

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
P_D	Average power dissipation Normal mode	V_{CC} = 5 V, V_{IO} = 1.8 V, T_J= 27°C, R_L = 60Ω, TXD input = 250 kHz 50% duty cycle squarewave, C_{L_RXD} = 15 pF		110		mW
		V_{CC} = 5 V, V_{IO} = 3.3 V, T_J= 27°C, R_L = 60Ω, TXD input = 250 kHz 50% duty cycle squarewave, C_{L_RXD} = 15 pF		110		mW
		V_{CC} = 5 V, V_{IO} = 5 V, T_J= 27°C, R_L = 60Ω, TXD input = 250 kHz 50% duty cycle squarewave, C_{L_RXD} = 15 pF		110		mW
		V_{CC} = 5.5 V, V_{IO} = 1.8 V, T_A= 125°C, R_L = 60Ω, TXD input = 2.5 MHz 50% duty cycle squarewave, C_{L_RXD} = 15 pF		120		mW
		V_{CC} = 5.5 V, V_{IO} = 3.3 V, T_A= 125°C, R_L = 60Ω, TXD input = 2.5 MHz 50% duty cycle squarewave, C_{L_RXD} = 15 pF		120		mW
T_{TSD}	Thermal shutdown temperature			192		°C
T_{TSD_HYS}	Thermal shutdown hysteresis			10		

6.8 Electrical Characteristics

Over recomended operating conditions with T_A = -40℃ to 125℃ (unless otherwise noted)

PARAMETER			TEST CONDITIONS	MIN	TYP	MAX	UNIT
Driver Electrical Characteristics							
$V_{O(DOM)}$	Dominant output voltage normal mode	CANH	See Figure 6 and Figure 13, TXD = 0 V, STB = 0 V, 50 Ω ≤ R_L ≤ 65 Ω, C_L = open, R_{CM} = open	2.75		4.5	V
		CANL		0.5		2.25	V
$V_{O(REC)}$	Recessive output voltage normal mode	CANH and CANL	See Figure 6 and Figure 13, TXD = V_{IO}, STB = 0 V, R_L = open (no load), R_{CM} = open	2	0.5 V_{CC}	3	V
V_{SYM}	Driver symmetry ($V_{O(CANH)}$ + $V_{O(CANL)}$)/V_{CC}		See Figure 6 and Figure 17, STB = 0 V, R_L = 60 Ω, C_{SPLIT} = 4.7 nF, C_L = open, R_{CM} = open, TXD = 250 kHz, 1 MHz, 2.5 MHz	0.9		1.1	V/V
V_{SYM_DC}	DC output symmetry (V_{CC} - $V_{O(CANH)}$ - $V_{O(CANL)}$)		See Figure 6 and Figure 13, STB = 0 V, R_L = 60 Ω, C_L = open	–400		400	mV
$V_{OD(DOM)}$	Differential output voltage normal mode Dominant	CANH - CANL	See Figure 6 and Figure 13, TXD = 0 V, STB = 0 V, 50 Ω ≤ R_L ≤ 65 Ω, C_L = open	1.5		3	V
			See Figure 6 and Figure 13, TXD = 0 V, STB = 0 V, 45 Ω ≤ R_L ≤ 70 Ω, C_L = open	1.4		3.3	V
			See Figure 6 and Figure 13, TXD = 0 V, STB = 0 V, R_L = 2240 Ω, C_L = open	1.5		5	V
$V_{OD(REC)}$	Differential output voltage normal mode Recessive	CANH - CANL	See Figure 6 and Figure 13, TXD = V_{IO}, STB = 0 V, R_L = 60 Ω, C_L = open	–120		12	mV
			See Figure 6 and Figure 13, TXD = V_{IO}, STB = 0 V, R_L = open, C_L = open	–50		50	mV
$V_{O(STB)}$	Bus output voltage standby mode	CANH	See Figure 6 and Figure 13, STB = V_{IO}, R_L = open (no load), R_{CM} = open	-0.1		0.1	V
		CANL		-0.1		0.1	V
		CANH - CANL		-0.2		0.2	V
$I_{OS(SS\_DOM)}$	Short-circuit steady-state output current, dominant, normal mode		See Figure 11 and Figure 13, STB = 0 V, $V_{(CANH)}$ = -15 V to 40 V, CANL = open, TXD = 0 V	–115			mA
			See Figure 11 and Figure 13, STB = 0 V, $V_{(CAN\_L)}$ = -15 V to 40 V, CANH = open, TXD = 0 V			115	mA
$I_{OS(SS\_REC)}$	Short-circuit steady-state output current, recessive, normal mode		See Figure 11 and Figure 13, STB = 0 V, –27 V ≤ V_{BUS} ≤ 32 V, Where V_{BUS} = CANH = CANL, TXD = V_{IO}	–6		6	mA
Receiver Electrical Characteristics							
V_{IT}	Input threshold voltage normal mode		See Figure 7, Table 1, and Table 6 STB = 0 V, -12 V ≤ V_{CM} ≤ 12 V	500		900	mV
$V_{IT(STB)}$	Input threshold standby mode		See Figure 7, Table 1, and Table 6 STB = V_{IO}, -12 V ≤ V_{CM} ≤ 12 V	400		1150	mV
V_{DOM}	Normal mode dominant state differential input voltage range		See Figure 7, Table 1, and Table 6 STB = 0 V, -12 V ≤ V_{CM} ≤ 12 V	0.9		9	V
V_{REC}	Normal mode recessive state differential input voltage range		See Figure 7, Table 1, and Table 6 STB = 0 V, -12 V ≤ V_{CM} ≤ 12 V	-4		0.5	V
$V_{DOM(STB)}$	Standby mode dominant state differential input voltage range		See Figure 7, Table 1, and Table 6 STB = V_{IO}, -12 V ≤ V_{CM} ≤ 12 V	1.15		9	V
$V_{REC(STB)}$	Standby mode recessive state differential input voltage range		See Figure 7, Table 1, and Table 6 STB = V_{IO}, -12 V ≤ V_{CM} ≤ 12 V	-4		0.4	V
V_{HYS}	Hysteresis voltage for input threshold normal mode		See Figure 7, Table 1, and Table 6 STB = 0 V, -12 V ≤ V_{CM} ≤ 12 V		100		mV
V_{CM}	Common mode range normal and standby modes		See Figure 7 and Table 6	–12		12	V
$I_{LKG(IOFF)}$	Unpowered bus input leakage current		CANH = CANL = 5 V, V_{CC} = V_{IO} = GND			5	µA
C_I	Input capacitance to ground (CANH or CANL)		TXD = V_{IO}			20	pF
C_{ID}	Differential input capacitance					10	pF
R_{ID}	Differential input resistance		TXD = V_{IO} STB = 0 V, -12 V ≤ V_{CM} ≤ 12 V	40		90	kΩ
R_{IN}	Single ended input resistance (CANH or CANL)			20		45	kΩ
$R_{IN(M)}$	Input resistance matching [1 – ($R_{IN(CANH)}$ / $R_{IN(CANL)}$)] × 100 %		$V_{(CAN\_H)}$ = $V_{(CAN\_L)}$ = 5 V	–1		1	%

Electrical Characteristics (continued)

Over recomended operating conditions with T_A = -40℃ to 125℃ (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
TXD Terminal (CAN Transmit Data Input)						
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 V	–2.5	0	1	µA
I_{IL}	Low-level input leakage current	TXD = 0 V, V_{CC}= V_{IO} = 5.5 V	–200	-100	–20	µA
$I_{LKG(OFF)}$	Unpowered leakage current	TXD = 5.5 V, V_{CC}= V_{IO} = 0 V	–1	0	1	µA
C_I	Input Capacitance	V_{IN} = 0.4×sin(2×π×2×10^6×t)+2.5 V		5		pF
RXD Terminal (CAN Receive Data Output)						
V_{OH}	High-level input voltage	See Figure 7, I_O = –2 mA	0.8 V_{IO}			V
V_{OL}	Low-level input voltage	See Figure 7, I_O = 2 mA			0.2 V_{IO}	V
$I_{LKG(OFF)}$	Unpowered leakage current	RXD = 5.5 V, V_{CC}= V_{IO} = 0 V	–1	0	1	µA
STB Terminal (Standby Mode Input)						
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 STB	V_{CC} = V_{IO} = STB = 5.5 V	–2		2	µA
I_{IL}	Low-level input leakage current STB	V_{CC} = V_{IO} = 5.5 V, STB = 0 V	–20		–2	µA
$I_{LKG(OFF)}$	Unpowered leakage current	STB = 5.5V, V_{CC}= V_{IO} = 0 V	–1	0	1	µA

6.9 Switching Characteristics

Over recomended operating conditions with T_A = -40℃ to 125℃ (unless otherwise noted)

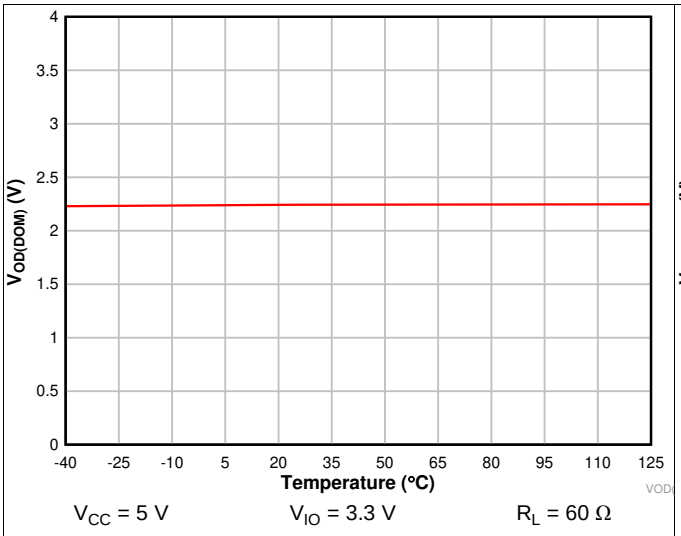
PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
Device Switching Characteristics						
$t_{PROP(LOOP1)}$	Total loop delay, driver input (TXD) to receiver output (RXD), recessive to dominant	See Figure 8, normal mode, V_{IO} = 2.8 V to 5.5 V, R_L = 60 Ω, C_L = 100 pF, $C_{L(RXD)}$ = 15 pF		125	210	ns
		See Figure 8, normal mode, V_{IO} = 1.7 V, R_L = 60 Ω, C_L = 100 pF, $C_{L(RXD)}$ = 15 pF		165	255	ns
$t_{PROP(LOOP2)}$	Total loop delay, driver input (TXD) to receiver output (RXD), dominant to recessive	See Figure 8, normal mode, V_{IO} = 2.8 V to 5.5 V, R_L = 60 Ω, C_L = 100 pF, $C_{L(RXD)}$ = 15 pF		150	210	ns
		See Figure 8, normal mode, V_{IO} = 1.7 V, R_L = 60 Ω, C_L = 100 pF, $C_{L(RXD)}$ = 15 pF		180	255	ns
t_{MODE}	Mode change time, from normal to standby or from standby to normal	See Figure 9			20	µs
t_{WK_FILTER}	Filter time for a valid wake-up pattern	See Figure 15	0.5		1.8	µs
$t_{WK\_TIMEOUT}$	Bus wake-up timeout value	See Figure 15	0.8		6	ms
Driver Switching Characteristics						
t_{pHR}	Propagation delay time, high TXD to driver recessive (dominant to recessive)	See Figure 6, STB = 0 V, R_L = 60 Ω, C_L = 100 pF, R_{CM} = open		80		ns
t_{pLD}	Propagation delay time, low TXD to driver dominant (recessive to dominant)			70		ns
$t_{sk(p)}$	Pulse skew (|tpHR - tpLD|)			20		ns
t_R	Differential output signal rise time			30		ns
t_F	Differential output signal fall time			50		ns
t_{TXD_DTO}	Dominant timeout	See Figure 10, R_L = 60 Ω, C_L = 100 pF, STB = 0 V	1.2		4.0	ms
Receiver Switching Characteristics						
t_{pRH}	Propagation delay time, bus recessive input to high output (dominant to recessive)	See Figure 7 STB = 0 V, $C_{L(RXD)}$ = 15 pF		90		ns
t_{pDL}	Propagation delay time, bus dominant input to low output (recessive to dominant)			65		ns
t_R	RXD output signal rise time			10		ns
t_F	RXD output signal fall time			10		ns

Switching Characteristics (continued)

Over recomended operating conditions with T_A = -40℃ to 125℃ (unless otherwise noted)

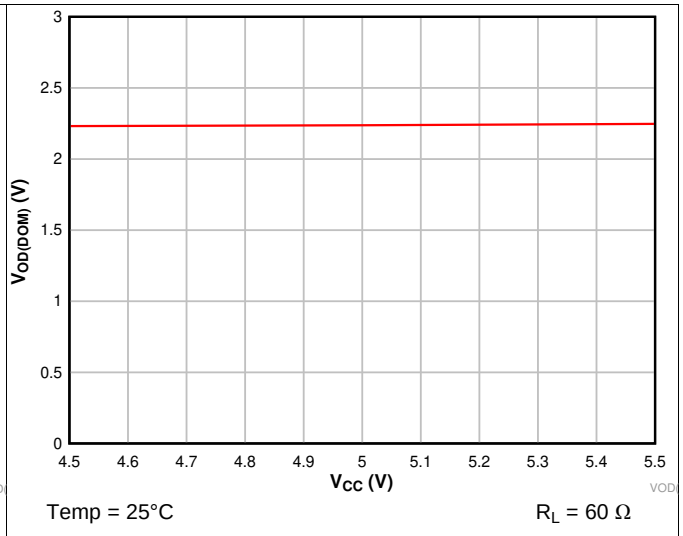
PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
FD Timing Characteristics						
$t_{BIT(BUS)}$	Bit time on CAN bus output pins with $t_{BIT(TXD)}$ = 500 ns	See Figure 8, STB = 0 V, R_L = 60 Ω, C_L = 100 pF, $C_{L(RXD)}$ = 15 pF STB = 0 V	450		530	ns
$t_{BIT(BUS)}$	Bit time on CAN bus output pins with $t_{BIT(TXD)}$ = 200 ns		155		210	ns
$t_{BIT(RXD)}$	Bit time on RXD output pins with $t_{BIT(TXD)}$ = 500 ns		400		550	ns
$t_{BIT(RXD)}$	Bit time on RXD output pins with $t_{BIT(TXD)}$ = 200 ns		120		220	ns
t_{REC}	Receiver timing symmetry with $t_{BIT(TXD)}$ = 500 ns	R_L = 60 Ω, C_L = 100 pF, $C_{L(RXD)}$ = 15 pF $\Delta t_{REC} = t_{BIT(RXD)} - t_{BIT(BUS)}$	-50		20	ns
t_{REC}	Receiver timing symmetry with $t_{BIT(TXD)}$ = 200 ns		-45		15	ns

6.10 Typical Characteristics



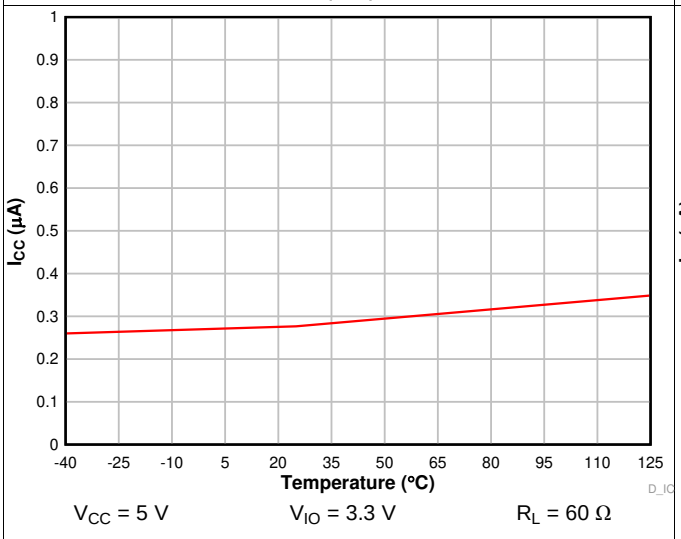
V_{CC} = 5 V V_{IO} = 3.3 V R_L = 60 Ω

Figure 1. $V_{OD(DOM)}$ vs Temperature



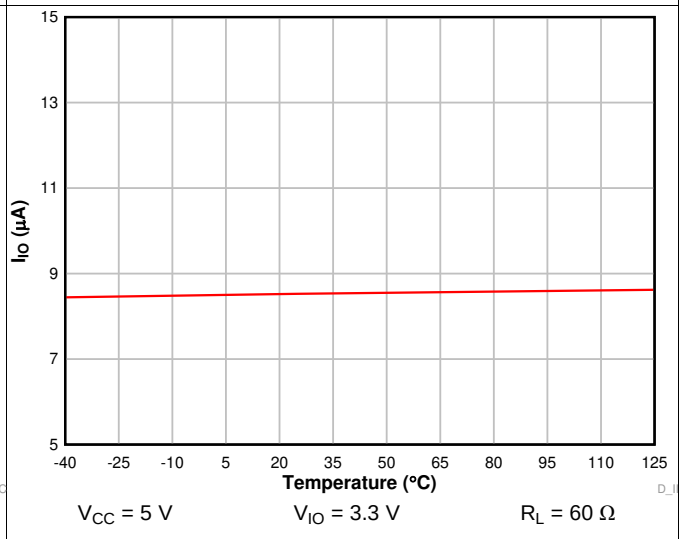
Temp = 25°C R_L = 60 Ω

Figure 2. $V_{OD(DOM)}$ vs V_{CC}



V_{CC} = 5 V V_{IO} = 3.3 V R_L = 60 Ω

Figure 3. I_{CC} Standby vs Temperature



V_{CC} = 5 V V_{IO} = 3.3 V R_L = 60 Ω

Figure 4. I_{IO} Standby vs Temperature

7 Parameter Measurement Information

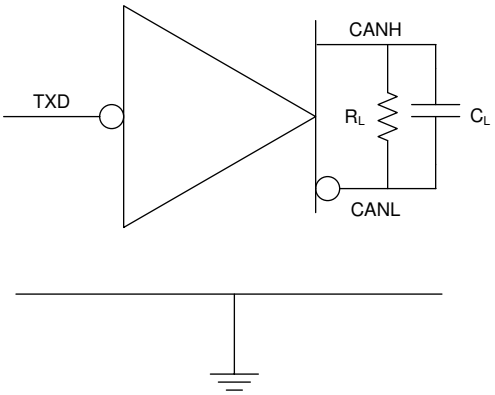


Figure 5. I_{CC} Test Circuit

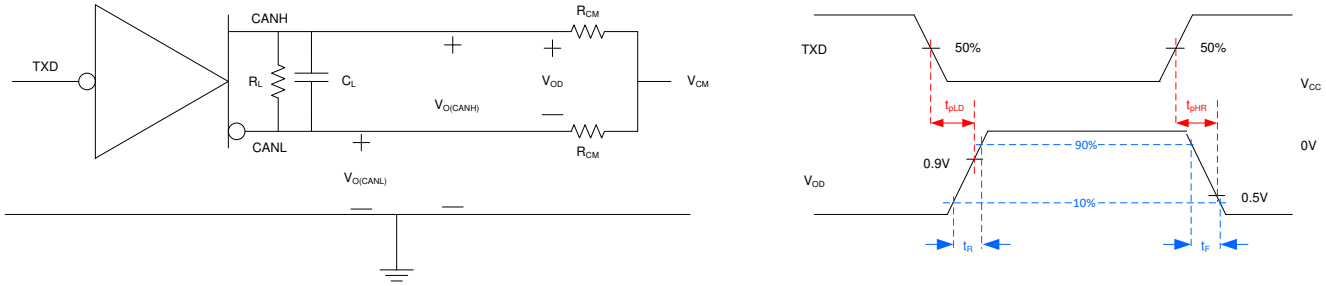


Figure 6. Driver Test Circuit and Measurement

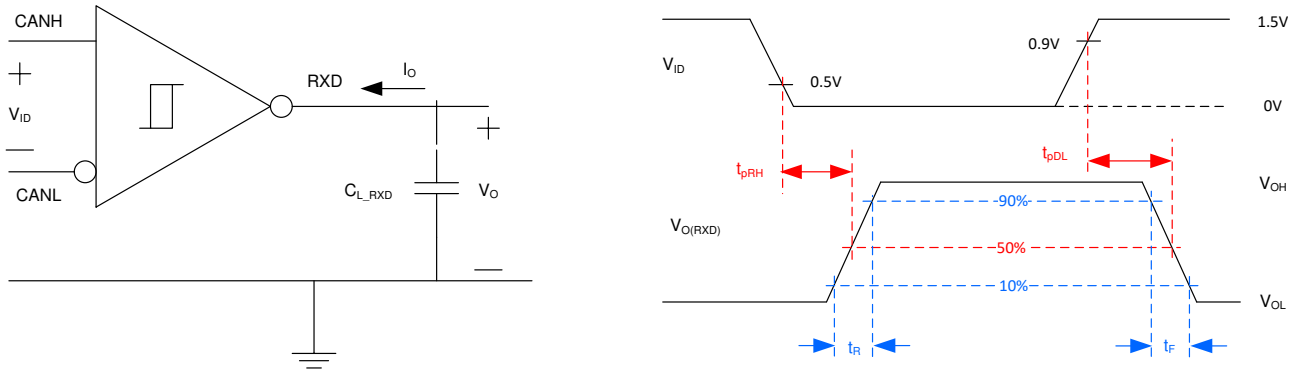


Figure 7. Receiver Test Circuit and Measurement

Parameter Measurement Information (continued)

Table 1. Receiver Differential Input Voltage Threshold Test (See Figure 7)

Input			Output	
V_{CANH}	V_{CANL}	$\lvert V_{ID}\rvert$	RXD	
-11.5 V	-12.5 V	1000 mV	L	V_{OL}
12.5 V	11.5 V	1000 mV		
-8.55 V	-9.45 V	900 mV		
9.45 V	8.55 V	900 mV		
-8.25 V	-9.25 V	500 mV	H	V_{OH}
9.25 V	8.25 V	500 mV		
-11.8 V	-12.2 V	400 mV		
12.2 V	11.8 V	400 mV		
Open	Open	X		

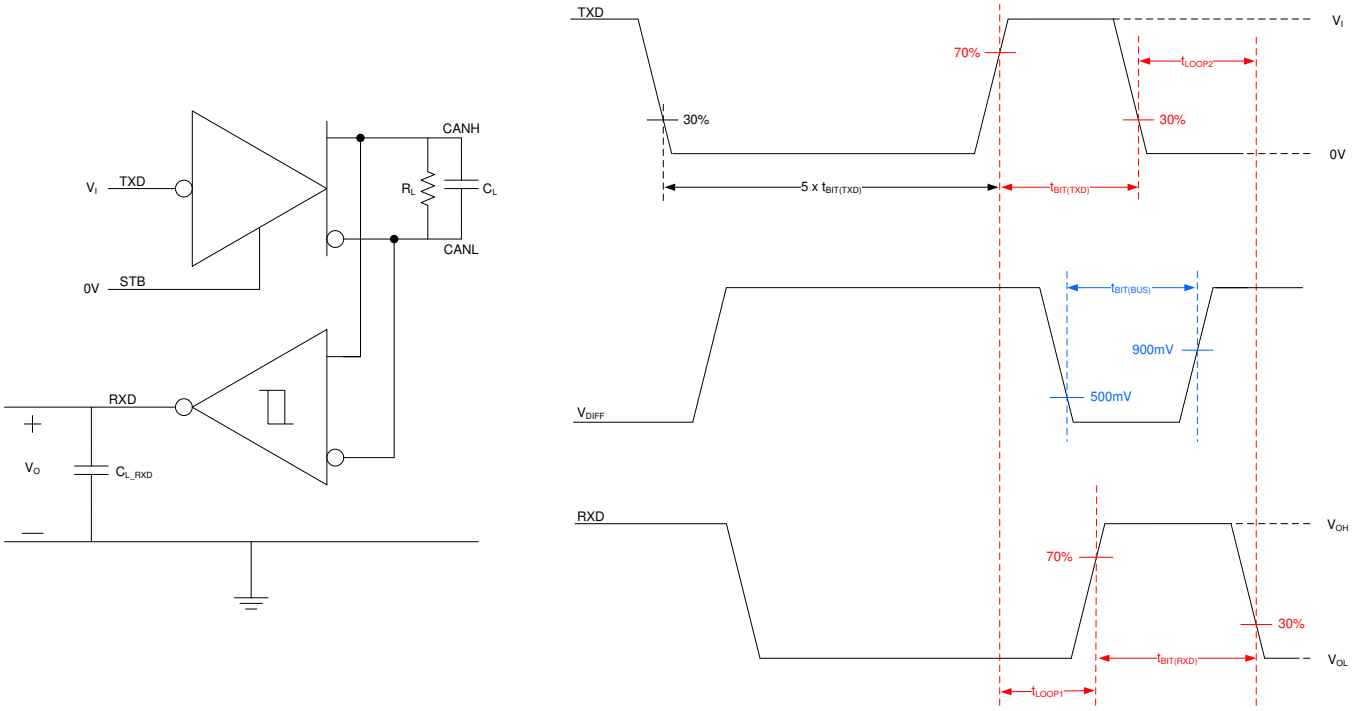


Figure 8. Transmitter and Receiver Timing Test Circuit and Measurement

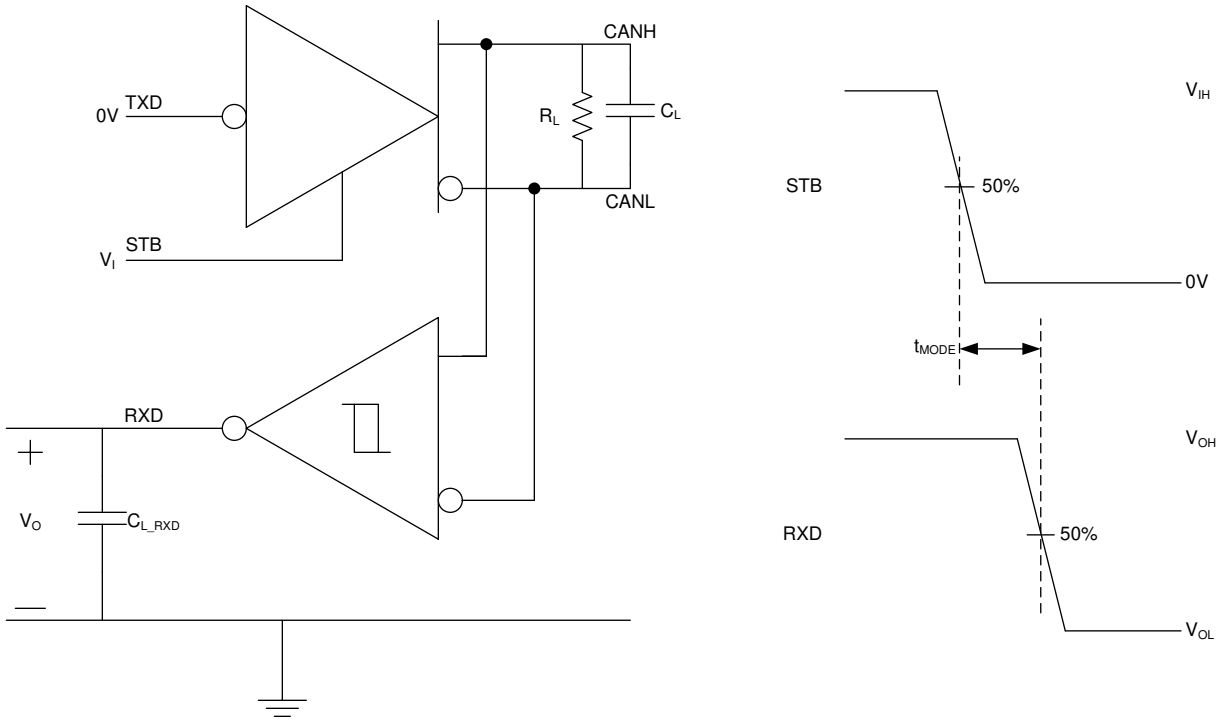


Figure 9. t_{MODE} Test Circuit and Measurement

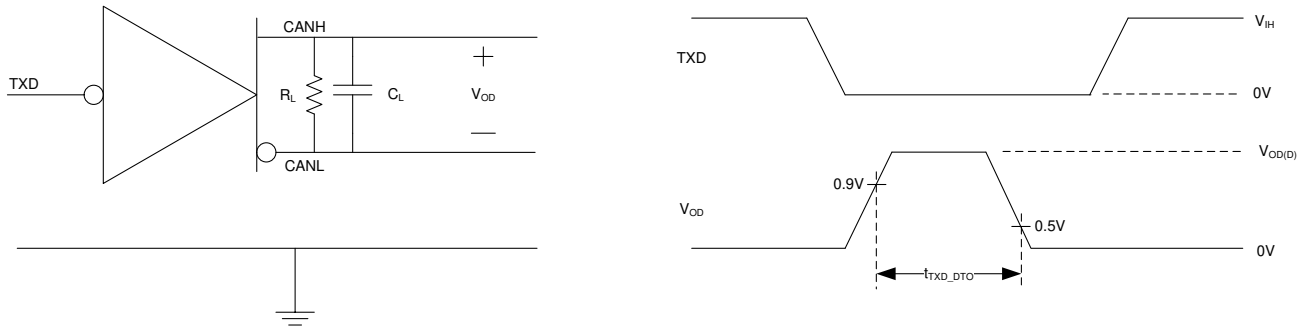


Figure 10. TXD Dominant Timeout Test Circuit and Measurement

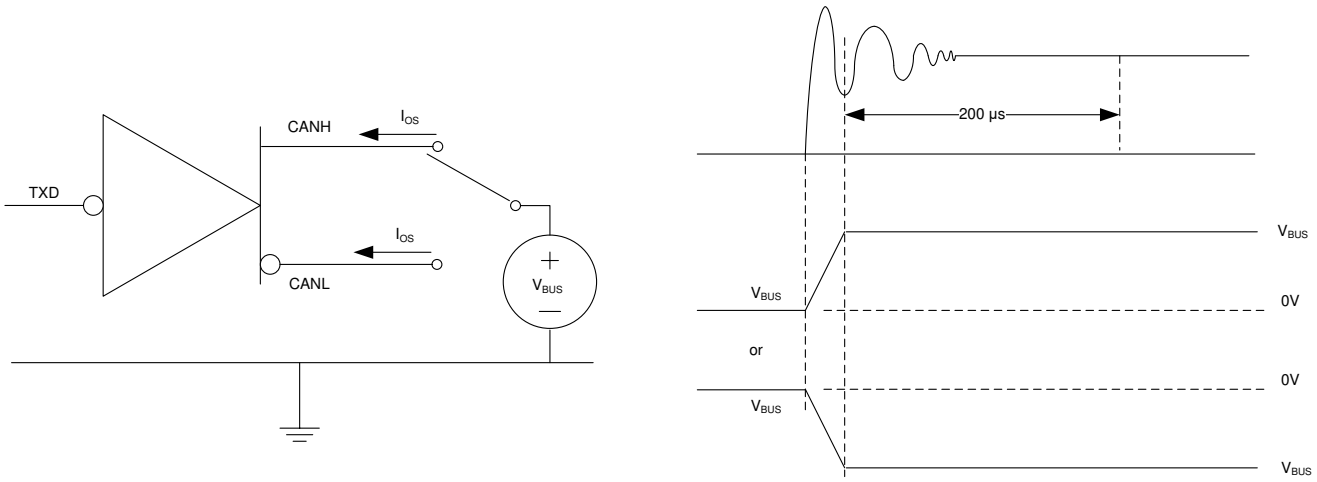


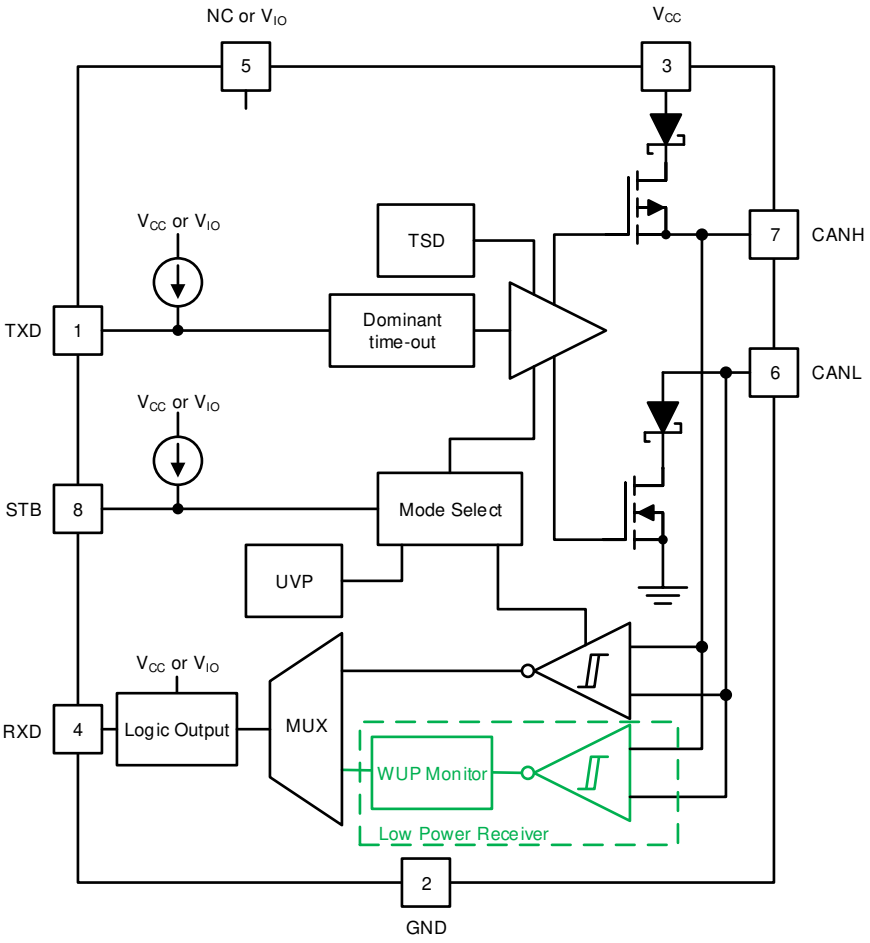
Figure 11. Driver Short-Circuit Current Test and Measurement

8 Detailed Description

8.1 Overview

The TCAN1044V 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 ISO 11898-2:2016 and ISO 11898-5:2007 physical layer requirements according to the GIFT/ICT high speed CAN test specification. The transceiver provides a number of different protection features making it ideal for the stringent industrial system requirements while also supporting CAN FD data rates up to 8 Mbps.

8.2 Functional Block Diagram



8.3 Feature Description

8.3.1 Pin Description

8.3.1.1 TXD

TXD is the logic-level signal, referenced to from a CAN controller to the device.

8.3.1.2 GND

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

8.3.1.3 V_{CC}

V_{CC} provides the 5-V nominal power supply to the CAN transceiver.

8.3.1.4 RXD

RXD is the logic-level signal, referenced to , from the TCAN1044V to a CAN controller. This pin is only driven once V_{IO} is present.

8.3.1.5 V_{IO}

The V_{IO} pin provides the digital IO voltage to match the CAN controller voltage thus avoiding the requirement for a level shifter. It supports voltages from 1.7 V to 5.5 V providing the widest range of controller support.

8.3.1.6 CANH and CANL

These are the CAN high and CAN low differential bus pins. These pins are connected to the CAN transceiver and the low-voltage WUP CAN 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. If normal mode is the only intended mode of operation than the STB pin can be tied directly to GND.

8.3.2 CAN Bus States

The CAN bus has two logical states during operation: recessive and dominant. See Figure 12 and Figure 13.

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 $V_{CC}/2$ via the high-resistance internal input resistors (R_{IN}) 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 TCAN1044V transceiver implements 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 Figure 12 and Figure 13.

Feature Description (continued)

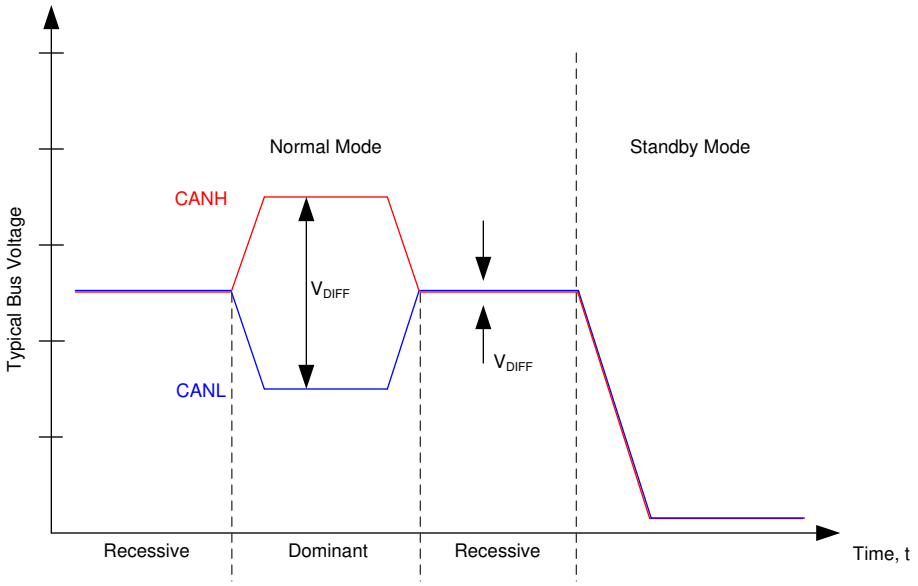
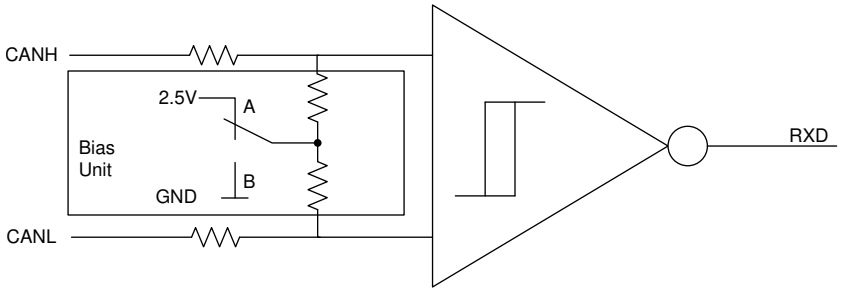


Figure 12. Bus States



A. Normal Mode

B. Standby Mode

Figure 13. 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 $V_{CC}/2$ 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 Equation 1.

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

Feature Description (continued)

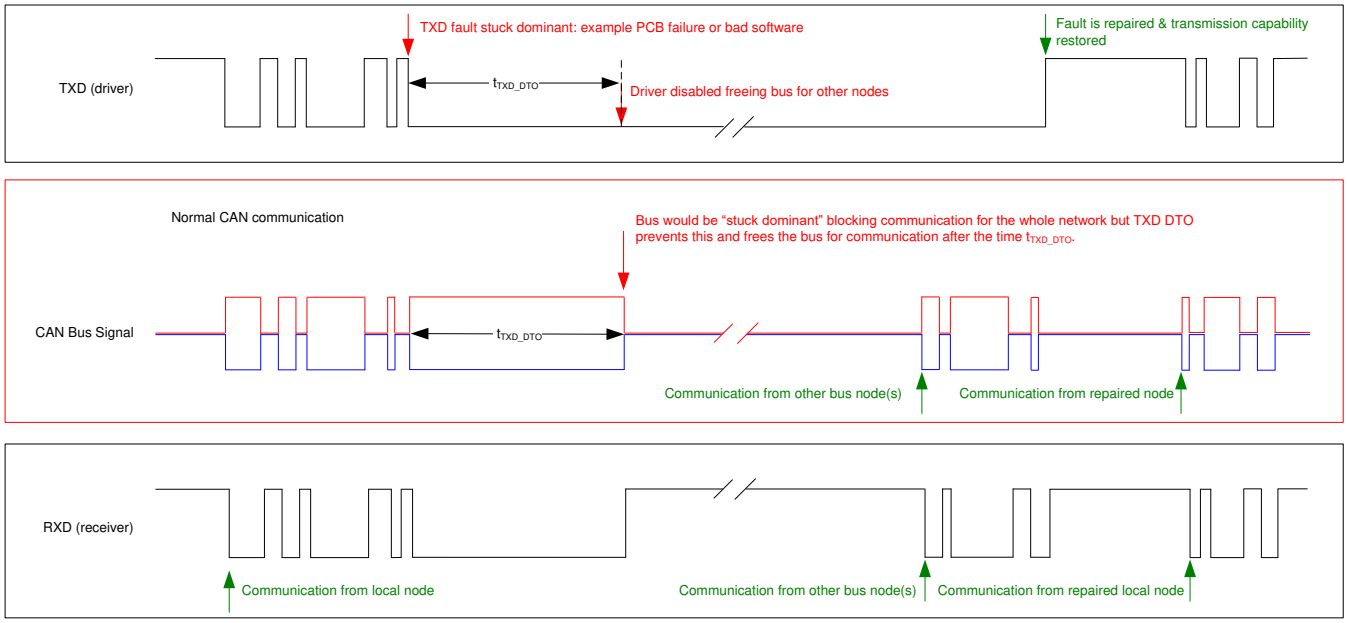


Figure 14. Example Timing Diagram for TXD Dominant Timeout

8.3.4 CAN Bus Short Circuit Current Limiting

The TCAN1044V has 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. These ensure 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 their respective short circuit currents. The average short circuit current may be calculated using Equation 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.

Feature Description (continued)

8.3.5 Thermal Shutdown (TSD)

If the junction temperature of the TCAN1044V exceeds 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 $V_{CC}/2$ during a TSD fault and the receiver to RXD path remains operational. If the fault condition that caused the TSD fault is still present, the junction temperature may rise again and the device enters a TSD fault again. The TCAN1044V TSD circuit includes hysteresis which prevents the CAN driver output from oscillating during a TSD fault. If there is prolonged exposure to a TSD fault condition the device reliability could be affected.

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.

Table 2. Undervoltage Lockout - TCAN1044V

V_{CC}	V_{IO}	Device State	Bus	RXD Pin
> UV_{VCC}	> UV_{VIO}	Normal	Per TXD	Mirrors bus
< UV_{VCC}	> UV_{VIO}	STB = V_{IO}: Standby mode	Biased to GND	V_{IO}: Remote wake request(1)
		STB = GND: Protected mode	High impedance	Recessive
> UV_{VCC}	< UV_{VIO}	Protected	High impedance	High impedance
< UV_{VCC}	< UV_{VIO}	Protected	High impedance	High impedance

(1) See Remote Wake Request via Wake-Up Pattern (WUP) in Standby Mode

Once an undervoltage condition is cleared and the supply has returned to a valid level the TCAN1044V transitions to normal mode after the t_{MODE} time has expired. The host controller should not attempt to send or receive messages until the t_{MODE} time has expired.

8.3.7 Unpowered Device

The TCAN1044V is designed to be an ideal passive or no load to the CAN bus if the device is unpowered. The bus pins were designed to have low leakage currents when the device is unpowered, so they do not load the bus. This is critical if some nodes of the network are unpowered while the rest of the of network remains operational.

The logic pins also have low leakage currents when the device is unpowered, so they do not load other circuits which may remain powered.

8.3.8 Floating pins

The TCAN1044V has internal pull-ups 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 are used an adequate external pull-up resistor must be used to ensure that the TXD output of the CAN controller maintains adequate bit timing to the input of the CAN transceiver. See Table 3 for details on pin bias conditions.

Table 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

8.4 Device Functional Modes

8.4.1 Operating Modes

The TCAN1044V 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 on the TCAN1044 device.

Table 4. Operating Modes

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 section 8.3.3.1
Low	Normal Mode	Enabled	Enabled	Mirrors bus state

8.4.2 Normal Mode

This is the normal operating mode of the TCAN1044V. 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 bus pins. The receiver is translating the differential signal from to a digital output on the RXD output.

8.4.3 Standby Mode

This is the low-power mode of the TCAN1044V. 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 15. 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 12 and Figure 13.

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 TCAN1044V supports 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 TCAN1044V.

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, and thus a wake request is always generated. See Figure 15 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 500 kbps, or two back to back bit times at 1 Mbps triggers the filter in either bus state. Any CAN frame at 500 kbps or less would contain a valid WUP.

For an additional layer of robustness and to prevent false wake-ups, the device implement 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 its current state without waking up. The full pattern must then be transmitted again, conforming to the constraints mentioned in this section. See Figure 15 for the timing diagram of the wake up pattern with wake timeout feature.

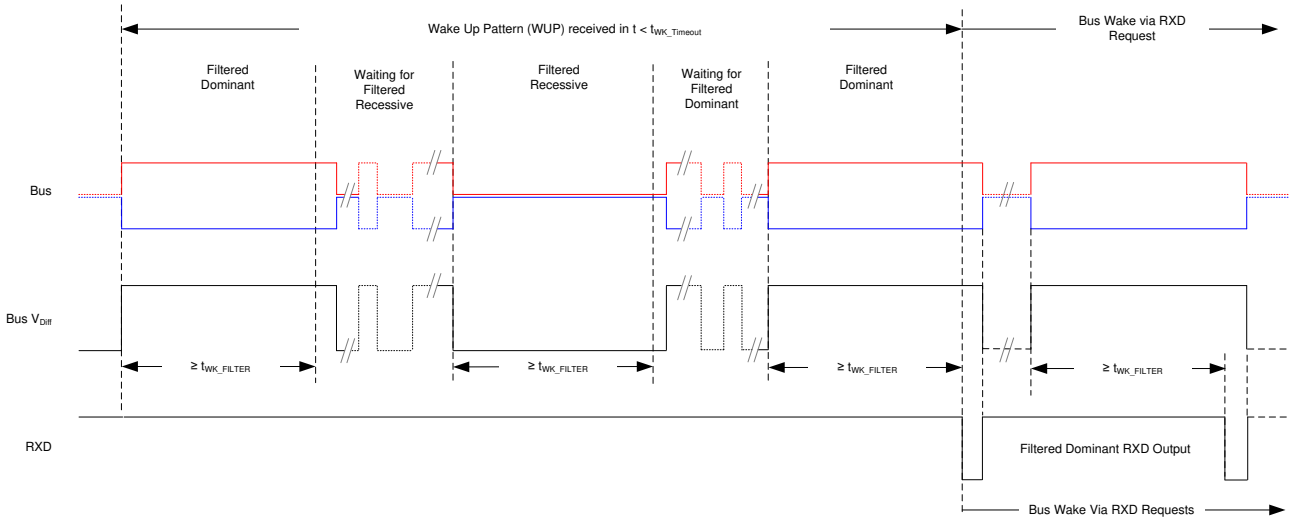


Figure 15. Wake-Up Pattern (WUP) with $t_{WK\_TIMEOUT}$

8.4.4 Driver and Receiver Function

The digital logic input and output levels for the TCAN1044V are CMOS levels with respect to V_{IO} for compatibility with protocol controllers having 1.8 V, 2.5 V, 3.3 V, or 5 V IO levels.

Table 5. Driver Function Table

Device Mode	TXD Input(1)	Bus Outputs		Driven Bus State(2)
		CANH	CANL	
Normal	Low	High	Low	Dominant
	High or open	Hi-Z	Hi-Z	Biased recessive
Standby	X	Hi-Z	Hi-Z	Weak pull-down to ground

(1) X = irrelevant
(2) For bus state and bias see Figure 12

Table 6. Receiver Function Table Normal and Standby Mode

Device Mode	CAN Differential Inputs $V_{ID} = V_{CANH} - V_{CANL}$	Bus State	RXD Pin
Normal	$V_{ID} \geq 0.9$ V	Dominant	Low
	0.5 V < V_{ID} < 0.9 V	Undefined	Undefined
	$V_{ID} \leq 0.5$ V	Recessive	High
Standby	$V_{ID} \geq 1.15$ V	Dominant	High Low if a remote wake event occurred See Figure 15
	0.4 V < V_{ID} < 1.15 V	Undefined	
	$V_{ID} \leq 0.4$ V	Recessive	
Any	Open ($V_{ID} \approx 0$ V)	Open	High

9 Application and Implementation

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. Customers should validate and test their design implementation to confirm system functionality.

9.1 Application Information

9.2 Typical Application

The TCAN1044V transceiver can be used in applications with a host controller or FPGA that includes the link layer portion of the CAN protocol. shows a typical application configuration for 5 V controller applications. The bus termination is shown for illustrative purposes.

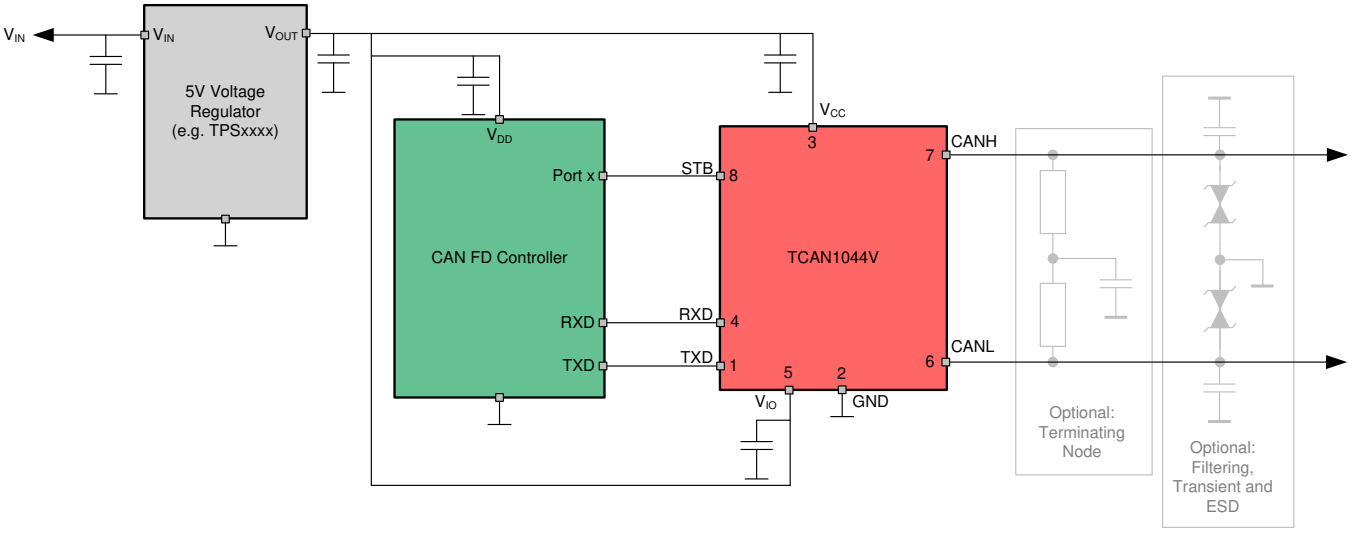


Figure 16. Transceiver Application Using 5 V IO Connections

9.2.1 Design Requirements

9.2.1.1 CAN Termination

Termination may be a single 120-Ω 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 may be used, see Figure 17. 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.

Typical Application (continued)

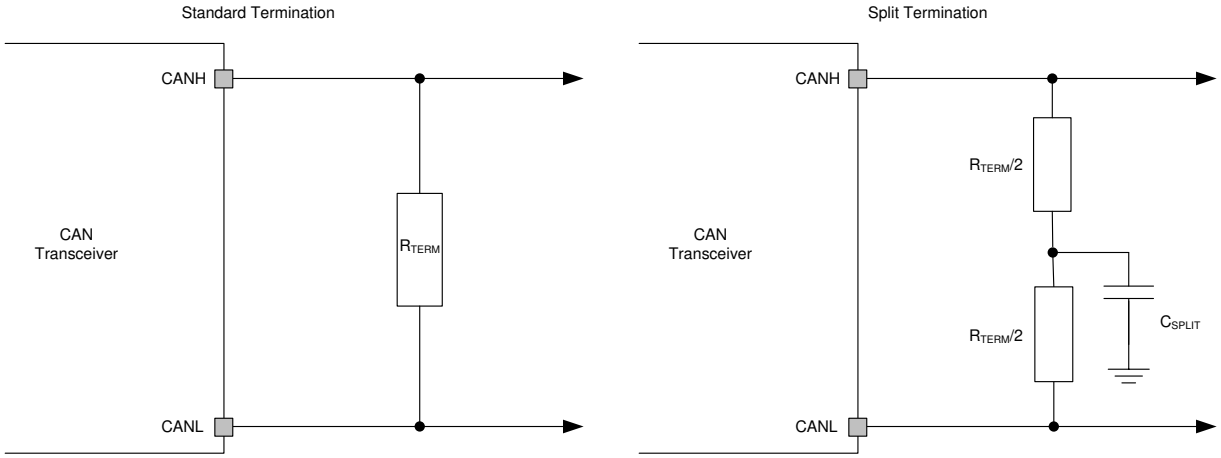


Figure 17. CAN Bus Termination Concepts

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 0.3 m. 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 TCAN1044V.

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, 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 50 Ω to 65 Ω where the differential output must be greater than 1.5 V. The TCAN1044V is specified to meet the 1.5-V requirement down to 50 Ω and is specified to meet 1.4-V differential output at 45Ω bus load. The differential input resistance of the TCAN1044V is a minimum of 40 kΩ. If 100 TCAN1044V transceivers are in parallel on a bus, this is equivalent to a 400-Ω differential load in parallel with the nominal 60 Ω bus termination which gives a total bus load of approximately 52 Ω. Therefore, the TCAN1044V 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 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 to ensure robust network operation.

Typical Application (continued)

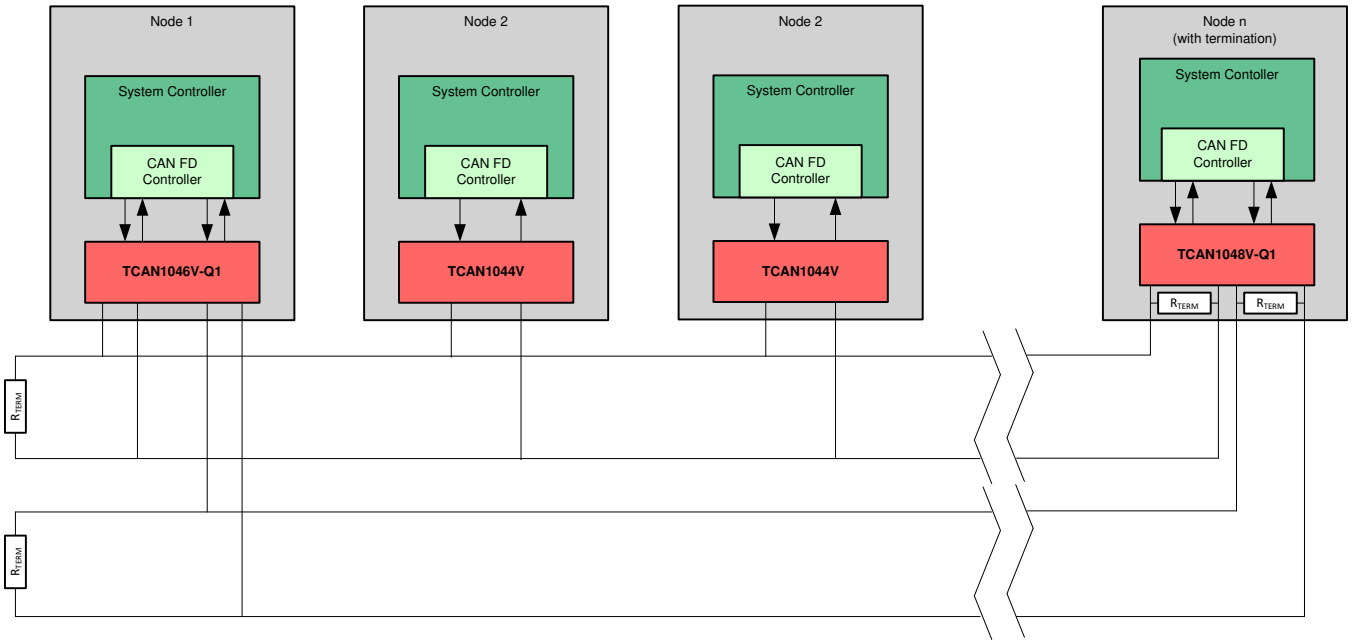
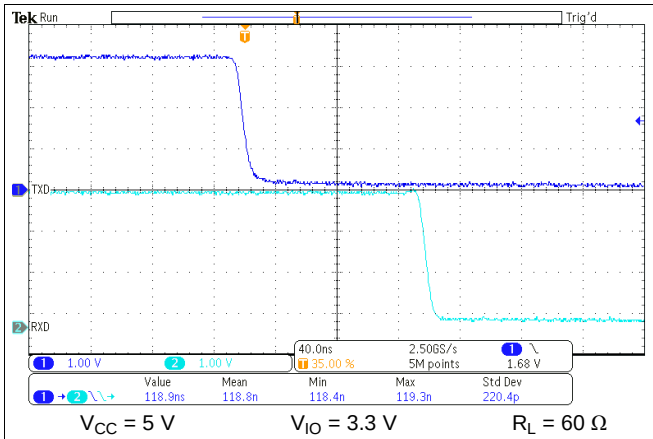


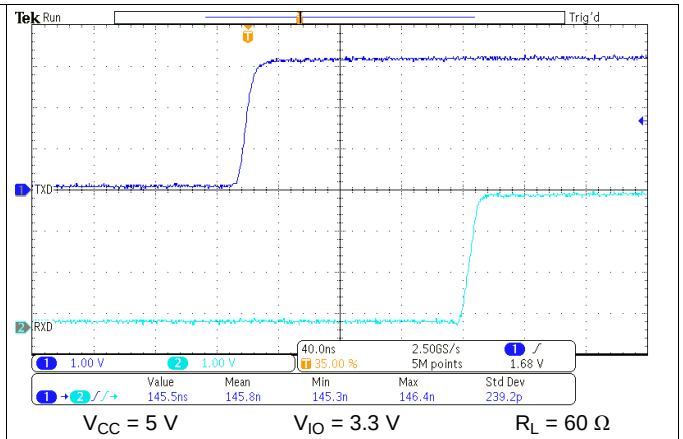
Figure 18. Typical CAN Bus

9.2.3 Application Curves



V_{CC} = 5 V V_{IO} = 3.3 V R_L = 60 Ω

Figure 19. $t_{PROP(LOOP1)}$



V_{CC} = 5 V V_{IO} = 3.3 V R_L = 60 Ω

Figure 20. $t_{PROP(LOOP2)}$

9.3 System Examples

The TCAN1044V CAN transceiver is typically used in applications with a host controller or FPGA that includes the link layer portion of the CAN protocol. A 1.8 V, 2.5 V, or 3.3 V application is shown in . The bus termination is shown for illustrative purposes.

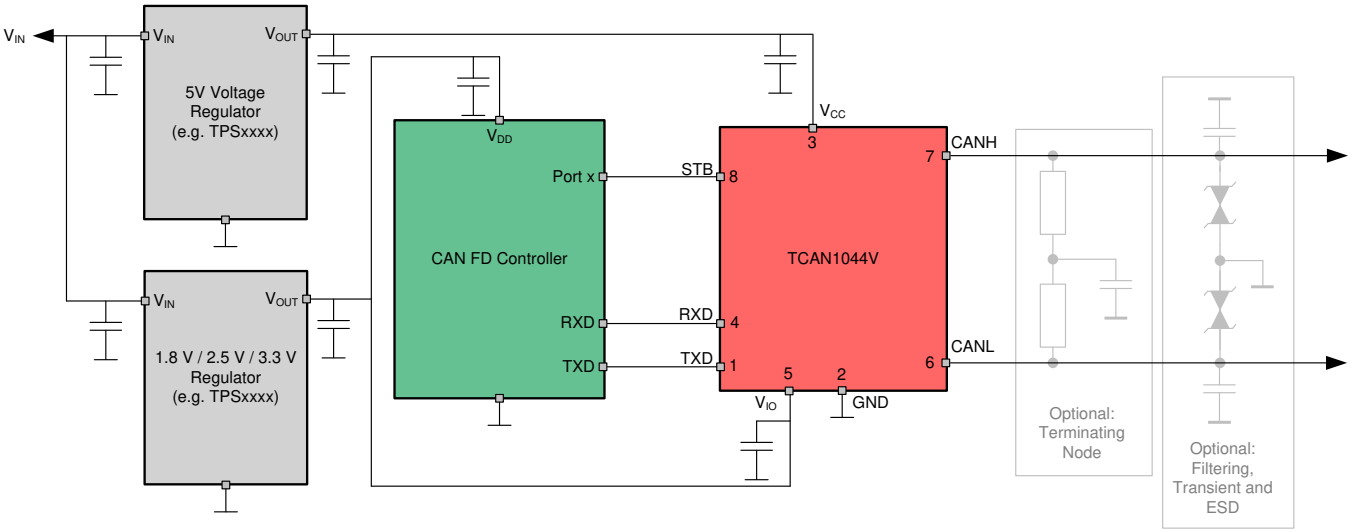


Figure 21. Typical Transceiver Application Using 1.8 V, 2.5 V, 3.3 V IO Connections

10 Power Supply Recommendations

The TCAN1044V transceiver is designed to operate with a main V_{CC} input voltage supply range between 4.5 V and 5.5 V. The TCAN1044V implements an IO level shifting supply input, V_{IO}, designed for a range between 1.8 V and 5.5 V. Both supply inputs must be well regulated. A decoupling capacitance, typically 100 nF, should be placed near the CAN transceiver's main V_{CC} supply pin in addition to bypass capacitors. A decoupling capacitor, typically 100 nF, should be placed near the CAN transceiver's V_{IO} supply pin in addition to bypass capacitors.

11 Layout

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

11.1 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 a 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.
- Use V_{CC} and GND planes to provide low inductance. Note that high frequency current follows the path of least impedance and not the path of least resistance.
- 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 V_{CC} and ground connections of decoupling capacitors and protection devices to minimize trace and via inductance.
- 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 Current Limiting, and Equation 2 for information on termination concepts and power ratings needed for the termination resistor(s).

11.2 Layout Example

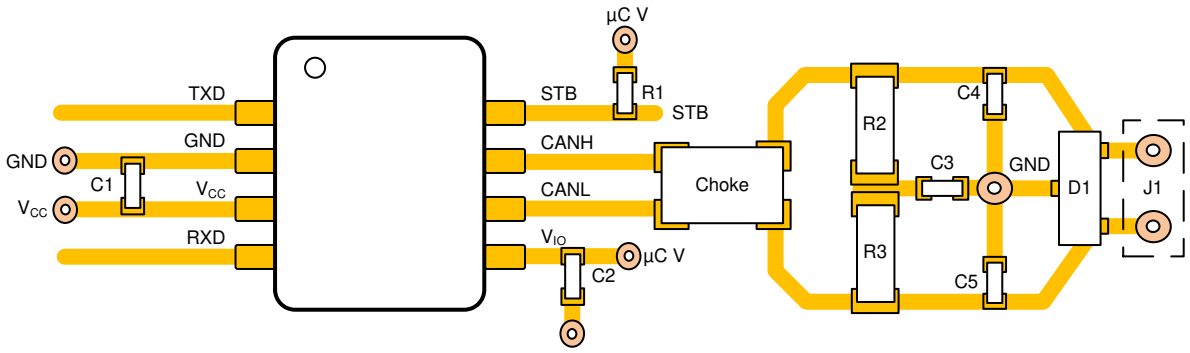


Figure 22. Layout Example

12 Device and Documentation Support

12.1 Documentation Support

12.1.1 Related Links

The table below lists quick access links. Categories include technical documents, support and community resources, tools and software, and quick access to order now.

Table 7. Related Links

PARTS	PRODUCT FOLDER	ORDER NOW	TECHNICAL DOCUMENTS	TOOLS & SOFTWARE	SUPPORT & COMMUNITY
TCAN1044V	Click here	Click here	Click here	Click here	Click here

12.2 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.

12.3 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.

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12.5 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.

12.6 Glossary

SLYZ022 — *TI Glossary*.

This glossary lists and explains terms, acronyms, and definitions.

13 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 (1)	Material type (2)	Package | Pins	Package qty | Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
TCAN1044VDDFR	Active	Production	SOT-23-THIN (DDF) | 8	3000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	27RF
TCAN1044VDDFR.A	Active	Production	SOT-23-THIN (DDF) | 8	3000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	27RF
TCAN1044VDDFRG4.A	Active	Production	SOT-23-THIN (DDF) | 8	3000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	27RF

(1) **Status:** For more details on status, see our product life cycle.

(2) **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.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the TI RoHS Statement for additional information and value definition.

(4) **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.

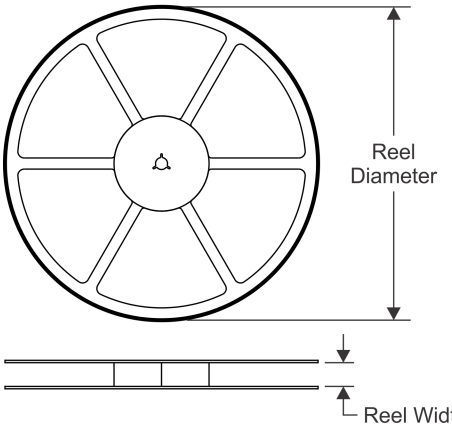
(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will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

(6) **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.

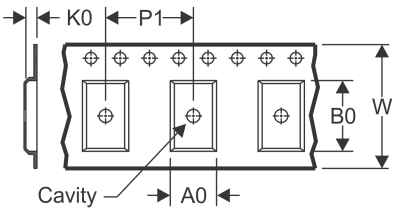
Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

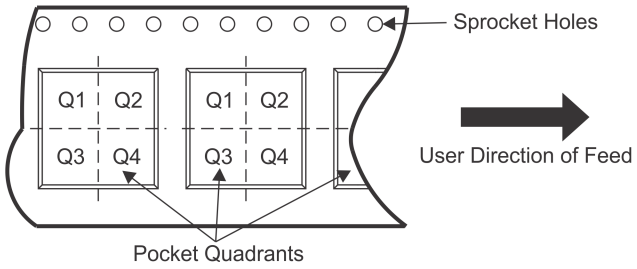


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

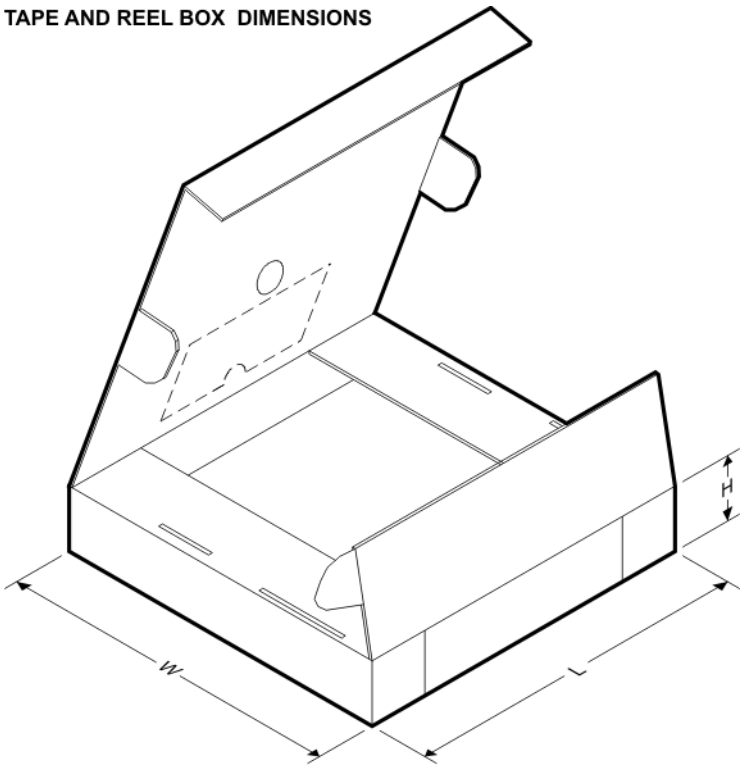
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
TCAN1044VDDFR	SOT-23-THIN	DDF	8	3000	180.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

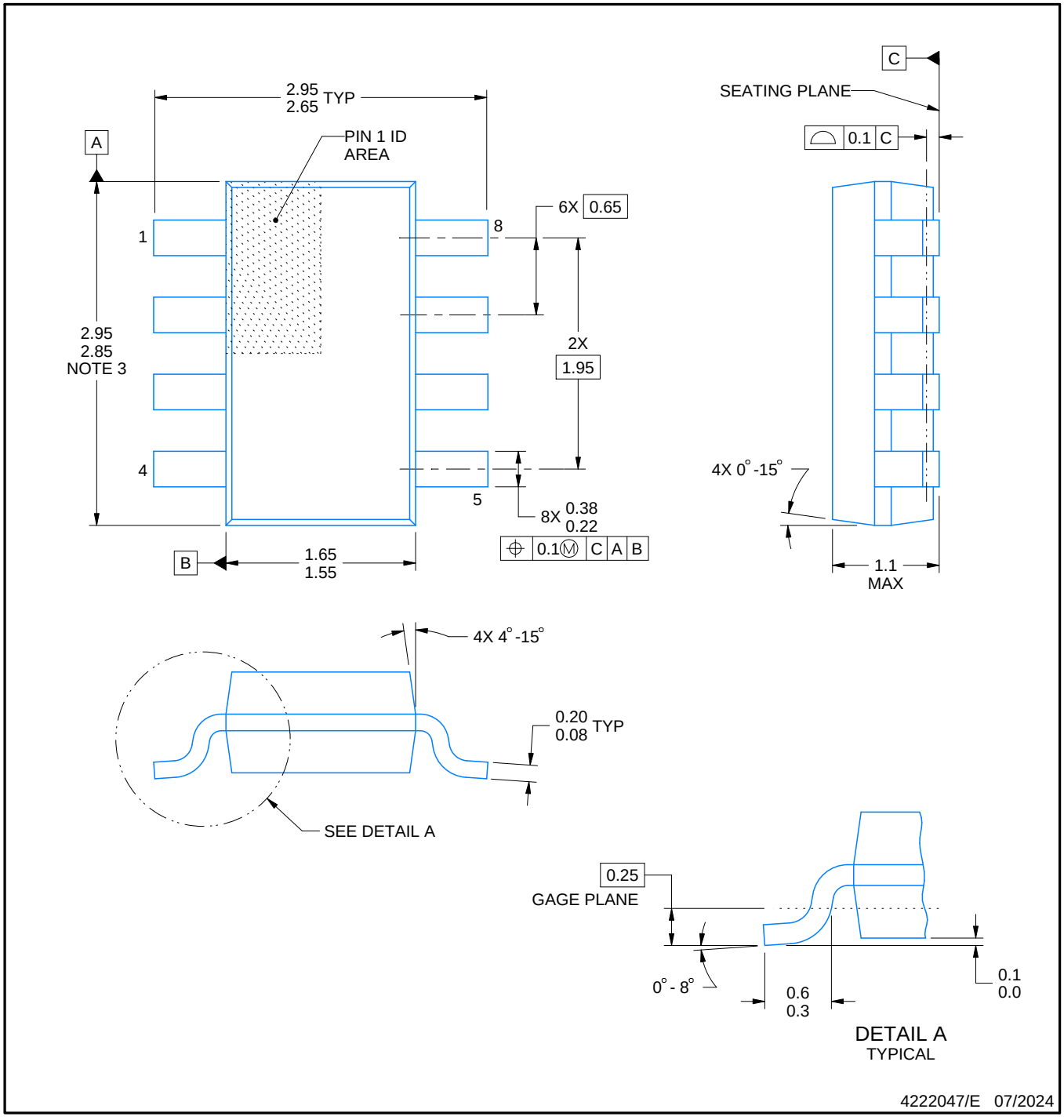
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TCAN1044VDDFR	SOT-23-THIN	DDF	8	3000	210.0	185.0	35.0

PACKAGE OUTLINE

DDF0008A

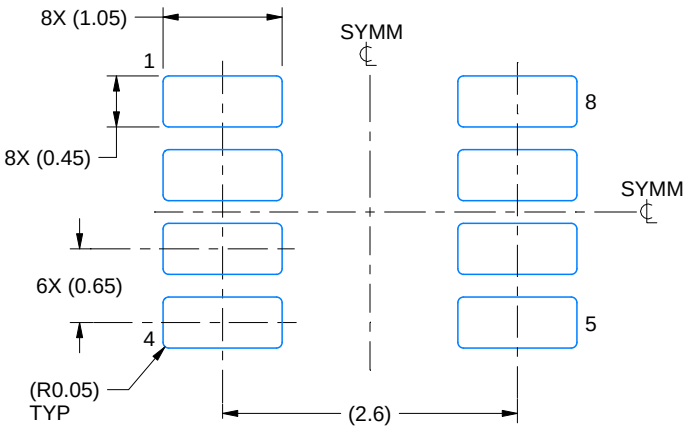
SOT-23-THIN - 1.1 mm max height

PLASTIC SMALL OUTLINE

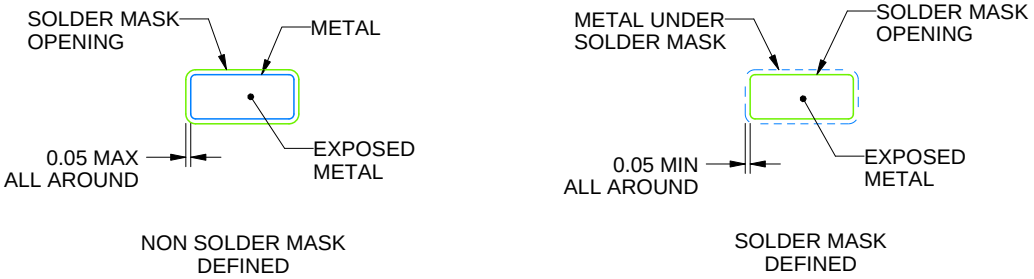


NOTES:

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. 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.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:15X



SOLDER MASK DETAILS

4222047/E 07/2024

NOTES: (continued)

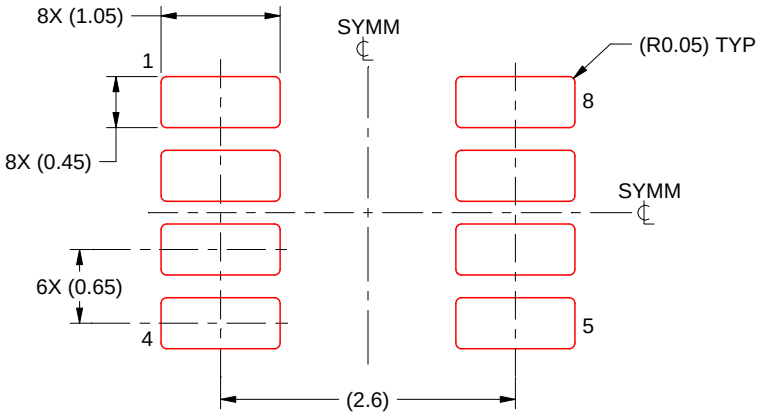
4. Publication IPC-7351 may have alternate designs.
5. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

DDF0008A

SOT-23-THIN - 1.1 mm max height

PLASTIC SMALL OUTLINE



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE:15X

4222047/E 07/2024

NOTES: (continued)

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

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