TCAN4420 CAN Transceiver with Polarity Control

1 Features

- Meets the Requirements of the ISO 11898-2 (2016) Physical Layer Standard
- External Polarity Control Through SW (switch) Pin
  - Can be Used to Switch Polarity to Normal (Default) or Reverse Configuration of CAN Bus
- Dual Power Supplies
  - 5-V V_{CC} Pin for CAN Driver and Receiver
  - 2.8-V to 5-V V_{IO} Pin for Powering RXD, TXD and SW pins
- Wide Operating Ranges
  - ±46-V Bus Fault Protection
  - ±12-V Common Mode
  - –40°C to 125°C Ambient Temperature
- Protection Feature
  - HBM ESD Protection up to ±12 kV
  - Under Voltage Protection on V_{CC} and V_{IO} Supplies
  - TXD Dominant Time Out (TXD DTO) – Supports Data Rates Down to 9.2 kbps
  - Thermal Shutdown Protection (TSD)
- Optimized Behavior when Unpowered
  - Bus and Logic Terminals are High Impedance (No Load to Operating Bus or Application)
  - Power Up and Down Glitch Free Operation
- Fast Loop Times: 150 ns

2 Applications

- Building Automation
  - Building Security Gateway
  - HVAC Gateway and System Controller
  - Elevator Main Panel

3 Description

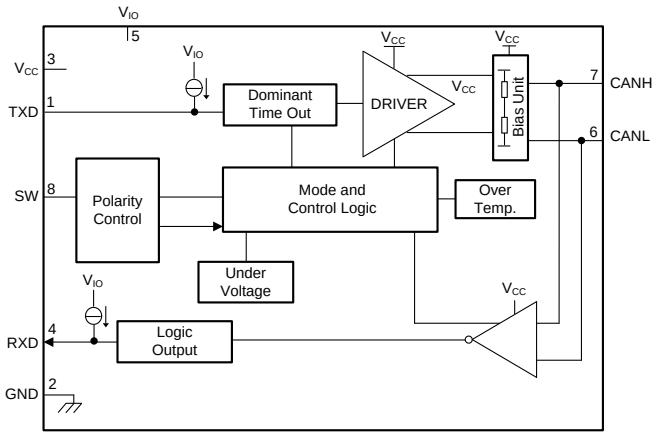
The TCAN4420 is a high-speed Controller Area Network (CAN) transceiver that meets the specifications of the ISO 11898-2 (2016) physical layer standard requirements. The device also allows the CAN bus polarity to be controlled externally by a microcontroller through the SW pin. The TCAN4420 includes many protection features providing device and CAN network robustness. Support for 2.8 V to 5 V MCUs and I/Os is included through the V_{IO} pin.

Device Information(1)

PART NUMBER	PACKAGE	BODY SIZE (NOM)
TCAN4420	SOIC (D) (8)	4.90 mm x 3.91 mm

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

Functional Block Diagram



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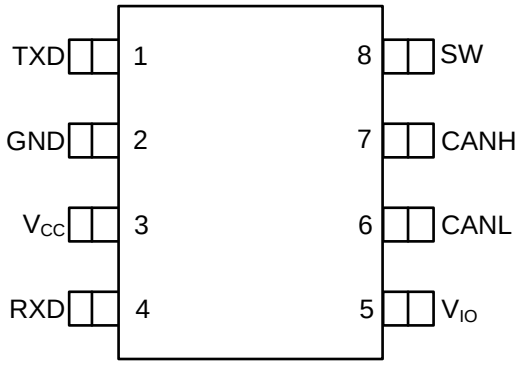
4 Revision History

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

DATE	REVISION	NOTES
December 2017	*	Initial release.

5 Pin Configuration and Functions

D Package
8-Pin SOIC
Top View



Pin Functions

PIN		I/O	DESCRIPTION
NAME	NO.		
TXD	1	Logic Input	CAN transmit data input (LOW for dominant and HIGH for recessive bus states)
GND	2	Ground	Ground connection
V_{CC}	3	Power	5 V ±10% supply voltage
RXD	4	Logic Output	CAN receive data output (LOW for dominant and HIGH for recessive bus states)
V_{IO}	5	Power	Transceiver I/O level shifting supply voltage
CANL	6	Bus I/O	Low level CAN bus input/output line
CANH	7	Bus I/O	High level CAN bus input/output line
SW	8	Logic Input	Polarity switch pin. Set to low for normal polarity (default), and high to reverse the polarity of the CAN pins

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 select for I/O level shifter	–0.3	6	
V_{BUS}	CAN Bus I/O voltage (CANH, CANL)	–46	46	
V_{Logic_Input}	Logic input terminal voltage	–0.3	6	
V_{RXD}	RXD output terminal voltage range	–0.3	6	
$I_{O(RXD)}$	RXD output current		8	mA
T_J	Operating virtual junction temperature range, packaged units	–40	150	°C
T_A	Ambient temperature	–40	125	
T_{STG}	Storage temperature	–65	150	

(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 I/O 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	All pins(1)	±4000	V
		Charged-device model (CDM), per AEC Q100-011	All pins(2)	±750	

(1) Tested in accordance to AEC-Q100-002.
(2) Tested in accordance to AEC-Q100-011.

6.3 ESD Ratings Specifications

				VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge(1)	Human bodt model (HBM)	CAN bus terminal (CANH, CANL)	±12000	V
	IEC 61400-4-2 according to IBEE CAN EMC test spec(2)	CANH and CANL terminals to GND(3) (4)		±8000	V
	IEC 61400-4-2 Air Discharge(2)	CANH and CANL terminals to GND(3) (4)		±15000	V
	ISO7637 Transients according to IBEE CAN EMC test spec(5)	CAN bus terminals (CANH, CANL)	Pulse 1	–100	V
			Pulse 2	75	V
			Pulse 3a	–150	V

(1) System level ESD test, results given here were performed at the system level with appropriate external components such TVS diodes. Different system level configurations may lead to different results.
(2) IEC 61000-4-2 is a system level ESD test. Results given here are specific to the IBEE CAN EMC Test specification conditions. Different system level configurations may lead to different results.
(3) IEC 61000-4-2 is a system level ESD test. Results given here were performed at the system level with appropriate external components such TVS diodes. Different system level configurations may lead to different results.
(4) Testing performed in accordance with 3rd party IBEE Zwickau test method.
(5) ISO7637 is a system level transient test. Results given here are specific to the IBEE CAN EMC Test specification conditions. Different system level configurations may lead to different results.

6.4 Recommended Operating Conditions

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

		MIN	NOM	MAX	UNIT
V_{CC}	Supply voltage	4.5	5	5.5	V
V_{IO}	Supply Voltage for I/O Level Shifter	2.8		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	Operational free-air temperature (see Thermal Characteristics table)	–40		125	°C

6.5 Thermal Information

THERMAL METRIC(1)		TCAN4420 SOIC 8 PINS	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance	114	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	48.2	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	59.2	°C/W
Ψ_{JT}	Junction-to-top characterization parameter	9.5	°C/W
Ψ_{JB}	Junction-to-board characterization parameter	58.1	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	–	°C/W

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

6.6 Power Supply Characteristics

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

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
I_{CC}	Supply Current Normal Mode	Dominant	See Figure 6, TXD = 0 V, R_L = 60 Ω, C_L = open,		55	70	mA
		Dominant	See Figure 6, TXD = 0 V, R_L = 50 Ω, C_L = open,		60	80	
		Dominant with bus Fault	See Figure 6, TXD = 0 V, STBx = 0 V, CANH = –25 V, R_L = open, C_L = open		100	180	
		Recessive	See Figure 6, TXD = V_{CC}, R_L = 60 Ω, C_L = open, R_{CM} = open, S or STB = 0 V		10	20	
UV_{VCC}		Under voltage detection on V_{CC} for protected mode		3.5		4.4	V
		Hysteresis voltage			200		mV
UV_{VIO}		Under voltage detection on V_{IO} for protected mode		1.3		2.7	V
P_D	Average Power Dissapation	V_{CC} = V_{IO}= 5 V, T_J = 25℃, R_L = 60 Ω, Input to TXD at 250 kHz, 25% duty cycle square wave, C_{L_RXD} = 15 pF. Typical CAN operating conditions at 500 kbps with 25% transmission (domiant) rate.			115		mW
		V_{CC} = V_{IO}= 5.5 V, T_J = 150℃, R_L = 50 Ω. Input to TXD at 500 kHz, 50% duty cycle square wave, C_{L_RXD} = 15 pF. Typical high load CAN operating conditions at 1 Mbps with 50% transmission (domiant) rate and loaded network.			268		
Thermal Shutdown Temperature					185		℃
Thermal Shutdown Hysterisis					15		

6.7 AC and DC Electrical Characteristics

All typical values are at 25°C and supply voltages of V_{CC} = 5 V. R_L = 60 Ω over operating free-air temperature range (unless otherwise noted)

PARAMETER			TEST CONDITIONS	MIN	TYP	MAX	UNIT
Driver Electrical Characteristics							
$V_{O(D)}$	Bus output voltage (dominant)	CANH	See Figure 8 and Figure 9, TXD = 0 V, R_L = 60 Ω, C_L = open, R_{CM} = open	2.75		4.5	V
		CANL		0.5		2.25	V
$V_{O(R)}$	Bus output voltage (recessive)		See Figure 6 and Figure 9, TXD = V_{CC}, R_L = open (no load), R_{CM} = open	2	0.5 x V_{CC}	3	V
$V_{OD(D)}$	Differential output voltage (dominant)		See Figure 6 and Figure 9, TXD = 0 V, 50 Ω ≤ R_L ≤ 65 Ω, C_L = open, R_{CM} = open 4.75 V ≤ V_{CC} ≤ 5.25 V	1.5		3	V
			See Figure 6 and Figure 9, TXD = 0 V, 50 Ω ≤ R_L ≤ 65 Ω, C_L = open, R_{CM} = open 4.5 V ≤ V_{CC} ≤ 5.5 V	1.3		3.2	V
$V_{OD(R)}$	Differential output voltage (recessive)		See Figure 6 and Figure 9, TXD = V_{CC}, R_L = 60 Ω, C_L = open, R_{CM} = open	–120		12	mV
			SeeFigure 6 and Figure 9,TXD = V_{CC}, R_L = open, C_L = open, R_{CM} = open	–50		50	mV
V_{SYM}	Output symmetry (dominant or recessive) (V_{CC} - $V_{O(CANH)}$ - $V_{O(CANL)}$)		See Figure 6 and Figure 9, R_L = 60 Ω, C_L = open, R_{CM} = open	–400		400	mV
$I_{OS(DOM)}$	Short-circuit steady-state output current, Dominant		See Figure 6 and Figure 12, $V_{(CAN\_H)}$ ≤ –5 V, CANL = open, TXD = 0 V	–115			mA
			See Figure 6 and Figure 12, $V_{(CAN\_L)}$ = 40 V, CANH = open, TXD = 0 V			115	mA
$I_{OS(REC)}$	Short-circuit steady-state output current, Recessive		See Figure 6 and Figure 12, –27 V ≤ V_{BUS} ≤ 32 V, V_{BUS} = CANH = CANL	–5		5	mA
Receiver Electrical Characteristics							
V_{IT}	Input threshold voltage		See Figure 10	500		900	mV
V_{HYS}	Hysteresis voltage for input threshold				120		mV
V_{CM}	Common Mode Range			–12		12	V
$I_{IOFF(LKG)}$	Power-off (unpowered) bus input leakage current		CANH = CANL = 5 V, V_{CC} to GND via 0 Ω		5		µA

AC and DC Electrical Characteristics (continued)

All typical values are at 25°C and supply voltages of V_{CC} = 5 V. R_L = 60 Ω over operating free-air temperature range (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
C_I	Input capacitance to ground (CANH or CANL)	TXD = V_{CC} = V_{IO}		40		pF
C_{ID}	Differential input capacitance			20		pF
R_{ID}	Differential input resistance		20		80	kΩ
R_{IN}	Single Ended Input resistance (CANH or CANL)		10		40	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%	
V_{IO} PIN						
V_{IO}	Supply voltage on V_{IO} pin		2.8		5.5	V
I_{IO}	Supply current on V_{IO} pin	RXD pin floating, TXD = 0 V			350	µA
		RXD pin floating, TXD = 5			50	µA
TXD Terminal (CAN Transmit Data Input)						
V_{IH}	High-level input voltage		0.7V_{IO}			V
V_{IL}	Low-level input voltage				0.3V_{IO}	V
I_{IH}	High-level input leakage current	V_{TXD} = V_{IO} = V_{CC} = 5.5 V	–2.5	0	1	µA
I_{IL}	Low-level input leakage current	V_{TXD} = 0 V, V_{CC} = 5.5 V	–200		–6	µA
$I_{LKG(OFF)}$	Unpowered leakage current	V_{TXD} = 5.5 V, V_{IO} = V_{CC} = 0 V	–1	0	1	µA
C_I	Input Capacitance	V_{IN} = 0.4 x sin(2 x M x 2 x 10^6 x t) + 2.5		20		pF
RXD Pin (CAN Receive Data Output)						
V_{OH}	High-level input voltage	See Figure 10, I_O = –2 mA	0.8V_{IO}			V
V_{OL}	Low-level input voltage	See Figure 10, I_O = –2 mA			0.2V_{IO}	V
$I_{LKG(OFF)}$	Unpowered leakage current	V_{RXD} = 5.5 V, V_{IO} = V_{CC} = 0 V	–1	0	1	µA
SW Pin (Polarity Switch Input)						
V_{IH}	High-level input voltage		0.7V_{IO}			V
V_{IL}	Low-level input voltage				0.3V_{IO}	V
I_{IH}	High-level input leakage current	SW = V_{IO} = V_{CC} = 5.5 V	0.5		20	µA
I_{IL}	Low-level input leakage current	SW = 0 V, V_{CC} = 5.5 V	–1		1	µA
$I_{LKG(OFF)}$	Unpowered leakage current	SW = 5.5 V, V_{IO} = V_{CC} = 0 V	–1	0	1	µA

6.8 Timing Requirements

			MIN	NOM	MAX	UNIT
Switching Characteristics						
t_{pHR}	Propagation delay time, high TXD to Driver Recessive	See Figure 9, Typical Conditions for DS: R_L = 60 Ω, C_L = 100 pF, R_{CM} = open		50		ns
t_{pLD}	Propagation delay time, low TXD to Driver Dominant			40		
$t_{sk(p)}$	Pulse skew (|t_{pHR} - t_{pLD}|)			10		
t_R	Differential output signal rise time			25		
t_F	Differential output signal fall time			25		
t_{TXD_DTO}	Dominant time out(1)	See Figure 13, R_L = 60 Ω, C_L = open	1.2		4	ms

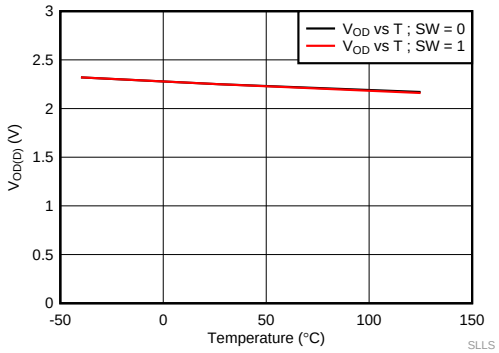
(1) The TXD dominant time out (t_{TXD_DTO}) disables the driver of the transceiver once the TXD has been dominant longer than t_{TXD_DTO}, which releases the bus lines to recessive, preventing a local failure from locking the bus dominant. The driver may only transmit dominant again after TXD has been returned HIGH (recessive). While this protects the bus from local faults, locking the bus dominant, it limits the minimum data rate possible. 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. This, along with the t_{TXD_DTO} minimum, limits the minimum bit rate. The minimum bit rate may be calculated by: Minimum Bit Rate = 11/ t_{TXD_DTO} = 11 bits / 1.2 ms = 9.2 kbps.

Timing Requirements (continued)

			MIN	NOM	MAX	UNIT
t_{pRH}	Propagation delay time, bus recessive input to high RXD_INT output	See Figure 10 $C_{L(RXD)}$ = 15 pF Typical Conditions for DS: CANL = 1.5 V, CANH = 3.5 V		50		ns
t_{pDL}	Propagation delay time, bus dominant input to RXD low output			50		
t_R	Differential output signal rise time			8		
t_F	Differential output signal fall time			8		
Device Switching Characteristics						
$t_{(LOOP1)}$	Total loop delay, driver input (TXD) to receiver output (RXD), recessive to dominant(2)	See Figure 10 Typical Conditions: R_L = 60 Ω, C_L = 100 pF, $C_{L(RXD)}$ = 15 pF			150	ns
$t_{(LOOP2)}$	Total loop delay, driver input (TXD) to receiver output (RXD), dominant to receissive(2)	See Figure 10 Typical Conditions: R_L = 60 Ω, C_L = 100 pF, $C_{L(RXD)}$ = 15 pF			150	
t_{MODE}	Mode change time from normal configuration to reverse				300	µs
$t_{UV\_RE\text{-}ENABLE}$	Re-enable time after UV event	See Figure 10. Time for device to return to normal operation from UV_{VCC} and UV_{VIO} under voltage event			300	µs

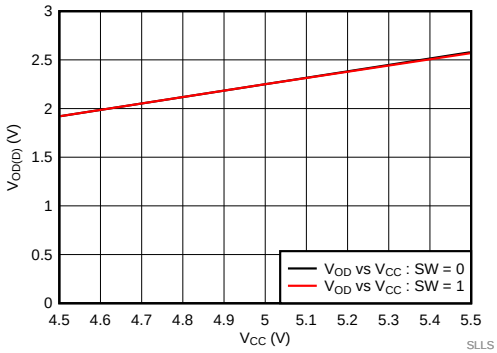
(2) Time span from signal edge on TXD input to next signal edge with same polarity on RXD output, the maximum of delay of both signal edges is to be considered.

6.9 Typical Characteristics



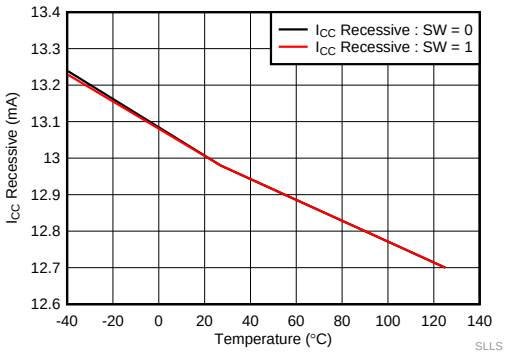
V_{CC} = 5 V | V_{IO} = 5 V | R_L= 60Ω
C_L = Open | R_{CM} = Open | SW = 0 / 1

Figure 1. $V_{OD(D)}$ over Temperature



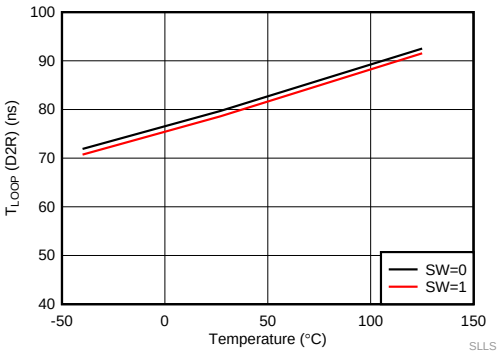
SW = 0 / 1 | V_{IO} = 5 V | R_L= 60Ω
C_L = Open | R_{CM} = Open | Temp = 25°C

Figure 2. $V_{OD(D)}$ over V_{CC} Supply Voltage



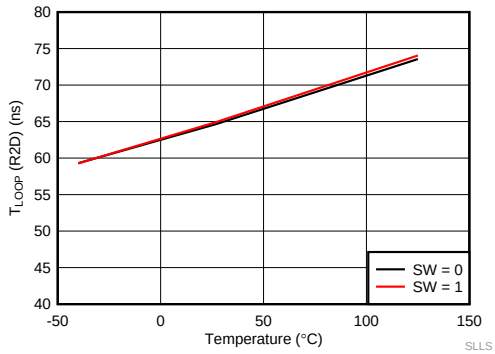
V_{CC} = 5 V | V_{IO} = 5 V | R_L= 60Ω
C_L = Open | R_{CM} = Open | SW = 0 / 1

Figure 3. I_{CC} over Temperature



V_{CC} = 5 V | V_{IO} = 5 V | R_L= 60Ω
C_L = Open | R_{CM} = Open | SW = 0 / 1

Figure 4. Dominant to Recessive T_{LOOP} over Temperature



V_{CC} = 5 V | V_{IO} = 5 V | R_L= 60 Ω
C_L = Open | R_{CM} = Open | SW = 0 / 1

Figure 5. Recessive to Dominant T_{LOOP} vs Temperature

7 Parameter Measurement Information

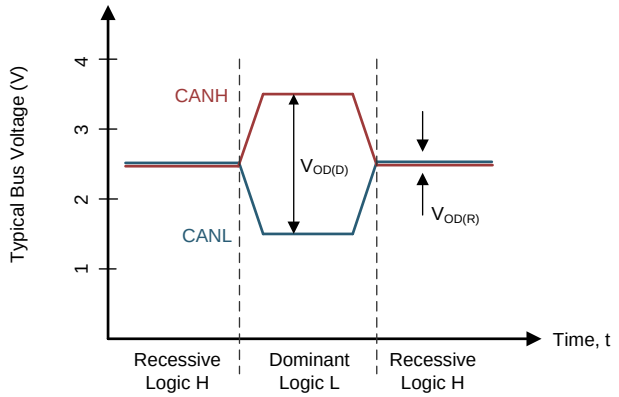


Figure 6. Bus States (Physical Bit Representation)

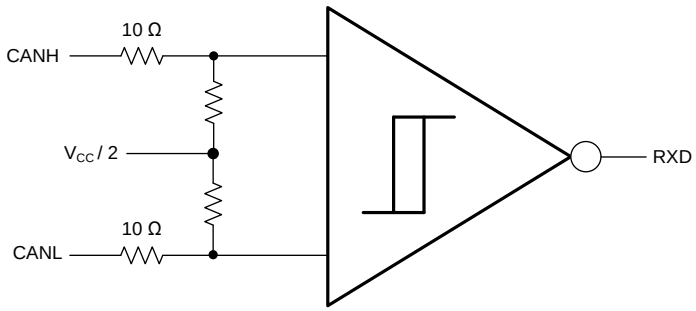


Figure 7. Common Mode Bias Unit and Receiver

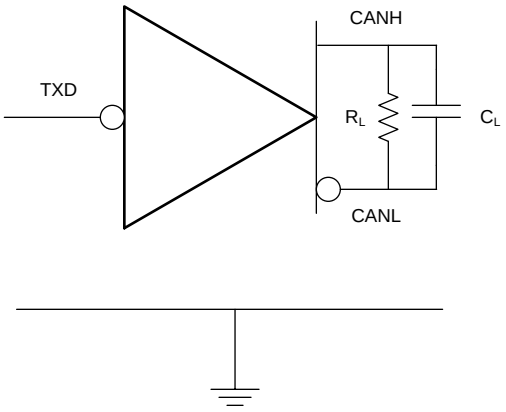


Figure 8. Supply Test Circuit

Parameter Measurement Information (continued)

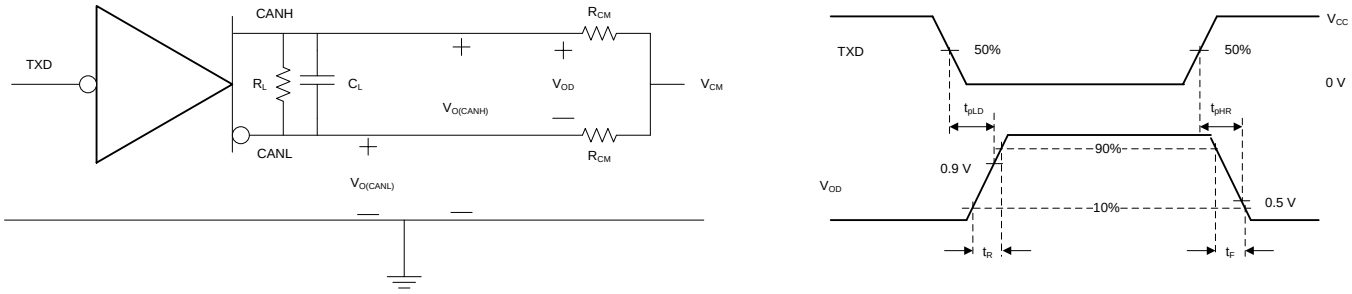


Figure 9. Driver Test Circuit and Measurement

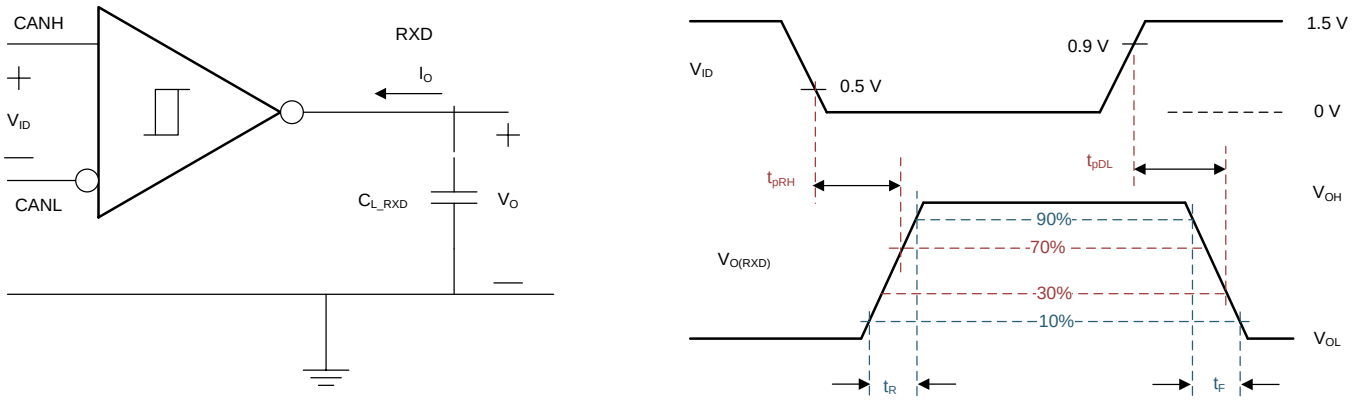


Figure 10. Receiver Test Circuit and Measurement

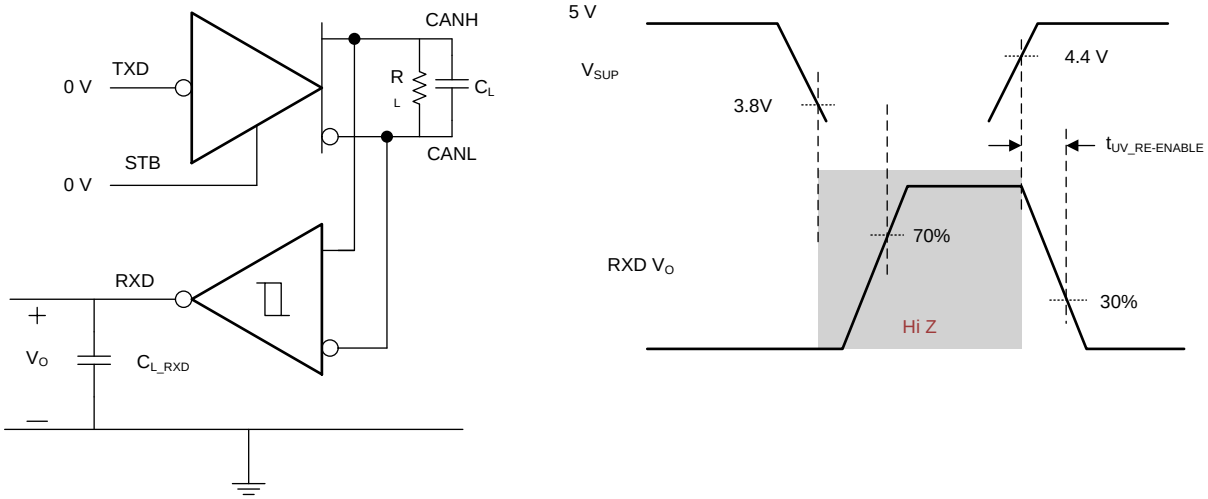


Figure 11. UV Re-enable Time after UV Event

Parameter Measurement Information (continued)

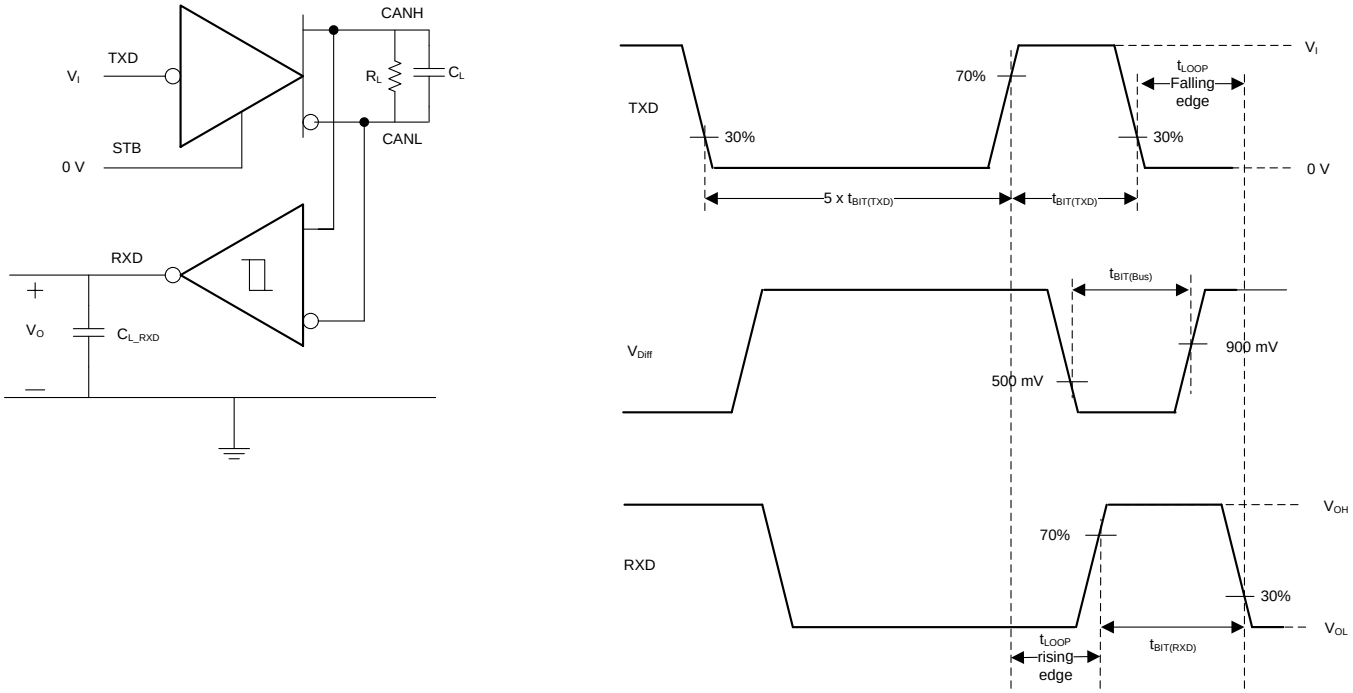


Figure 12. Transmitter and Receiver Timing Behavior Test Circuit and Measurement

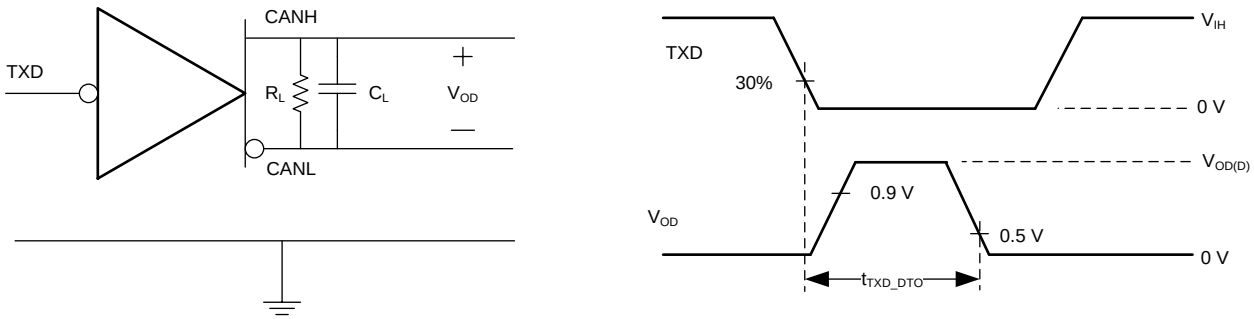


Figure 13. TXD_INT Dominant Time Out Test Circuit and Measurement

Parameter Measurement Information (continued)

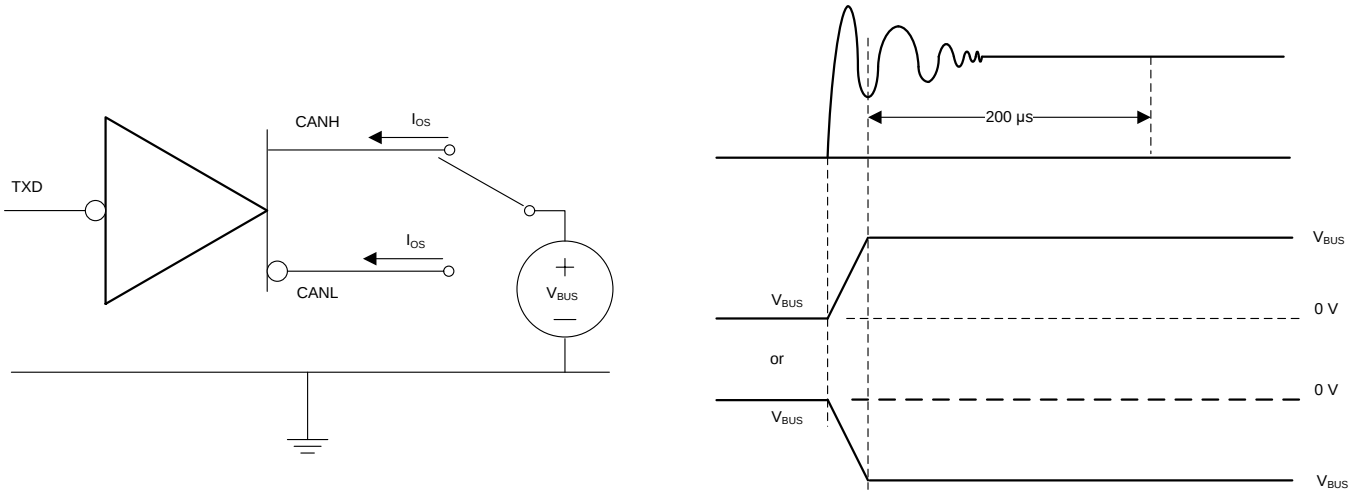


Figure 14. Driver Short-Circuit Current Test and Measurement

8 Detailed Description

8.1 Overview

The TCAN4420 is a high-speed CAN transceiver that meets the specifications of the ISO 11898-2 (2016) High Speed CAN (Controller Are Network) physical layer standards. It includes many protection features providing device and CAN network robustness. It also allows for the polarity of the CAN pins to be controlled externally by a micro-controller through the use of the polarity switch pin, SW.

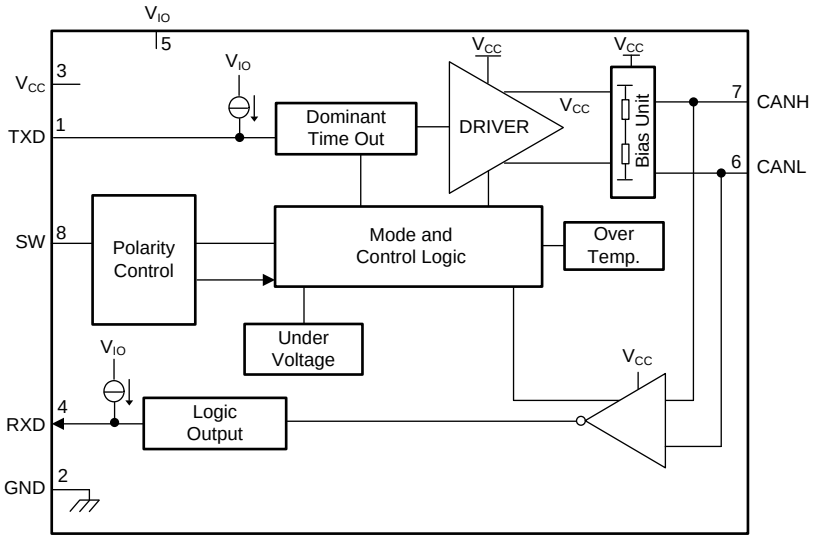
The CAN bus has two logical states during operation: recessive and dominant. See Figure 6 and Figure 7.

A recessive bus state occurs when the bus is biased to a common mode of $V_{CC}/2$ via the receivers bias unit. Recessive is equivalent to logic high on the TXD pin and is typically a differential voltage on the bus of approximately 0 V.

A dominant bus state occurs when the bus is driven differentially by one or more drivers. The driver produces a current which flows through the termination resistors on the bus and generates a differential voltage. Dominant is equivalent to logic low on the TXD pin and is a differential voltage on the bus greater than the minimum required threshold for a CAN dominant.

The host microprocessor of the CAN node uses the TXD terminal, pin 1, to drive the bus and receives data from the bus via the RXD terminal, pin 4. The TCAN4420 integrates level shifting capabilities into the RXD output via the V_{IO} pin. This feature eliminates the need for an additional level shifter between the host microprocessor and the RXD output of the CAN transceiver.

8.2 Functional Block Diagrams



8.3 Feature Description

8.3.1 TXD Dominant Time Out (DTO)

The TXD DTO circuit prevents the local node from blocking network communication in event of a hardware or software failure where TXD is held dominant longer than the time out period t_{TXD_DTO}. The DTO circuit timer starts on a falling edge on TXD. The DTO circuit disables the CAN bus driver if no rising edge is seen before the timeout period expires. This frees the bus for communication between other nodes on the network. The CAN driver is re-activated when a recessive signal is seen on the TXD terminal, thus clearing the TXD DTO condition. The receiver and RXD terminal still reflect activity on the CAN bus, and the bus terminals are biased to the recessive level during a TXD dominant timeout.

Feature Description (continued)

8.3.2 CAN Bus Short Circuit Current Limiting

The TCAN4420 has several protection features that limit the short circuit current when a CAN bus line is shorted. These include CAN driver current limiting (dominant and recessive). During CAN communication the bus switches between dominant and recessive states, thus the short circuit current may be viewed either as the current during each bus state or as a DC average current. For system current and power considerations in the termination resistors and common mode choke ratings the average short circuit current should be used. The percentage dominant is limited by the TXD dominant time out and CAN protocol which has forced state changes and recessive bits such as bit stuffing, control fields, and inter frame space. These ensure there is a minimum recessive amount of time on the bus even if the data field contains a high percentage of dominant bits.

The short circuit current of the bus depends on the ratio of recessive to dominant bits and their respective short circuit currents. The average short circuit current may be calculated using Equation 1.

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

Where:

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

NOTE

The short circuit current and possible fault cases of the network should be taken into consideration when sizing the power ratings of the termination resistance, other network components, and the power supply used to generate V_{CC}.

8.3.3 Thermal Shutdown

If the junction temperature of the device exceeds the thermal shut down threshold of 170ºC the device turns off the CAN driver circuitry thus blocking the TXD to bus transmission path. The shutdown condition is cleared when the junction temperature of the device drops below the thermal shutdown temperature of the device. If the fault condition that caused the thermal shutdown is still present, the temperature may rise again and the device enters thermal shut down again. Prolonged operation with thermal shutdown conditions may affect device reliability. The thermal shutdown circuit includes hysteresis to avoid oscillation of the driver output.

NOTE

During thermal shutdown the CAN bus driver is turned off thus no transmission is possible from TXD to the bus. The CAN bus terminals are biased to recessive level during a thermal shutdown, and the receiver to RXD path remains operational.

8.3.4 Under Voltage Lockout (UVLO) and Unpowered Device

The V_{CC} and V_{IO} supply terminals have under voltage detection circuitry which places the device in a protected mode if an under voltage fault occurs. This protects the bus during an under voltage event on these terminals. If V_{IO} is under voltage the RXD terminal is tri-stated (high impedance) and the device does not pass any signals from the bus. If V_{CC} supply is lost, or has a brown out that triggers the UVLO, the device transitions to a protected mode. See Table 1.

If V_{IO} drops below UV_{VIO} under voltage detection, the transceiver switches off and disengage from the bus until V_{IO} has recovered.

Feature Description (continued)

The device is designed to be an "ideal passive" or “no load” to the CAN bus if the device is unpowered. The bus terminals (CANH, CANL) have extremely 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. Logic terminals also have low leakage currents when the device is unpowered, so they do not load other circuits which may remain powered.

Table 1. Under Voltage Lockout Protection

V_{CC}	V_{IO}	DEVICE STATE	BUS	RXD
> UV_{VCC}	> UV_{VIO}	Normal	Per TXD	Mirrors Bus
< UV_{VCC}	> UV_{VIO}	Protected	High Impedance	High (Recessive)
> UV_{VCC}	< UV_{VIO}	Protected	High Impedance	High Impedance
< UV_{VCC}	< UV_{VIO}	Protected	High Impedance	High Impedance

NOTE

Once an under voltage condition is cleared and the V_{CC} supply has returned to valid level the device typically needs t_{MODE} to transition to normal operation. The host processor should not attempt to send or receive messages until this transition time has expired.

8.3.4.1 V_{IO} Supply PIN

A separate V_{IO} supply pin is supported on this device. This pin should be connected to the supply voltage of the microcontroller, see Figure 17 and Figure 18. This sets the signal levels for TXD, RXD and SW pins to the I/O level of the microcontroller.

8.4 Device Functional Modes

8.4.1 Polarity Configuration

The device supports two polarity configurations on the CAN pins. For a conventional (normal) CAN connection, connect SW pin to GND. Allow for a time interval equal to t_{MODE} after changing the SW pin, before reading the bus or the RXD pin. To support a reverse connection of the CAN pins, connect the SW pin to V_{IO}. This approach enables compatibility with existing boards that already use this pin (pin 8) to be connected to GND for normal operation. See Table 2.

Table 2. Polarity Configurations

SW Pin	Device Polarity	V_{OD}(TX) or V_{ID} (RX)
LOW	Normal	= CANH-CANL
HIGH	Reverse	= CANL-CANH

8.4.2 Normal Polarity Mode

This is the normal configuration of the device. The CAN driver and receiver are fully operational and CAN communication is bi-directional. The driver is translating a digital input on TXD to a differential output on CANH and CANL. The receiver is translating the differential signal from CANH and CANL to a digital output on RXD. Normal Mode is enabled when there is a logic low on the SW pin.

8.4.3 Reverse Polarity Mode

The TCAN4420 supports a reverse polarity configuration when the SW pin is connected to supply. In this configuration, both the driver and receiver remain fully operational, the key difference being that both V_{OD} and V_{ID} are now defined as the difference between CANL and CANH pins as indicated in Table 2. Also see Table Table 3 and Table 4 for the pin voltage levels in this configuration.

8.4.4 Driver and Receiver Function

The digital logic input and output levels for these devices are TTL levels with respect to V_{IO} for compatibility with protocol controllers having 2.8 V to 5 V logic or I/O.

Table 3 and Table 4 provide the states of the CAN driver and CAN receiver in each mode.

Table 3. Driver Function Table

DEVICE MODE	TXD INPUT(1)	BUS OUTPUTS(2)		DRIVEN BUS STATE(3)
		CANH	CANL	
Normal	L	H	L	Dominant
	H or Open	Z	Z	Biased Recessive
Reverse	L	L	H	Dominant
	H or Open	Z	Z	Biased Recessive

(1) H = high level, L = low level
(2) H = high level, L = low level, Z = high Z receiver bias
(3) For Bus state and bias see Figure 7

Table 4. Receiver Function Table

DEVICE MODE	CAN DIFFERENTIAL INPUTS $V_{ID} = V_{CANH} - V_{CANL}$	BUS STATE	RXD TERMINAL(1)
Normal: $V_{ID} = V_{CANH} - V_{CANL}$ Reverse: $V_{ID} = V_{CANL} - V_{CANH}$	$V_{ID} \geq 0.9$ V	Dominant	L
	0.5 V < V_{ID} < 0.9 V	Undefined	Undefined
	$V_{ID} \leq 0.5$ V	Recessive	H

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

8.4.5 Floating Terminals

The TCAN4420 has internal pull ups and pull downs on critical terminals to place the device into known states if the terminal floats. See Table 5 for details on terminal bias conditions

Table 5. Terminal Bias

TERMINAL	PULL UP or PULL DOWN	COMMENT
TXD	Pull up	Weakly biases TXD toward recessive to prevent bus blockage or TXD DTO triggering
SW	Pull down	Weakly biases SW terminal towards GND to use the default (normal) polarity configuration

NOTE

The internal bias should not be relied upon as only termination, especially in noisy environments but should be considered a failsafe protection. Special care needs to be taken when the device is used with MCUs which implement open drain outputs. TXD is weakly internally pulled up. The TXD pull up strength and CAN bit timing require special consideration when this device is used with an open drain TXD output on the microprocessor CAN controller. An adequate external pull up resistor must be used to ensure that the TXD output of the microprocessor maintains adequate bit timing input to the CAN transceiver.

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

These CAN transceivers are typically used in applications with a host microprocessor or FPGA that includes the data link layer portion of the CAN protocol. Below are typical application configurations for both 5 V and 3.3 V microprocessor applications. The bus termination is shown for illustrative purposes.

9.2 Typical Application

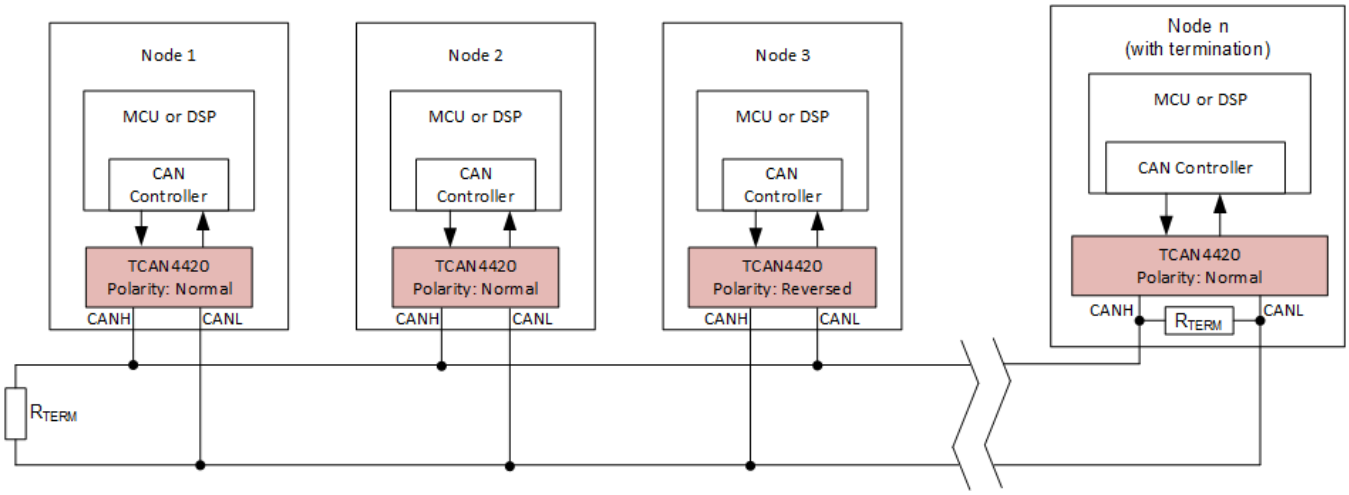


Figure 15. Typical CAN Bus Application

9.2.1 Design Requirements

9.2.1.1 Bus Loading, Length and Number of Nodes

A typical CAN application can have a maximum bus length of 40 meters and maximum stub length of 0.3 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 require a transceiver with high input impedance such as the TCAN4420 transceiver.

Many CAN organizations and standards have scaled the use of CAN for applications outside the original ISO11898-2 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 ARINC825, CANopen, DeviceNet, SAE J2284, SAE J1939, and NMEA 2000.

A CAN network system design is a series of tradeoffs. In ISO 11898-2 the driver differential output is specified with a 60-Ω bus load where the differential output must be greater than 1.5 V. The TCAN4420 is specified to meet the 1.5 V requirement across this load and is specified to meet 1.3-V differential output at 50-Ω bus load. The differential input resistance of this family of transceiver is a minimum of 20 kΩ. If 67 of these transceivers are in parallel on a bus, this is equivalent to an 300-Ω differential load in parallel with the 60 Ω bus termination which gives a total bus load of 50 Ω. Therefore, this family theoretically supports over 67 transceivers on a single bus segment with margin to the 0.9-V minimum differential input voltage requirement at each receiving node. However, for network design, margin must be given for signal loss across the system and cabling, parasitic loadings, timing, network imbalances, ground offsets and signal integrity thus a practical maximum number of nodes is much lower. Bus length 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 on the bus, and significantly lowered data rate.

Typical Application (continued)

This flexibility in network design is one of its key strengths allowing for these system level network extensions and additional standards to build on the typical CAN bus length parameters. However, when using this flexibility the network system designer must take the responsibility of good network design to ensure robust network operation.

9.2.2 Detailed Design Procedure

9.2.2.1 CAN Termination

The ISO 11898 standard specifies the interconnect to be a twisted-pair cable (shielded or unshielded) with 120-Ω characteristic impedance (Z_O). Resistors equal to the characteristic impedance of the line must be used to terminate both ends of the cable to prevent signal reflections. Unterminated drop lines, stubs, connecting nodes to the bus must be kept as short as possible to minimize signal reflections. The termination may be on the cable or in a node, but if nodes may be removed from the bus, the termination must be carefully placed so that it is not removed from the bus

Termination may be a single 120-Ω resistor at the 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 16. Split termination improves the electromagnetic emissions behavior of the network by eliminating fluctuations in the bus common-mode voltages.

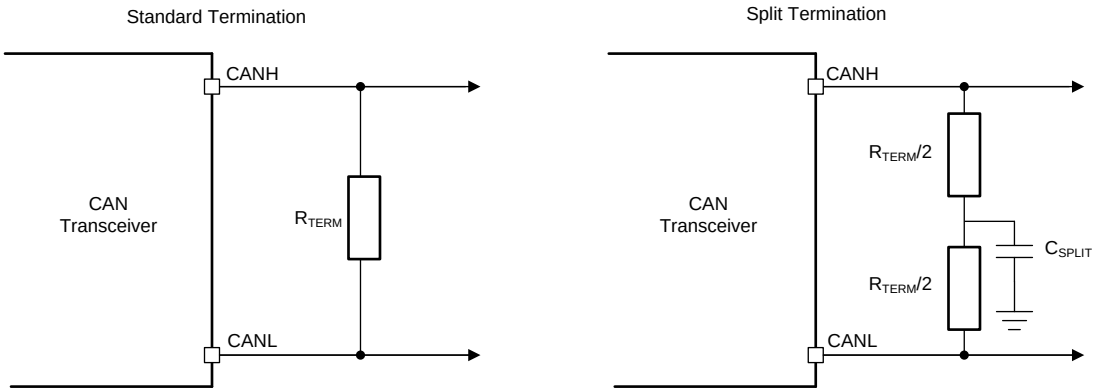


Figure 16. CAN Bus Termination Concepts

The TCAN4420 transceiver supports both 5-V only applications and applications where level shifting is needed for a 3.3-V microcontroller. See Figure 17 and Figure 18 for application examples.

Typical Application (continued)

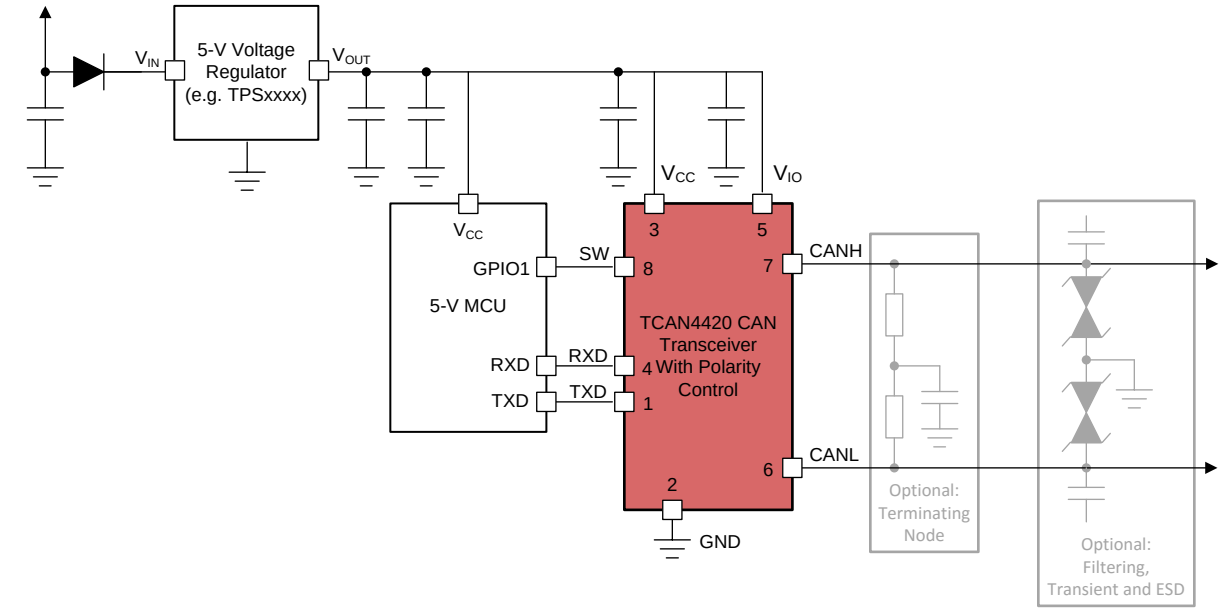


Figure 17. Typical CAN Bus Application Using TCAN4420 with 5 V µC

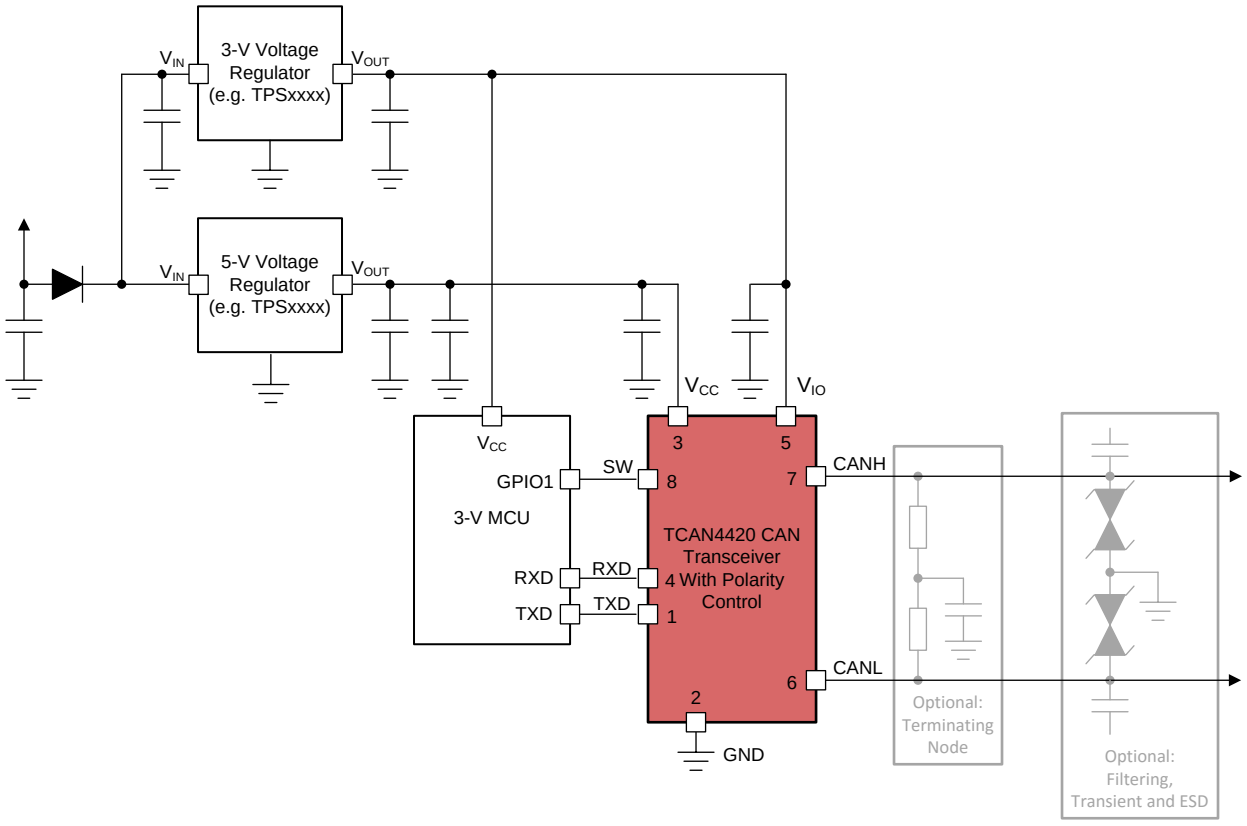


Figure 18. Typical CAN Application Using TCAN4420 with 3.3 V µC

Typical Application (continued)

9.2.3 Application Curves

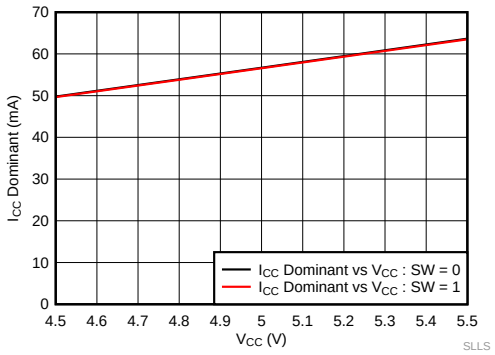


Figure 19. I_{CC} Dominant Current over V_{CC} Supply Voltage

10 Power Supply Recommendations

The TCAN4420 device is designed to operate with a main V_{CC} input voltage supply range between 4.5 V and 5.5 V. The device also has an IO level shifting supply input, V_{IO}, designed for a range between 2.8 V and 5.5 V. To ensure reliable operation at all data rates and supply voltages, each supply should be decoupled with a 100-nF ceramic capacitor located as close to the supply pins as possible. This helps to reduce supply voltage ripple present on the outputs of switched-mode power supplies and also helps to compensate for the resistance and inductance of the PCB power planes.

11 Layout

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

11.1 Layout Guidelines

- Place the protection and filtering circuitry as close to the bus connector, J1, to prevent transients, ESD and noise from propagating onto the board. In this layout example a transient voltage suppression (TVS) device, D1, has been used for added protection. The production solution can be either bi-directional TVS diode or varistor with ratings matching the application requirements. This example also shows optional bus filter capacitors C3 and C4. Additionally (not shown) a series common mode choke (CMC) can be placed on the CANH and CANL lines between the TCAN4420 transceiver and connector J1.
- Design the bus protection components in the direction of the signal path. Do not force the transient current to divert from the signal path to reach the protection device.
- Use supply (V_{CC}) and ground planes to provide low inductance.

NOTE

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

- Use at least two vias for supply (V_{CC}) and ground connections of bypass capacitors and protection devices to minimize trace and via inductance.
- Bypass capacitors should be placed as close as possible to the supply terminals of transceiver, examples are C1 on the V_{CC} supply and C5 on the V_{IO} supply.
- Bus termination: this layout example shows split termination. This is where the termination is split into two resistors, R6 and R7, with the center or split tap of the termination connected to ground via capacitor C2. Split termination provides common mode filtering for the bus. When bus termination is placed on the board instead of directly on the bus, additional care must be taken to ensure the terminating node is not removed from the bus thus also removing the termination. See the application section for information on power ratings needed for the termination resistor(s).
- To limit current of digital lines, serial resistors may be used. Examples are R2, R3, and R4. These are not required.
- Pin 1: R1 is shown optionally for the TXD input of the device. If an open drain host processor is used, this is mandatory to ensure the bit timing into the device is met.
- Pin 5: A bypass capacitor should be placed as close to the pin as possible (example C5). A voltage must be applied to the V_{IO} for normal operation.
- Pin 8: is shows the SW terminal with R4 and R5 as optional resistors. The SW terminal can also be tied to an IO for soft polarity configuration.

11.2 Layout Example

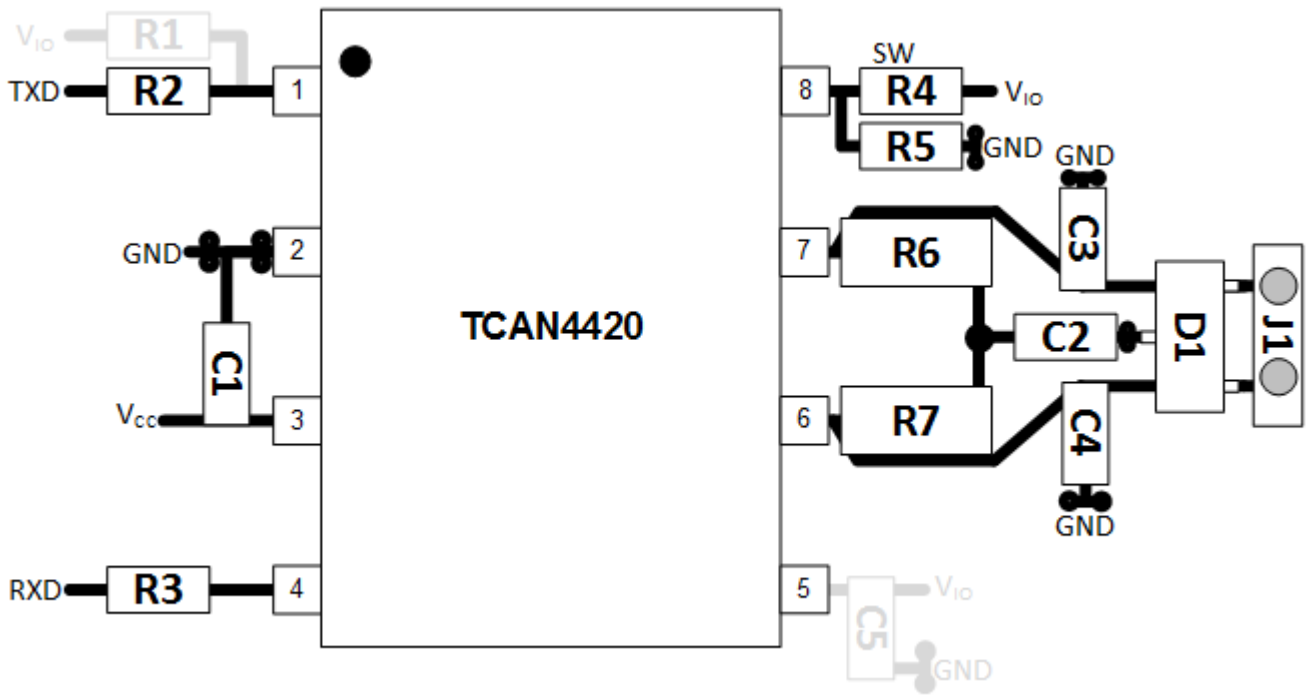


Figure 20. Example Layout

12 Device and Documentation Support

12.1 Device Support

This device will conform to the following CAN standards. The core of what is needed is covered within this system specifications; however, reference should be made to these standards and any discrepancies pointed out and discussed. This document should provide all the basics of what is needed. However, for a full understanding of CAN including the protocol these additional sources will be helpful as the scope of CAN protocol in detail is outside the scope of this physical layer (transceiver) specifications.

12.1.1 Device Nomenclature

CAN Transceiver Physical Layer Standards:

- ISO11898-2 High speed medium access unit (original High Speed CAN transceiver standard)
- ISO11898-5 High speed medium access unit with low power mode (super sets -2 standard electrically in several specs and adds the original wake up capability via the bus in low power mode).

Conformance Test requirements:

- A Comprehensible Guide to Controller Area Network”, Wilfried Voss, Copperhill Media Corporation
- "CAN System Engineering: From Theory to Practical Applications”, 2nd Edition, 2013; Dr. Wolfhard Lawrenz, Springer.

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 Community Resources

The following links connect to TI community resources. Linked contents are provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's Terms of Use.

TI E2E™ Online Community ***TI's Engineer-to-Engineer (E2E) Community.*** Created to foster collaboration among engineers. At e2e.ti.com, you can ask questions, share knowledge, explore ideas and help solve problems with fellow engineers.

Design Support ***TI's Design Support*** Quickly find helpful E2E forums along with design support tools and contact information for technical support.

12.4 Trademarks

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

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

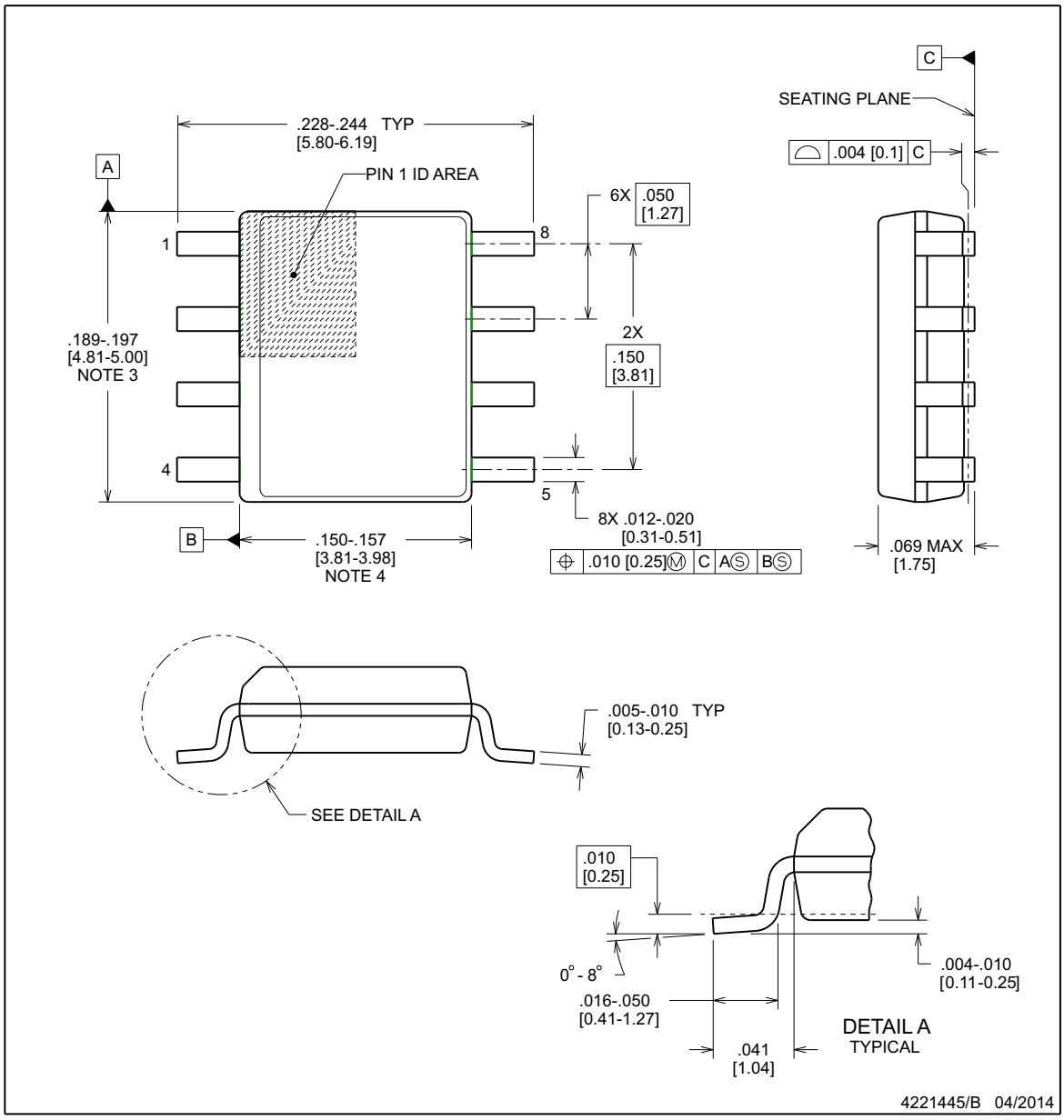
The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand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

PACKAGE OUTLINE

D0008B

SOIC - 1.75 mm max height

SOIC



NOTES:

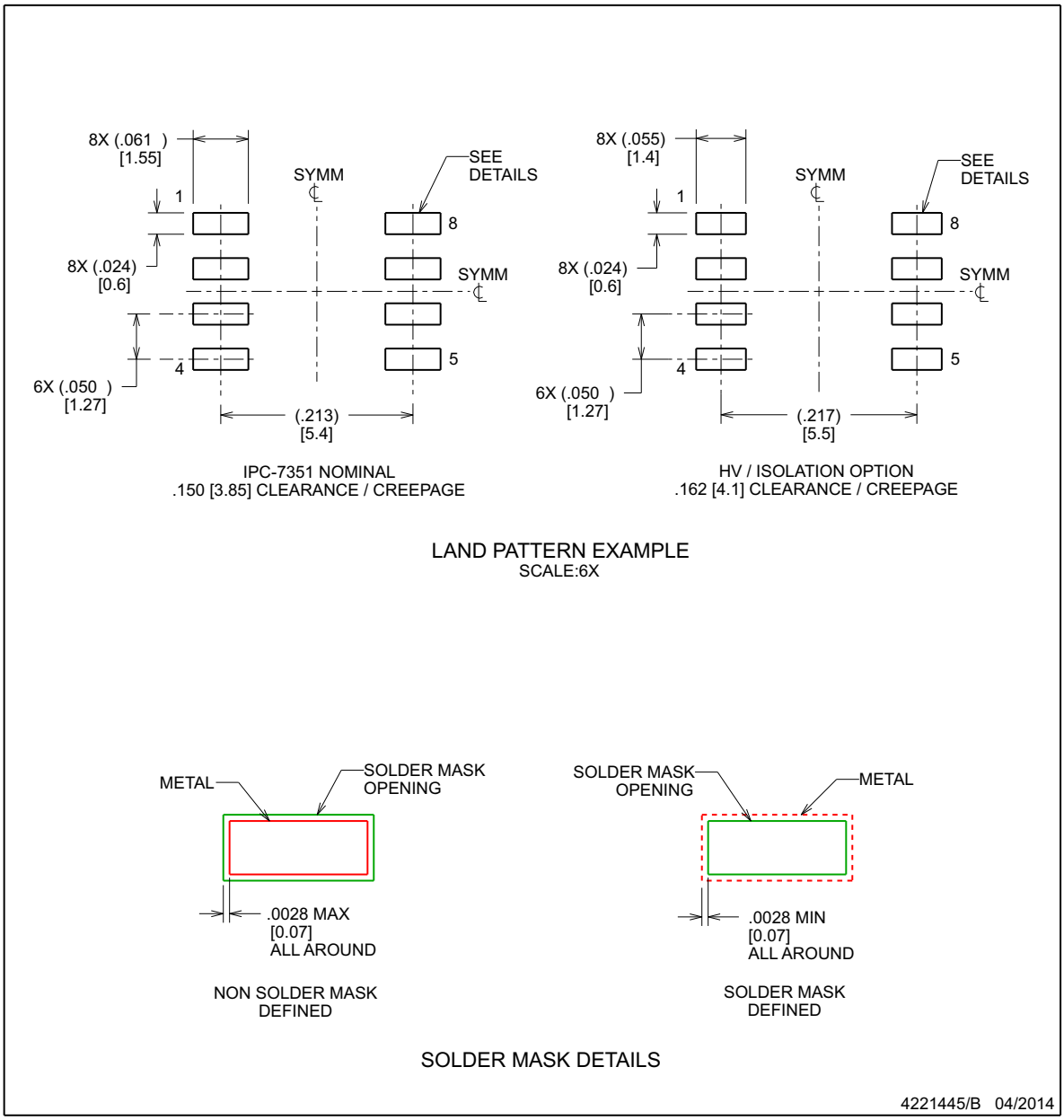
1. Linear dimensions are in inches [millimeters]. Dimensions in parenthesis are for reference only. Controlling dimensions are in inches. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed .006 [0.15], per side.
4. This dimension does not include interlead flash.
5. Reference JEDEC registration MS-012, variation AA.

EXAMPLE BOARD LAYOUT

D0008B

SOIC - 1.75 mm max height

SOIC



NOTES: (continued)

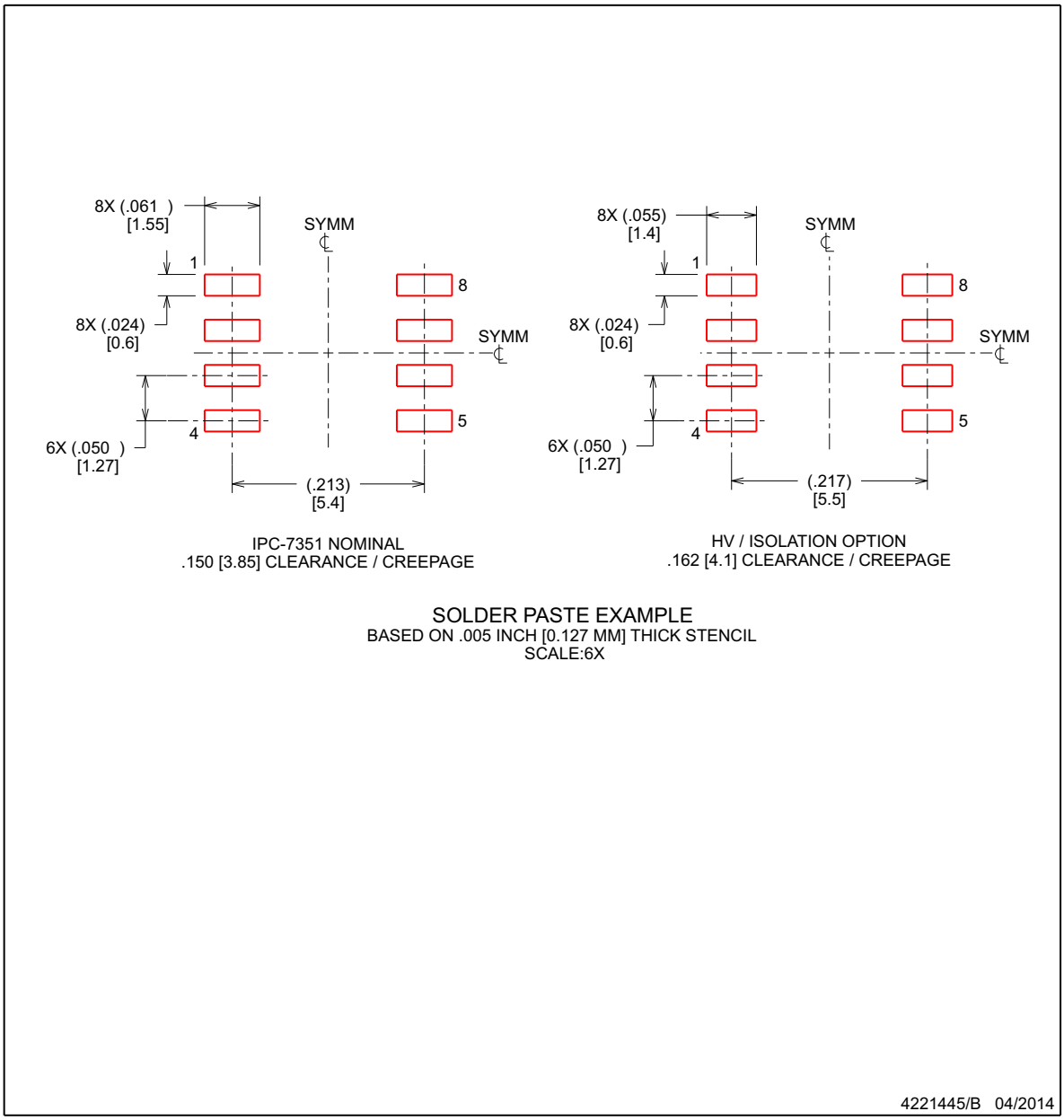
6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

D0008B

SOIC - 1.75 mm max height

SOIC



NOTES: (continued)

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

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)
TCAN4420DR	Active	Production	SOIC (D) | 8	2500 | LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	4420
TCAN4420DR.A	Active	Production	SOIC (D) | 8	2500 | LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	4420

(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.

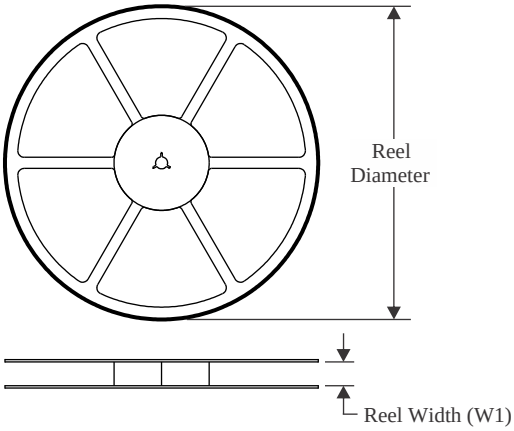
(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will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

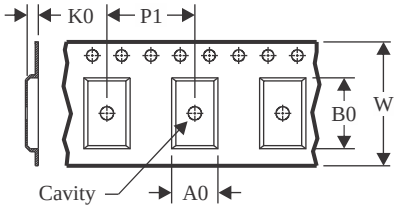
Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

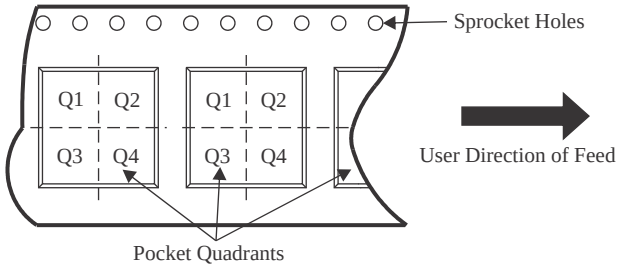


TAPE DIMENSIONS



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

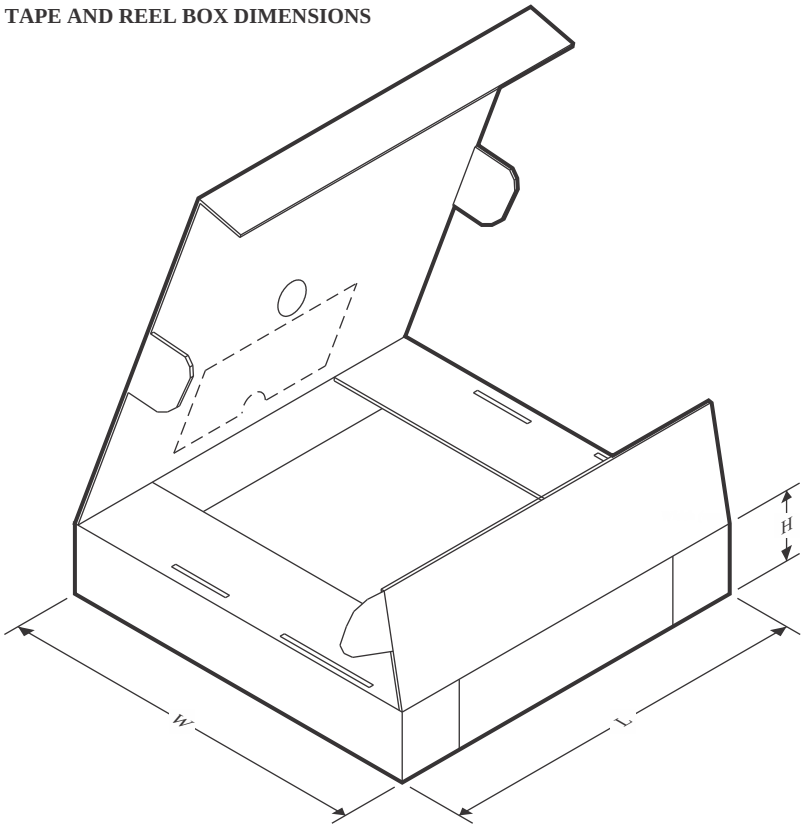
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
TCAN4420DR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TCAN4420DR	SOIC	D	8	2500	353.0	353.0	32.0

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