TEXAS INSTRUMENTS

TCAN1042H, TCAN1042HG
TCAN1042HGV, TCAN1042HV

ZHCSEK9 – FEBRUARY 2016

TCAN1042具有 CAN FD 和故障保护功能的汽车类 CAN 收发器

1 特性

- 符合 ISO11898-2 (2016) 标准的要求
- “Turbo”CAN：
  - 所有器件均支持 2Mbps CAN FD（灵活数据速率），包含“G”后缀的器件支持 5Mbps
  - 短暂且对称的传播延迟时间以及针对增强型时序裕量的快速环路时间
  - 在高负载 CAN 网络中实现更快的数据速率
- I/O 电压范围支持 3.3V 和 5V 微控制器 (MCU)
- 未上电时的理想无源特性
  - 总线和逻辑引脚处于高阻态（无负载）
  - 上电和掉电时总线和 RXD 输出上无毛刺脉冲
- 保护 特性
  - 人体模型 (HBM) ESD 保护超过 ±10kV
  - IEC ESD 保护超过 ±8kV
  - 总线故障保护：±70V
  - V_{CC} 和 V_{IO} 电源引脚上的欠压保护
  - 驱动器显性超时 (TXD DTO) - 数据速率低至 10kbps
  - 热关断保护
- 额定环境温度范围为 –55°C 至 125°C

2 应用

- 所有器件均支持“传统 CAN”和数据速率高达 2Mbps 的 CAN FD 应用
- "G" 器件支持数据速率高达 5Mbps 的 CAN FD 应用
- 所有器件均支持高负载 CAN 网络
- 工业自动化、控制、传感器和驱动系统
- 楼宇安全和恒温控制自动化
- 电信基站状态和控制
- 诸如 CANopen、DeviceNet、NMEA2000、ARNIC825、ISO11783、CANaerospace 的 CAN 总线标准

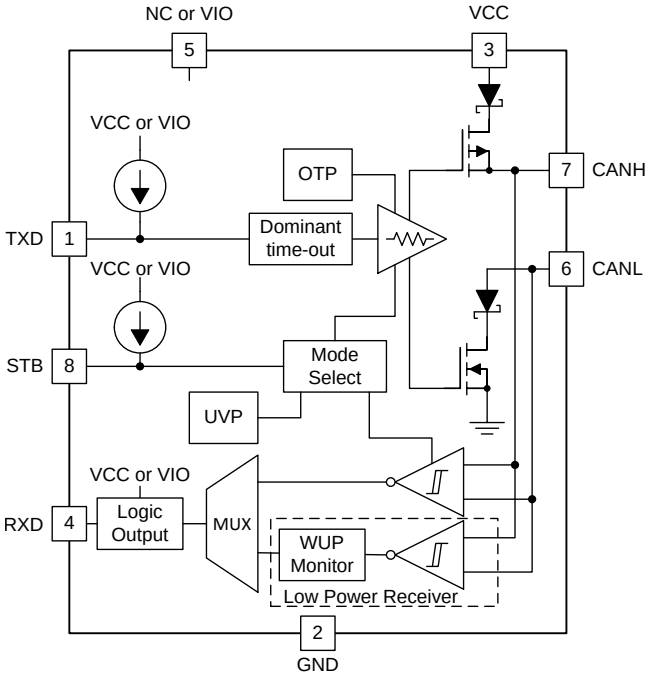
3 说明

这款 CAN 收发器系列符合 ISO1189-2 (2016) 高速 CAN（控制器局域网）物理层标准。所有器件均设计用于数据速率高达 2Mbps（兆位每秒）的 CAN FD 网络。部件号包含“G”后缀的器件设计用于数据速率高达 5Mbps 的 CAN FD 网络，部件号包含“V”后缀的器件配有用于 I/O 电平转换的辅助电源输入（用于设置输入引脚阈值和 RXD 输出电平）。该系列具备低功耗待机模式及远程唤醒请求特性。 此外，所有器件均包含许多保护 功能， 从而提高器件和 CAN 网络的稳定性。

器件信息

订货编号	封装	封装尺寸
TCAN1042Hx	SOIC (8)	4.90mm x 3.91mm

功能框图



A. 引脚 5 的功能取决于器件；在不含 V 后缀的器件上为无连接 (NC) 引脚，在包含 V 后缀的器件上为用于 I/O 电平转换的 V_{IO} 引脚

B. RXD 逻辑输出在不含“V”后缀的器件上驱动为 V_{CC}，而在包含“V”后缀的器件上驱动为 V_{IO}。

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4 修订历史记录

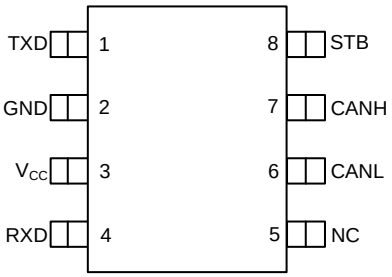
日期	修订版本	注释
2 月 2016	*	最初发布。

5 Device Comparison Table

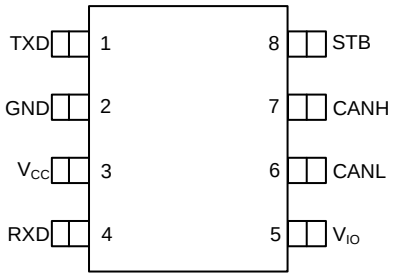
DEVICE NUMBER	BUS FAULT PROTECTION	5-Mbps FLEXIBLE DATA RATE	3-V LEVEL SHIFTER INTEGRATED	PIN 8 MODE SELECTION
TCAN1042H	±70 V			Low Power Standby Mode with Remote Wake
TCAN1042HG	±70 V	X		
TCAN1042HGV	±70 V	X	X	
TCAN1042HV	±70 V		X	

6 Pin Configurations and Functions

D Package for (H) and (HG)
8 PIN (SOIC)
Top View



D Package for (HV) and (HGV)
8 PIN (SOIC)
Top View



Pin Functions

PINS			TYPE	DESCRIPTION
NAME	(H), (HG)	(HV), (HGV)		
TXD	1	1	I	CAN transmit data input (LOW for dominant and HIGH for recessive bus states)
GND	2	2	GND	Ground connection
VCC	3	3	I	Transceiver 5-V supply voltage
RXD	4	4	O	CAN receive data output (LOW for dominant and HIGH for recessive bus states)
NC	5	—	—	No Connect
V_{IO}	—	5	I	Transceiver I/O level shifting supply voltage (Devices with "V" suffix only)
CANL	6	6	I/O	Low level CAN bus line
CANH	7	7	I/O	High level CAN bus line
STB	8	8	I	Standby Mode control input (active high)

7 Specifications

7.1 Absolute Maximum Ratings (1) (2)

			MIN	MAX	UNIT
V_{CC}	5V bus supply voltage range		–0.3	+7	V
V_{IO}	I/O Level Shifting Voltage Range	Devices with the "V" suffix	–0.3	+7	
V_{BUS}	CAN Bus I/O voltage range (CANH, CANL)	Devices with the "H" suffix	-70	+70	
$V_{(Logic\_Input)}$	Logic input terminal voltage range (TXD, STB)		–0.3	+7 and $V_I \le V_{IO}$ + 0.3	
$V_{(Logic\_Output)}$	Logic output terminal voltage range (RXD)		–0.3	+7 and $V_I \le V_{IO}$ + 0.3	
$I_{O(RXD)}$	RXD (Receiver) output current		-8	+8	mA
T_J	Operating virtual junction temperature range (see Thermal Information)		–55	150	°C

(1) Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. 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.

7.2 ESD Ratings

	TEST CONDITIONS		VALUE	UNIT
Human Body Model (HBM) ESD stress voltage	All terminals (1)		±6000	V
	CAN bus terminals (CANH, CANL) to GND (2)		±10000	
Charged Device Model (CDM) ESD stress voltage	All terminals (3)		±750	V
Machine Model (MM)	All terminals (4)		±200	
System Level Electro-Static Discharge (ESD)	CAN bus terminals (CANH, CANL) to GND	IEC 61400-4-2: Unpowered Air Discharge	±15000	V
		IEC 61400-4-2: Powered on Contact Discharge	±8000	

(1) Tested in accordance to JEDEC Standard 22, Test Method A114.
(2) Test method based upon JEDEC Standard 22 Test Method A114, CAN bus is stressed with respect to GND.
(3) Tested in accordance to JEDEC Standard 22, Test Method C101.
(4) Tested in accordance to JEDEC Standard 22, Test Method A115.

7.3 Recommended Operating Conditions

		MIN	MAX	UNIT
V_{CC}	5V Bus Supply Voltage Range	4.5	5.5	V
V_{IO}	I/O Level Shifting Voltage Range	3	5.5	
$I_{OH(RXD)}$	RXD terminal HIGH level output current	–2		mA
$I_{OL(RXD)}$	RXD terminal LOW level output current		2	

7.4 Thermal Information

THERMAL METRIC(1)		TEST CONDITIONS	TCAN1042 D (SOIC) 8 Pins	UNIT
$R_{\theta JA}$	Junction-to-air thermal resistance	High-K thermal resistance(2)	105.8	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance(3)		46.8	°C/W
$R_{\theta JC(TOP)}$	Junction-to-case (top) thermal resistance(4)		48.3	°C/W
Ψ_{JT}	Junction-to-top characterization parameter(5)		8.7	°C/W
Ψ_{JB}	Junction-to-board characterization parameter(6)		46.2	°C/W
P_D	Average power dissipation	V_{CC} = 5 V, V_{RXD} = 5 V, T_J = 27°C, R_L = 60 Ω, STB at 0 V, Input to TXD at 250 kHz, 25% duty cycle square wave, C_{L_RXD} = 15 pF. Typical CAN operating conditions at 500kbps with 25% transmission (dominant) rate.	115	mW
		V_{CC} = 5.5 V, V_{RXD} = 5.5 V, T_J = 150°C, R_L = 50 Ω, STB at 0 V, 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 (dominant) rate and loaded network.	268	
	Thermal shutdown temperature		170	°C
	Thermal shutdown hysteresis		5	°C

(1) For more information about traditional and new thermal metrics, see the IC Package Thermal Metrics application report, SPRA953.
(2) The junction-to-ambient thermal resistance under natural convection is obtained in a simulation on a JEDEC-standard, High-K board, as specified in JESD51-7, in an environment described in JESD51-2a.
(3) The junction-to-board thermal resistance is obtained by simulating in an environment with a ring cold plate fixture to control the PCB temperature, as described in JESD51-8.
(4) The junction-to-case (top) thermal resistance is obtained by simulating a cold plate test on the package top. No specific JEDEC-standard test exists, but a close description can be found in the ANSI SEMI standard G30-88.
(5) The junction-to-top characterization parameter, Ψ_{JT}, estimates the junction temperature of a device in a real system and is extracted from the simulation data for obtaining θ_{JA}, using a procedure described in JESD51-2a (sections 6 and 7).
(6) The junction-to-board characterization parameter, Ψ_{JB} estimates the junction temperature of a device in a real system and is extracted from the simulation data for obtaining θ_{JA}, using a procedure described in JESD51-2a (sections 6 and 7).

7.5 Electrical Characteristics

Over recommended operating conditions with T_A = –55°C to 125°C (unless otherwise noted).

PARAMETER			TEST CONDITIONS	MIN	TYP(1)	MAX	UNIT
SUPPLY CHARACTERISTICS							
I_{CC}	5-V Supply current	Normal Mode (Driving Dominant)	See 图 5, TXD = 0 V, R_L = 60 Ω, C_L = open, R_{CM} = open, STB = 0 V, Typical Bus Load		40	70	mA
			See 图 5, TXD = 0 V, R_L = 50 Ω, C_L = open, R_{CM} = open, STB = 0 V, High Bus Load		45	80	
		Normal Mode (Driving Dominant – with bus fault)	See 图 5, TXD = 0 V, STB = 0V, CANH = -12V, R_L = open, C_L = open, R_{CM} = open			180	
		Normal Mode (Recessive)	See 图 5, TXD = V_{CC} or V_{IO}, R_L = 50 Ω, C_L = open, R_{CM} = open, STB = 0V		1.5	2.5	
		Standby Mode	Devices with the "V" suffix (I/O Level Shifting Devices), V_{CC} not needed in Standby Mode, See 图 5, TXD = V_{IO}, R_L = 50 Ω, C_L = open, R_{CM} = open, STB = V_{IO}		0.5	5	µA
			Devices without the "V" suffix (5V only), See 图 5, TXD = V_{CC}, R_L = 50 Ω, C_L = open, R_{CM} = open, STB = V_{CC}			22	
I_{IO}	I/O Supply Current	Normal Mode	RXD floating, TXD = STB = 0 or 5.5 V		90	300	
		Standby Mode	RXD floating, TXD = STB = V_{IO}, V_{CC} = 0 or 5.5 V		12	17	
UV_{VCC}	Rising Undervoltage detection on V_{CC} for protected mode				4.2	4.4	V
	Falling Undervoltage detection on V_{CC} for protected mode			3.8	4.0	4.25	
$V_{HYS(UVVCC)}$	Hysteresis voltage on UV_{VCC}				200		mV
$UV_{(VIO)}$	Undervoltage detection on V_{IO} for protected mode		Devices with the "V" suffix (I/O Level Shifting Devices)	1.3		2.75	V
$V_{HYS(UVIO)}$	Hysteresis voltage on UV_{IO}				80		mV
STB TERMINAL (MODE SELECT INPUT)							
V_{IH}	HIGH-level input voltage		Devices with the "V" suffix (I/O Level Shifting Devices)	0.7 x V_{IO}			V
			Devices without the "V" suffix (5V only)	2			
V_{IL}	LOW-level input voltage		Devices with the "V" suffix (I/O Level Shifting Devices)			0.3 x V_{IO}	
			Devices without the "V" suffix (5V only)			0.8	
I_{IH}	HIGH-level input leakage current		STB = V_{CC} = V_{IO} = 5.5 V	-2		2	µA
I_{IL}	Low-level input leakage current		STB = 0V, V_{CC} = V_{IO} = 5.5 V	–20	0	-2	
$I_{lkg(OFF)}$	Unpowered leakage current		STB = 5.5 V, V_{CC} = V_{IO} = 0 V	-1	0	1	
TXD TERMINAL (CAN TRANSMIT DATA INPUT)							
V_{IH}	HIGH level input voltage		Devices with the "V" suffix (I/O Level Shifting Devices)	0.7 x V_{IO}			V
			Devices without the "V" suffix (5V only)	2			
V_{IL}	LOW level input voltage		Devices with the "V" suffix (I/O Level Shifting Devices)			0.3 x V_{IO}	V
			Devices without the "V" suffix (5V only)			0.8	
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 = 0V, V_{CC} = V_{IO} = 5.5 V	–100	-25	–7	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				5		pF

(1) All typical values are at 25°C and supply voltages of V_{CC} = 5 V and V_{IO} = 5 V, R_L = 60 Ω.

Electrical Characteristics (continued)

Over recommended operating conditions with T_A = –55°C to 125°C (unless otherwise noted).

PARAMETER			TEST CONDITIONS	MIN	TYP(1)	MAX	UNIT
RXD TERMINAL (CAN RECEIVE DATA OUTPUT)							
V_{OH}	HIGH level output voltage		Devices with the "V" suffix (I/O Level Shifting Devices), See 图 6, I_O = –2 mA.	0.8 × V_{IO}			V
			Devices without the "V" suffix (5V only), See 图 6, I_O = –2 mA.	4	4.6		
V_{OL}	LOW level output voltage		Devices with the "V" suffix (I/O Level Shifting Devices), See 图 6, I_O = +2 mA.			0.2 x V_{IO}	
			Devices without the "V" suffix (5V only), See 图 6, I_O = +2 mA.		0.2	0.4	
$I_{lkg(OFF)}$	Unpowered leakage current		RXD = 5.5 V, V_{CC} = 0 V, V_{IO} = 0 V	–1	0	1	µA
DRIVER ELECTRICAL CHARACTERISTICS							
$V_{O(D)}$	Bus output voltage (dominant)	CANH	See 图 13 and 图 5, 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	
$V_{O(R)}$	Bus output voltage (recessive)	CANH and CANL	See 图 13 and 图 5, TXD = V_{CC} or V_{IO}, V_{IO} = V_{CC}, STB = 0 V , R_L = open (no load), R_{CM} = open	2	0.5 × V_{CC}	3	
$V_{OD(D)}$	Differential output voltage (dominant)	CANH - CANL	See 图 13 and 图 5, TXD = 0 V, STB = 0 V, 50 Ω ≤ R_L ≤ 65 Ω, C_L = open, R_{CM} = open	1.5		3	
			See 图 13 and 图 5, TXD = 0 V, STB = 0 V, 45 Ω ≤ R_L < 50 Ω, C_L = open, R_{CM} = open	1.4		3	
$V_{OD(R)}$	Differential output voltage (recessive)	CANH - CANL	See 图 13 and 图 5, TXD = V_{CC}, STB = 0 V, R_L = 60 Ω, C_L = open, R_{CM} = open	–120		12	mV
			See 图 13 and 图 5, TXD = V_{CC}, STB = 0 V, R_L = open (no load), C_L = open, R_{CM} = open	–50		50	
V_{SYM}	Output symmetry (dominant or recessive) (V_{CC} – $V_{O(CANH)}$ – $V_{O(CANL)}$)		See 图 13 and 图 5, STB at 0 V, R_L = 60 Ω, C_L = open, R_{CM} = open	–0.4		0.4	V
$I_{OS(SS\_DOM)}$	Short circuit steady-state output current, Dominant		See 图 13 and 图 11, STB at 0 V, V_{CANH} = 0 V, CANL = open, TXD = 0 V	–100			mA
			See 图 13 and 图 11, STB at 0 V, V_{CANL} = 32 V, CANH = open, TXD = 0 V			100	
$I_{OS(SS\_REC)}$	Short circuit steady-state output current, Recessive		See 图 13 and 图 11, STB at 0 V, –20 V ≤ V_{BUS} ≤ 32 V, Where V_{BUS} = CANH = CANL, TXD = V_{CC}, Normal Mode	–5		5	mA
RECEIVER ELECTRICAL CHARACTERISTICS							
CM	Common mode range, normal mode		See 图 6 and 表 1, STB = 0 V	-30		+30	V
V_{IT+}	Positive-going input threshold voltage, normal mode		See 图 6, 表 6 and 表 1, STB = 0 V, -20 V ≤ CM ≤ +20 V			900	mV
$V_{IT–}$	Negative-going input threshold voltage, normal mode			500			
V_{IT+}	Positive-going input threshold voltage, normal mode		See 图 6, 表 6 and 表 1, STB = 0 V, -30 V ≤ CM ≤ +30 V			1000	
$V_{IT–}$	Negative-going input threshold voltage, normal mode			400			
V_{HYS}	Hysteresis voltage (V_{IT+} - $V_{IT–}$), normal mode		See 图 6, 表 6 and 表 1, STB = 0 V		120		

Electrical Characteristics (continued)

Over recommended operating conditions with T_A = –55°C to 125°C (unless otherwise noted).

PARAMETER		TEST CONDITIONS	MIN	TYP(1)	MAX	UNIT
CM	Common mode range, standby mode	Devices with the "V" suffix (I/O Level Shifting Devices), See 图 6, 表 6 and 表 1, STB = V_{IO}, 4.5 V ≤ V_{IO} ≤ 5.5 V	-12		12	V
		Devices with the "V" suffix (I/O Level Shifting Devices), See 图 6, 表 6 and 表 1, STB = V_{IO}, 3.0 V ≤ V_{IO} ≤ 4.5 V	-2		+7	
		Devices without the "V" suffix (5V only), See 图 6, 表 6 and 表 1, STB = V_{CC}	-12		12	
$V_{IT(STANDBY)}$	Input threshold voltage, standby mode	STB = V_{CC} or V_{IO}	400		1150	mV
$I_{LKG(IOFF)}$	Power-off (unpowered) bus input leakage current	CANH = CANL = 5 V, V_{CC} = V_{IO} = 0 V			6	µA
C_I	Input capacitance to ground (CANH or CANL)	TXD = V_{CC}, V_{IO} = V_{CC}, V_I = 0.4 sin (4E6 π t) + 2.5 V		24	30	pF
C_{ID}	Differential input capacitance (CANH to CANL)	TXD = V_{CC}, V_{IO} = V_{CC}, V_I = 0.4 sin (4E6 π t)		12	15	
R_{ID}	Differential input resistance	TXD = V_{CC} = V_{IO} = 5 V, STB = 0 V	30		80	kΩ
R_{IN}	Input resistance (CANH or CANL)		15		40	
$R_{IN(M)}$	Input resistance matching: [1 – $R_{IN(CANH)}$ / $R_{IN(CANL)}$] × 100%	$V_{(CANH)}$ = $V_{(CANL)}$	–2%		2%	

7.6 Switching Characteristics

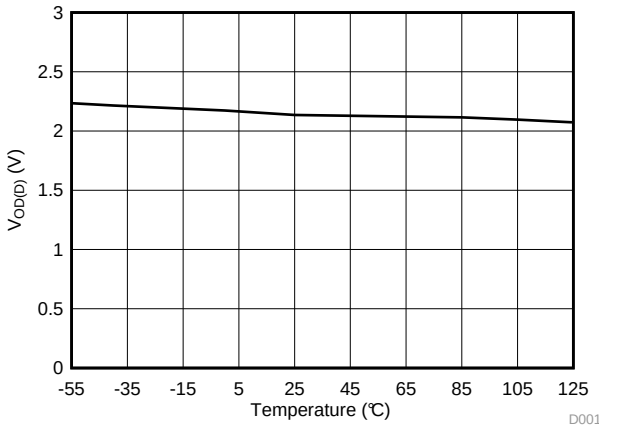
Over recommended operating conditions with T_A = -55°C to 125°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP(1)	MAX	UNIT
DEVICE SWITCHING CHARACTERISTICS						
$t_{PROP(LOOP1)}$	Total loop delay, driver input (TXD) to receiver output (RXD), recessive to dominant	See 图 8, STB = 0 V, R_L = 60 Ω, C_L = 100 pF, $C_{L(RXD)}$ = 15 pF		100	160	ns
$t_{PROP(LOOP2)}$	Total loop delay, driver input (TXD) to receiver output (RXD), dominant to recessive			110	175	
t_{MODE}	Mode change time, from Normal to Standby or from Standby to Normal	See 图 7		1	45	µs
t_{WK_FILTER}			0.5		1.85	
DRIVER SWITCHING CHARACTERISTICS						
t_{pHR}	Propagation delay time, HIGH TXD to Driver Recessive	See 图 5, STB = 0 V, R_L = 60 Ω, C_L = 100 pF, R_{CM} = open		75		ns
t_{pLD}	Propagation delay time, LOW TXD to Driver Dominant			55		
$t_{sk(p)}$	Pulse skew ($\lvert t_{pHR} - t_{pLD} \rvert$)			20		
t_R	Differential output signal rise time			45		
t_F	Differential output signal fall time			45		
t_{TXD_DTO}	Dominant timeout(2)	See 图 10, STB = 0 V, R_L = 60 Ω, C_L = open	1.2		3.8	ms
RECEIVER SWITCHING CHARACTERISTICS						
t_{pRH}	Propagation delay time, bus recessive input to high output	See 图 6, STB = 0 V, $C_{L(RXD)}$ = 15 pF		65		ns
t_{pDL}	Propagation delay time, bus dominant input to low output			50		ns
t_R	RXD Output signal rise time			10		ns
t_F	RXD Output signal fall time			10		ns
FD Timing Parameters						
$t_{BIT(BUS)}$	Bit time on CAN bus output pins with $t_{BIT(TXD)}$ = 500 ns, all devices	See 图 9 , STB = 0 V, R_L = 60Ω, C_L = 100pF, $C_{L(RXD)}$ = 15pF	435		530	ns
	Bit time on CAN bus output pins with $t_{BIT(TXD)}$ = 200 ns, G device variants only		155		210	
$t_{BIT(RXD)}$	Bit time on RXD output pins with $t_{BIT(TXD)}$ = 500 ns, all devices		400		550	
	Bit time on RXD output pins with $t_{BIT(TXD)}$ = 200 ns, G device variants only		120		220	
Δt_{REC}	Receiver timing symmetry with $t_{BIT(TXD)}$ = 500 ns, all devices		-65		40	
	Receiver timing symmetry with $t_{BIT(TXD)}$ = 200 ns, G device variants only		-45		15	

(1) All typical values are at 25°C and supply voltages of V_{CC} = 5 V and V_{IO} = 5 V, R_L = 60 Ω.

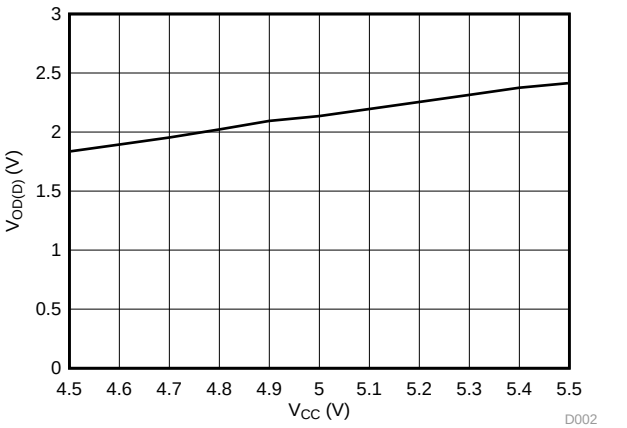
(2) The TXD dominant timeout ($t_{(TXD\_DTO)}$) disables the driver of the transceiver once the TXD has been dominant longer than $t_{(TXD\_DTO)}$, which releases the bus lines to recessive, preventing a local failure from locking the bus dominant. The driver may only transmit dominant again after TXD 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 / $t_{(TXD\_DTO)}$

7.7 Typical Characteristics



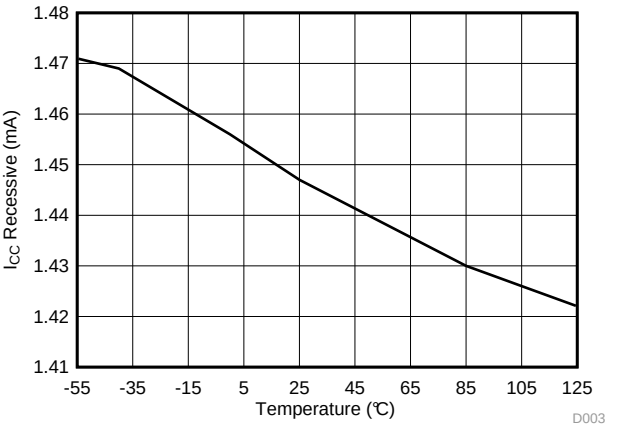
V_{CC} = 5 V　　V_{IO} = 3.3 V　　R_L = 60 Ω
C_L = Open　　RCM = Open　　STB = 0 V

图 1. $V_{OD(D)}$ over Temperature



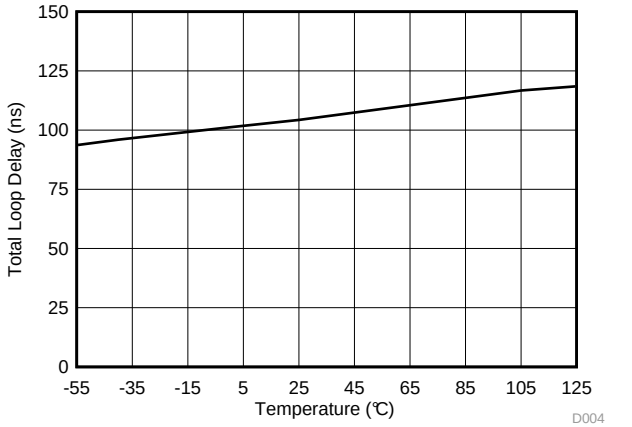
V_{IO} = 5 V　　STB = 0 V　　R_L = 60 Ω
C_L = Open　　RCM = Open　　Temp = 25°C

图 2. $V_{OD(D)}$ over V_{CC}



V_{CC} = 5 V　　V_{IO} = 3.3 V　　R_L = 60 Ω
C_L = Open　　RCM = Open　　STB = 0 V

图 3. I_{CC} Recessive over Temperature



V_{CC} = 5 V　　V_{IO} = 3.3 V　　R_L = 60 Ω
C_L = 100 pF　　C_{L_RXD} = 15 pF　　STB = 0 V

图 4. Total Loop Delay over Temperature

8 Parameter Measurement Information

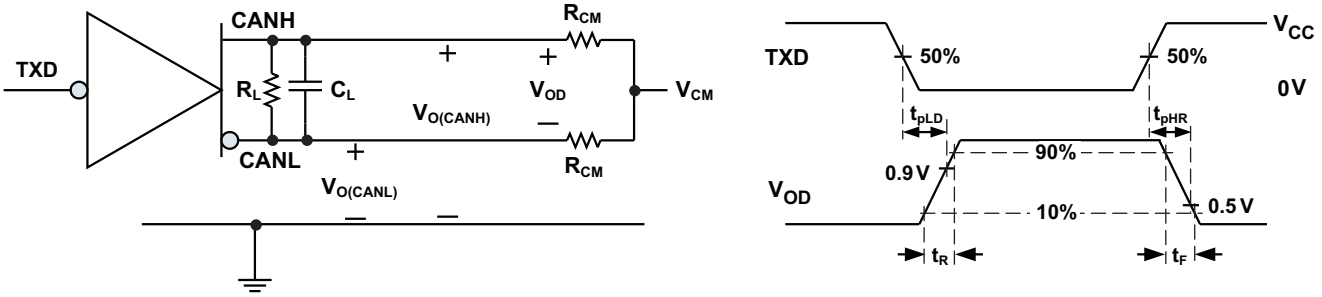


图 5. Driver Test Circuit and Measurement

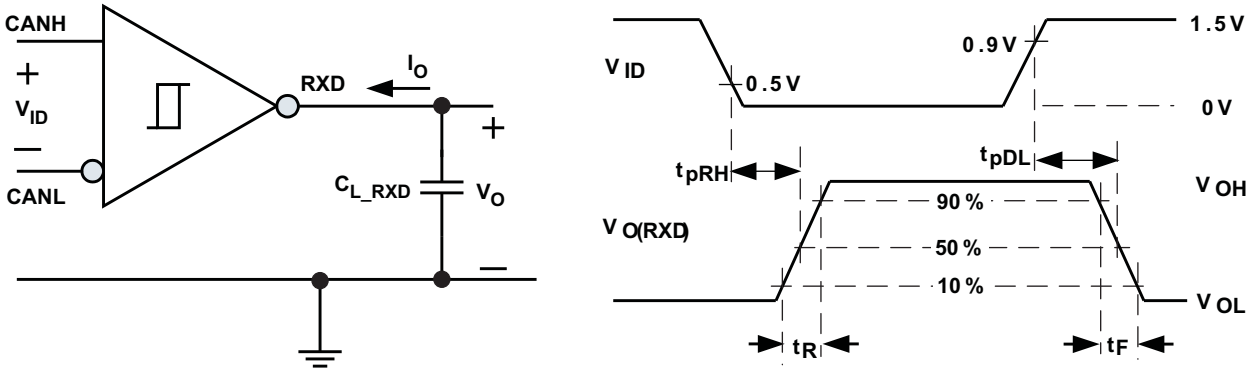


图 6. Receiver Test Circuit and Measurement

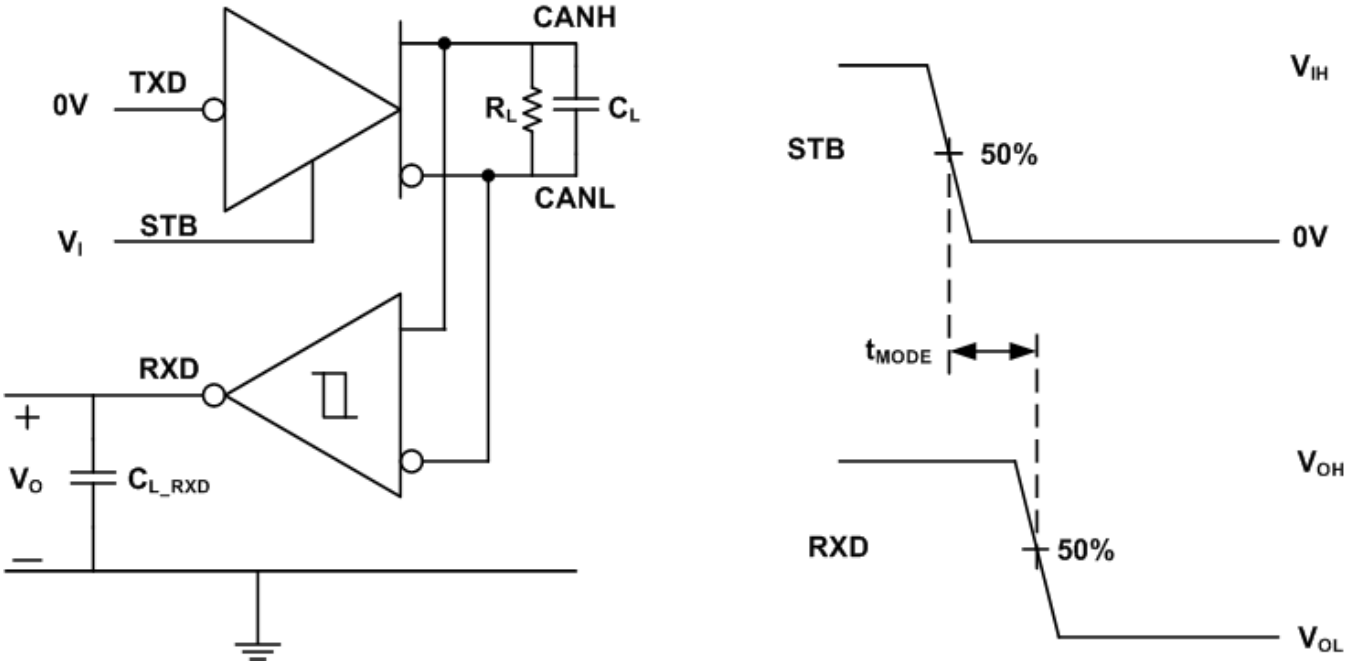


图 7. t_{MODE} Test Circuit and Measurement

Parameter Measurement Information (接下页)

表 1. Receiver Differential Input Voltage Threshold Test

INPUT			OUTPUT	
V_{CANH}	V_{CANL}	$\lvert V_{ID}\rvert$	RXD	
-29.5	-30.5	1000 mV	L	V_{OL}
30.5	29.5	1000 mV	L	
-19.55	-20.45	900 mV	L	
20.45	19.55	900 mV	L	
-19.75	-20.25	500 mV	H	V_{OH}
20.25	19.75	500 mV	H	
-29.8	-30.2	400 mV	H	
30.2	29.8	400 mV	H	
Open	Open	X	H	

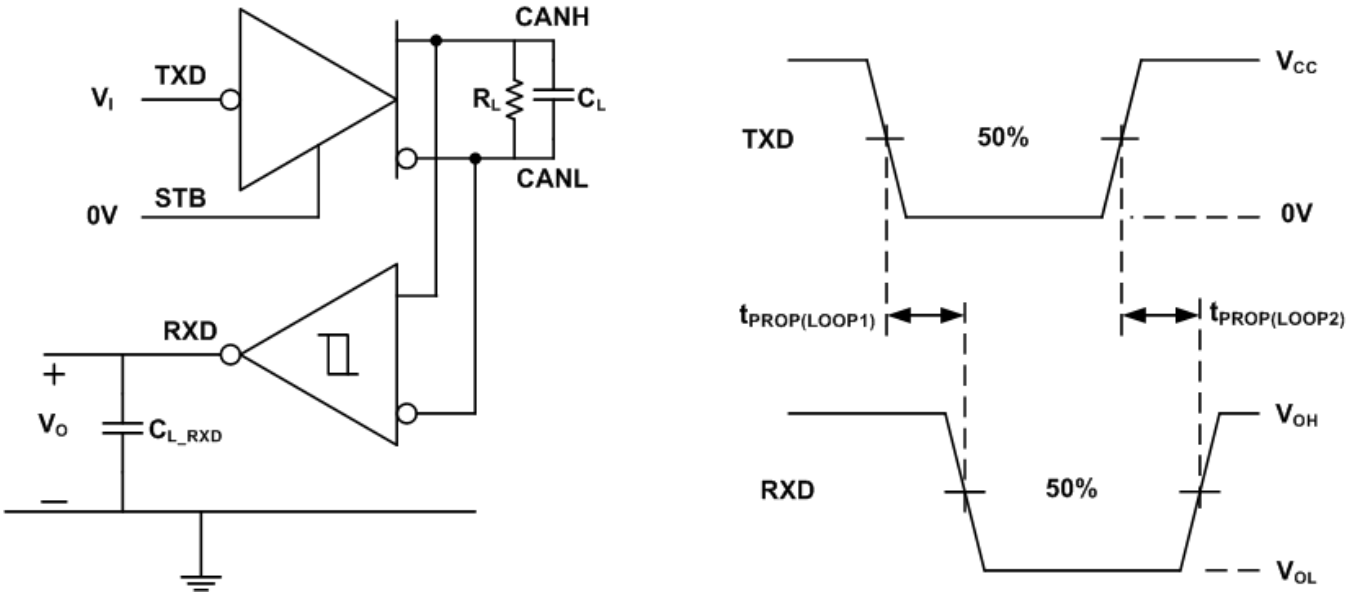


图 8. $T_{PROP(LOOP)}$ Test Circuit and Measurement

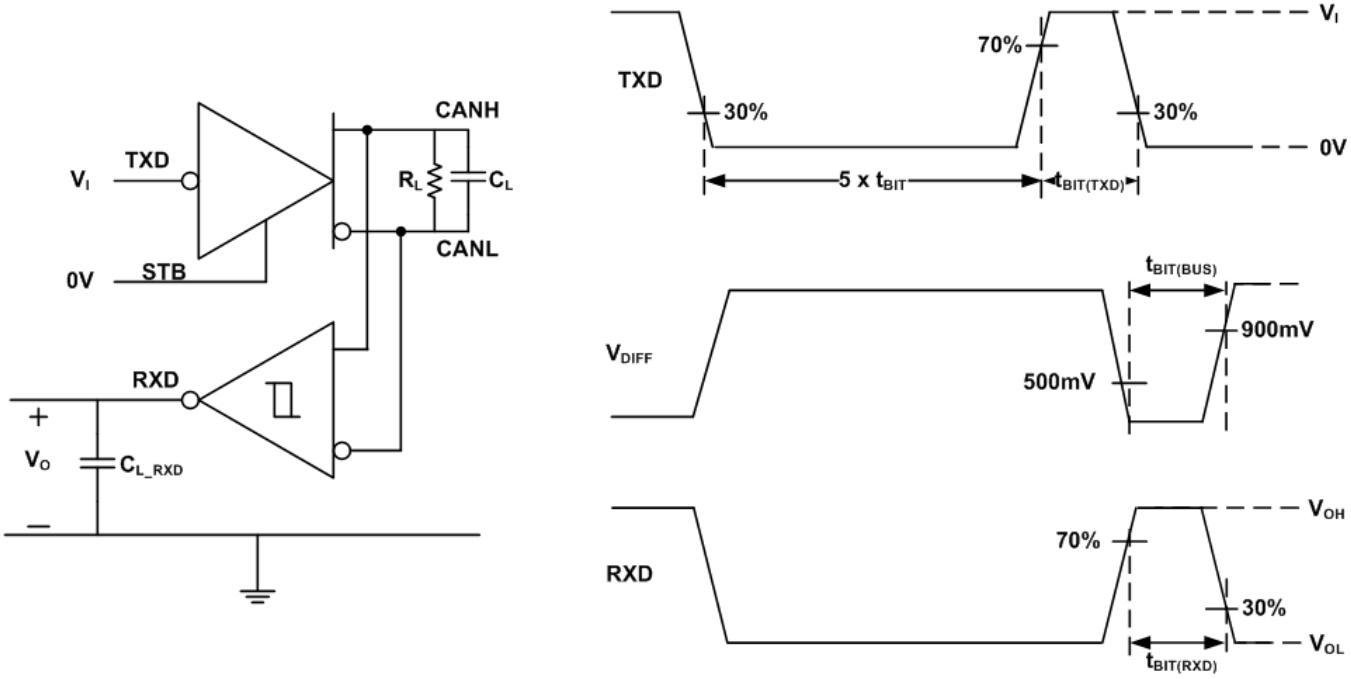


图 9. CAN FD Timing Parameter Measurement

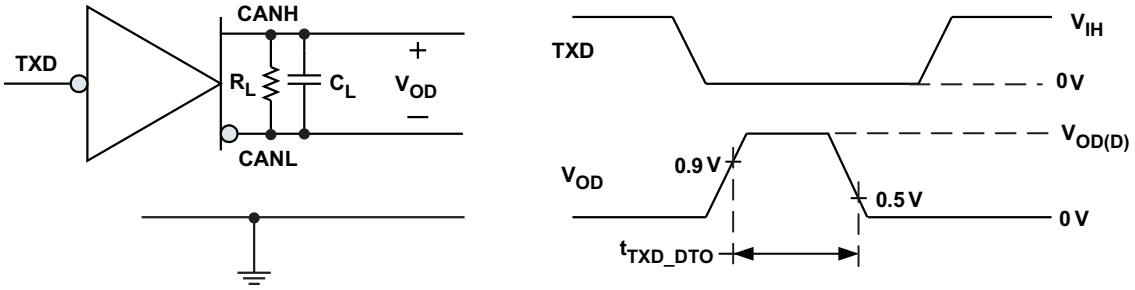


图 10. TXD Dominant Timeout Test Circuit and Measurement

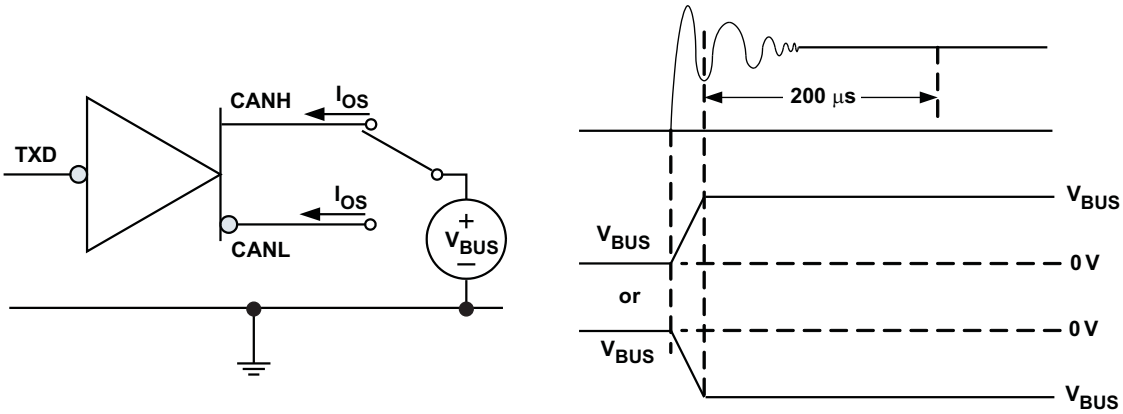


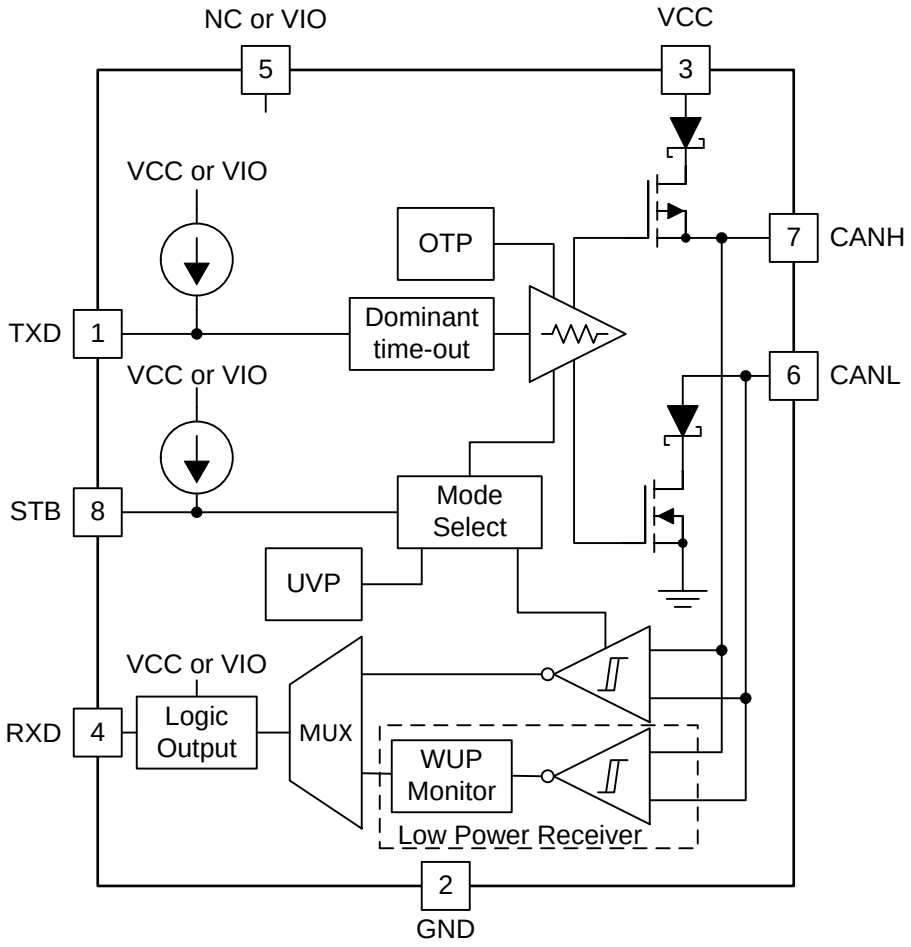
图 11. Driver Short Circuit Current Test and Measurement

9 Detailed Description

9.1 Overview

These CAN transceivers meet the ISO1189-2 (2016) High Speed CAN (Controller Area Network) physical layer standard. They are designed for data rates in excess of 1 Mbps for CAN FD, and enhanced timing margin / higher data rates in long and highly-loaded networks. These devices provide many protection features to enhance device and CAN-network robustness.

9.2 Functional Block Diagram



9.3 Feature Description

9.3.1 TXD Dominant Timeout (DTO)

During normal mode (the only mode where the CAN driver is active), the TXD DTO circuit prevents the transceiver 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 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.

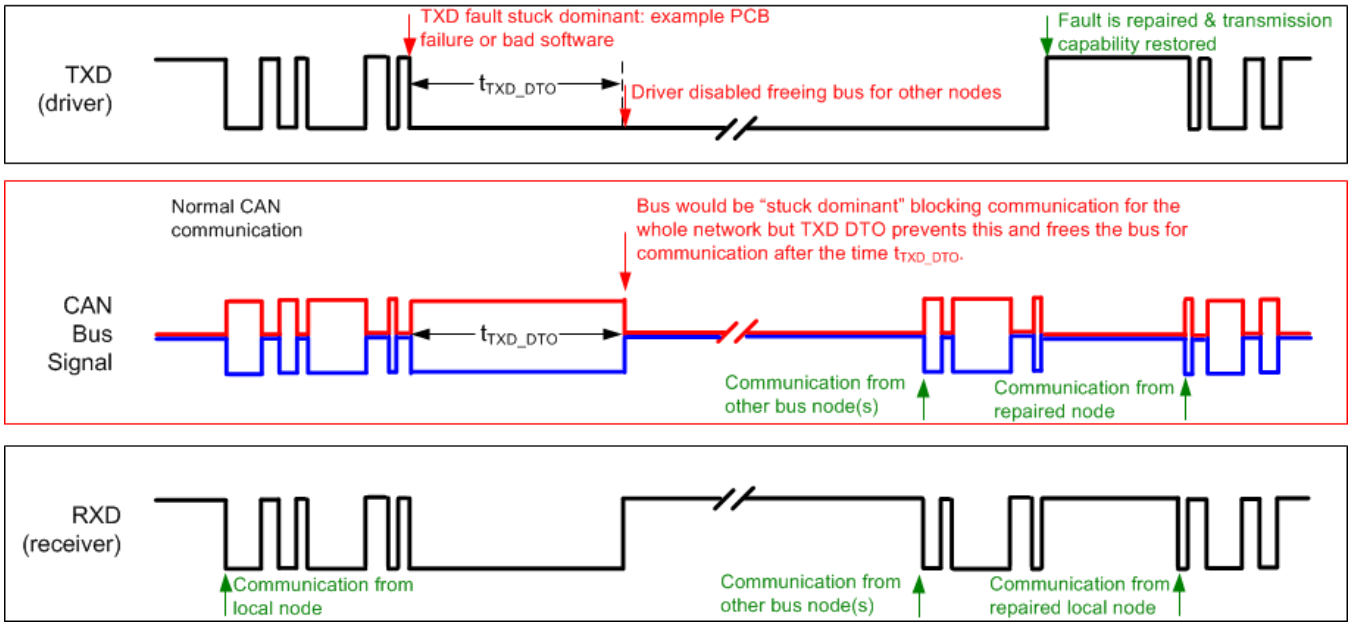


图 12. Example Timing Diagram for TXD DTO

注

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. This, along with the t_{TXD_DTO} minimum, limits the minimum data rate. Calculate the minimum transmitted data rate by: Minimum Data Rate = 11 / t_{TXD_DTO}.

9.3.2 Thermal Shutdown

If the junction temperature of the device exceeds the thermal shut down threshold, the device turns off the CAN driver circuits thus blocking the TXD to bus transmission path. The shutdown condition is cleared when the junction temperature drops below the thermal shutdown temperature of the device.

注

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

Feature Description (接下页)

9.3.3 Undervoltage Lockout

The supply terminals have undervoltage detection that places the device in protected mode. This protects the bus during an undervoltage event on either the V_{CC} or V_{IO} supply terminals.

表 2. Undervoltage Lockout 5 V Only Devices (Devices without the "V" Suffix)(1)

V_{CC}	DEVICE STATE	BUS OUTPUT	RXD
GOOD	Normal	Per Device State and TXD	Mirrors Bus
BAD	Protected	High Impedance	High Impedance (3-state)

(1) See the V_{IT} section of the *Electrical Characteristics*.

表 3. Undervoltage Lockout I/O Level Shifting Devices (Devices with the "V" Suffix)

V_{CC}	V_{IO}	DEVICE STATE	BUS OUTPUT	RXD
GOOD	GOOD	Normal	Per STB and TXD	Mirrors Bus
BAD	GOOD	Protected	High Impedance	High (Recessive)
GOOD	BAD	Protected	Recessive	High Impedance (3-state)
BAD	BAD	Protected	High Impedance	High Impedance (3-state)

注

After an undervoltage condition is cleared and the supplies have returned to valid levels, the device typically resumes normal operation within 300 µs.

9.3.4 Unpowered Device

The device is designed to be an 'ideal passive' or 'no load' to the CAN bus if it is unpowered. The bus terminals (CANH, CANL) have extremely low leakage currents when the device is unpowered so they will not load down the bus. This is critical if some nodes of the network are unpowered while the rest of the of network remains in operation. The logic terminals also have extremely low leakage currents when the device is unpowered to avoid loading down other circuits that may remain powered.

9.3.5 Floating Terminals

These devices have internal pull ups on critical terminals to place the device into known states if the terminals float. The TXD terminal is pulled up to V_{CC} or V_{IO} to force a recessive input level if the terminal floats. The STB terminal is also pulled up to force the device into low power standby mode if the terminal floats.

9.3.6 CAN Bus Short Circuit Current Limiting

The device has several protection features that limit the short circuit current when a CAN bus line is shorted. These include driver current limiting (dominant and recessive). The device has TXD dominant state time out to prevent permanent higher short circuit current of the dominant state during a system fault. During CAN communication the bus switches between dominant and recessive states with the data and control fields bits, thus the short circuit current may be viewed either as the instantaneous current during each bus state, or as a DC average current. For system current (power supply) and power considerations in the termination resistors and common-mode choke ratings, use the average short circuit current. Determine the ratio of dominant and recessive bits by the data in the CAN frame plus the following factors of the protocol and PHY that force either recessive or dominant at certain times:

- Control fields with set bits
- Bit stuffing
- Interframe space
- TXD dominant time out (fault case limiting)

These ensure a minimum recessive amount of time on the bus even if the data field contains a high percentage of dominant bits.

注

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 with the following formula:

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

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

注

Consider the short circuit current and possible fault cases of the network when sizing the power ratings of the termination resistance and other network components.

9.3.7 Digital Inputs and Outputs

9.3.7.1 5 V V_{CC} Only Devices (Devices without the "V" Suffix):

The 5 V V_{CC} only devices are supplied by a single 5 V rail. The digital inputs have TTL input thresholds and are therefore 5 V and 3.3 V compatible. The RXD outputs on these devices are driven to the V_{CC} rail for logic high output. Additionally, the TXD and STB pins are internally pulled up to V_{CC}.

注

TXD and STB are internally pulled up to V_{CC}. However, the internal bias may only put the device into a known state if the terminals float. The internal bias may be inadequate for system-level biasing. TXD pull up strength and CAN bit timing require special consideration when these devices are used with CAN controllers with an open-drain TXD output. An adequate external pull up resistor must be used to ensure that the CAN controller output of the micrcontroller maintains adequate bit timing to the TXD input.

9.3.7.2 5 V V_{CC} with V_{IO} I/O Level Shifting (Devices with the "V" Suffix):

These devices use a 5 V V_{CC} power supply for the CAN driver and high speed receiver blocks. These transceivers have a second separate supply for I/O level shifting (V_{IO}). This supply is used to set the CMOS input thresholds of the TXD and STB pins and the RXD high level output voltage. The internal pull ups on TXD and STB are weakly pulled up to V_{IO}.

9.4 Device Functional Modes

The device has two main operating modes: normal mode and standby mode. Operating mode selection is made via the STB input terminal.

表 4. Operating Modes

STB Terminal	MODE	DRIVER	RECEIVER	RXD Terminal
LOW	Normal Mode	Enabled (ON)	Enabled (ON)	Mirrors Bus State(1)
HIGH	Standby Mode	Disabled (OFF)	Disabled (OFF) (Low Power Bus Monitor is Active)	High (Unless valid WUP has been received)

(1) Mirrors bus state: low if CAN bus is dominant, high if CAN bus is recessive.

9.4.1 Can Bus States

The CAN bus has two states during powered operation of the device; *dominant* and *recessive*. A dominant bus state is when the bus is driven differentially, corresponding to a logic low on the TXD and RXD terminal. A recessive bus state is when the bus is biased to V_{CC} / 2 via the high-resistance internal input resistors R_{IN} of the receiver, corresponding to a logic high on the TXD and RXD terminals. See 图 13 and 图 14.

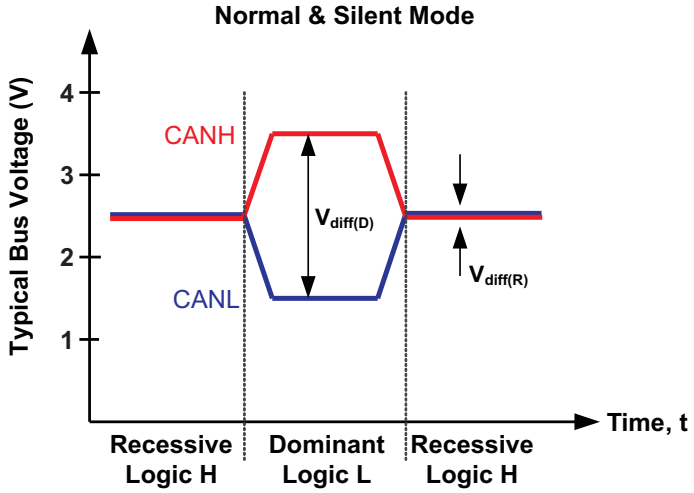


图 13. Bus States (Physical Bit Representation)

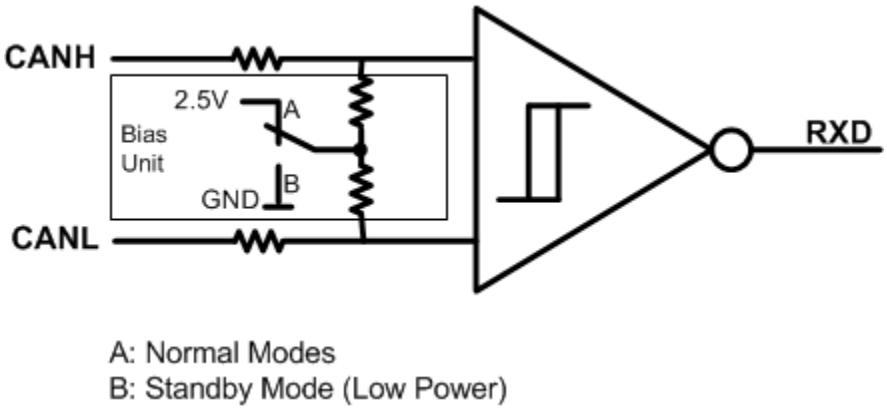


图 14. Bias Unit (Recessive Common Mode Bias) and Receiver

9.4.2 Normal Mode

Select the *normal mode* of device operation by setting STB low. 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.

9.4.3 Standby Mode

Activate low power *standby mode* by setting STB high. The CAN driver and high speed receiver are turned off to save system power. A low power receiver remains active to monitor the bus for a valid wake up pattern (WUP). The RXD output will remain high until a valid WUP has been received.

9.4.3.1 Remote Wake Request via Wake Up Pattern (WUP) in Standby Mode

The TCAN1042 family offers a remote wake request feature that is used to indicate to the host micrcontroller that the bus is active and the node should return to normal operation.

These devices use the multiple filtered dominant wake up pattern (WUP) from the ISO11898-2 (2016) to qualify bus activity. Once a valid WUP has been received the wake request will be indicated to the micrcontroller by a falling edge and low corresponding to a "filtered" dominant on the RXD output terminal.

The WUP consists of a filtered dominant pulse, followed by a filtered recessive pulse, and finally by a second filtered dominant pulse. These filtered dominant, recessive, dominant pulses do not need to occur in immediate succession. There is no timeout that will occur between filtered bits of the WUP. Once a full WUP has been detected the device will continue to drive the RXD output low every time an additional filtered dominant signal is received from the bus.

For a dominant or recessive signal to be considered "filtered", the bus must continually remain in that state for more than t_{WK_FILTER}. Due to variability in the t_{WK_FILTER}, the following three scenarios can exist:

1. Bus signals that last less than $t_{WK\_FILTER(MIN)}$ will never be detected as part of a valid WUP
2. Bus signals that last more than $t_{WK\_FILTER(MIN)}$ but less than $t_{WK\_FILTER(MAX)}$ may be detected as part of a valid WUP
3. Bus signals that last more than $t_{WK\_FILTER(MAX)}$ will always be detected as part of a valid WUP

Once the first filtered dominant signal is received, the device is now waiting on a filtered recessive signal, other bus traffic will not reset the bus monitor. Once the filtered recessive signal is received, the monitor is now waiting on a second filtered dominant signal, and again other bus traffic will not reset the monitor. After reception of the full WUP, the device will transition to driving the RXD output pin low for the remainder of any dominant signal that remains on the bus for longer than t_{WK_FILTER}.

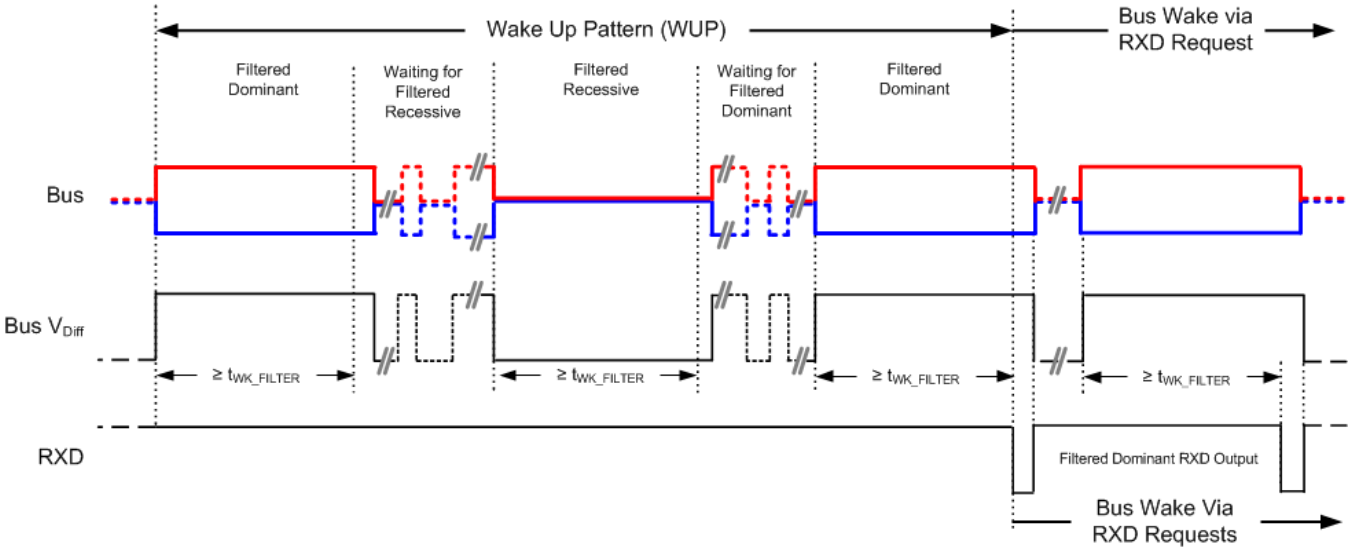


图 15. Wake Up Pattern (WUP)

9.4.4 Driver and Receiver Function Tables

表 5. Driver Function Table

DEVICE	INPUTS		OUTPUTS		DRIVEN BUS STATE
	STB(1) (2)	TXD(1) (3)	CANH(1)	CANL(1)	
All Devices	L	L	H	L	Dominant
		H or Open	Z	Z	Recessive
	H or Open	X	Z	Z	Recessive

(1) H = high level, L = low level, X= irrelevant, Z = common mode (recessive) bias to V_{CC} / 2. See 图 13 and 图 14 for bus state and common mode bias information.
(2) Devices have an internal pull up to V_{CC} or V_{IO} on STB terminal. If STB terminal is open the terminal will be pulled high and the device will be in standby mode.
(3) Devices have an internal pull up to V_{CC} or V_{IO} on TXD terminal. If the TXD terminal is open the terminal will be pulled high and the transmitter will remain in recessive (non-driven) state.

表 6. Receiver Function Table

DEVICE MODE	CAN DIFFERENTIAL INPUTS $V_{ID} = V_{CANH} - V_{CANL}$	BUS STATE	RXD TERMINAL(1)
Normal or Silent	$V_{ID} \geq 0.9$ V	Dominant	L(2)
	0.5 V < V_{ID} < 0.9 V	?	?(2)
	$V_{ID} \leq 0.5$ V	Recessive	H(2)
	Open ($V_{ID} \approx 0$ V)	Open	H

(1) H = high level, L = low level, ? = indeterminate.
(2) See Receiver Electrical Characteristics section for input thresholds.

10 Application and Implementation

注

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.

10.1 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.

10.2 Typical Applicationspurposes. Typical

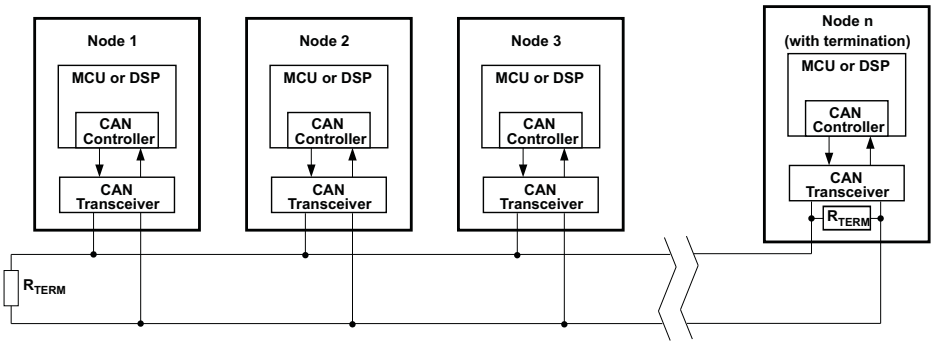


图 16. Typical 5 V Application

10.2.1 Design Requirements

10.2.1.1 Bus Loading, Length and Number of Nodes

The ISO11898 Standard specifies a maximum bus length of 40m and maximum stub length of 0.3m. However, with careful design, users can have longer cables, longer stub lengths, and many more nodes to a bus. A large number of nodes requires transceivers with high input impedance such as the TCAN1042 family of transceivers.

Many CAN organizations and standards have scaled the use of CAN for applications outside the original ISO11898. They have made system level trade offs for data rate, cable length, and parasitic loading of the bus. Examples of some of these specifications are ARINC825, CANopen, DeviceNet and NMEA2000.

A CAN network design is a series of tradeoffs, but these devices operate over wide common-mode range. In ISO11898-2 the driver differential output is specified with a 60 Ω load (the two 120 Ω termination resistors in parallel) and the differential output must be greater than 1.5 V. The TCAN1042 family is specified to meet the 1.5 V requirement with a 50Ω load incorporating the worst case including parallel transceivers. The differential input resistance of the TCAN1042 family is a minimum of 30 kΩ. If 100 TCAN1042 family transceivers are in parallel on a bus, this is equivalent to a 300Ω differential load worst case. That transceiver load of 300 Ω in parallel with the 60Ω gives an equivalent loading of 50 Ω. Therefore, the TCAN1042 family theoretically supports up to 100 transceivers on a single bus segment with margin to the 1.2 V minimum differential input at each node. However for CAN network design, margin must be given for signal loss across the system and cabling, parasitic loadings, network imbalances, ground offsets and signal integrity thus a practical maximum number of nodes is typically much lower. Bus length may also be extended beyond the original ISO11898 standard of 40m by careful system design and datarate tradeoffs. For example CANopen network design guidelines allow the network to be up to 1km with changes in the termination resistance, cabling, less than 64 nodes and significantly lowered data rate.

This flexibility in CAN network design is one of the key strengths of the various extensions and additional standards that have been built on the original ISO11898 CAN standard. In using this flexibility comes the responsibility of good network design and balancing these tradeoffs.

Typical Applicationspurposes. Typical (接下页)

10.2.2 Detailed Design Procedures

10.2.2.1 Can Termination

The ISO11898 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 should be used to terminate both ends of the cable to prevent signal reflections. Unterminated drop lines (stubs) connecting nodes to the bus should 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 two terminations always exist on the network.

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 图 17). Split termination improves the electromagnetic emissions behavior of the network by eliminating fluctuations in the bus common-mode voltages at the start and end of message transmissions.

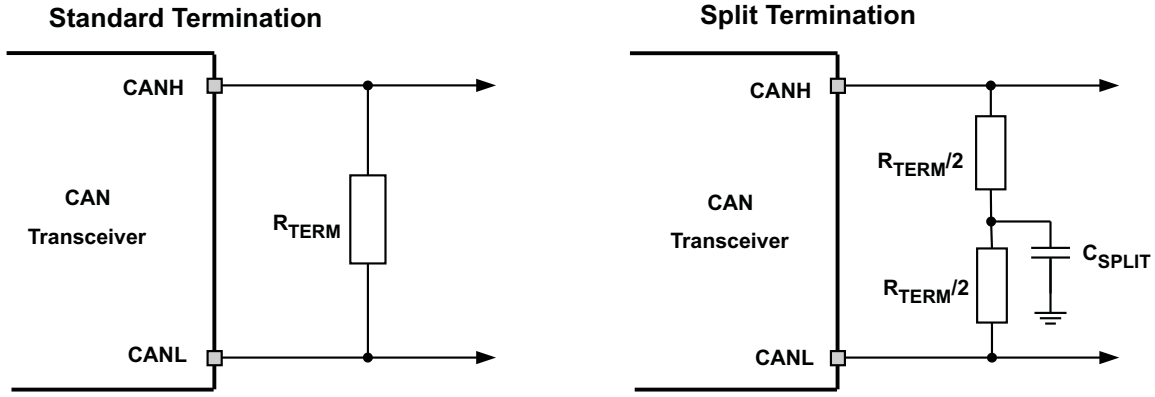


图 17. CAN Bus Termination Concepts

The TCAN1042 family of transceivers have variants for both 5 V only applications and applications where level shifting is needed for a 3.3 V micrcontroller.

Typical Applicationspurposes. Typical (接下页)

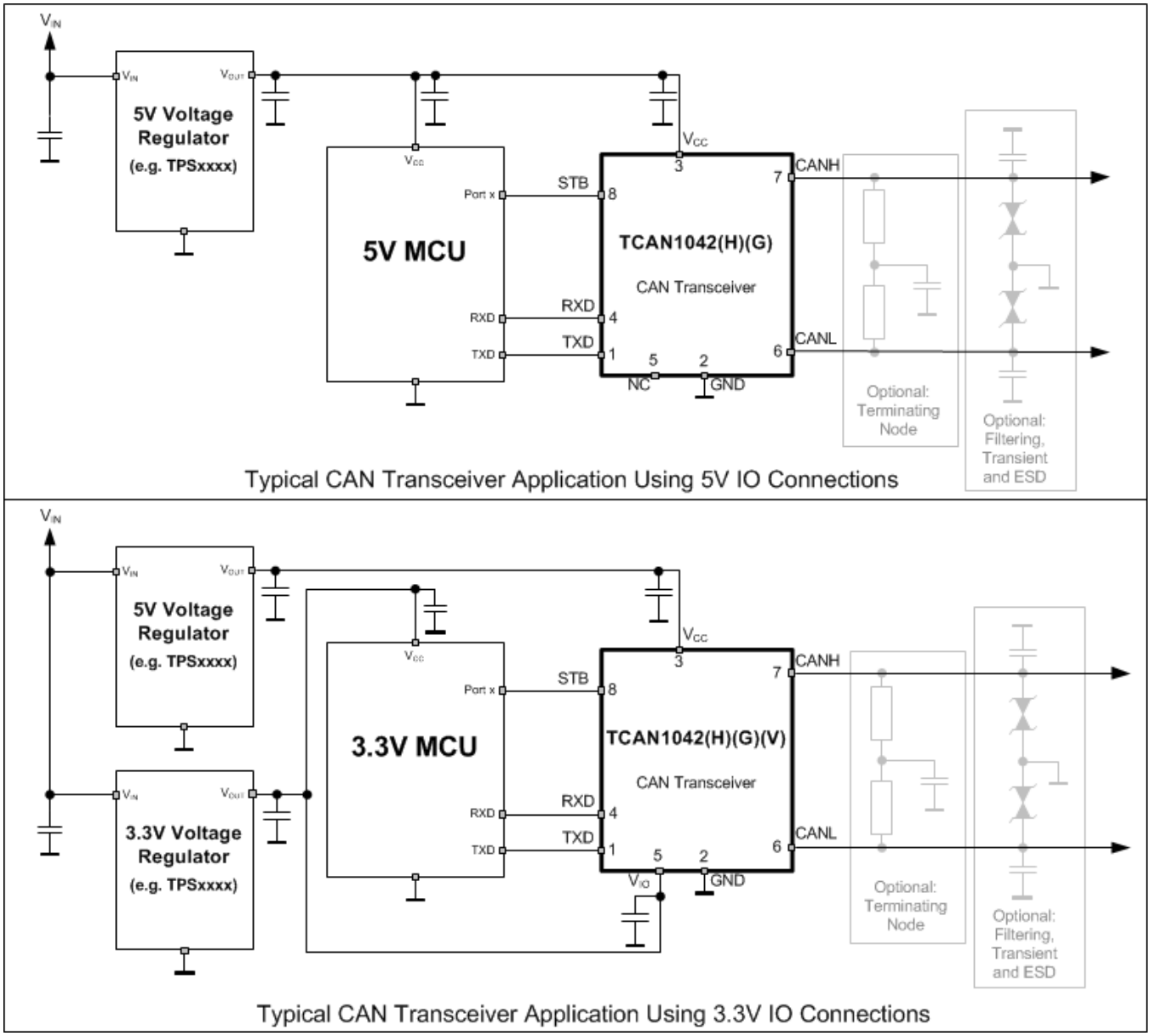
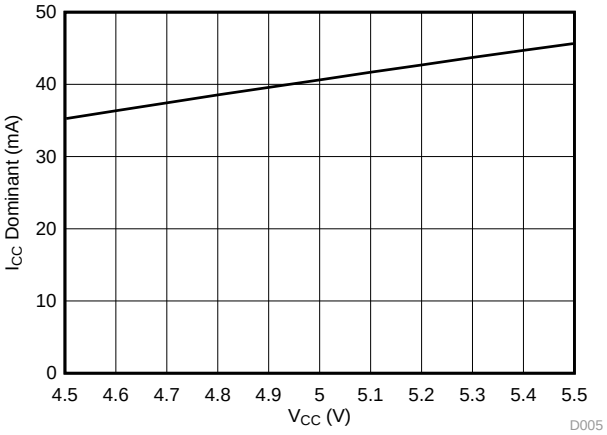


图 18. Typical CAN Bus

Typical Applicationspurposes. Typical (接下页)

10.2.3 Application Curves



V_{CC} = 4.5 V to 5.5 V　　V_{IO} = 3.3 V　　R_L = 60 Ω

C_L = Open　　Temp = 25°C　　STB = 0 V

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

11 Power Supply Requirements

These devices are designed to operate from main V_{CC} input voltage supply range between 4.5 V and 5.5 V. Some devices have an output level shifting supply input, V_{IO}, designed for a range between 3.0 V and 5.5 V. Both supply inputs must be well regulated. A bulk capacitance, typically 4.7 µF, should be placed near the CAN transceiver's main V_{CC} supply terminal in addition to bypass capacitors. A bulk capacitance, typically 1 µF, should be placed near the CAN transceiver's V_{IO} supply terminal in addition to bypass capacitors.

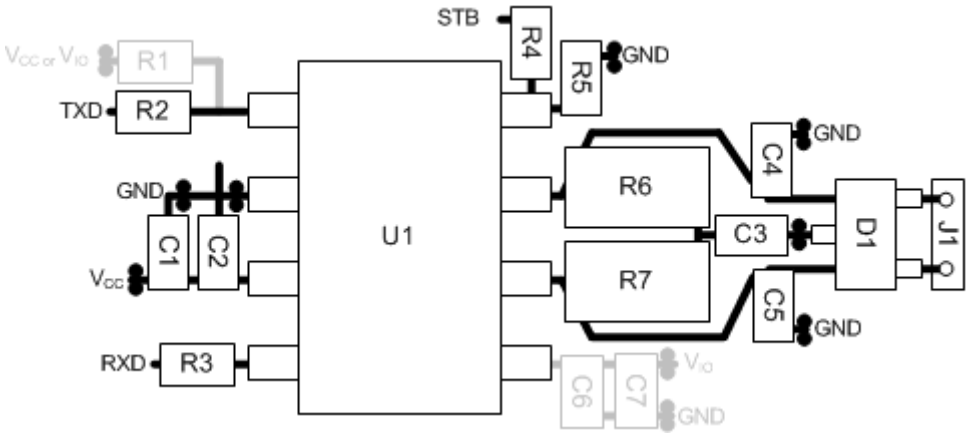
12 Layout

In order for the PCB design to be successful, start with design of the protection and filtering circuitry. Because ESD and transients have a wide frequency bandwidth from approximately 3 MHz to 3 GHz, high frequency layout techniques must be applied during PCB design. The TCAN1042 family comes with high on chip IEC ESD protection but if higher levels of system level immunity are desired, external TVS diodes can be used. TVS diodes and bus filtering capacitors should be placed as close to the on board connectors as possible to prevents noisy transient events from propagating further into the PCB and system.

12.1 Layout Guidelines

- Place the protection and filtering circuitry as close to the bus connector, J1, to prevent transients, ESD and noise from penetrating onto the board. In this layout example for protection a Transient Voltage Suppression (TVS) device, D1, has been used. 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 C4 and C5. Additionally (not shown) a series optional Common Mode Choke (CMC) can be placed on the CANH and CANL lines between the transceiver U1 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 current follows the path of least inductance 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 and bulk capacitors should be placed as close as possible to the supply terminals of transceiver, examples C1, C2 (V_{CC}).
- 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 C3. 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.
- Terminal 1: R1 is shown optionally for the TXD input of the device. If an open drain host processor is used, this is mandatory to ensure the bit timing into the device is met.
- Terminal 5: For "V" variants of the TCAN1042 family, bypass capacitors should be placed as close to the pin as possible (example C6 and C7). For device options without V_{IO} I/O level shifting, this pin is not internally connected and can be left floating or tied to any existing net, for example a split pin connection.
- Terminal 8: is shown assuming the mode terminal, STB, will be used. If the device will only be used in normal mode, R4 is not needed and R5 could be used for the pull down resistor to GND.

12.2 Layout Example



13 器件和文档支持

13.1 相关链接

以下表格列出了快速访问链接。范围包括技术文档、支持与社区资源、工具和软件，并且可以快速访问样片或购买链接。

表 7. 相关链接

器件	产品文件夹	样片与购买	技术文章	工具与软件	支持与社区
TCAN1042H	请单击此处	请单击此处	请单击此处	请单击此处	请单击此处
TCAN1042HG	请单击此处	请单击此处	请单击此处	请单击此处	请单击此处
TCAN1042HGV	请单击此处	请单击此处	请单击此处	请单击此处	请单击此处
TCAN1042HV	请单击此处	请单击此处	请单击此处	请单击此处	请单击此处

13.2 商标

All trademarks are the property of their respective owners.

13.3 静电放电警告

这些装置包含有限的内置 ESD 保护。 存储或装卸时，应将导线一起截短或将装置放置于导电泡棉中，以防止 MOS 门极遭受静电损伤。

13.4 Glossary

SLYZ022 — *TI Glossary*.

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

14 机械、封装和可订购信息

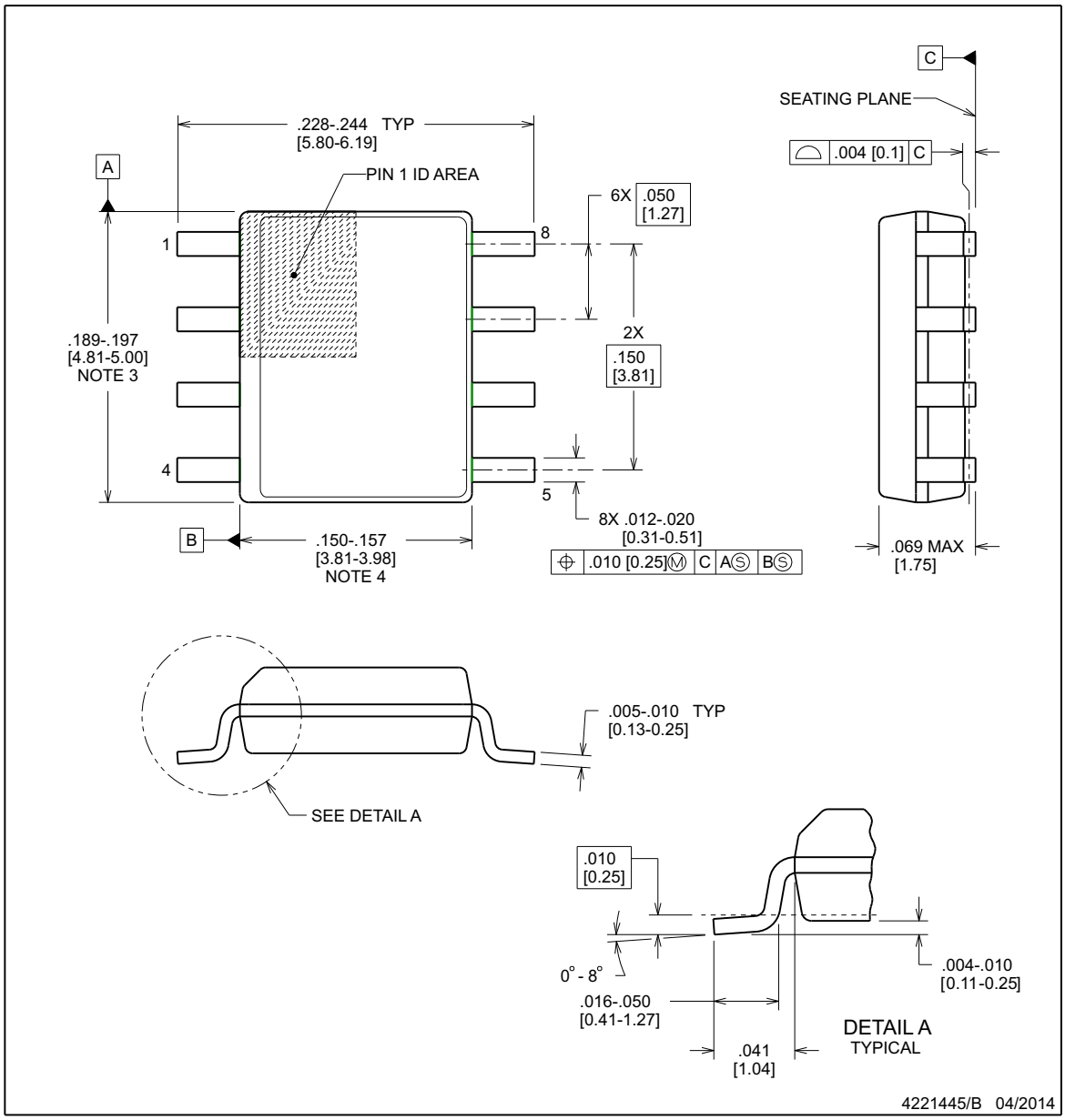
以下页中包括机械、封装和可订购信息。这些信息是针对指定器件可提供的最新数据。这些数据会在无通知且不对本文档进行修订的情况下发生改变。欲获得该数据表的浏览器版本，请查阅左侧的导航栏。

PACKAGE OUTLINE

D0008B

SOIC - 1.75 mm max height

SOIC



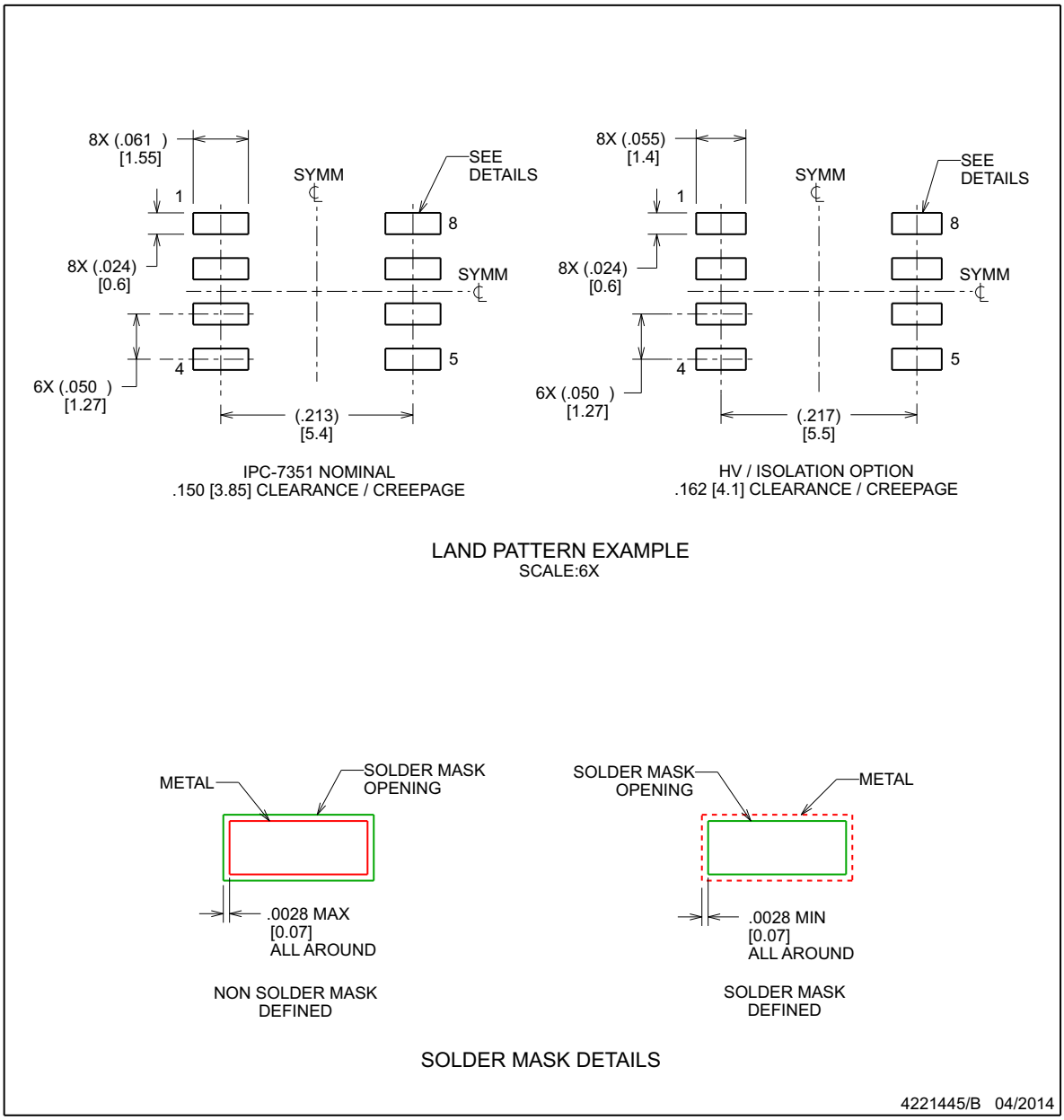
NOTES:

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



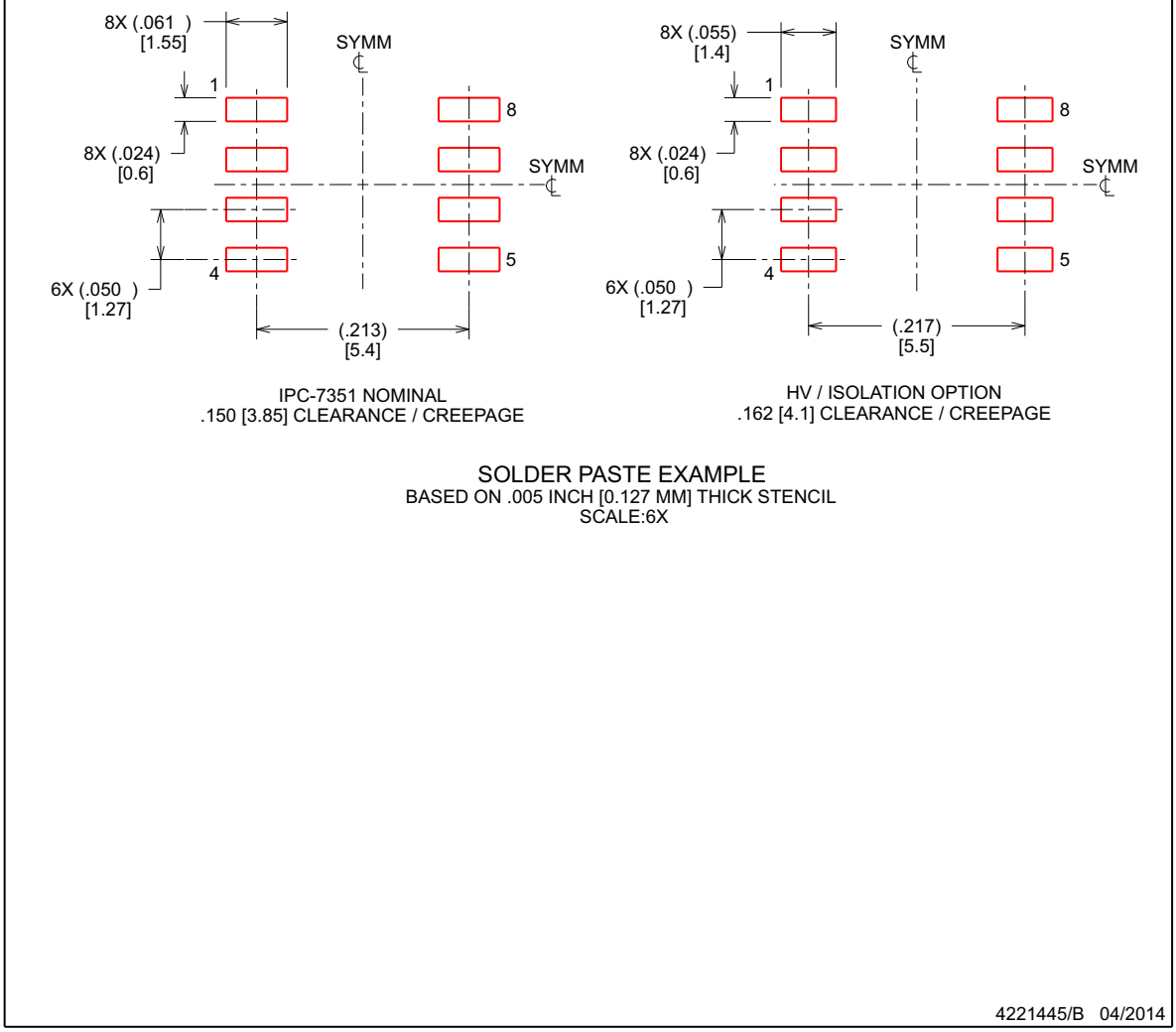
NOTES: (continued)

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.

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PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
TCAN1042HD	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-55 to 125	1042	Samples
TCAN1042HDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-55 to 125	1042	Samples
TCAN1042HGD	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-55 to 125	1042	Samples
TCAN1042HGDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-55 to 125	1042	Samples
TCAN1042HGVD	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-55 to 125	1042V	Samples
TCAN1042HGVDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-55 to 125	1042V	Samples
TCAN1042HVD	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-55 to 125	1042V	Samples
TCAN1042HVDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-55 to 125	1042V	Samples

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

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

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

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

(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

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