

TCAN341x 具有待机模式和 $\pm 58V$ 总线关断的 3.3V CAN FD 收发器

1 特性

- 3.3V 单电源工作
 - 无需使用 5V 稳压器，从而节省 BOM 成本并减小 PCB 空间
- 在同构和异构网络中实现出色的 EMC 运行
- 符合 ISO 11898-2:2016 物理层标准要求
- 支持传统 CAN 和经优化的 CAN FD 性能（数据速率为 2、5 和 8Mbps）
 - 具有较短的对称传播延迟时间，可增加时序裕量
- TCAN3413：I/O 电压范围支持：1.7V 至 3.6V
- 接收器共模输入电压： $\pm 30V$
- 保护特性：
 - 总线故障保护： $\pm 58V$
 - 总线引脚上提供 IEC ESD 保护： $\pm 10kV$
 - 欠压保护
 - TXD 显性超时 (DTO)
 - 热关断保护 (TSD)
- 工作模式：
 - 正常模式
 - 支持远程唤醒请求功能的低功耗待机模式
 - 超低功耗关断模式：仅 TCAN3414
- 优化了未上电时的性能
 - 总线和逻辑引脚为高阻抗（运行总线或应用上无负载）
 - 支持热插拔：在总线和 RXD 输出上可实现上电和断电无干扰运行
- 小型 8 引脚 SOIC SOT-23 和无引线 VSON-8 封装，提高了自动光学检测 (AOI) 能力

2 应用

- 工厂自动化
- 电网基础设施
- 工业运输
- 电机驱动器

3 说明

TCAN3413 and TCAN3414 是符合 ISO 11898-2:2016 高速 CAN 规范物理层要求的控制器局域网 (CAN) FD 收发器。

此类收发器具有经过认证的电磁兼容性 (EMC)，适用于数据速率高达 5 兆位/秒 (Mbps) 的传统 CAN 和 CAN FD 网络。这些器件可以在更简单的网络中实现高达 8Mbps 的运行速度。TCAN3413 包括通过 V_{IO} 引脚实现的内部逻辑电平转换。允许收发器 I/O 直接连接到 1.8V、2.5V 或 3.3V 逻辑电平。此类收发器支持低功耗待机模式，并且可通过符合 ISO 11898-2:2016 所定义唤醒模式 (WUP) 的 CAN 来唤醒。

此外，该收发器支持热关断 (TSD)、TXD 显性超时 (DTO)、电源欠压检测和 $\pm 58V$ 的总线故障保护。这些器件定义了电源欠压或浮动引脚情况下的失效防护行为。这些收发器采用业界通用的 SOIC-8、VSON-8 和节省空间的小尺寸 SOT-23 封装。

封装信息

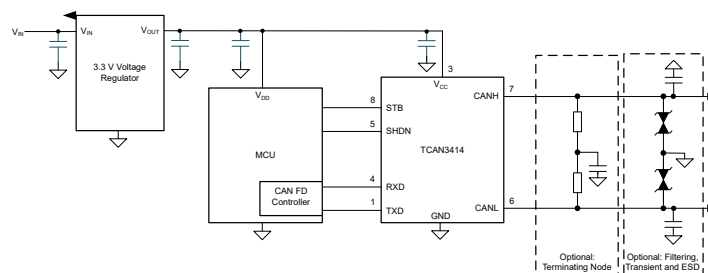
器件型号	封装 ⁽¹⁾	封装尺寸 ⁽²⁾
TCAN3413 TCAN3414	SOIC (D)	4.9mm x 6mm
	VSON (DRB)	3mm x 3mm
	SOT-23 (DDF)	2.9mm x 2.8mm

(1) 有关详细信息，请参阅节 12。

(2) 封装尺寸（长 × 宽）为标称值，并包括引脚（如适用）。

器件信息

器件型号	引脚 5	引脚 8
TCAN3414	超低功耗关断模式	具有远程唤醒功能的低功耗待机模式
TCAN3413	低压 I/O 支持	



简化原理图



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4 Pin Configuration and Functions

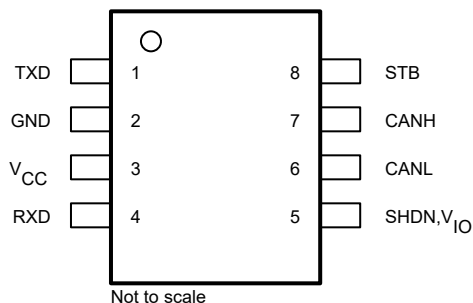


图 4-1. DDF Package, 8-Pin SOT
(Top View)

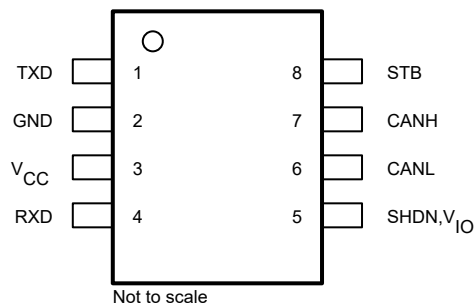


图 4-2. D Package, 8-Pin SOIC
(Top View)

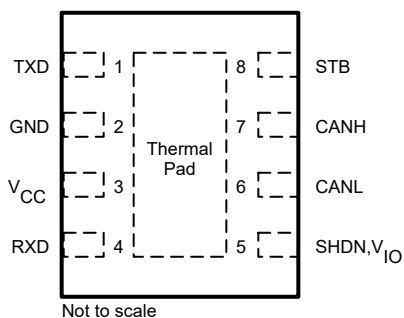


图 4-3. DRB Package, 8-Pin VSON
(Top View)

表 4-1. Pin Functions

Pins		Type ⁽¹⁾	Description
Name	No.		
TXD	1	Digital Input	CAN transmit data input; integrated pull-up
GND	2	G	Ground connection
V _{CC}	3	Supply	3.3 V supply voltage
RXD	4	Digital Output	CAN receive data output, tri-stated when device powered off
SHDN	5	Digital Input	Device in ultra-low power shutdown mode if pin is high; integrated pull-down (TCAN3414 only)
V _{IO}		Supply	I/O supply voltage (TCAN3413 only)
CANL	6	Bus IO	Low-level CAN bus input/output line
CANH	7	Bus IO	High-level CAN bus input/output line
STB	8	Digital Input	Standby input for mode control; integrated pull-up
Thermal Pad (VSON only)		—	Connect the thermal pad to any internal PCB ground plane using multiple vias for optimal thermal performance.

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

5 Specifications

5.1 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 I/O level shifter (only for TCAN3413)	- 0.3	6	V
V _{BUS}	CAN bus I/O voltage range on CANH and CANL	- 58	58	V
V _{DIFF}	Max differential voltage between CANH and CANL V _{DIFF} = (CANH - CANL)	- 58	58	V
V _{Logic_Input}	Logic pin input voltage (TXD, STB, SHDN)	- 0.3	6	V
V _{RXD}	Logic output voltage range (RXD)	- 0.3	6	V
I _{O(RXD)}	RXD output current	- 8	8	mA
T _J	Junction temperature	- 40	165	°C
T _{STG}	Storage temperature	- 65	150	°C

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

5.2 ESD Ratings

				VALUE	UNIT
V _{ESD}	Electrostatic discharge	Human-body model (HBM)	HBM classification level 3A for all pins	±4000	V
			HBM classification level 3B for global pins CANH and CANL with respect to GND	±10000	V
		Charged-device model (CDM) CDM classification level C5 for all pins		±750	V

5.3 ESD Ratings, IEC Transients

				VALUE	UNIT
V _{ESD}	System level electrostatic discharge	CAN bus terminals (CANH, CANL) to GND	IEC61000-4-2	±10000	V

5.4 Recommended Operating Conditions

		MIN	NOM	MAX	UNIT
V _{CC}	Supply voltage	3	3.3	3.6	V
V _{IO}	Supply voltage for I/O level shifter (only for TCAN3413)	1.7		3.6	V
I _{OH(RXD)}	RXD terminal high-level output current	- 2			mA
I _{OL(RXD)}	RXD terminal low-level output current			2	mA
I _{OH(RXD)}	RXD terminal high-level output current (only for TCAN3413)	- 1.5			mA
I _{OL(RXD)}	RXD terminal low-level output current (only for TCAN3413)			1.5	mA
T _J	Junction temperature	- 40		150	°C

5.5 Thermal Characteristics

THERMAL METRIC ⁽¹⁾		TCAN3413/3414			UNIT
		D (SOIC)	DDF (SOT)	DRB (VSON)	
R _{θJA}	Junction-to-ambient thermal resistance	114.4	122.9	50.9	°C/W

5.5 Thermal Characteristics (续)

THERMAL METRIC ⁽¹⁾		TCAN3413/3414			UNIT
		D (SOIC)	DDF (SOT)	DRB (VSON)	
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	49.0	51.7	55.8	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	58.0	45.7	23.2	°C/W
Ψ_{JT}	Junction-to-top characterization parameter	7.0	1.3	1.4	°C/W
Ψ_{JB}	Junction-to-board characterization parameter	57.1	45.4	23.2	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	N/A	N/A	7.7	°C/W

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

5.6 Supply Characteristics

parameters valid over recommended operating conditions with $-40^{\circ}\text{C} \leq T_J \leq 150^{\circ}\text{C}$ (Typical values are at $V_{CC} = 3.3\text{ V}$; $V_{IO} = 3.3\text{ V}$ for TCAN3413, Device ambient maintained at 27°C) unless otherwise noted

PARAMETER			TEST CONDITIONS			MIN	TYP	MAX	UNIT
I_{CC}	Supply current normal mode	Dominant	TXD = 0 V, STB = 0 V $R_L = 60\ \Omega$, $C_L = \text{open}$ See 图 6-1				42	55	mA
		Dominant	TXD = 0 V, STB = 0 V $R_L = 50\ \Omega$, $C_L = \text{open}$ See 图 6-1				50	60	mA
		Recessive	TXD = V_{CC} , STB = 0 V $R_L = 50\ \Omega$, $C_L = \text{open}$ See 图 6-1				7	8.2	mA
I_{CC}	Supply current normal mode	Dominant with bus fault	TXD = 0 V, STB = 0 V CANH = CANL = $\pm 25\text{ V}$ $R_L = \text{open}$, $C_L = \text{open}$ See 图 6-1					130	mA
	Supply current standby mode (TCAN3413)		TXD = STB = V_{IO} , $R_L = 50\ \Omega$, $C_L = \text{open}$, $T_J \leq 85^{\circ}\text{C}$, See 图 6-1				1	2	μA
			TXD = STB = V_{IO} , $R_L = 50\ \Omega$, $C_L = \text{open}$, $T_J \leq 125^{\circ}\text{C}$, See 图 6-1				1	3	
			TXD = STB = V_{IO} , $R_L = 50\ \Omega$, $C_L = \text{open}$, $T_J \leq 150^{\circ}\text{C}$, See 图 6-1				1	4	
	Supply current standby mode (TCAN3414)		TXD = STB = V_{CC} , $R_L = 50\ \Omega$, $C_L = \text{open}$, $T_J \leq 85^{\circ}\text{C}$, See 图 6-1				10	15	μA
			TXD = STB = V_{CC} , $R_L = 50\ \Omega$, $C_L = \text{open}$, $T_J \leq 125^{\circ}\text{C}$, See 图 6-1				10	16	
			TXD = STB = V_{CC} , $R_L = 50\ \Omega$, $C_L = \text{open}$, $T_J \leq 150^{\circ}\text{C}$, See 图 6-1				10	17	
I_{IO} (only for TCAN3413)	I/O supply current normal mode	Dominant	TXD = 0 V, STB = 0 V $R_L = 60\ \Omega$, $C_L = \text{open}$ RXD floating				125	300	μA
		recessive	TXD = V_{IO} , STB = 0 V $R_L = 60\ \Omega$, $C_L = \text{open}$ RXD floating				19	48	
	I/O supply current standby mode		TXD = V_{IO} , STB = V_{IO} $R_L = 60\ \Omega$, $C_L = \text{open}$ RXD floating, $T_J \leq 85^{\circ}\text{C}$				9	13	
			TXD = V_{IO} , STB = V_{IO} $R_L = 60\ \Omega$, $C_L = \text{open}$ RXD floating, $T_J \leq 125^{\circ}\text{C}$				9	14	
			TXD = V_{IO} , STB = V_{IO} $R_L = 60\ \Omega$, $C_L = \text{open}$ RXD floating, $T_J \leq 150^{\circ}\text{C}$				9	15	

5.6 Supply Characteristics (续)

parameters valid over recommended operating conditions with $-40^{\circ}\text{C} \leq T_J \leq 150^{\circ}\text{C}$ (Typical values are at $V_{CC} = 3.3\text{ V}$; $V_{IO} = 3.3\text{ V}$ for TCAN3413, Device ambient maintained at 27°C) unless otherwise noted

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
I _{CC}	Supply current (V _{CC} pin current), shutdown mode (TCAN3414)	SHDN = V _{CC} , RXD floating, TXD = V _{CC} , T _J <= 85 °C				2	μA
		SHDN = V _{CC} , RXD floating, TXD = V _{CC} , T _J <= 150 °C				5	
UV _{CC(R)}	Undervoltage detection V _{CC} rising	Ramp up			2.75	2.9	V
UV _{CC(F)}	Undervoltage detection on V _{CC} falling	Ramp down	2.5	2.65			
V _{HYS (UVCC)}	Hysteresis voltage on UV _{CC}				120		mV
UV _{IO(R)}	Undervoltage detection V _{IO} rising (TCAN3413)	Ramp up			1.6	1.65	V
UV _{IO(F)}	Undervoltage detection on V _{IO} falling (TCAN3413)	Ramp down	1.4	1.5			
V _{HYS(UVIO)}	Hysteresis voltage on UV _{IO}				50		mV

5.7 Dissipation Ratings

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
P _D	Average power dissipation Normal mode	V _{CC} = 3.3 V, T _J = 27°C, R _L = 60 Ω , C _{L_RXD} = 15 pF TXD input = 250 kHz 50% duty cycle square wave		50		mW
		V _{CC} = 3.6 V, T _J = 150°C, R _L = 50 Ω , C _{L_RXD} = 15 pF TXD input = 2.5 MHz 50% duty cycle square wave		60		mW
T _{TSD}	Thermal shutdown temperature			192		°C
T _{TSD_HYS}	Thermal shutdown hysteresis			10		

5.8 Electrical Characteristics

parameters valid over recommended operating conditions with $-40^{\circ}\text{C} \leq T_J \leq 150^{\circ}\text{C}$ (Typical values are at $V_{CC} = 3.3\text{ V}$, $V_{IO} = 3.3\text{ V}$ for TCAN3413, Device ambient maintained at 27°C) unless otherwise noted

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT	
Driver Electrical Characteristics								
V _{O(DOM)}	Dominant output voltage normal mode	CANH	TXD = 0 V, STB, SHDN = 0 V	2.25		V _{CC}	V	
		CANL	50 Ω ≤ R _L ≤ 65 Ω, C _L = open See 图 6-2 and 图 7-3					0.5
V _{O(REC)}	Recessive output voltage normal mode	CANH and CANL		TXD = V _{IO} or V _{CC} , STB, SHDN = 0 V R _L = open (no load), C _L = open See 图 6-2 and 图 7-3	1.5	1.9	2.25	V
V _{SYM}	Driver symmetry {(V _{O(CANH)} + V _{O(CANL)})/(V _{O(REC_CANH)} + V _{O(REC_CANL)})}		TXD = 250 kHz, 1 MHz, 2.5 MHz, STB, SHDN = 0 V R _L = 60, C _{SPLIT} = 4.7 nF, C _L = open See 图 6-2 and 图 8-2		0.9		1.1	V/V
V _{SYM_DC}	DC output symmetry (CANH _{REC} + CANL _{REC} - CANH _{DOM} - CANL _{DOM})		STB, SHDN = 0 V R _L = 60 Ω, C _L = open See 图 6-2 and 图 7-3		- 400		400	mV

5.8 Electrical Characteristics (续)

parameters valid over recommended operating conditions with $-40^{\circ}\text{C} \leq T_J \leq 150^{\circ}\text{C}$ (Typical values are at $V_{CC} = 3.3\text{ V}$, $V_{IO} = 3.3\text{ V}$ for TCAN3413, Device ambient maintained at 27°C) unless otherwise noted

PARAMETER			TEST CONDITIONS	MIN	TYP	MAX	UNIT
V _{OD(DOM)}	Differential output voltage normal mode Dominant	CANH - CANL	TXD = 0 V, STB, SHDN = 0 V 50 Ω ≤ R _L ≤ 65 Ω, C _L = open See 图 6-2 and 图 7-3	1.5		3	V
			TXD = 0 V, STB, SHDN = 0 V 45 Ω ≤ R _L ≤ 70 Ω, C _L = open See 图 6-2 and 图 7-3	1.4		3	V
		CANH - CANL	TXD = 0 V, STB, SHDN = 0 V R _L = 2240 Ω, C _L = open See 图 6-2 and 图 7-3	1.5		3.4	V
V _{OD(REC)}	Differential output voltage normal mode Recessive	CANH - CANL	TXD = V _{IO} or V _{CC} , STB, SHDN = 0 V R _L = 60 Ω, C _L = open See 图 6-2 and 图 7-3	- 120		12	mV
		CANH - CANL	TXD = V _{IO} or V _{CC} , STB, SHDN = 0 V R _L = open, C _L = open See 图 6-2 and 图 7-3	- 50		50	mV
V _{O(STB)}	Bus output voltage standby mode	CANH	TXD = STB = V _{IO} or V _{CC} , R _L = open , C _L = open See 图 6-2 and 图 7-3	-0.1		0.1	V
		CANL		-0.1		0.1	V
		CANH - CANL		-0.2		0.2	V
I _{OS(DOM)}	Short-circuit bus output current, dominant, normal mode	See 图 6-7 and 图 7-3, V _(CANH) = -15 V to 40 V, CANL = open, TXD = 0 V		- 115		115	mA
		See 图 6-7 and 图 7-3 , V _(CANL) = -15 V to 40 V, CANH = open, TXD = 0 V		- 115		115	mA
I _{OS(REC)}	Short-circuit steady-state output current, recessive, normal mode	See 图 6-7 and 图 7-3 , V _(CANH) = -27 V to 32 V, CANL = open, STB=0, TXD = V _{IO} or V _{CC} ,		- 7		7	mA
		See 图 6-7 and 图 7-3 , V _(CANL) = -27 V to 32 V, CANH = open, STB = 0, TXD = V _{IO} or V _{CC} ,		- 7		7	mA

Receiver Electrical Characteristics

V_{IT}	Input threshold voltage normal mode	See 图 6-3 and 表 7-6 $-30\text{ V} \leq V_{CM} \leq 30\text{ V}$, STB, SHDN= 0 V	500		900	mV
$V_{IT(STB)}$	Input threshold standby mode, TCAN3414	See 图 6-3 and 表 7-6 $-30\text{ V} \leq V_{CM} \leq 30\text{ V}$, SHDN= 0 V, STB= V_{CC}	400		1150	mV
	Input threshold standby mode, TCAN3413	See 图 6-3 and 表 7-6 $V_{IO} = 3\text{ V}$ to 3.6 V , $-30\text{ V} \leq V_{CM} \leq 30\text{ V}$, STB= V_{IO}	400		1150	mV
		See 图 6-3 and 表 7-6 $V_{IO} = 1.7\text{ V}$ to 1.9 V , 2.25 V to 2.75 V , $-12\text{ V} \leq V_{CM} \leq 12\text{ V}$, STB= V_{IO}	400		1150	mV
V_{DOM}	Normal mode dominant state differential input voltage range	See 图 6-3 and 表 7-6 $-30\text{ V} \leq V_{CM} \leq 30\text{ V}$, STB, SHDN= 0 V	0.9		9	V
V_{REC}	Normal mode recessive state differential input voltage range	See 图 6-3 and 表 7-6 $-30\text{ V} \leq V_{CM} \leq 30\text{ V}$, STB, SHDN= 0 V	-4		0.5	V
$V_{DOM(STB)}$	Standby mode dominant state differential input voltage range	See 图 6-3 and 表 7-6 SHDN= 0 V, STB = V_{IO} , $-30\text{ V} \leq V_{CM} \leq 30\text{ V}$	1.15		9	V
$V_{REC(STB)}$	Standby mode recessive state differential input voltage range	See 图 6-3 and 表 7-6 SHDN = 0 V, STB = V_{IO} , $-30\text{ V} \leq V_{CM} \leq 30\text{ V}$	-4		0.4	V
V_{HYS}	Hysteresis voltage for input threshold normal mode	See 图 6-3 and 表 7-6 $-30\text{ V} \leq V_{CM} \leq 30\text{ V}$, STB, SHDN= 0 V		50		mV
V_{CM}	Common mode range normal and standby modes	See 图 6-3 and 表 7-6	-30		30	V
$I_{LKG(IOFF)}$	Unpowered bus input leakage current	CANH = CANL = 5 V, $V_{CC} = V_{IO} = \text{GND}$			5	μA

5.8 Electrical Characteristics (续)

parameters valid over recommended operating conditions with $-40^{\circ}\text{C} \leq T_J \leq 150^{\circ}\text{C}$ (Typical values are at $V_{CC} = 3.3\text{ V}$, $V_{IO} = 3.3\text{ V}$ for TCAN3413, Device ambient maintained at 27°C) unless otherwise noted

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
C_I	Input capacitance to ground (CANH or CANL)	$\text{TXD} = V_{IO}$			40	pF
C_{ID}	Differential input capacitance				20	pF
R_{ID}	Differential input resistance	$\text{TXD} = V_{IO}$, $\text{STB} = 0\text{ V}$, $-30\text{ V} \leq V_{CM} \leq 30\text{ V}$	25		50	k Ω
R_{IN}	Single ended input resistance (CANH or CANL)		13		25	k Ω
$R_{IN(M)}$	Input resistance matching [1 - ($R_{IN(CANH)} / R_{IN(CANL)}$)] $\times 100\%$	$V_{(CAN_H)} = V_{(CAN_L)} = 5\text{ V}$	-3		3	%
TXD Terminal (CAN Transmit Data Input)						
V_{IH}	High-level input voltage	TCAN3414	$0.7 V_{CC}$			V
V_{IH}	High-level input voltage	TCAN3413	$0.7 V_{IO}$			V
V_{IL}	Low-level input voltage	TCAN3414	$0.3 V_{CC}$			V
V_{IL}	Low-level input voltage	TCAN3413	$0.3 V_{IO}$			V
I_{IH}	High-level input leakage current	$\text{TXD} = V_{CC} = V_{IO} = 3.6\text{ V}$	-2.5	0	1	μA
I_{IL}	Low-level input leakage current	$\text{TXD} = 0\text{ V}$, $V_{CC} = V_{IO} = 3.6\text{ V}$	-200	-100	-20	μA
$I_{LKG(OFF)}$	Unpowered leakage current	$\text{TXD} = 3.6\text{ V}$, $V_{CC} = V_{IO} = 0\text{ V}$	-1	0	1	μA
C_I	Input capacitance			4		pF
RXD Terminal (CAN Receive Data Output)						
V_{OH}	High-level output voltage	TCAN3414 See 图 6-3, $I_O = -2\text{ mA}$	$0.8 V_{CC}$			V
V_{OH}	High-level output voltage	See 图 6-3, $I_O = -1.5\text{ mA}$, TCAN3413	$0.8 V_{IO}$			V
V_{OL}	Low-level output voltage	TCAN3414 See 图 6-3, $I_O = 2\text{ mA}$	$0.2 V_{CC}$			V
V_{OL}	Low-level output voltage	TCAN3413 See 图 6-3, $I_O = 1.5\text{ mA}$	$0.2 V_{IO}$			V
$I_{LKG(OFF)}$	Unpowered leakage current	$\text{RXD} = 3.6\text{ V}$, $V_{CC} = V_{IO} = 0\text{ V}$	-1	0	1	μA
STB Terminal (Standby Mode Input)						
V_{IH}	High-level input voltage	TCAN3414	$0.7 V_{CC}$			V
V_{IH}	High-level input voltage	TCAN3413	$0.7 V_{IO}$			V
V_{IL}	Low-level input voltage	TCAN3414	$0.3 V_{CC}$			V
V_{IL}	Low-level input voltage	TCAN3413	$0.3 V_{IO}$			V
I_{IH}	High-level input leakage current	$V_{CC} = V_{IO} = \text{STB} = 3.6\text{ V}$	-2		2	μA
I_{IL}	Low-level input leakage current	$V_{CC} = V_{IO} = 3.6\text{ V}$, $\text{STB} = 0\text{ V}$	-20		-2	μA
$I_{LKG(OFF)}$	Unpowered leakage current	$\text{STB} = 3.6\text{ V}$, $V_{CC} = V_{IO} = 0\text{ V}$	-1	0	1	μA
SHDN Terminal (Shutdown mode input)						
V_{IH}	High-level input voltage	TCAN3414	$0.7 V_{CC}$			V
V_{IL}	Low-level input voltage	TCAN3414	$0.3 V_{CC}$			V
I_{IH}	High-level input leakage current	$V_{CC} = V_{IO} = \text{SHDN} = 3.6\text{ V}$	2		5.5	μA
I_{IL}	Low-level input leakage current	$V_{CC} = V_{IO} = 3.6\text{ V}$, $\text{SHDN} = 0\text{ V}$	-2		2	μA
$I_{LKG(OFF)}$	Unpowered leakage current	$\text{SHDN} = 3.6\text{ V}$, $V_{CC} = V_{IO} = 0\text{ V}$	-1	0	1	μA

5.9 Switching Characteristics

parameters valid over recommended operating conditions with $-40^{\circ}\text{C} \leq T_J \leq 150^{\circ}\text{C}$ (Typical values are at $V_{CC} = 3.3\text{ V}$, $V_{IO} = 3.3\text{ V}$ for TCAN3413, Device ambient maintained at 27°C) unless otherwise noted

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Device Switching Characteristics					

5.9 Switching Characteristics (续)

parameters valid over recommended operating conditions with $-40^{\circ}\text{C} \leq T_J \leq 150^{\circ}\text{C}$ (Typical values are at $V_{CC} = 3.3\text{ V}$, $V_{IO} = 3.3\text{ V}$ for TCAN3413, Device ambient maintained at 27°C) unless otherwise noted

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$t_{\text{PROP(LOOP1)}}$	Total loop delay, driver input (TXD) to receiver output (RXD), recessive to dominant	See 图 6-4, normal mode, $V_{CC} = V_{IO} = 3\text{ V}$ to 3.6 V , $R_L = 60\ \Omega$, $C_L = 100\text{ pF}$, $C_{L(\text{RXD})} = 15\text{ pF}$ TCAN3414, TCAN3413		95	180	ns
		See 图 6-4, normal mode, $V_{CC} = 3$ to 3.6 V , $V_{IO} = 2.25\text{ V}$ to 2.75 V , $R_L = 60\ \Omega$, $C_L = 100\text{ pF}$, $C_{L(\text{RXD})} = 15\text{ pF}$ TCAN3413		102	190	ns
		See 图 6-4, normal mode, $V_{CC} = 3$ to 3.6 V , $V_{IO} = 1.71\text{ V}$ to 1.89 V , $R_L = 60\ \Omega$, $C_L = 100\text{ pF}$, $C_{L(\text{RXD})} = 15\text{ pF}$ TCAN3413		115	210	ns
$t_{\text{PROP(LOOP2)}}$	Total loop delay, driver input (TXD) to receiver output (RXD), dominant to recessive	See 图 6-4, normal mode, $V_{CC} = V_{IO} = 3\text{ V}$ to 3.6 V , $R_L = 60\ \Omega$, $C_L = 100\text{ pF}$, $C_{L(\text{RXD})} = 15\text{ pF}$ TCAN3414, TCAN3413		120	180	ns
		See 图 6-4, normal mode, $V_{CC} = 3$ to 3.6 V , $V_{IO} = 2.25\text{ V}$ to 2.75 V , $R_L = 60\ \Omega$, $C_L = 100\text{ pF}$, $C_{L(\text{RXD})} = 15\text{ pF}$ TCAN3413		125	190	ns
		See 图 6-4, normal mode, $V_{CC} = 3$ to 3.6 V , $V_{IO} = 1.71\text{ V}$ to 1.89 V , $R_L = 60\ \Omega$, $C_L = 100\text{ pF}$, $C_{L(\text{RXD})} = 15\text{ pF}$ TCAN3413		140	210	ns
t_{MODE}	Mode change time, from normal to standby or from standby to normal	See 图 6-5			30	μs
t_{SHDN1}	Mode change time from normal mode to shutdown mode	With TXD = High, Time from SHDN pin (low to high edge 50%) to CANH going from recessive level $V_{o(\text{rec})}$ to 0.5 V			40	μs
t_{SHDN2}	Mode change time from shutdown mode to normal mode	With TXD high, time from SHDN pin (high to low edge 50%) to CANH going from 0.5 V to $V_{o(\text{rec})}$			200	μs
$t_{\text{WK_FILTER}}$	Filter time for a valid wake-up pattern	See 图 7-5	0.5		1.8	μs
$t_{\text{WK_TIMEOUT}}$	Bus wake-up timeout value		0.8		6	ms
T_{startup}	Time duration after V_{CC} or V_{IO} has cleared UV+, and device can resume normal operation				1.5	ms
$T_{\text{filter(STB)}}$	Filter on STB pin to filter out any glitches		0.5	1	2	μs
$T_{\text{filter(SHDN)}}$	Filter on SHDN pin to filter out any glitches		0.5	1	2	μs
Driver Switching Characteristics						
$t_{\text{prop(TxD-busrec)}}$	Propagation delay time, low-to-high TXD edge to driver recessive (dominant to recessive)	See 图 6-2, STB, SHDN = 0 V , $R_L = 60\ \Omega$, $C_L = 100\text{ pF}$, $V_{CC} = V_{IO} = 3\text{ V}$ to 3.6 V TCAN3414, TCAN3413		65	100	ns
		See 图 6-2, STB, SHDN = 0 V , $R_L = 60\ \Omega$, $C_L = 100\text{ pF}$, $V_{CC} = 3$ to 3.6 V , $V_{IO} = 2.25\text{ V}$ to 2.75 V TCAN3413		67	110	ns
		See 图 6-2, STB, SHDN = 0 V , $R_L = 60\ \Omega$, $C_L = 100\text{ pF}$, $V_{CC} = 3$ to 3.6 V , $V_{IO} = 1.71\text{ V}$ to 1.89 V TCAN3413		71	110	ns

5.9 Switching Characteristics (续)

parameters valid over recommended operating conditions with $-40^{\circ}\text{C} \leq T_J \leq 150^{\circ}\text{C}$ (Typical values are at $V_{CC} = 3.3\text{ V}$, $V_{IO} = 3.3\text{ V}$ for TCAN3413, Device ambient maintained at 27°C) unless otherwise noted

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
t _{prop(TxD-busdom)}	Propagation delay time, high-to-low TXD edge to driver dominant (recessive to dominant)	See 图 6-2 , STB, SHDN = 0 V, R _L = 60 Ω, C _L = 100 pF, V _{CC} = V _{IO} = 3 V to 3.6 V TCAN3414, TCAN3413		46	100	ns
		See 图 6-2 , STB, SHDN = 0 V, R _L = 60 Ω, C _L = 100 pF, V _{CC} = 3 to 3.6 V, V _{IO} = 2.25 V to 2.75 V TCAN3413		48	110	ns
		See 图 6-2 , STB, SHDN = 0 V, R _L = 60 Ω, C _L = 100 pF, V _{CC} = 3 to 3.6 V, V _{IO} = 1.71 V to 1.89 V TCAN3413		53	110	ns
t _{sk(p)}	Pulse skew (t _{prop(TxD-busrec)} - t _{prop(TxD-busdom)})	, STB, SHDN = 0 V, R _L = 60 Ω, C _L = 100 pF, See 图 6-2		18	28	ns
t _R	Differential output signal rise time	See 图 6-2 , STB, SHDN = 0 V, R _L = 60 Ω, C _L = 100 pF		32	57	ns
t _F	Differential output signal fall time			30	50	ns
t _{TXD_DTO}	Dominant timeout	See 图 6-6 , STB, SHDN = 0 V, R _L = 60 Ω, C _L = 100 pF	1.2		4.0	ms
Receiver Switching Characteristics						
t _{prop(busrec-RXD)}	Propagation delay time, bus recessive input to RXD high output (dominant to recessive)	See 图 6-3 , STB, SHDN = 0 V, C _{L(RXD)} = 15 pF, V _{CC} = V _{IO} = 3 V to 3.6 V TCAN3414, TCAN3413		55	90	ns
		See 图 6-3 , STB, SHDN = 0 V, C _{L(RXD)} = 15 pF, V _{CC} = 3 to 3.6 V, V _{IO} = 2.25 V to 2.75 V TCAN3413		60	90	ns
		See 图 6-3 , STB, SHDN = 0 V, C _{L(RXD)} = 15 pF, V _{CC} = 3 to 3.6 V, V _{IO} = 1.71 V to 1.89 V TCAN3413		70	102	ns
t _{prop(busdom-RXD)}	Propagation delay time, bus dominant input to RXD low output (recessive to dominant)	See 图 6-3 , STB, SHDN = 0 V, C _{L(RXD)} = 15 pF, V _{CC} = V _{IO} = 3 V to 3.6 V TCAN3414, TCAN3413		45	90	ns
		See 图 6-3 , STB, SHDN = 0 V, C _{L(RXD)} = 15 pF, V _{CC} = 3 to 3.6 V, V _{IO} = 2.25 V to 2.75 V TCAN3413		51	90	ns
		See 图 6-3 , STB, SHDN = 0 V, C _{L(RXD)} = 15 pF, V _{CC} = 3 to 3.6 V, V _{IO} = 1.71 V to 1.89 V TCAN3413		60	100	ns
t _R	RXD output signal rise time	See 图 6-3 , STB, SHDN = 0 V C _{L(RXD)} = 15 pF		10	25	ns
t _F	RXD output signal fall time			10	28	ns
FD Timing Characteristics						
t _{BIT(BUS)}	Bit time on CAN bus output pins with t _{BIT(TXD)} = 500 ns	See 图 6-4 , STB, SHDN = 0 V, R _L = 60 Ω, C _L = 100 pF, C _{L(RXD)} = 15 pF	450		525	ns
	Bit time on CAN bus output pins with t _{BIT(TXD)} = 200 ns		160		205	ns
	Bit time on CAN bus output pins with t _{BIT(TXD)} = 125 ns ⁽¹⁾		85		130	ns
t _{BIT(RXD)}	Bit time on RXD output pins with t _{BIT(TXD)} = 500 ns	See 图 6-4 , STB, SHDN = 0 V, R _L = 60 Ω, C _L = 100 pF, C _{L(RXD)} = 15 pF	410		540	ns
	Bit time on RXD output pins with t _{BIT(TXD)} = 200 ns		130		210	ns
	Bit time on RXD output pins with t _{BIT(TXD)} = 125 ns ⁽¹⁾		75		135	ns

5.9 Switching Characteristics (续)

parameters valid over recommended operating conditions with $-40^{\circ}\text{C} \leq T_J \leq 150^{\circ}\text{C}$ (Typical values are at $V_{CC} = 3.3\text{ V}$, $V_{IO} = 3.3\text{ V}$ for TCAN3413, Device ambient maintained at 27°C) unless otherwise noted

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
Δt_{REC}	Receiver timing symmetry with $t_{\text{BIT(TXD)}} = 500\text{ ns}$	See 图 6-4, STB, SHDN = 0 V, $R_L = 60\ \Omega$, $C_L = 100\text{ pF}$, $C_{L(\text{RXD})} = 15\text{ pF}$ $\Delta t_{\text{REC}} = t_{\text{BIT(RXD)}} - t_{\text{BIT(BUS)}}$	-50		20	ns
	Receiver timing symmetry with $t_{\text{BIT(TXD)}} = 200\text{ ns}$		-40		10	ns
	Receiver timing symmetry with $t_{\text{BIT(TXD)}} = 125\text{ ns}^{(1)}$		-40		10	ns

(1) Min/Max limits based on characterization.

5.10 Typical Characteristics

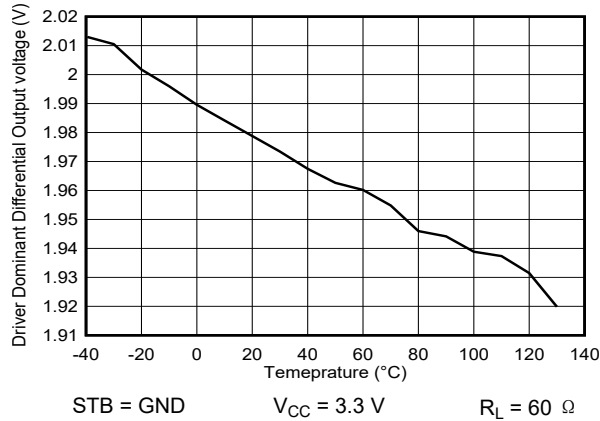
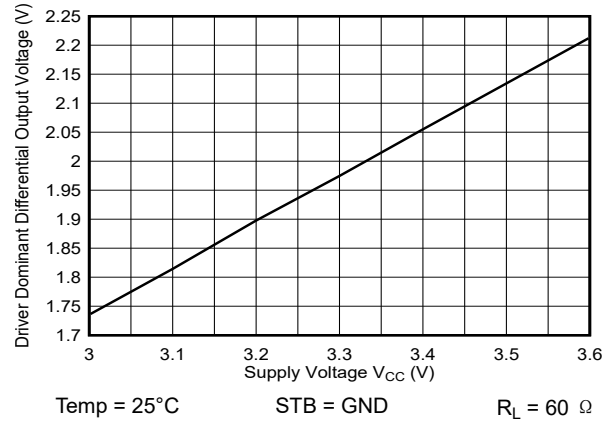
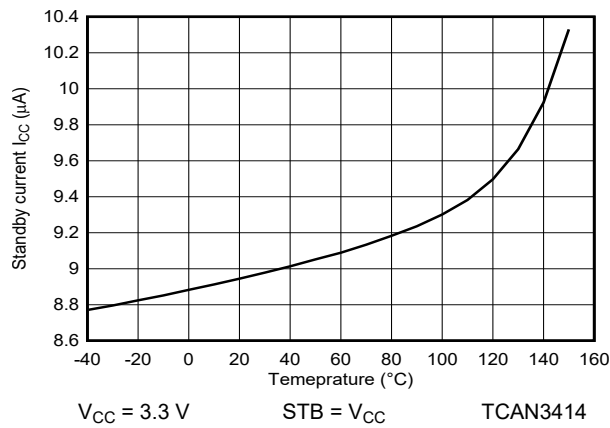
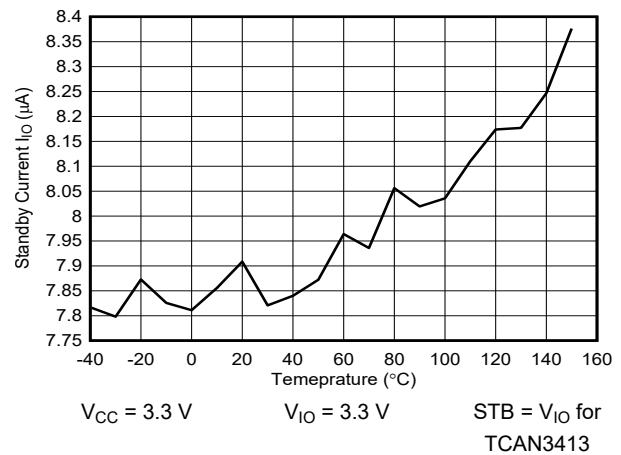
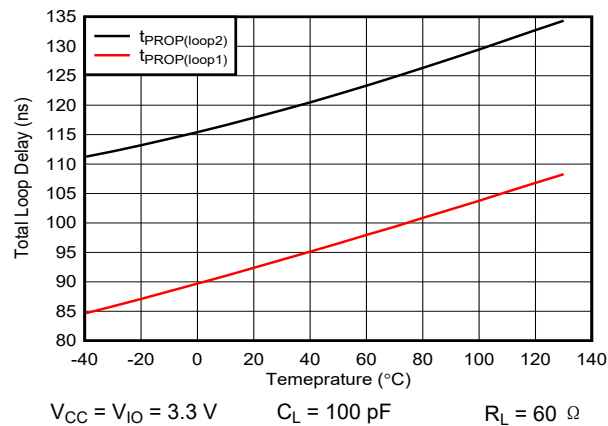
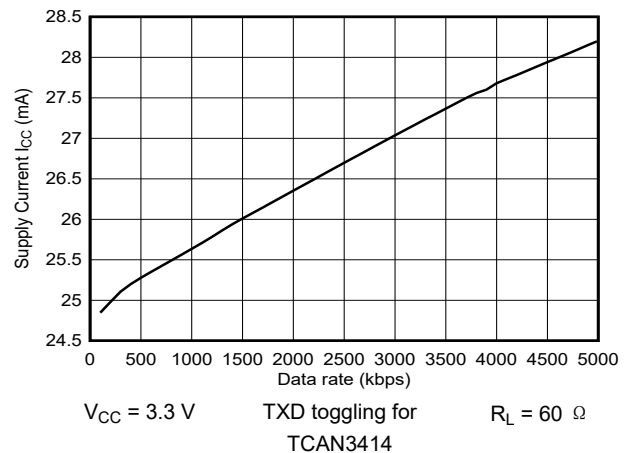
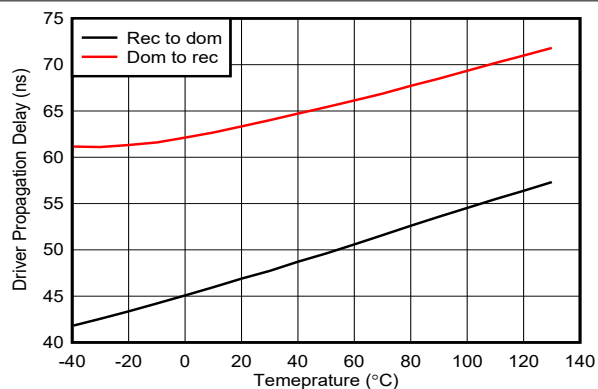
图 5-1. $V_{OD(DOM)}$ vs Temperature图 5-2. $V_{OD(DOM)}$ vs V_{CC} 图 5-3. I_{CC} Standby vs Temperature图 5-4. I_{IO} Standby vs Temperature

图 5-5. Total Loop Delay vs Temperature

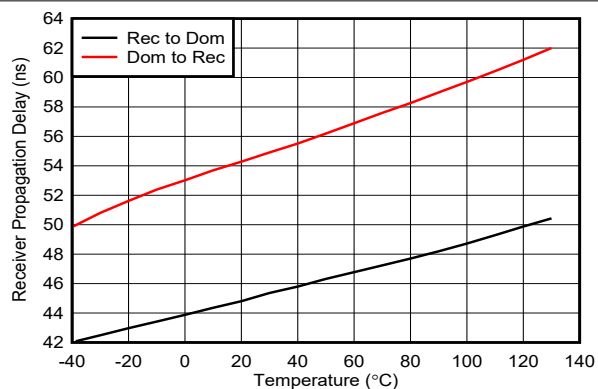
图 5-6. I_{CC} vs Data Rate

5.10 Typical Characteristics (continued)



$V_{CC} = V_{IO} = 3.3\text{ V}$ $C_L = 100\text{ pF}$ $R_L = 60\ \Omega$

图 5-7. Driver Propagation Delay vs Temperature



$V_{CC} = V_{IO} = 3.3\text{ V}$ $C_L = 100\text{ pF}$ $R_L = 60\ \Omega$

图 5-8. Receiver Propagation Delay vs Temperature

6 Parameter Measurement Information

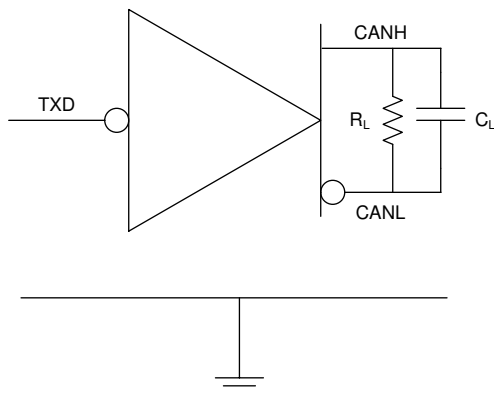


图 6-1. I_{CC} Test Circuit

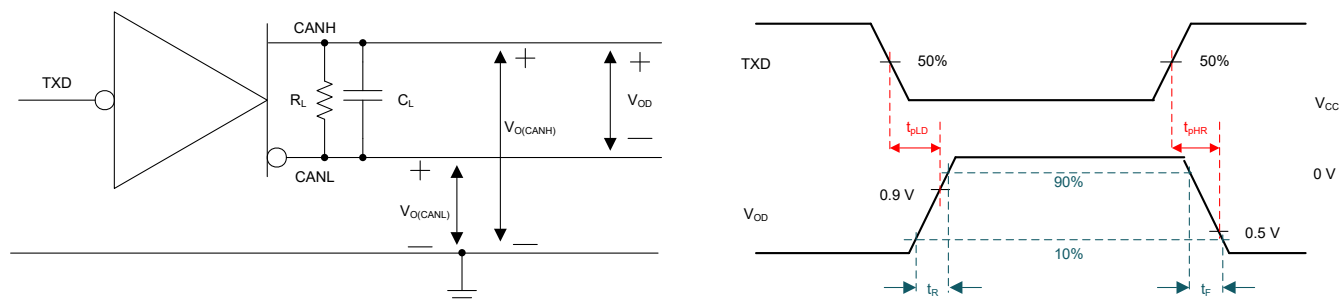


图 6-2. Driver Test Circuit and Measurement

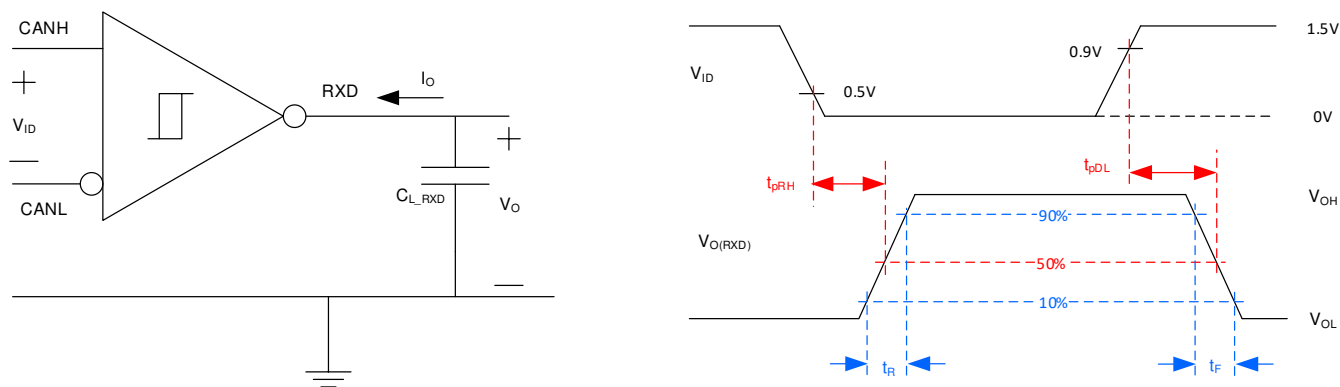


图 6-3. Receiver Test Circuit and Measurement

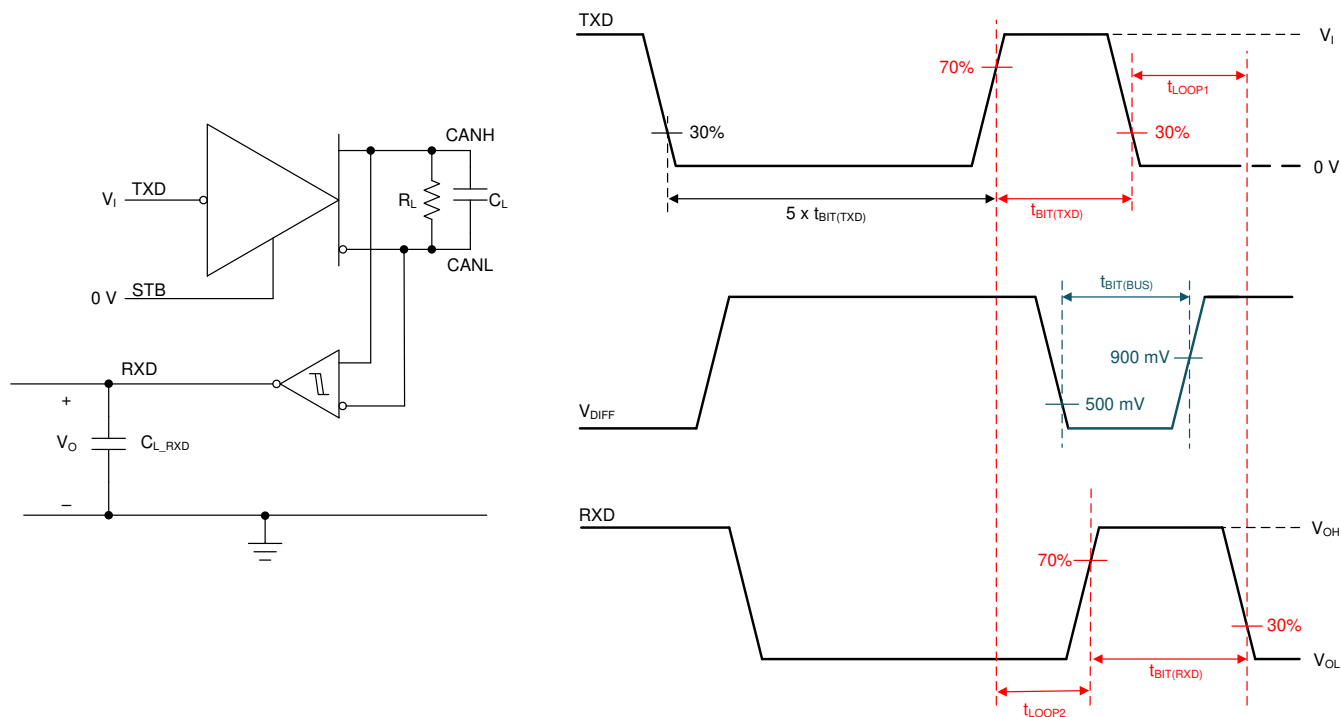


图 6-4. Transmitter and Receiver Timing Test Circuit and Measurement

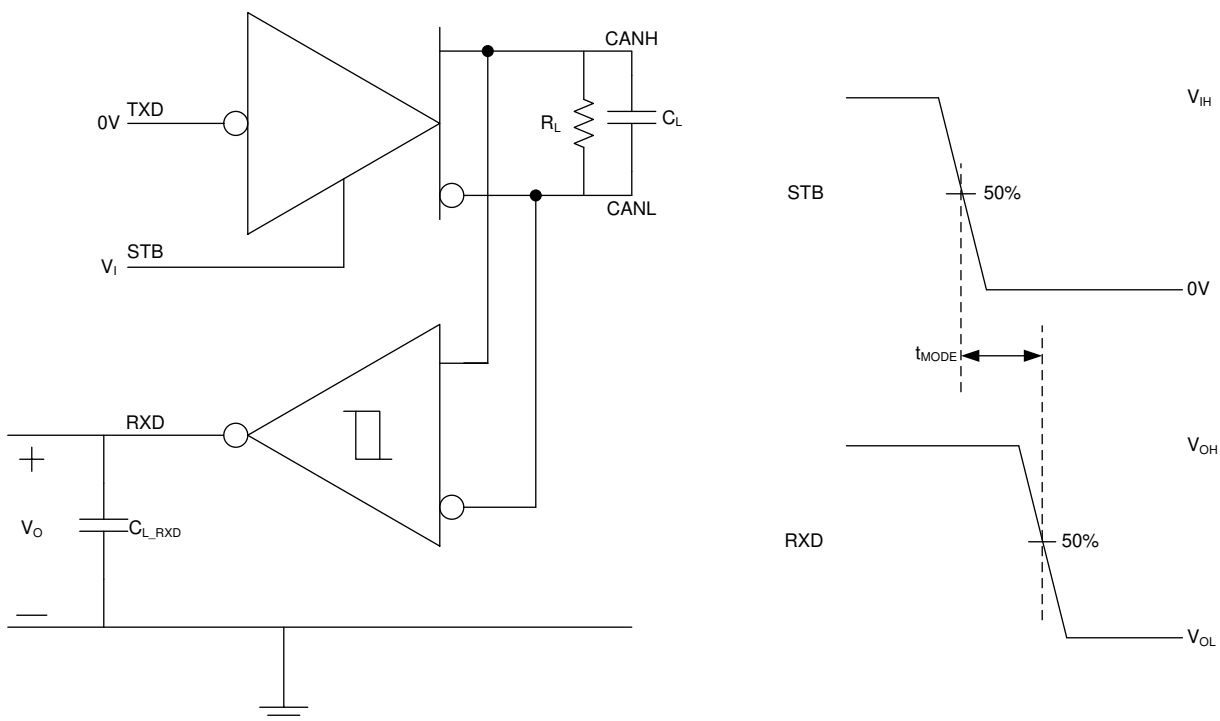


图 6-5. t_{MODE} Test Circuit and Measurement

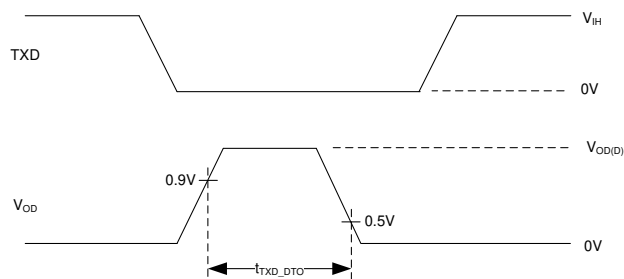
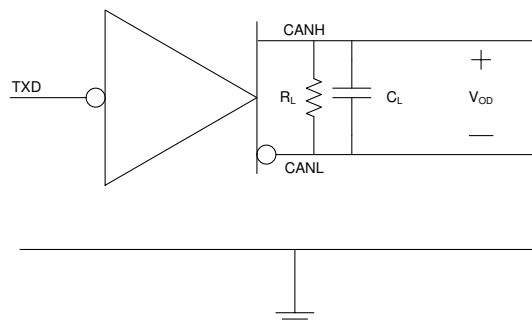


图 6-6. TXD Dominant Timeout Test Circuit and Measurement

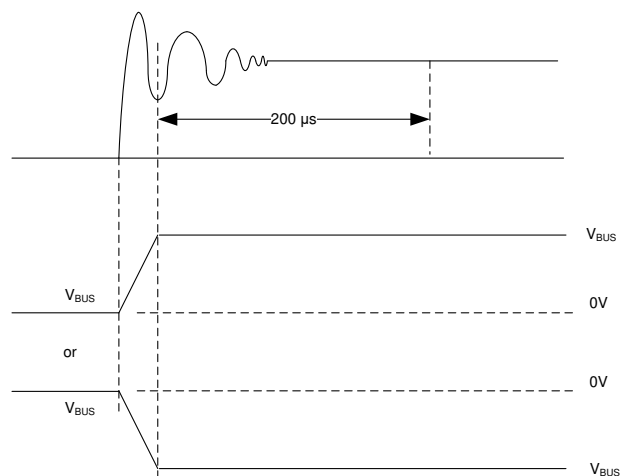
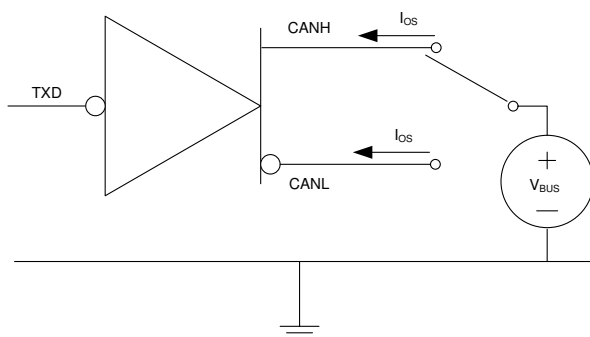


图 6-7. Driver Short-Circuit Current Test and Measurement

7 Detailed Description

7.1 Overview

The TCAN341x devices are 3.3 V CAN FD transceivers with robust EMC performance. The devices are data rate agnostic making them backward compatible for supporting classical CAN applications while also supporting CAN FD networks up to 8 Mbps. The devices have standby mode support which puts the transceiver in low current consumption mode. Upon receiving valid wake-up pattern on CAN bus, the device signals to the micro-controller through the RXD pin. The MCU can then place the device in normal mode using STB pin.

TCAN3414 supports ultra-low power shutdown mode where most of the internal blocks are disabled. This feature is optimized for battery-powered applications. TCAN3413 supports V_{IO} pin for low voltage logic level interface. It can be interfaced to 1.8 V, 2.5 V or 3.3 V micro controllers.

7.2 Functional Block Diagram

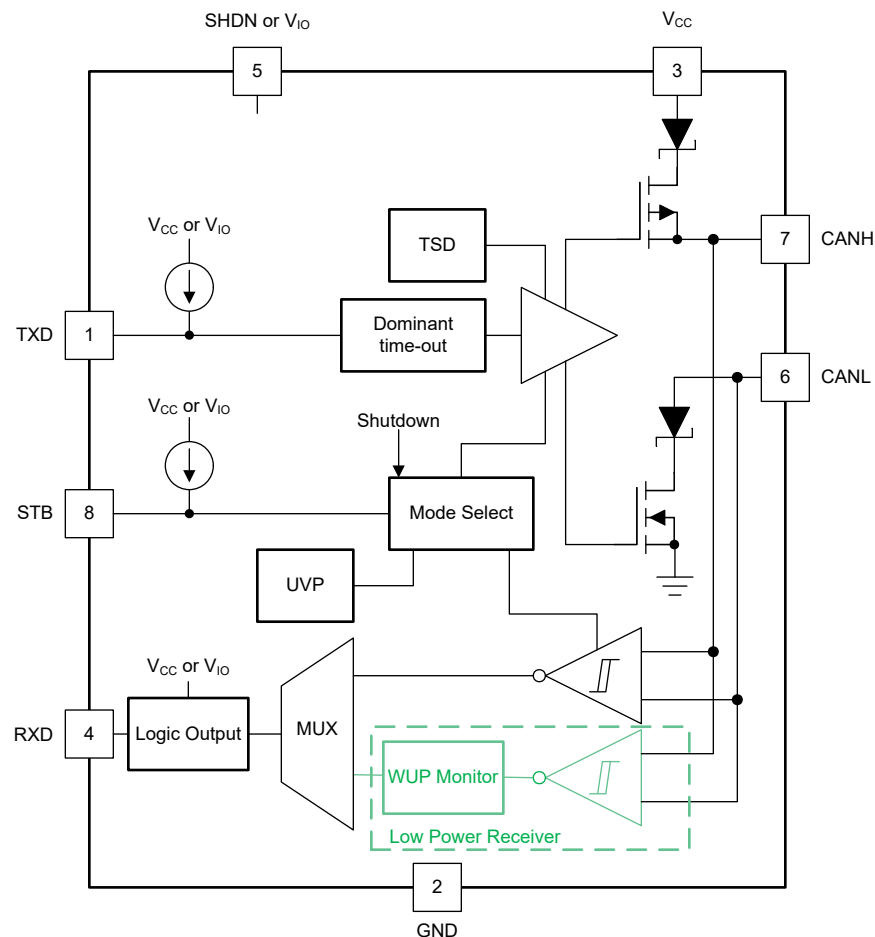


图 7-1. Block Diagram

7.3 Feature Description

7.3.1 Pin Description

7.3.1.1 TXD

The TXD input is a logic-level signal from a CAN controller to the transceiver. The signal is referenced to V_{CC} for the TCAN3414, or to V_{IO} for the TCAN3413.

7.3.1.2 GND

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

7.3.1.3 V_{CC}

V_{CC} provides the 3.3 V power supply to the CAN transceiver.

7.3.1.4 RXD

The RXD output is a logic-level signal from the CAN transceiver to the CAN controller. The signal is referenced to V_{CC} for TCAN3414 and V_{IO} for TCAN3413. For TCAN3413, the pin is only driven once V_{IO} is present.

When a CAN bus wake-up event takes place, RXD is driven low.

7.3.1.5 V_{IO} (TCAN3413 only)

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

7.3.1.6 CANH and CANL

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

7.3.1.7 STB (Standby)

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

7.3.1.8 SHDN (Shutdown)

The SHDN pin is only applicable to TCAN3414 and is used to put the device in ultra-low power mode. SHDN pin has an internal pull-down resistor on-chip, so if the pin is left floating, the device is in normal mode or standby mode depending on the state of STB pin. Pulling SHDN pin high externally puts the device in shutdown. All blocks (including low power wakeup receiver) are disabled in this mode. SHDN pin has higher priority compared to STB pin.

7.3.2 CAN Bus States

The CAN bus has two logical states during operation: recessive and dominant. See [图 7-2](#) and [图 7-3](#).

A dominant bus state occurs when the bus is driven differentially and corresponds to a logic low on the TXD and RXD pins. A recessive bus state occurs when the bus is biased to roughly $V_{CC}/2$ via the high-resistance internal input resistors (R_{IN}) of the receiver and corresponds to a logic high on the TXD and RXD pins.

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

The TCAN341x transceivers implement a low-power standby (STB) mode which enables a third bus state where the bus pins are weakly biased to ground via the high resistance internal resistors of the receiver. See [图 7-2](#) and [图 7-3](#).

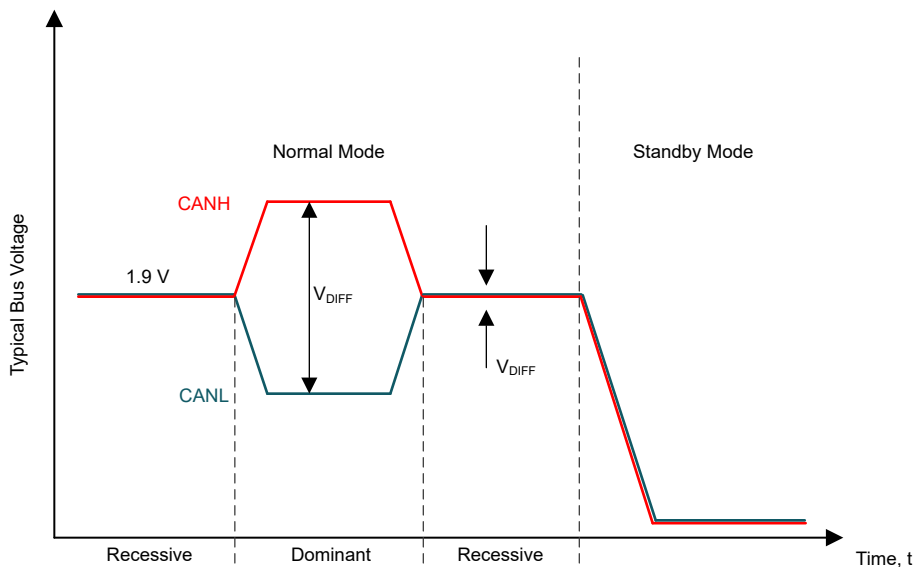
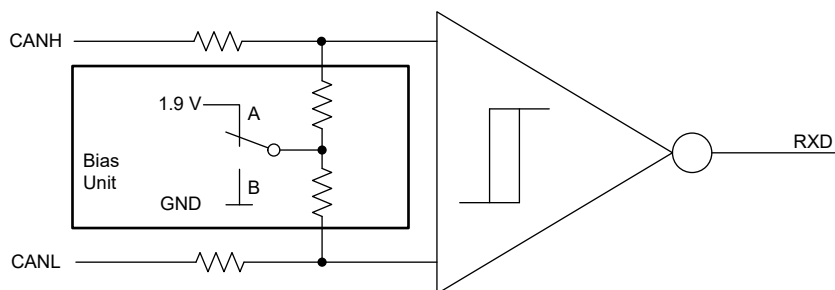


图 7-2. Bus States



A - Normal Mode B - Standby Mode

图 7-3. Simplified Recessive Common Mode Bias Unit and Receiver

7.3.3 TXD Dominant Timeout (DTO)

During normal mode, the only mode where the CAN driver is active, the TXD DTO circuit prevents the local node from blocking network communication in the event of a hardware or software failure where TXD is held dominant longer than the timeout period t_{TXD_DTO} . The TXD DTO circuit is triggered by a falling edge on TXD. If no rising edge is seen before the timeout period of the circuit, t_{TXD_DTO} , the CAN driver is disabled. This frees the bus for communication between other nodes on the network. The CAN driver is reactivated when a recessive signal is seen on the TXD pin, thus clearing the dominant time out. The receiver remains active and biased to approximately 1.9 V and the RXD output reflects the activity on the CAN bus during the TXD DTO fault.

The minimum dominant TXD time allowed by the TXD DTO circuit limits the minimum possible transmitted data rate of the device. The CAN protocol allows a maximum of eleven successive dominant bits (on TXD) for the worst case, where five successive dominant bits are followed immediately by an error frame. The minimum transmitted data rate may be calculated using 方程式 1 .

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

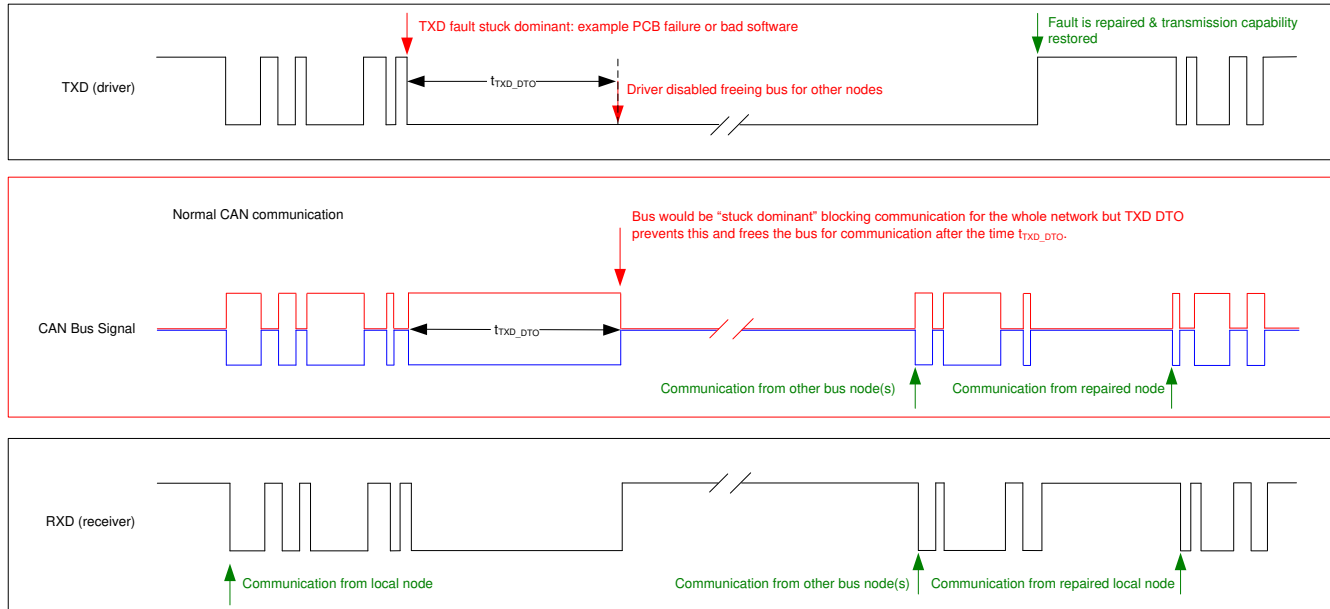


图 7-4. Example Timing Diagram for TXD Dominant Timeout

7.3.4 CAN Bus short-circuit current limiting

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

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

$$I_{OS(AVG)} = \% \text{ Transmit} \times [(\% \text{ REC_Bits} \times I_{OS(SS_REC)}) + (\% \text{ DOM_Bits} \times I_{OS(SS_DOM)})] + [\% \text{ Receive} \times I_{OS(SS_REC)}] \quad (2)$$

Where:

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

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

7.3.5 Thermal Shutdown (TSD)

If the junction temperature of the devices exceed the thermal shutdown threshold, T_{TSD} , the device turns off the CAN driver circuitry and blocks the TXD to bus transmission path. The shutdown condition is cleared when the

junction temperature of the device drops below T_{TSD} . The CAN bus pins are biased to $\sim 1.9\text{ V}$ during a TSD fault and the receiver to RXD path remains operational. The TCAN341x TSD circuit includes hysteresis which prevents the CAN driver output from oscillating during a TSD fault.

7.3.6 Undervoltage Lockout

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

表 7-1. Undervoltage Lockout - TCAN3414

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

表 7-2. Undervoltage Lockout - TCAN3413

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

Once the undervoltage condition is cleared and t_{MODE} or t_{SHDN2} has expired, the TCAN341x transitions to normal mode. The host controller again sends and receives CAN traffic.

7.3.7 Unpowered Device

For unpowered conditions, the TCAN341x is designed to be a passive or no load to the CAN bus. This is because the bus pins were designed to have low leakage currents to not load the bus. This design consideration is critical if some nodes of the network are unpowered while the rest of the network remains operational.

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

7.3.8 Floating pins

The TCAN341x devices have internal pull-up/pull-down resistors on critical pins which place the device into known states if the pin floats. This internal bias should not be relied upon by design though, especially in noisy environments, but instead should be considered a failsafe protection feature.

When a CAN controller supporting open-drain outputs is used, an adequate external pull-up resistor must be chosen. This makes sure the TXD output of the CAN controller maintains acceptable bit time to the input of the CAN transceiver. See [表 7-3](#) for details on pin bias conditions.

表 7-3. Pin Bias

Pin	Pull-up or Pull-down	Comment
TXD	Pull-up	Weakly biases TXD towards recessive to prevent bus blockage or TXD DTO triggering
STB	Pull-up	Weakly biases STB towards low-power standby mode to prevent excessive system power
SHDN	Pull-down	Weakly biases SHDN towards normal mode to allow normal communication. SHDN pin has higher priority than STB for TCAN3414.

7.4 Device Functional Modes

7.4.1 Operating Modes

The TCAN341x has two main operating modes; normal mode and standby mode. Operating mode selection is made by applying a high or low level to the STB pin. TCAN3414 has a third mode: shutdown activated through SHDN pin. Pulling SHDN pin high disables most internal blocks and puts the device in lowest power consumption mode.

表 7-4. Operating Modes for STB pin

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

7.4.2 Normal Mode

This is the normal operating mode of the TCAN341x. The CAN driver and receiver are fully operational and CAN communication is bi-directional. The driver is translating a digital input on the TXD input to a differential output on the CANH and CANL bus pins. The receiver is translating the differential signal from CANH and CANL to a digital output on the RXD output.

7.4.3 Standby Mode

This is the low-power mode of the TCAN341x. The CAN driver and main receiver are switched off and bi-directional CAN communication is not possible. The low-power receiver and bus monitor circuits are enabled to allow for RXD wake-up requests via the CAN bus. A wake-up request is output to RXD as shown in [Remote Wake Request via Wake-Up Pattern \(WUP\) in Standby Mode](#). The local CAN protocol controller should monitor RXD for transitions (high-to-low) and reactivate the device to normal mode by pulling the STB pin low. The CAN bus pins are weakly pulled to GND in this mode; see [图 7-2](#) and [图 7-3](#).

For TCAN3413 in standby mode, only the V_{IO} supply is required; therefore, the V_{CC} may be switched off for additional system level current savings.

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

The TCAN341x devices support a remote wake-up request that is used to indicate to the host controller that the bus is active and the node should return to normal operation.

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

The WUP consists of a filtered dominant pulse, followed by a filtered recessive pulse, and finally by a second filtered dominant pulse. The first filtered dominant initiates the WUP, and the bus monitor then waits on a filtered recessive; other bus traffic does not reset the bus monitor. Once a filtered recessive is received the bus monitor is waiting for a filtered dominant and again, other bus traffic does not reset the bus monitor. Immediately upon

reception of the second filtered dominant the bus monitor recognizes the WUP and drives the RXD output low every time an additional filtered dominant signal is received from the bus.

For a dominant or recessive to be considered filtered, the bus must be in that state for more than the t_{WK_FILTER} time. Due to variability in t_{WK_FILTER} the following scenarios are applicable. Bus state times less than $t_{WK_FILTER(MIN)}$ are never detected as part of a WUP and thus no wake request is generated. Bus state times between $t_{WK_FILTER(MIN)}$ and $t_{WK_FILTER(MAX)}$ may be detected as part of a WUP and a wake-up request may be generated. Bus state times greater than $t_{WK_FILTER(MAX)}$ are always detected as part of a WUP; therefore, a wake request is always generated. See Figure 7-5 for the timing diagram of the wake-up pattern.

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

The ISO 11898-2:2016 standard has defined times for a short and long wake-up filter time. The t_{WK_FILTER} timing for the device has been picked to be within the minimum and maximum values of both filter ranges. This timing has been chosen such that a single bit time at 500 kbps, or two back-to-back bit times at 1 Mbps triggers the filter in either bus state. Any CAN frame at 500 kbps or less would contain a valid WUP.

For an additional layer of robustness and to prevent false wake-ups, the device implements a wake-up timeout feature. For a remote wake-up event to successfully occur, the entire WUP must be received within the timeout value $t \leq t_{WK_TIMEOUT}$. If not, the internal logic is reset and the transceiver remains in its current state without waking up. The full pattern must then be transmitted again, conforming to the constraints mentioned in this section. See Figure 7-5 for the timing diagram of the wake-up pattern with wake timeout feature.

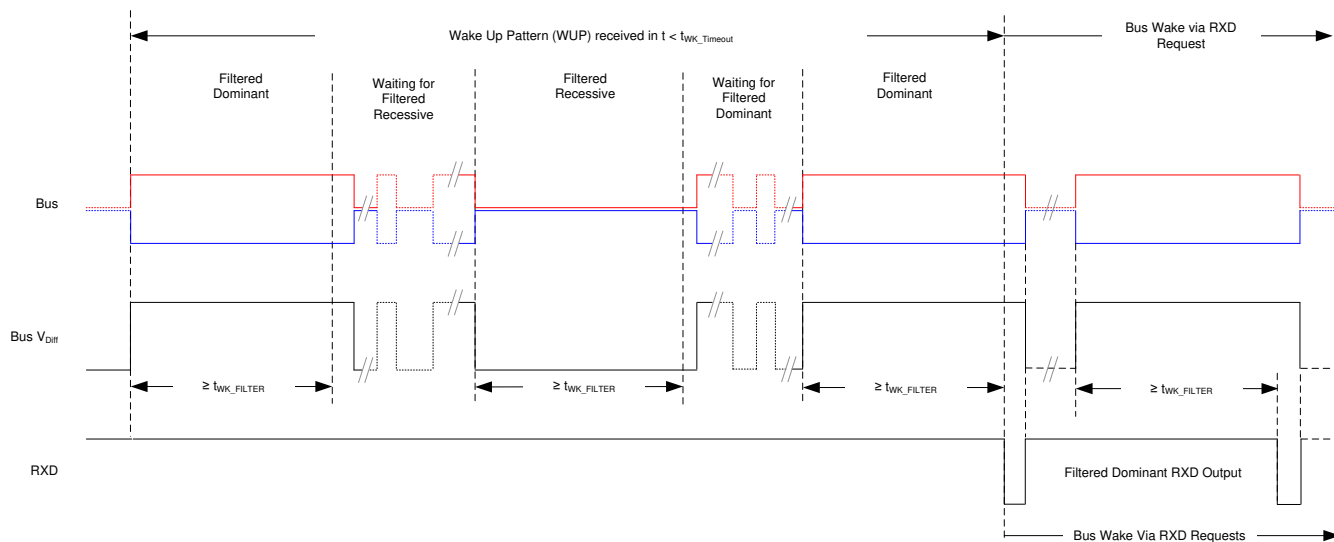


图 7-5. Wake-Up Pattern (WUP) with $t_{WK_TIMEOUT}$

7.4.4 Shutdown Mode

This is the lowest power state of TCAN3414. All internal blocks including CAN driver, main receiver and low power wake-up receiver are switched off and bi-directional CAN communication is not possible. Wakeup over CAN bus is also not possible in this mode. CAN bus pins are weakly biased towards GND and RXD is high in this state,

7.4.5 Driver and Receiver Function

The TCAN341x logic I/O supports CMOS levels with respect to either V_{CC} for 3.3-V systems (TCAN3414) or V_{IO} (TCAN3413) for compatibility with MCUs that support 1.8-V, 2.5-V, or 3.3-V systems.

表 7-5. Driver Function Table

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

(1) X = irrelevant

(2) For bus state and bias See [图 7-2](#) and [图 7-3](#).

表 7-6. Receiver Function Table Normal and Standby Mode

Device Mode	CAN Differential Inputs $V_{ID} = V_{CANH} - V_{CANL}$	Bus State	RXD Pin
Normal	$V_{ID} \geq 0.9 \text{ V}$	Dominant	Low
	$0.5 \text{ V} < V_{ID} < 0.9 \text{ V}$	Undefined	Undefined
	$V_{ID} \leq 0.5 \text{ V}$	Recessive	High
Standby	$V_{ID} \geq 1.15 \text{ V}$	Dominant	High Low if a remote wake event occurred See 图 7-5
	$0.4 \text{ V} < V_{ID} < 1.15 \text{ V}$	Undefined	
	$V_{ID} \leq 0.4 \text{ V}$	Recessive	
Any	Open ($V_{ID} \approx 0 \text{ V}$)	Open	High

8 Application and Implementation

备注

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8.1 Application Information

The TCAN341x transceivers can be used in applications with a host controller or FPGA that includes the link layer portion of the CAN protocol. 图 8-1 shows a typical configuration for 3.3-V controller applications. The bus termination is shown for illustrative purposes.

8.2 Typical Application

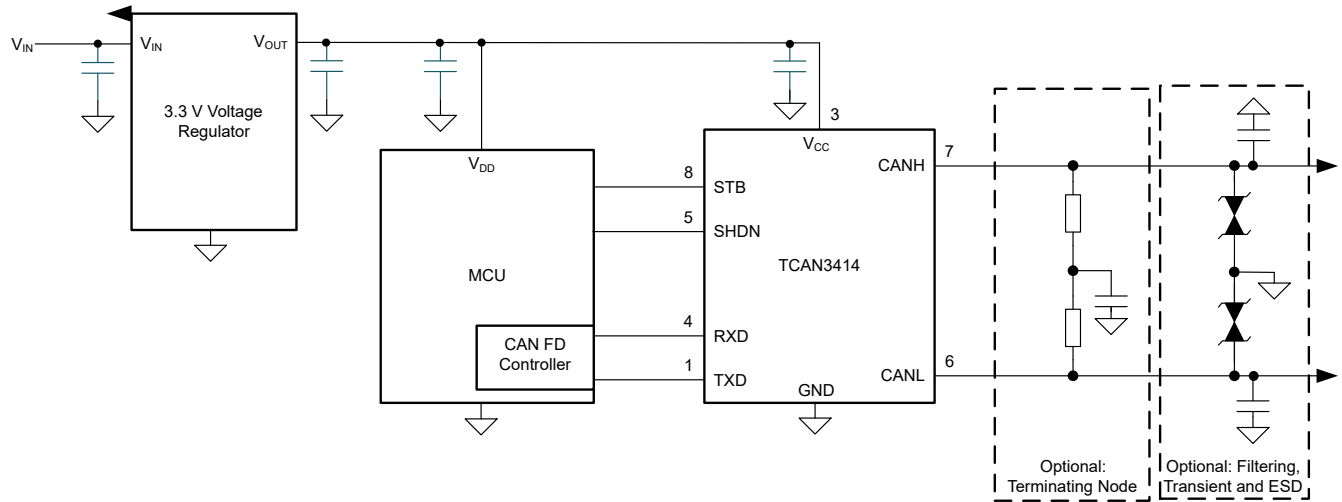


图 8-1. Transceiver Application Using 3.3-V I/O Connections

8.2.1 Design Requirements

8.2.1.1 CAN Termination

Termination may be a single 120-Ω resistor at each end of the bus, either on the cable or in a terminating node. If filtering and stabilization of the common-mode voltage of the bus is desired then split termination may be used, see 图 8-2. Split termination improves the electromagnetic emissions behavior of the network by filtering higher-frequency common-mode noise that may be present on the differential signal lines.

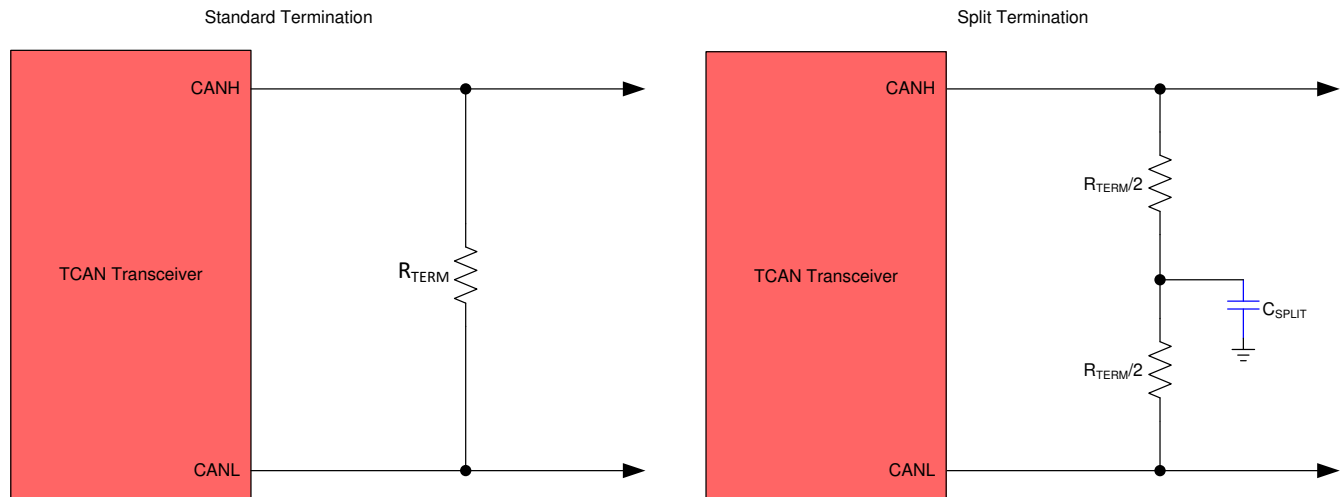


图 8-2. CAN Bus Termination Concepts

8.2.2 Detailed Design Procedures

8.2.2.1 Bus Loading, Length and Number of Nodes

A typical CAN application may have a maximum bus length of 40 meters and maximum stub length of 0.3 m. However, with careful design, users can have longer cables, longer stub lengths, and many more nodes to a bus. A high number of nodes requires a transceiver with high input impedance such as the TCAN341x.

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

A CAN network system design is a series of tradeoffs. In the ISO 11898-2:2016 specification the driver differential output is specified with a bus load that can range from 50 Ω to 65 Ω where the differential output must be greater than 1.5 V. The TCAN341x family is specified to meet the 1.5-V requirement down to 50 Ω and is specified to meet 1.4-V differential output at 45- Ω bus load. The differential input resistance of the TCAN341x is a minimum of 22 k Ω . If 55 TCAN341x transceivers are in parallel on a bus, this is equivalent to a 400- Ω differential load in parallel with the nominal 60- Ω bus termination which gives a total bus load of approximately 52 Ω . Therefore, the TCAN341x family theoretically supports over 50 transceivers on a single bus segment. However, for a CAN network design margin must be given for signal loss across the system and cabling, parasitic loadings, timing, network imbalances, ground offsets, and signal integrity thus a practical maximum number of nodes is often lower. Bus length may also be extended beyond 40 meters by careful system design and data rate tradeoffs. For example, CANopen network design guidelines allow the network to be up to 1 km with changes in the termination resistance, cabling, less than 64 nodes and significantly lowered data rate.

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

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

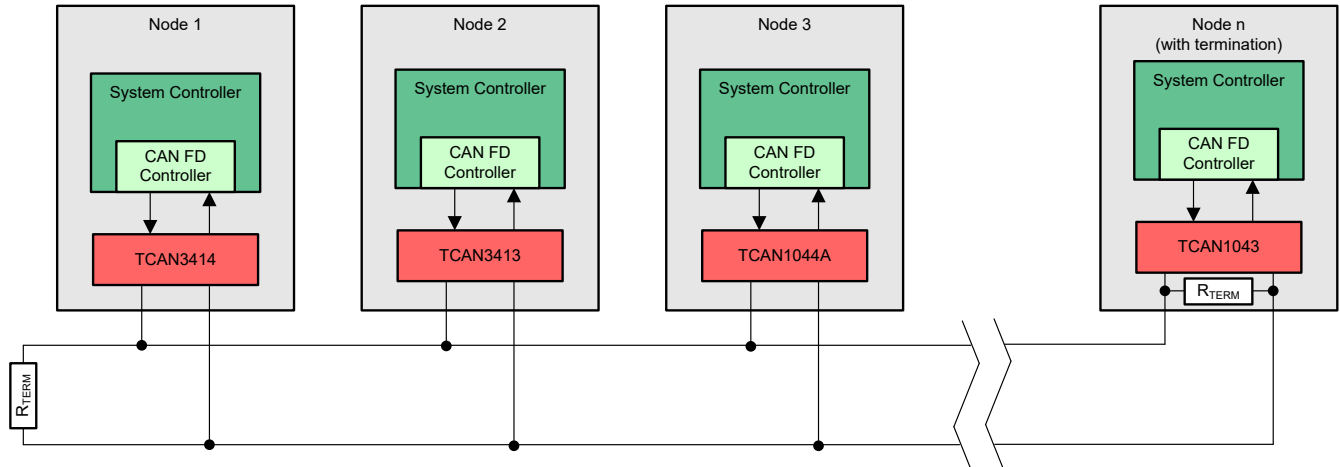


图 8-3. Typical CAN Bus

8.2.3 Application Curves

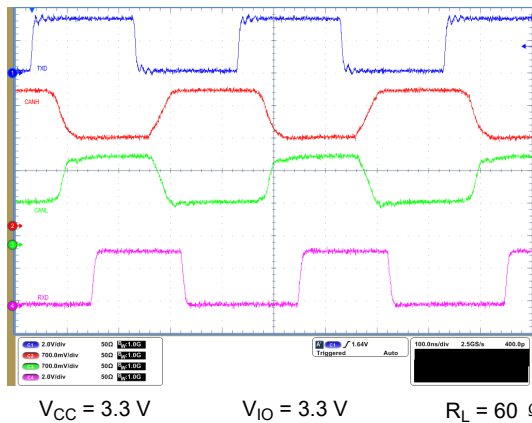


图 8-4. TXD_CANH_CANL_RXD waveforms for 60ohm load at 5Mbps toggling

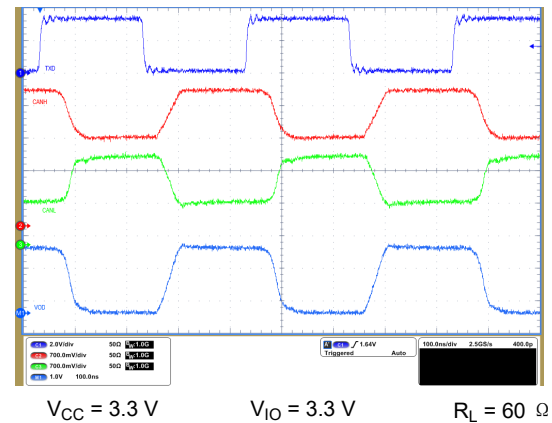


图 8-5. TXD_CANH_CANL_Vod waveforms for 60ohm load at 5Mbps toggling

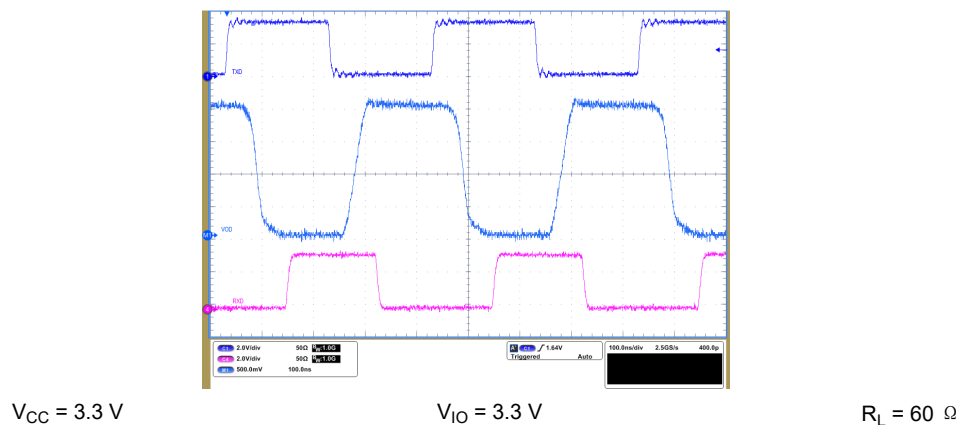


图 8-6. TXD_Vod_RXD waveforms for 60ohm load at 5Mbps toggling

8.3 System Examples

The TCAN341x CAN transceiver is typically used in applications with a host controller or FPGA that includes the link layer portion of the CAN protocol. A 1.8-V or 2.5-V application is shown in 图 8-7. The bus termination is shown for illustrative purposes.

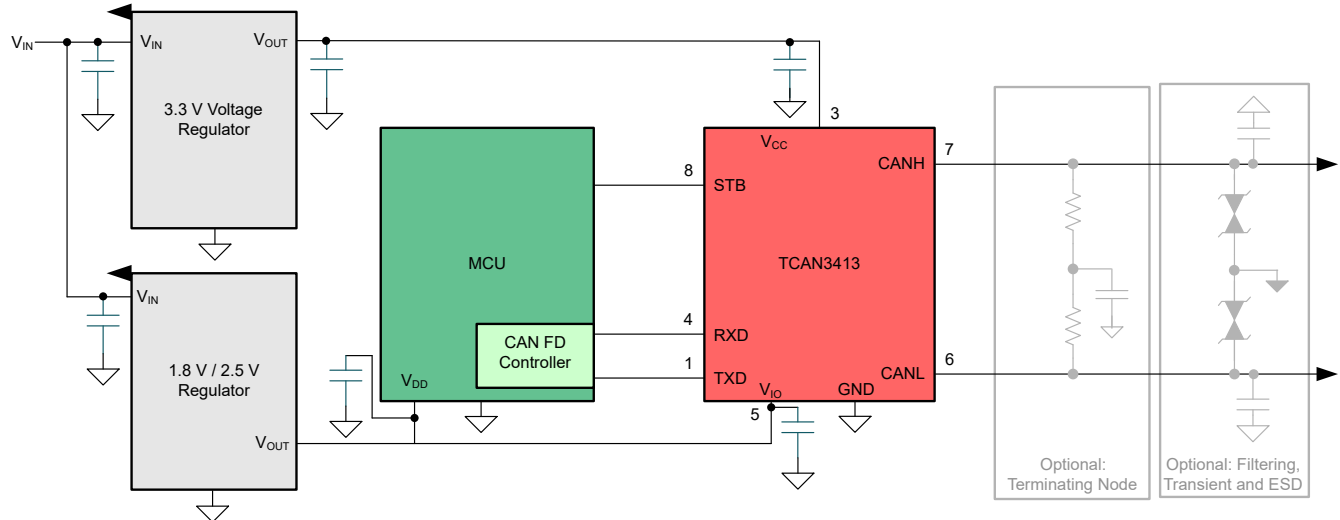


图 8-7. Typical Transceiver Application Using 1.8-V, 2.5-V I/O Connections

8.3.1 ISO 11898-2 Compatibility of TCAN341x Family of 3.3-V CAN Transceivers

8.3.1.1 Introduction

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

8.3.1.2 Differential Signal

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

The CAN driver creates the differential voltage between CANH and CANL in the dominant state. The dominant differential output of the TCAN341x is greater than 1.5 V and less than 3 V across a 60-Ω load as defined by the ISO 11898-2 standard. These are the same limiting values for 5 V supplied CAN transceivers. The bus termination resistors drive the recessive bus state and not the CAN driver.

A CAN receiver is required to output a recessive state when less than 500 mV of differential voltage exists on the bus, and a dominant state when more than 900 mV of differential voltage exists on the bus. The CAN receiver must do this with common-mode input voltages from -12 V to 12 V. The TCAN341x device receivers meet and exceed these receiver input specifications.

8.3.1.3 Common-Mode Signal

A common-mode signal is an average voltage of the two signal wires that the differential receiver rejects. The common-mode signal comes from the CAN driver, ground noise, and coupled bus noise. The TCAN341x family has the recessive bias voltage set to 1.9V. This is intentional to match the common mode of recessive output with the common mode of dominant output signal from TCAN341x. Furthermore, TCAN341x has special design techniques for optimum EMC performance in a heterogeneous bus consisting of TCAN341x and 5 V CAN transceivers.

8.3.1.4 Interoperability of 3.3-V CAN in 5-V CAN Systems

The 3.3-V supplied TCAN341x family of CAN transceivers are fully compatible with 5-V CAN transceivers. The minimum differential output voltage is the same, and the receivers have the same input threshold specifications. The only difference is in the recessive common mode output voltage which is little lower for 3.3-V CAN transceiver than 5-V supplied transceiver. But this does not impact regular functionality. Furthermore, special design techniques in TCAN341x provide optimum EMC performance in heterogeneous network consisting of TCAN341x and 5 V supplied CAN transceivers on same CAN bus.

8.4 Power Supply Recommendations

The TCAN3414 transceiver is designed to operate with a main V_{CC} input voltage supply range between 3 V and 3.6 V.

The TCAN3413 implements an I/O level shifting supply input, V_{IO} , designed for a range between 1.8 V and 3.6 V.

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

8.5 Layout

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

8.5.1 Layout Guidelines

- Place the protection and filtering circuitry close to the bus connector, J1, to prevent transients, ESD, and noise from propagating onto the board. This layout example shows an optional transient voltage suppression (TVS) diode, D1, which may be implemented if the system-level requirements exceed the specified rating of the transceiver. This example also shows optional bus filter capacitors C4 and C5.
- Design the bus protection components in the direction of the signal path. Do not force the transient current to divert from the signal path to reach the protection device.
- Decoupling capacitors should be placed as close as possible to the supply pins V_{CC} and V_{IO} of transceiver.
- Use at least two vias for supply and ground connections of bypass capacitors and protection devices to minimize trace and via inductance.

备注

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

- This layout example shows how split termination could be implemented on the CAN node. The termination is split into two resistors, R2 and R3, with the center or split tap of the termination connected to ground via capacitor C3. Split termination provides common mode filtering for the bus. See [节 8.2.1.1](#), and [节 7.3.4](#) for information on termination concepts and power ratings needed for the termination resistor(s).

8.5.2 Layout Example

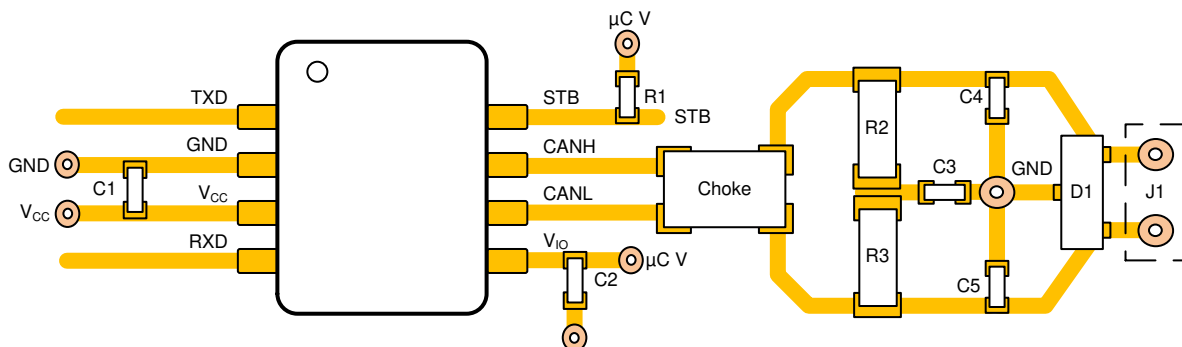


图 8-8. Layout Example

9 Device and Documentation Support

9.1 接收文档更新通知

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ESD 的损坏小至导致微小的性能降级，大至整个器件故障。精密的集成电路可能更容易受到损坏，这是因为非常细微的参数更改都可能会导致器件与其发布的规格不相符。

9.5 术语表

TI 术语表 本术语表列出并解释了术语、首字母缩略词和定义。

10 Revision History

注：以前版本的页码可能与当前版本的页码不同

Changes from Revision * (March 2023) to Revision A (November 2023)	Page
• 将文档状态从：预告信息 更改为量产数据.....	1

11 Mechanical, Packaging, and Orderable Information

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

PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package Pins	Package qty Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
TCAN3413DDFR	Active	Production	SOT-23-THIN (DDF) 8	3000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	2THF
TCAN3413DDFR.A	Active	Production	SOT-23-THIN (DDF) 8	3000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	2THF
TCAN3413DR	Active	Production	SOIC (D) 8	2500 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	34X3
TCAN3413DR.A	Active	Production	SOIC (D) 8	2500 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	34X3
TCAN3413DRBR	Active	Production	SON (DRB) 8	3000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	3413
TCAN3413DRBR.A	Active	Production	SON (DRB) 8	3000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	3413
TCAN3414DDFR	Active	Production	SOT-23-THIN (DDF) 8	3000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	2TIF
TCAN3414DDFR.A	Active	Production	SOT-23-THIN (DDF) 8	3000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	2TIF
TCAN3414DR	Active	Production	SOIC (D) 8	2500 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	34X4
TCAN3414DR.A	Active	Production	SOIC (D) 8	2500 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	34X4
TCAN3414DRBR	Active	Production	SON (DRB) 8	3000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	3414
TCAN3414DRBR.A	Active	Production	SON (DRB) 8	3000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	3414

⁽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.

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