TPIC1021A-Q1 LIN 物理接口

1 特性

- 符合 LIN 物理层规范修订版本 2.0，并符合适用于 LIN 的 SAEJ2602 推荐实践要求
- LIN 总线速度高达 LIN 指定的最大值 20kbps
- 睡眠模式：超低电流消耗，支持来自 LIN 总线、唤醒输入（外部开关）或主机 MCU 的唤醒事件
- 支持高速接收
- LIN 引脚提供 ±12kV（人体放电模型）ESD 保护
- LIN 引脚可处理 –40V 至 40V 的电压
- 可在汽车环境中耐受瞬态损伤 (ISO 7637)
- 7V 至 27V 的直流电源扩展工作电压范围（LIN 规范 7V 至 18V）
- 使用 5V 或者 3.3V I/O 引脚连接到 MCU
- 显性状态超时保护
- RXD 引脚上的唤醒请求
- 外部稳压器控制（INH 引脚）
- 适用于 LIN 响应器应用的集成上拉电阻器和串联二极管
- 低电磁辐射 (EME)、高电磁抗扰度 (EMI)
- 针对电池短路或接地短路提供总线端子短路保护
- 热保护
- 系统级接地断开失效防护
- 系统级接地漂移运行
- 未供电节点不会干扰网络
- 支持类似 ISO9141 (K-Line) 的功能

2 应用

- 车载网络

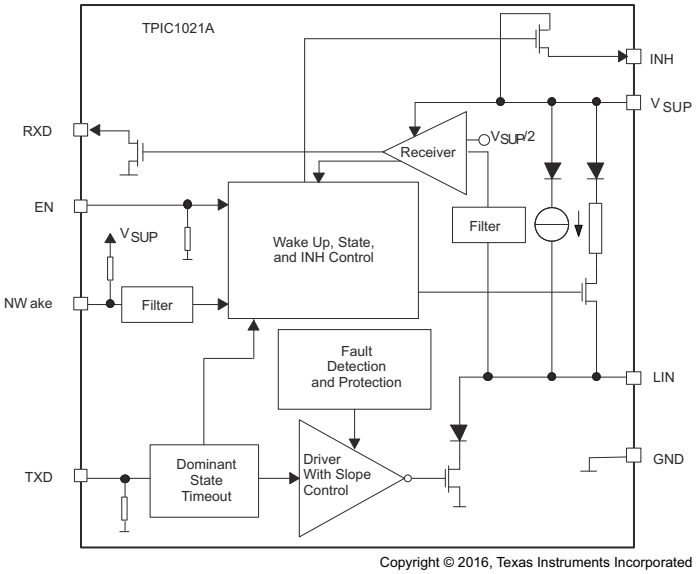
3 说明

TPIC1021A 是本地互连网络 (LIN) 物理接口，此接口集成了具有唤醒和保护特性的串行收发器。LIN 总线是一根单线制双向总线，通常用于低速车载网络，数据传输速率在 2.4kbps 和 20kbps 之间。TPIC1021A 通过 LIN 物理层规范修订版 2.0 中概述的限流波形整型驱动器将 TXD 上的 LIN 协议输出数据流转换为 LIN 总线信号。接收器对来自 LIN 总线上的数据流进行转换并通过 RXD 将此数据流输出。LIN 总线共有两种状态：显性状态（电压接近接地）和隐性状态（电压接近电池）。在隐性状态下，LIN 总线被 TPIC1021A 的内部上拉电阻器 (30kΩ)
和串联二极管拉高，所以响应器应用无需外部上拉元件。按照 LIN 规范，“指挥官”应用需要一个外部上拉电阻器 (1kΩ) 加上一个串联二极管。

器件信息

器件型号	封装(1)	封装尺寸（标称值）
TPIC1021A-Q1	SOIC (8)	4.90mm × 3.91mm

(1) 如需了解所有可用封装，请参阅数据表末尾的可订购产品附录。



功能方框图

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4 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 B (February 2016) to Revision C (May 2022)	Page
• 将提到的所有旧术语实例更改为“指挥官”和“响应者”	1

Changes from Revision A (June 2009) to Revision B (February 2016)	Page
• 添加了 *ESD 等级* 表、*特性说明* 部分、*器件功能模式*、*应用和实施* 部分、*电源相关建议* 部分、*布局* 部分、*器件和文档支持* 部分以及*机械、封装和可订购信息* 部分。	1
• 删除了 *订购信息* 表，请参阅数据表末尾的 POA	1

5 说明（续）

在睡眠模式下，即使唤醒电路保持工作状态，TPIC1021A 也需要低静态电流，从而支持通过 LIN 总线进行远程唤醒或者通过 NWake 或 EN 引脚进行本地唤醒。

TPIC1021A 设计用于在恶劣的汽车环境中运行。该器件可处理从 40V 向下至接地的 LIN 总线电压摆幅，并且可在 –40V 的电压下运行。该器件还可在接地漂移或电源电压断开的情况下防止反馈电流经 LIN 流向电源输入。它还特有欠压，过热，和接地故障保护。一旦发生故障情况，此输出便会立即关闭并在故障情况被解决之前一直保持关闭状态。

6 Device Comparison Table

The TPIC1021A is pin-to-pin compatible to the TPIC1021 device. The TPIC1021A is an enhanced LIN transceiver, including enhanced immunity to RF disturbances. See 表 6-1 for a summary of the differences between the two devices.

表 6-1. TPIC1021A vs TPIC1021 Differences

SPECIFICATION	TPIC1021A	TPIC1021
LIN termination	Weak current pullup in sleep mode	High Ω in low-power mode
LIN receiver	Enhanced high-speed receive capable	High-speed receive capable
LIN leakage current (unpowered device): 7 V < LIN < 12 V, V_{SUP} = GND	<5 μA at 12 V (max)	<10 μA at 12 V (typ)
LIN bus wakeup	Remote wakeup through recessive-to-dominant transition on LIN bus where dominant bus state is held for at least t_{LINBUS} time followed by a transition back to the recessive state	Remote wakeup through recessive-to-dominant transition on LIN bus where dominant bus state is held for at least t_{LINBUS} time
Low-power current	<30 μA at 12 V (max)	<50 μA at 14 V (max)
INH pin	Enhanced driving of bus commander termination through lower R_{on}	Driving of bus commander termination

7 Pin Configuration and Functions

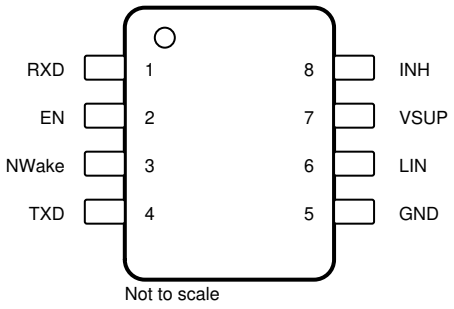


图 7-1. D Package, 8-Pin SOIC (Top View)

表 7-1. Pin Functions

PIN		TYPE(1)	DESCRIPTION
NO.	NAME		
1	RXD	O	RXD output (open drain) interface reporting state of LIN bus voltage
2	EN	I	Enable input
3	NWake	I	High voltage input for device wakeup
4	TXD	I	TXD input interface to control state of LIN output
5	GND	G	Ground
6	LIN	I/O	LIN bus single-wire transmitter and receiver
7	V_{SUP}	P	Device supply voltage (connected to battery in series with external reverse blocking diode)
8	INH	O	Inhibit controls external voltage regulator with inhibit input

(1) G = Ground, I = Input, O = Output, P = Power

8 Specifications

8.1 Absolute Maximum Ratings

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

		MIN	MAX	UNIT
V_{SUP} (2)	Supply line supply voltage(3)	0	40	V
V_{NWake}	NWake dc and transient input voltage (through 33-kΩ serial resistor)	– 0.3	40	V
V_{INH}	INH voltage	– 0.3	V_{SUP} + 0.3	V
	Logic pin input voltage (RXD, TXD, EN)	– 0.3	5.5	V
V_{LIN}	LIN dc-input voltage	– 40	40	V
I_{NWake}	NWake current(4)		– 3.6	mA
	Thermal shutdown		200	°C
	Thermal shutdown hysteresis		25	°C
T_J	Junction temperature	– 40	150	°C
T_{stg}	Storage temperature	– 40	165	°C

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
(2) All voltage values are with respect to GND.
(3) The device is specified for operation in the range of V_{SUP} from 7 V to 27 V. Operating the device above 27 V may significantly raise the junction temperature of the device and system level thermal design requires consideration.
(4) If due to ground shifts, $V_{NWake} \leqslant V_{GND}$ – 0.3 V, thus the current into NWake must be limited through a serial resistance.

8.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001(1) All pins except 3 and 6	±4000	V
		Pin 3	±11000	
		Pin 6	±12000	
		Charged-device model (CDM), per JEDEC specification JESD22-C101(2)	±1500	

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

8.3 Recommended Operating Conditions

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

		MIN	MAX	UNIT
T_{SUP}	Supply voltage	7	27	V
T_{AMB}	Ambient temperature	– 40	125	°C

8.4 Thermal Information

THERMAL METRIC(1)		TPIC1021 D (SOIC) 8 PINS	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance	145	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	61.9	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	55.5	°C/W
ψ_{JT}	Junction-to-top characterization parameter	14.3	°C/W
ψ_{JB}	Junction-to-board characterization parameter	55	°C/W

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

8.5 Electrical Characteristics

V_{SUP} = 7 V to 27 V, T_A = –40°C to 125°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP(1)	MAX	UNIT
SUPPLY						
	Operational supply voltage(2)	Device is operational beyond the LIN 2.0 defined nominal supply line voltage range of 7 V < V_{SUP} < 18 V	7	14	27	V
	Nominal supply line voltage	Normal and standby modes	7	14	18	V
		Sleep mode	7	12	18	V
	V_{SUP} undervoltage threshold			4.5	6.2	V
I_{CC}	Supply current	Normal mode, EN = High, Bus dominant (total bus load where $R_{LIN} \geq 500\ \Omega$ and $C_{LIN} \leq 10$ nF (see 图 9-1)(3), INH = V_{SUP}, NWake = V_{SUP}		1.2	7.5	mA
		Standby mode, EN = Low, Bus dominant (total bus load, where $R_{LIN} \geq 500\ \Omega$ and $C_{LIN} \leq 10$ nF (see 图 9-1)(3), INH = V_{SUP}, NWake = V_{SUP}		1	2.1	mA
		Normal mode, EN = High, Bus recessive, LIN = V_{SUP}, INH = V_{SUP}, NWake = V_{SUP}		450	775	µA
		Standby mode, EN = Low, Bus recessive, LIN = V_{SUP}, INH = V_{SUP}, NWake = V_{SUP}		450	775	µA
		Sleep mode, EN = 0, 7 V < $V_{SUP} \leq$ 12 V, LIN = V_{SUP}, NWake = V_{SUP}		15	30	µA
		Sleep mode, EN = 0, 12 V < V_{SUP} < 27 V, LIN = V_{SUP}, NWake = V_{SUP}			50	µA
RXD OUTPUT PIN						
V_O	Output voltage		–0.3		5.5	V
I_{OL}	Low-level output current, open drain	LIN = 0 V, RXD = 0.4 V	3.5			mA
I_{IKG}	Leakage current, high-level	LIN = V_{SUP}, RXD = 5 V	–5	0	5	µA
TXD INPUT PIN						
V_{IL}	Low-level input voltage		–0.3		0.8	V
V_{IH}	High-level input voltage		2		5.5	V
V_{IT}	Input threshold hysteresis voltage		30		500	mV
	Pulldown resistor		125	350	800	kΩ
I_{IL}	Low-level input current	TXD = Low	–5	0	5	µA
LIN PIN (REFERENCED TO V_{SUP})						
V_{OH}	High-level output voltage	LIN recessive, TXD = High, I_O = 0 mA, V_{SUP} = 14 V	V_{SUP} – 1			V
V_{OL}	Low-level output voltage	LIN dominant, TXD = Low, I_O = 40 mA, V_{SUP} = 14 V	0		0.2 × V_{SUP}	V

8.5 Electrical Characteristics (continued)

V_{SUP} = 7 V to 27 V, T_A = –40°C to 125°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP[1]	MAX	UNIT
$R_{RESPONDER}$	Pullup resistor to V_{SUP}	Normal and standby modes	20	30	60	kΩ
	Pullup current source to V_{SUP}	Sleep mode, V_{SUP} = 14 V, LIN = GND	–2		–20	μA
I_L	Limiting current	TXD = 0 V	45	160	250	mA
I_{LKG}	Leakage current	LIN = V_{SUP}	–5	0	5	μA
I_{LKG}	Leakage current, loss of supply	7 V < LIN ≤ 12 V, V_{SUP} = GND			5	μA
		12 V < LIN < 18 V, V_{SUP} = GND			10	
V_{IL}	Low-level input voltage	LIN dominant			0.4 × V_{SUP}	V
V_{IH}	High-level input voltage	LIN recessive	0.6 × V_{SUP}			
V_{IT}	Input threshold voltage		0.4 × V_{SUP}	0.5 × V_{SUP}	0.6 × V_{SUP}	
V_{hys}	Hysteresis voltage		0.05 × V_{SUP}		0.175 × V_{SUP}	
V_{IL}	Low-level input voltage for wake-up				0.4 × V_{SUP}	
EN PIN						
V_{IL}	Low-level input voltage		–0.3		0.8	V
V_{IH}	High-level input voltage		2		5.5	
V_{hys}	Hysteresis voltage		30		500	mV
	Pulldown resistor		125	350	800	kΩ
I_{IL}	Low-level input current	EN = Low	–5	0	5	μA
INH PIN						
V_o	DC output voltage		–0.3		V_{SUP} + 0.3	V
R_{on}	On state resistance	Between V_{SUP} and INH, INH = 2-mA drive, Normal or standby mode		35	85	Ω
I_{IKG}	Leakage current	Low-power mode, 0 < INH < V_{SUP}	–5	0	5	μA
NWake PIN						
V_{IL}	Low-level input voltage		–0.3		V_{SUP} – 3.3	V
V_{IH}	High-level input voltage		V_{SUP} – 1		V_{SUP} + 0.3	
	Pullup current	NWake = 0 V	–45	–10	–2	μA
I_{IKG}	Leakage current	V_{SUP} = NWake	–5	0	5	
THERMAL SHUTDOWN						
	Thermal shutdown junction temperature			190		°C
AC CHARACTERISTICS						
D1	Duty cycle 1[4]	$TH_{REC(max)}$ = 0.744 × V_{SUP}, $TH_{DOM(max)}$ = 0.581 × V_{SUP}, V_{SUP} = 7 V to 18 V, t_{BIT} = 50 μs (20 kbps), D1 = $t_{Bus\_rec(min)}$/ (2 × t_{BIT}). See 图 8-1	0.396			
D2	Duty cycle 2[4]	$TH_{REC(min)}$ = 0.422 × V_{SUP}, $TH_{DOM(min)}$ = 0.284 × V_{SUP}, V_{SUP} = 7.6 V to 18 V, t_{BIT} = 50 μs (20 kbps), D2 = $t_{Bus\_rec(max)}$/ (2 × t_{BIT}). See 图 8-1			0.581	
D3	Duty cycle 3[4]	$TH_{REC(max)}$ = 0.778 × V_{SUP}, $TH_{DOM(max)}$ = 0.616 × V_{SUP}, V_{SUP} = 7 V to 18 V, t_{BIT} = 96 μs (10.4 kbps), D3 = $t_{Bus\_rec(min)}$/ (2 × t_{BIT}). See 图 8-1	0.417			

8.5 Electrical Characteristics (continued)

V_{SUP} = 7 V to 27 V, T_A = –40°C to 125°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP(1)	MAX	UNIT
D4	Duty cycle 4(4)	$TH_{REC(min)}$ = 0.389 × V_{SUP}, $TH_{DOM(min)}$ = 0.251 × V_{SUP}, V_{SUP} = 7.6 V to 18 V, t_{BIT} = 96 µs (10.4 kbps), D4 = $t_{Bus\_rec(max)}$/ (2 × t_{BIT}). See 图 8-1			0.59	
t_{rx_pdr}	Receiver rising propagation delay time	R_{RXD} = 2.4 kΩ, C_{RXD} = 20 pF See 图 8-2 See 图 9-1			6	µs
t_{rx_pdf}	Receiver falling propagation delay time	R_{RXD} = 2.4 kΩ, C_{RXD} = 20 pF See 图 8-2 See 图 9-1			6	
t_{rx_sym}	Symmetry of receiver propagation delay time	rising edge with respect to falling edge (t_{rx_sym} = t_{rx_pdf} - t_{rx_pdr}) R_{RXD} = 2.4 kΩ, C_{RXD} = 20 pF See 图 8-2 See 图 9-1	–2		2	
t_{NWake}	NWake filter time for local wakeup	See 图 10-4	25	50	150	
t_{LINBUS}	LIN wake-up filter time (dominant time for wakeup through LIN bus)	See 图 10-3	25	50	150	
t_{DST}	Dominant state time-out(5)		5.5		20	ms
$t_{go\_to\_operate}$		See 图 10-2 to 图 10-3		0.5	1	µs

(1) Typical values are given for V_{SUP} = 14 V at 25°C, except for low power mode where typical values are given for V_{SUP} = 12 V at 25°C.
(2) All voltages are defined with respect to ground; positive currents flow into the TPIC1021A device.
(3) In the dominant state, the supply current increases as the supply voltage increases due to the integrated LIN responder termination resistance. At higher voltages the majority of supply current is through the termination resistance. The minimum resistance of the LIN responder termination is 20 kΩ, so the maximum supply current attributed to the termination is:
$I_{SUP\ (dom)\ max\ termination} = (V_{SUP} - (V_{LIN\_Dominant} + 0.7\ V) / 20\ k\Omega$
(4) Duty cycles: LIN driver bus load conditions (C_{LINBUS}, R_{LINBUS}): Load1 = 1 nF, 1 kΩ; Load2 = 10 nF, 500 Ω. Duty cycles 3 and 4 are defined for 10.4-kbps operation. The TPIC1021A also meets these lower data rate requirements, while it is capable of the higher speed 20-kbps operation as specified by Duty cycles 1 and 2. SAEJ2602 derives propagation delay equations from the LIN 2.0 duty cycle definitions, for details see the SAEJ2602 specification.
(5) Dominant state time-out limits the minimum data rate to 2.4 kbps.

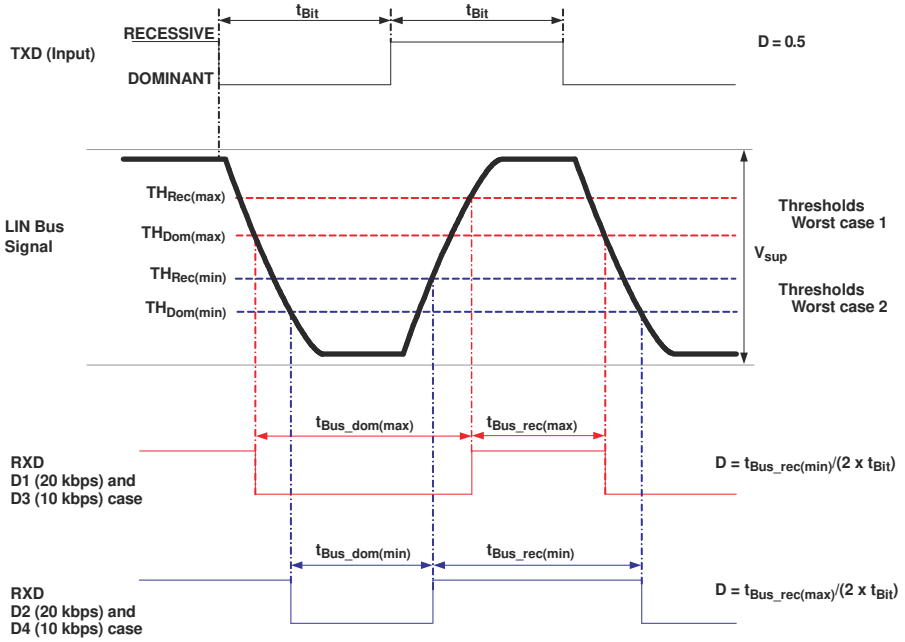


图 8-1. Definition of Bus Timing Parameters

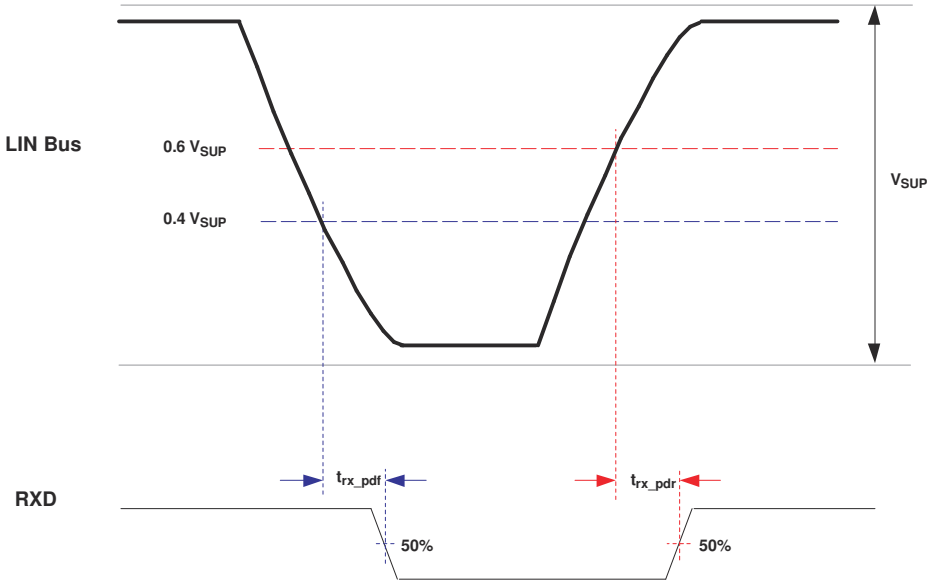


图 8-2. Propagation Delay

8.6 Typical Characteristics

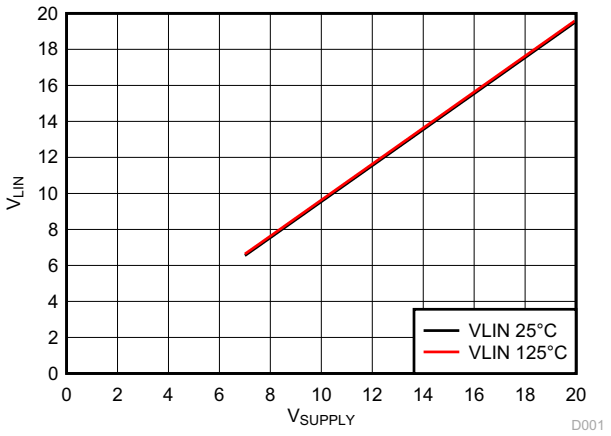


图 8-3. V_{OH} vs V_{SUPPLY} and Temperature

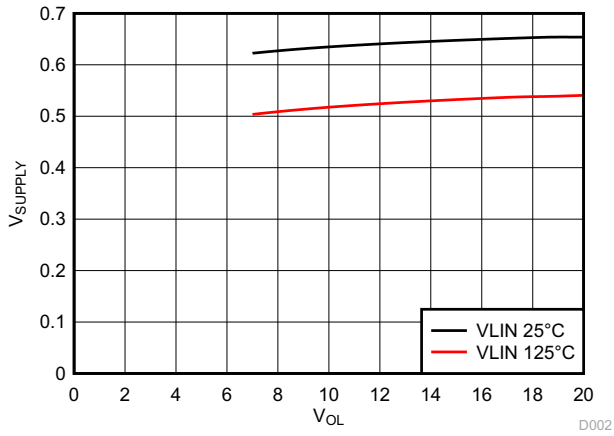


图 8-4. V_{OL} vs V_{SUPPLY} and Temperature

9 Parameter Measurement Information

9.1 Test Circuit

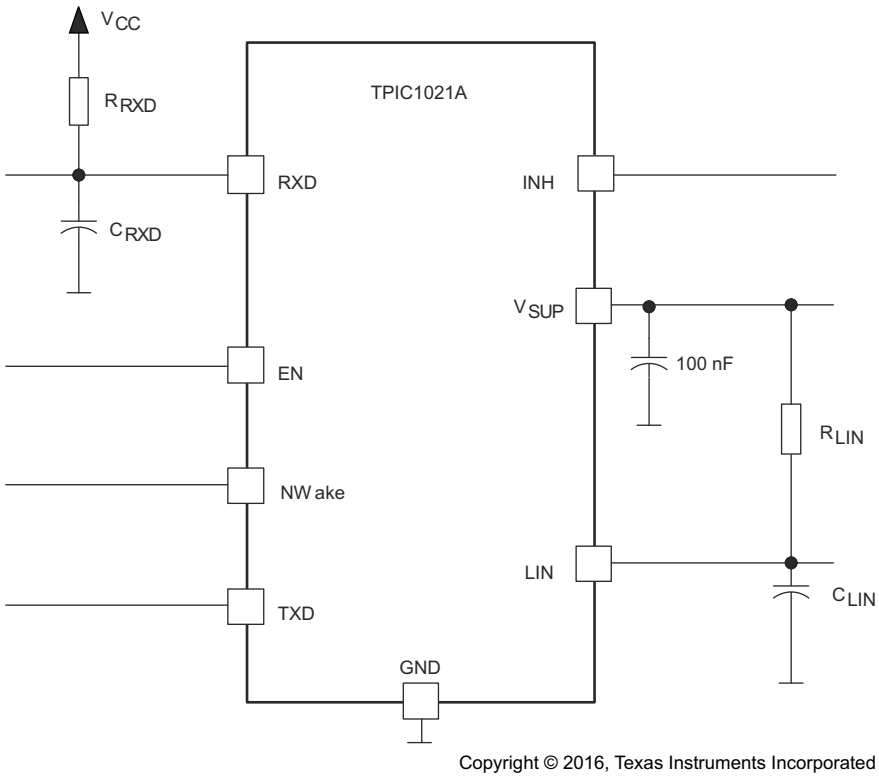


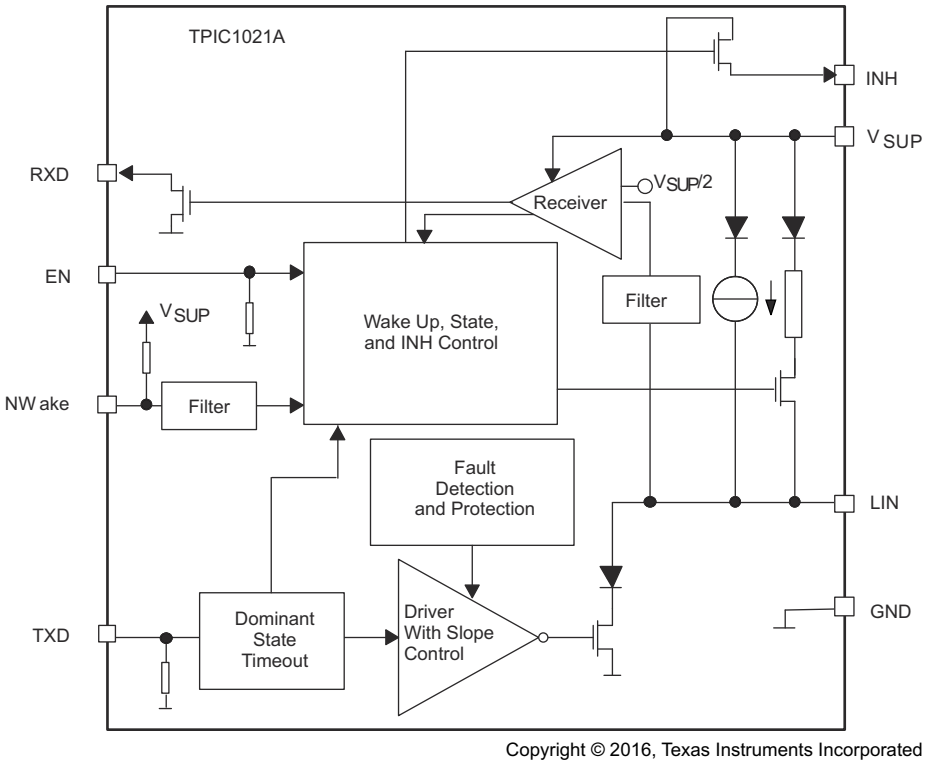
图 9-1. Test Circuit for AC Characteristics

10 Detailed Description

10.1 Overview

The TPIC1021A is a LIN (Local Interconnect Network) physical layer transceiver which integrates a serial transceiver with wake-up and protection features. The LIN bus is a single-wire, bidirectional bus that typically is used in low speed in vehicle networks with data rates that range from 2.4 kbps to 20 kbps.

10.2 Functional Block Diagram



10.3 Feature Description

10.3.1 Local Interconnect Network (LIN) Bus

This I/O pin is the single-wire LIN bus transmitter and receiver.

10.3.1.1 Transmitter Characteristics

The driver is a low-side transistor with internal current limitation and thermal shutdown. There is an internal 30-kΩ pullup resistor with a serial diode structure to V_{SUP}, so no external pullup components are required for LIN responder mode applications. An external pullup resistor of 1 kΩ, plus a series diode to V_{SUP} must be added when the device is used for commander node applications.

Voltage on LIN can go from –40-V to 40-V dc without any currents other than through the pullup resistance. There are no reverse currents from the LIN bus to supply (V_{SUP}), even in the event of a ground shift or loss of supply (V_{SUP}).

The LIN thresholds and ac parameters are LIN Protocol Specification Revision 2.0 compliant.

During a thermal shutdown condition, the driver is disabled.

10.3.1.2 Receiver Characteristics

The receiver’s characteristic thresholds are ratio-metric with the device supply pin. Typical thresholds are 50%, with a hysteresis between 5% and 17.5% of supply.

The receiver is capable of receiving higher data rates (>100 kbps) than supported by LIN or SAEJ2602 specifications. This allows the TPIC1021A to be used for high-speed downloads at end-of-line production or other applications. The actual data rates achievable depend on system time constants (bus capacitance and pullup resistance) and driver characteristics used in the system.

10.3.2 Transmit Input (TXD)

TXD is the interface to the MCU’s LIN protocol controller or SCI/UART used to control the state of the LIN output. When TXD is low, the LIN output is dominant (near ground). When TXD is high, the LIN output is recessive (near battery). The TXD input structure is compatible with microcontrollers with 3.3-V and 5-V I/O. TXD has an internal pulldown resistor.

10.3.2.1 TXD Dominant State Time-Out

If TXD is inadvertently driven permanently low by a hardware or software application failure, the LIN bus is protected by TPIC1021A’s dominant state time-out timer. This timer is triggered by a falling edge on TXD. If the low signal remains on TXD for longer than t_{DST}, the transmitter is disabled, thus allowing the LIN bus to return to the recessive state and communication to resume on the bus. The timer is reset by a rising edge on TXD.

10.3.3 Receive Output (RXD)

RXD is the interface to the MCU’s LIN protocol controller or SCI/UART, which reports the state of the LIN bus voltage. LIN recessive (near battery) is represented by a high level on RXD and LIN dominant (near ground) is represented by a low level on RXD. The RXD output structure is an open-drain output stage. This allows the TPIC1021A to be used with 3.3-V and 5-V I/O microcontrollers. If the microcontroller’s RXD pin does not have an integrated pullup, an external pullup resistor to the microcontroller I/O supply voltage is required.

10.3.3.1 RXD Wake-up Request

When the TPIC1021A has been in low-power mode and encounters a wake-up event from the LIN bus or NWake pin, RXD goes low, while the device enters and remains in standby mode (until EN is reasserted high and the device enters normal mode).

10.3.4 Supply Voltage (V_{SUP})

V_{SUP} is the TPIC1021A device power supply pin. V_{SUP} is connected to the battery through an external reverse battery blocking diode. The characterized operating voltage range for the TPIC1021A is from 7 V to 27 V. V_{SUP} is protected for harsh automotive conditions up to 40 V.

The device contains a reset circuit to avoid false bus messages during undervoltage conditions when V_{SUP} is less than V_{SUP_UNDER}.

10.3.5 Ground (GND)

GND is the TPIC1021A device ground connection. The TPIC1021A can operate with a ground shift as long as the ground shift does not reduce V_{SUP} below the minimum operating voltage. If there is a loss of ground at the ECU level, the TPIC1021A does not have a significant current consumption on LIN bus.

10.3.6 Enable Input (EN)

EN controls the operation mode of the TPIC1021A (normal or sleep mode). When EN is high, the TPIC1021A is in normal mode allowing a transmission path from TXD to LIN and from LIN to RXD. When EN is low the device is put into sleep mode and there are no transmission paths available. The device can enter normal mode only after being woken up. EN has an internal pulldown resistor to ensure the device remains in low-power mode even if EN floats.

10.3.7 NWake Input (NWake)

NWake is a high-voltage input used to wake up the TPIC1021A from low-power mode. NWake is usually connected to an external switch in the application. A low on NWake that is asserted longer than the filter time (t_{NWAKE}) results in a local wakeup. NWake provides an internal pullup source to V_{SUP}.

10.3.8 Inhibit Output (INH)

INH is used to control an external voltage regulator that has an inhibit input. When the TPIC1021A is in normal operating mode, the inhibit high-side switch is enabled and the external voltage regulator is activated. When TPIC1021A is in low-power mode, the inhibit switch is turned off, which disables the voltage regulator. A wake-up event on for the TPIC1021A returns INH to V_{SUP} level. INH can also drive an external transistor connected to an MCU interrupt input.

10.4 Device Functional Modes

10.4.1 Operating States

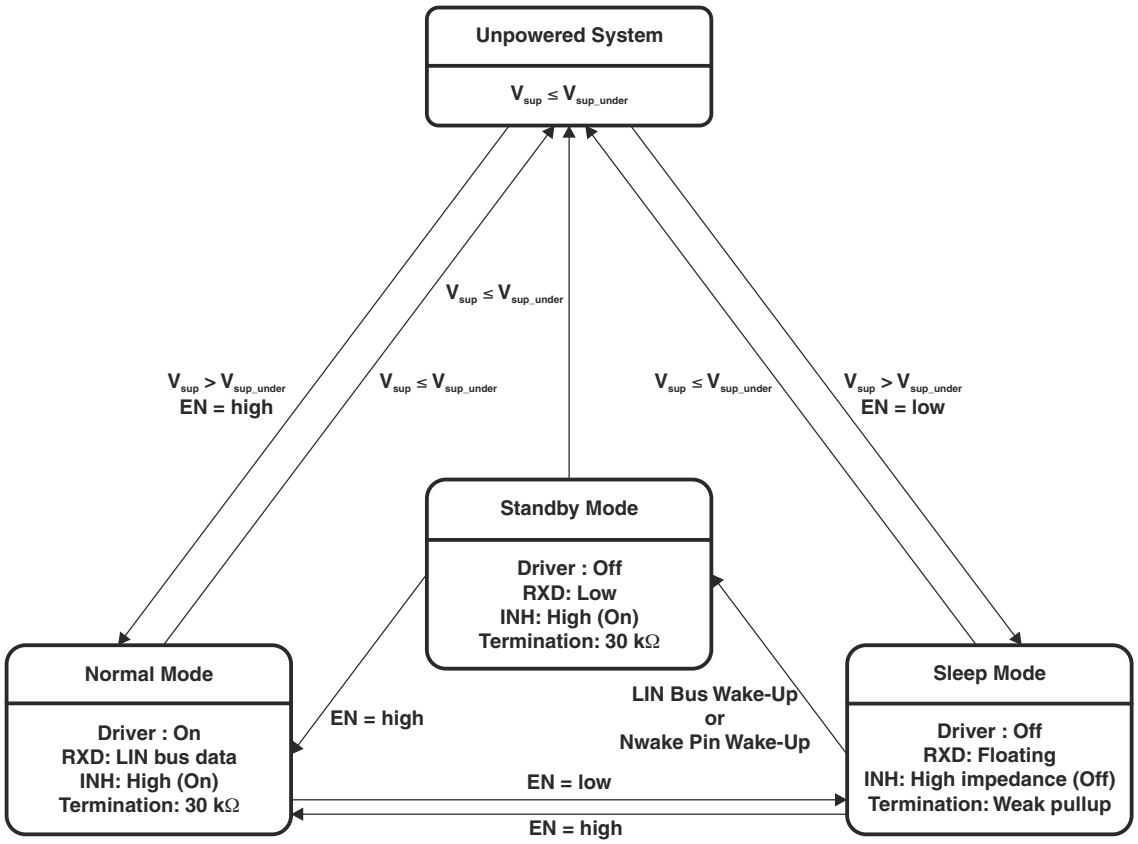


图 10-1. Operating States Diagram

表 10-1. Operating Modes

MODE	EN	RXD	LIN BUS TERMINATION	INH	TRANSMITTER	COMMENTS
Sleep	Low	Floating	Weak current pullup	High impedance	Off	
Standby	Low	Low	30 kΩ (typical)	High	Off	Wake-up event detected, waiting on MCU to set EN
Normal	High	LIN bus data	30 kΩ (typical)	High	On	LIN transmission up to 20 kbps

10.4.1.1 Normal Mode

This is the normal operational mode, in which the receiver and driver are active, and LIN transmission up to the LIN specified maximum of 20 kbps is supported. The receiver detects the data stream on the LIN bus and outputs it on RXD for the LIN controller, where recessive on the LIN bus is a digital high, and dominate on the LIN bus is digital low. The driver transmits input data on TXD to the LIN bus. Normal mode is entered as EN transitions high while the TPIC1021A is in sleep or standby mode.

10.4.1.2 Sleep Mode

Sleep mode is the power saving mode for the TPIC1021A and the default state after power up (assuming EN is low during power up). Even with the extremely low current consumption in this mode, the TPIC1021A can still wake up from LIN bus through a wake-up signal, a low on NWake, or if EN is set high. The LIN bus and NWake are filtered to prevent false wake-up events. The wake-up events must be active for their respective time periods (t_{LINBUS}, t_{NWake}).

The sleep mode is entered by setting EN low.

While the device is in sleep mode, the following conditions exist:

- The LIN bus driver is disabled and the internal LIN bus termination is switched off (to minimize power loss if LIN is short circuited to ground). However, the weak current pullup is active to prevent false wake-up events in case an external connection to the LIN bus is lost.
- The normal receiver is disabled.
- INH is high impedance.
- EN input, NWake input, and the LIN wake-up receiver are active.

10.4.1.2.1 Wake-Up Events

There are three ways to wake up the TPIC1021A from sleep mode:

- Remote wakeup through recessive (high) to dominant (low) state transition on LIN bus. The dominant state must be held for t_{LINBUS} filter time and then the bus must return to the recessive state (to eliminate false wakeups from disturbances on the LIN bus or if the bus is shorted to ground).
- Local wakeup through a low on NWake, which is asserted low longer than the filter time t_{NWake} (to eliminate false wakeups from disturbances on NWake)
- Local wakeup through EN being set high

10.4.1.3 Standby Mode

This mode is entered whenever a wake-up event occurs through LIN bus or NWake while the TPIC1021A is in sleep mode. The LIN bus responder termination circuit and INH are turned on when standby mode is entered. The application system powers up once INH is turned on, assuming the system is using a voltage regulator connected through INH. Standby mode is signaled through a low level on RXD.

When EN is set high while the TPIC1021A is in standby mode the device returns to normal mode and the normal transmission paths from TXD to LIN bus and LIN bus to RXD are enabled.

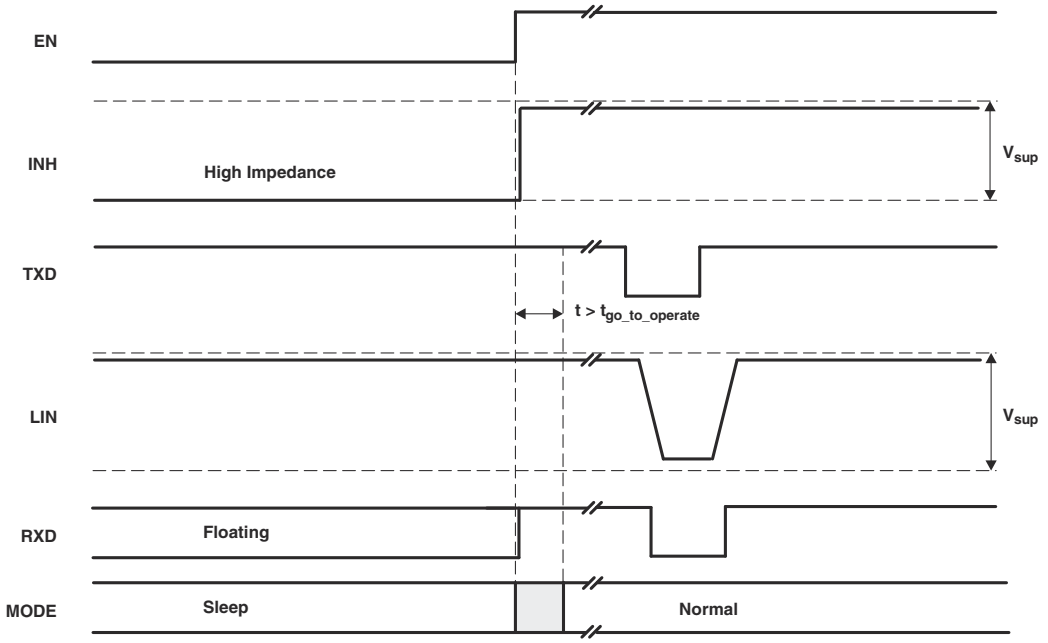


图 10-2. Wakeup Through EN

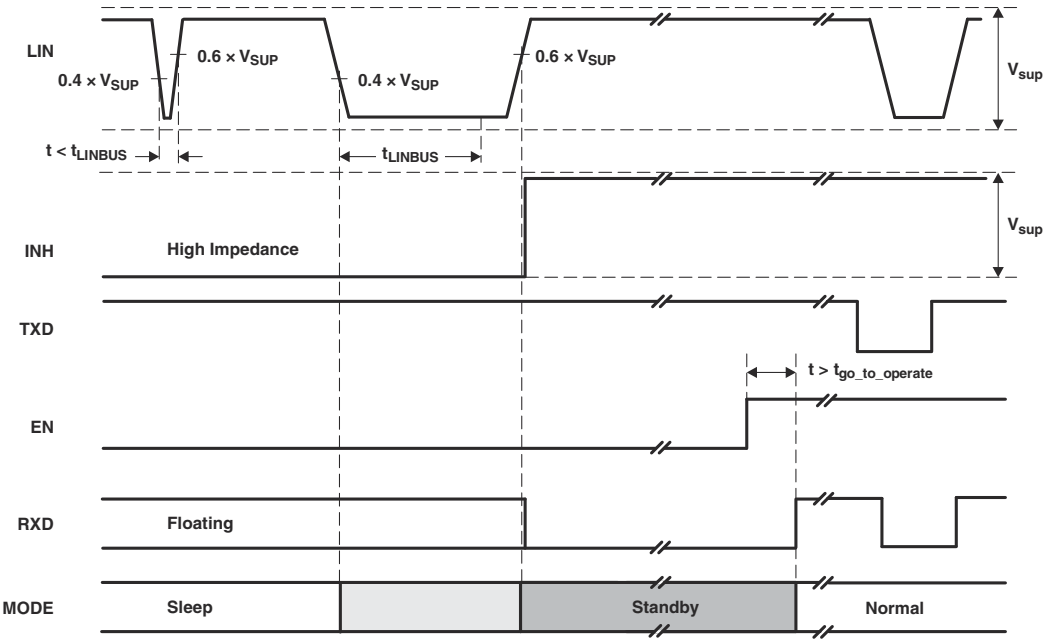


图 10-3. Wakeup Through LIN

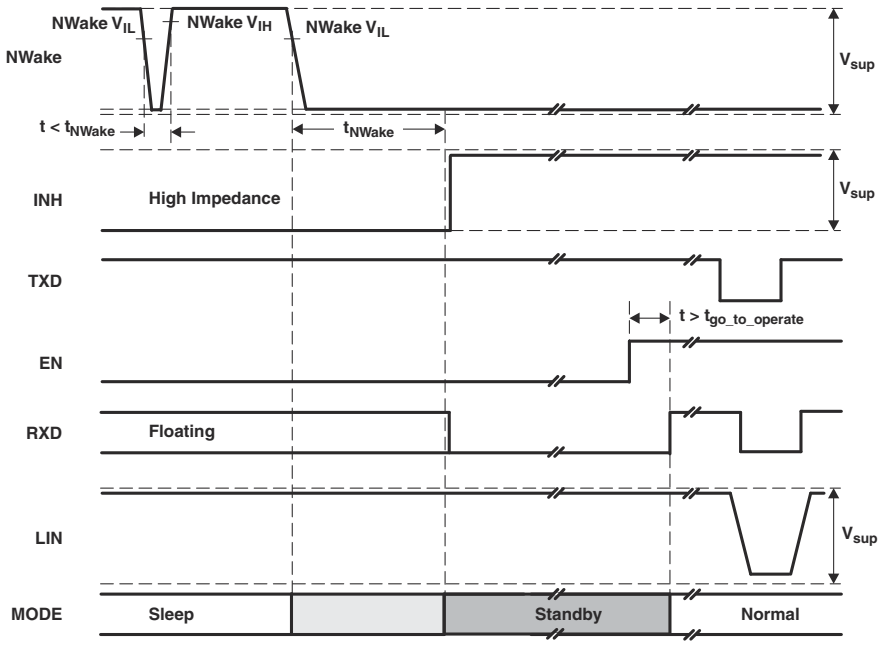


图 10-4. Wakeup Through NWake

11 Application and Implementation

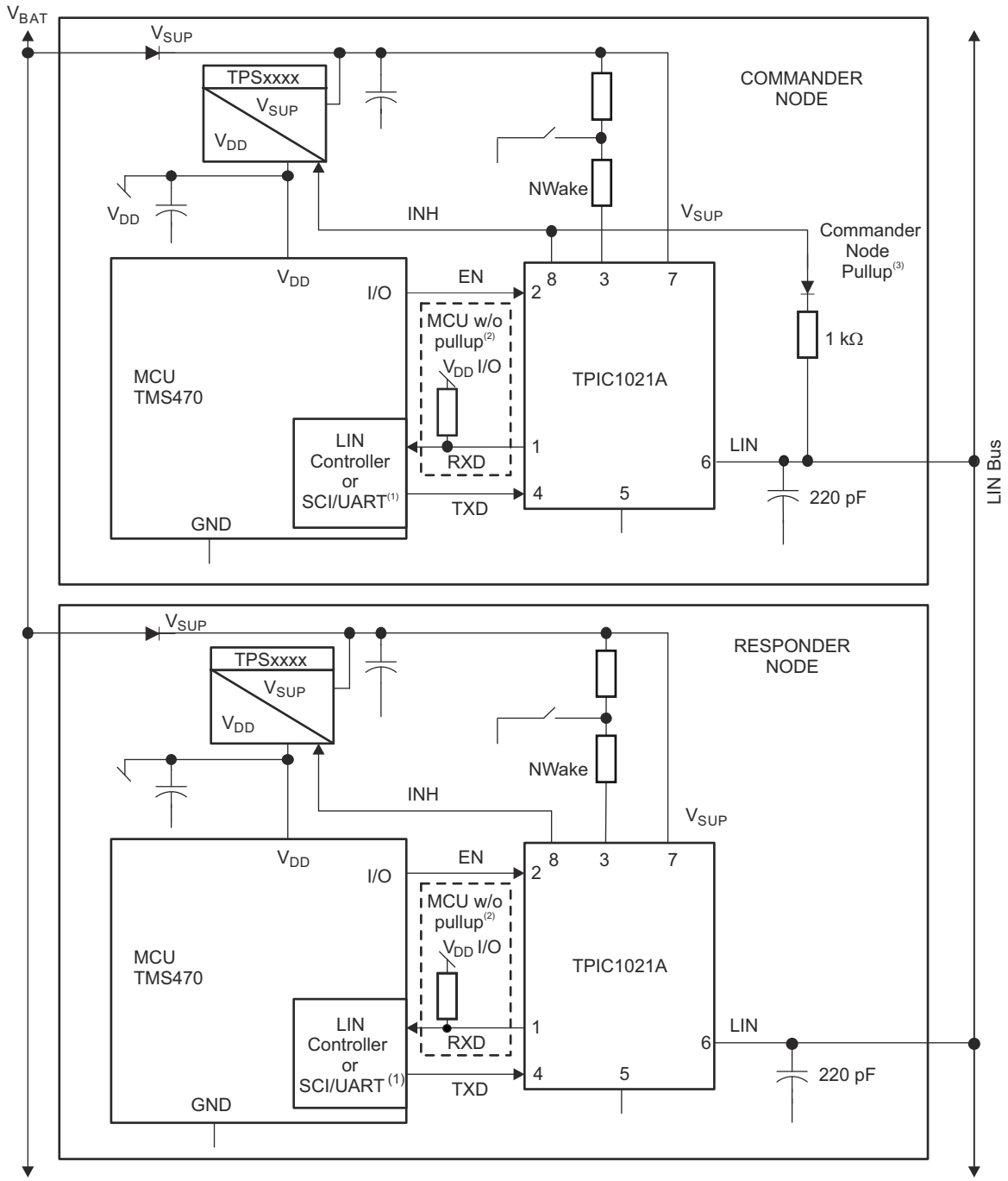
备注

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.

11.1 Application Information

The TPIC1021A can be used as both a responder device and a commander device in a LIN network. It comes with the ability to support both remote wake-up requests and local wake-up requests.

11.2 Typical Application



A. RXD on MCU or LIN responder has internal pullup, no external pullup resistor is required.
B. RXD on MCU or LIN responder without internal pullup, requires external pullup resistor.
C. Commander node applications require an external 1-kΩ pullup resistor and serial diode.

图 11-1. Typical Application Schematic

11.2.1 Design Requirements

For this application example, use these requirements:

1. RXD on MCU or LIN Responder has internal pullup, no external pullup resistor is required.
2. RXD on MCU or LIN Responder without internal pullup, requires external pullup resistor.
3. Commander Node applications require an external 1-kΩ pullup resistor and serial diode.

11.2.2 Detailed Design Procedure

The RXD output structure is an open-drain output stage. This allows the TPIC1021A to be used with 3.3-V and 5-V I/O microcontrollers. If the RXD pin of the microcontroller does not have an integrated pullup, an external pullup resistor to the microcontroller I/O supply voltage is required.

The V_{SUP} pin of the device must be decoupled with a 100-nF capacitor as close to the supply pin of the device as possible.

The NWAKE pin is a high voltage wake-up input to the device. If this pin is not being used it must be tied to V_{SUP}.

11.2.3 Application Curves

图 11-2 and 图 11-3 show the propagation delay from the TXD pin to the LIN pin for both the recessive to dominant and dominant to recessive states under lightly loaded conditions.

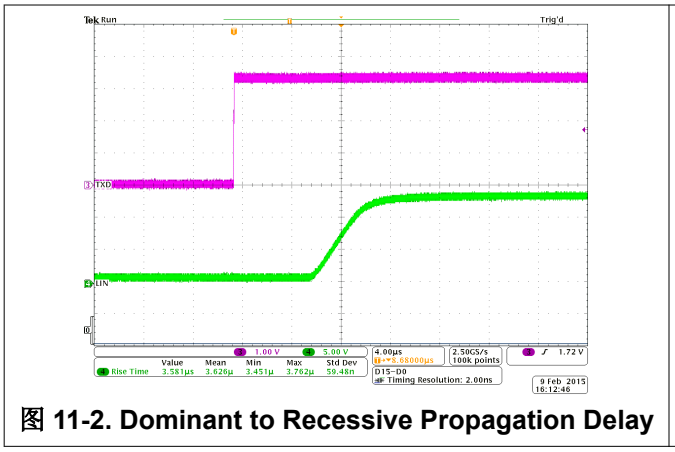


图 11-2. Dominant to Recessive Propagation Delay

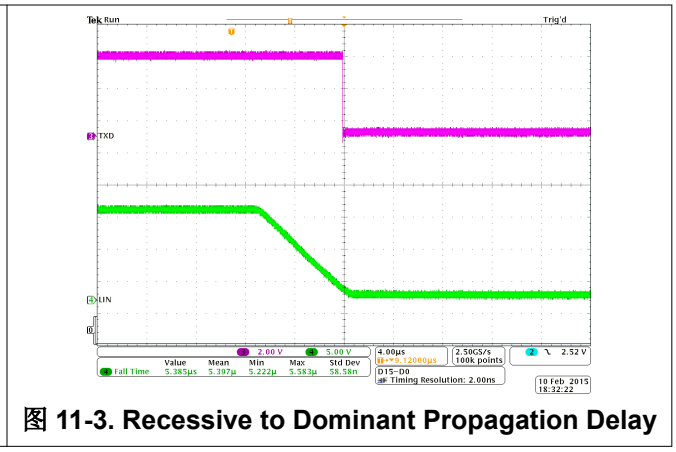


图 11-3. Recessive to Dominant Propagation Delay

11.3 Power Supply Recommendations

The TPIC1021A was designed to operate directly off car battery, or any other DC supply ranging from 7 V to 27 V. A 100-nF decoupling capacitor must be placed as close to the V_{SUP} pin of the device as possible.

11.4 Layout

11.4.1 Layout Guidelines

- Pin 1 is the RXD output of the TPIC1021A. It is an open-drain output and requires an external pullup resistor in the range of 1 to 10 kΩ to function properly. If the micro-processor paired with the transceiver does not have an integrated pullup, and external resistor must be placed between RXD and the regulated voltage supply for the micro-processor.
- Pin 2 is the EN input pin for the device that is used to place the device in low power sleep mode. If this feature is not used on the device, the pin must be pulled high to the regulated voltage supply of the micro-processor through a series 1-kΩ to 10-kΩ series resistor. Additionally, a series resistor may be placed on the pin to limit the current on the digital lines in the case of an overvoltage fault.
- Pin 3 is a high-voltage local wake-up input pin. The device is typically externally controlled by a normally open switch tied between NWAKE and ground. When the momentary switch is pressed the NWAKE pin is pulled to ground signaling a local wake-up event. A series resistor between VBATT and the switch, and

NWAKE and the switch must be placed to limit current. If the NWAKE local wake-up feature is not used, the pin can be tied to V_{SUP} through a 1-kΩ to 10-kΩ pullup resistor.

- Pin 4 is the transmit input signal to the device. A series resistor can be placed to limit the input current to the device in the case of an overvoltage on this pin. Also a capacitor to ground can be placed close to the input pin of the device to filter noise.
- Pin 5 is the ground connection of the device. This pin must be tied to a ground plane through a short trace with the use of two vias to limit total return inductance.
- Pin 6 is the LIN bus connection of the device. For responder applications a 220-pF bus capacitor is implemented. For commander applications an additional series resistor and blocking diode must be placed between the LIN pin and the V_{SUP} pin.
- Pin 7 is the supply pin for the device. A 100-nF decoupling capacitor must be placed as close to the device as possible.
- Pin 8 is a high-voltage output pin that may be used to control the local power supplies. If this feature is not used the pin may be left floating.

备注

All ground and power connections must be made as short as possible and use at least two vias to minimize the total loop inductance.

11.4.2 Layout Example

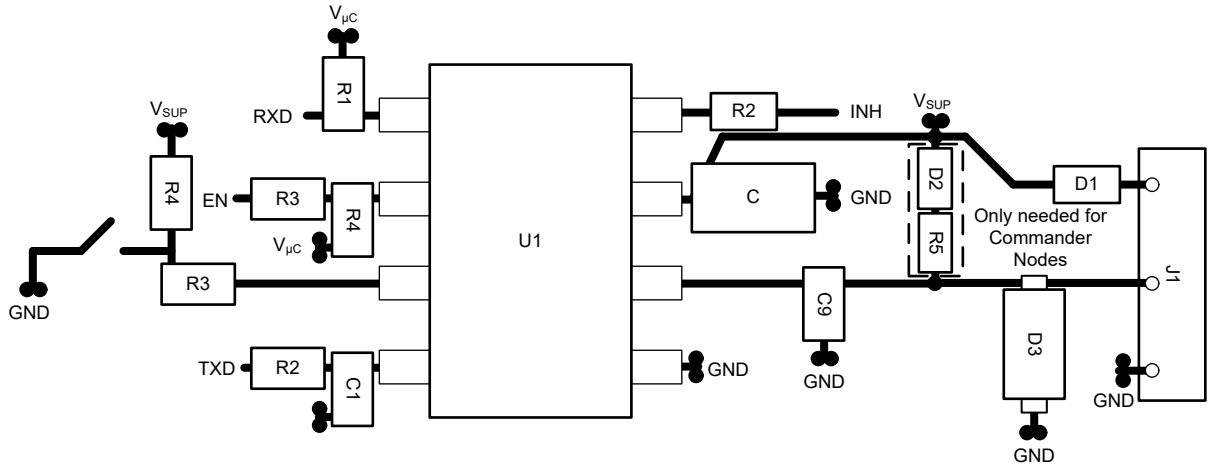


图 11-4. TPIC1021A-Q1 Layout

12 Device and Documentation Support

12.1 接收文档更新通知

要接收文档更新通知，请导航至 ti.com 上的器件产品文件夹。点击 *订阅更新* 进行注册，即可每周接收产品信息更改摘要。有关更改的详细信息，请查看任何已修订文档中包含的修订历史记录。

12.2 支持资源

TI E2E™ 支持论坛是工程师的重要参考资料，可直接从专家获得快速、经过验证的解答和设计帮助。搜索现有解答或提出自己的问题可获得所需的快速设计帮助。

链接的内容由各个贡献者“按原样”提供。这些内容并不构成 TI 技术规范，并且不一定反映 TI 的观点；请参阅 TI 的《使用条款》。

12.3 Trademarks

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12.4 Electrostatic Discharge Caution

This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

12.5 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。

13 Mechanical, Packaging, and Orderable Information

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

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
TPIC1021AQDRQ1	NRND	SOIC	D	8	2500	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	T1021A	

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

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".
RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.
Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

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

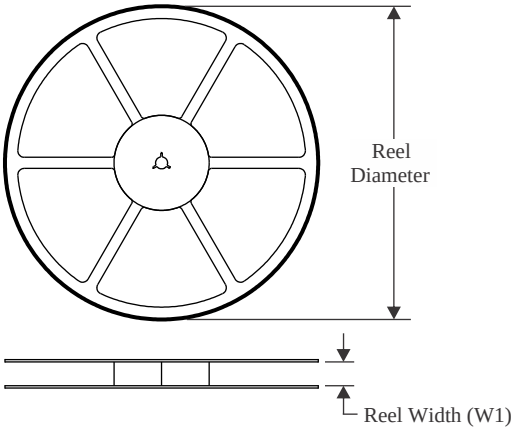
(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

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

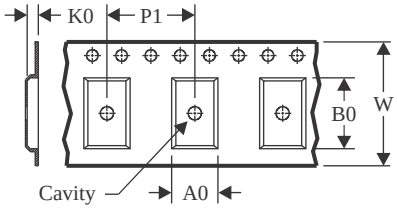
(6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

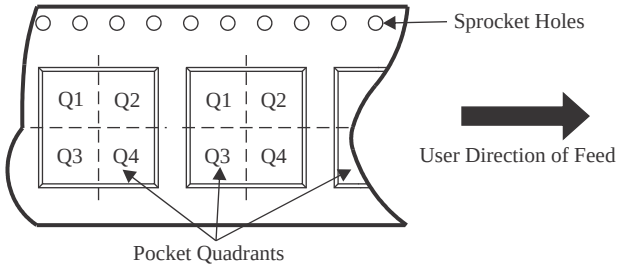


TAPE DIMENSIONS



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

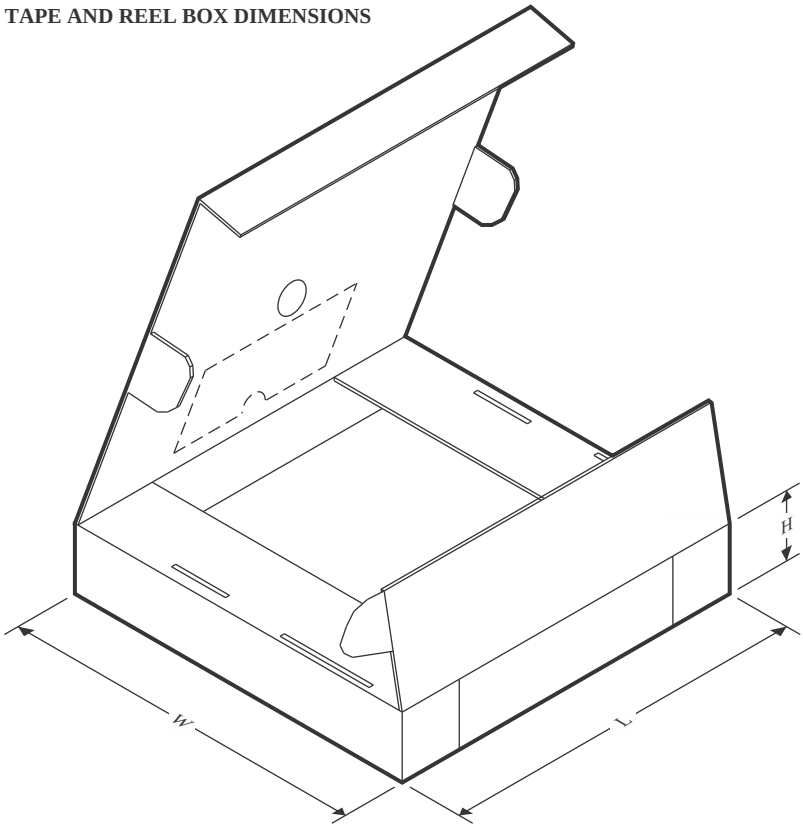
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

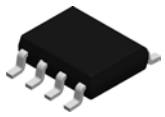
Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TPIC1021AQDRQ1	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TPIC1021AQDRQ1	SOIC	D	8	2500	356.0	356.0	35.0

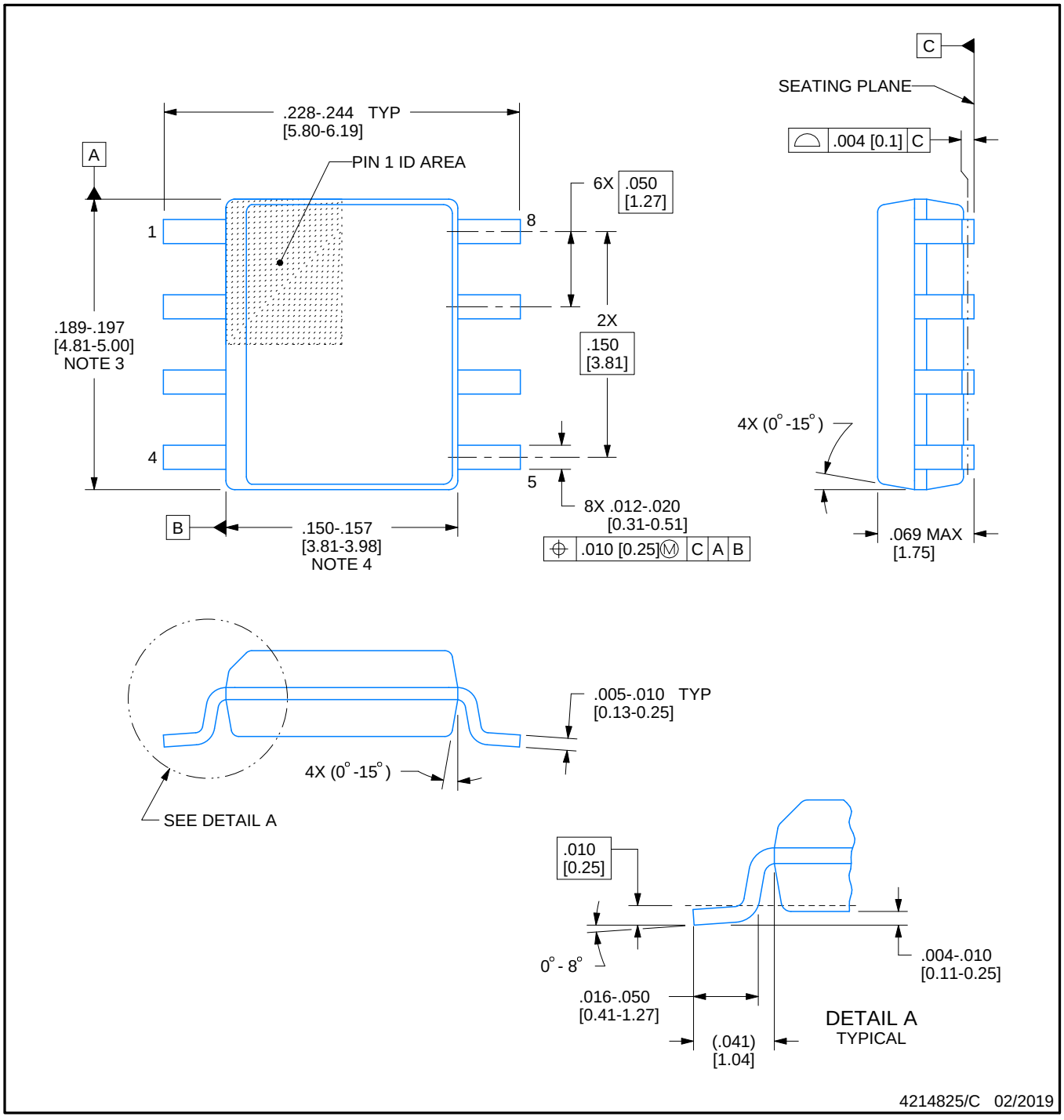


PACKAGE OUTLINE

D0008A

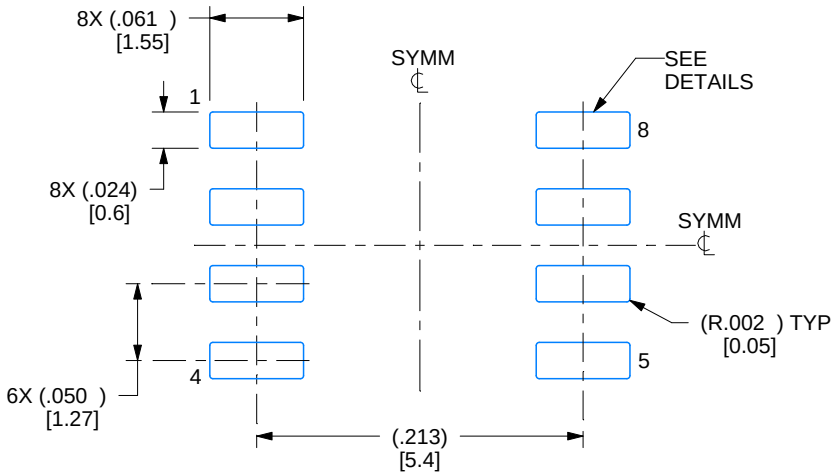
SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT

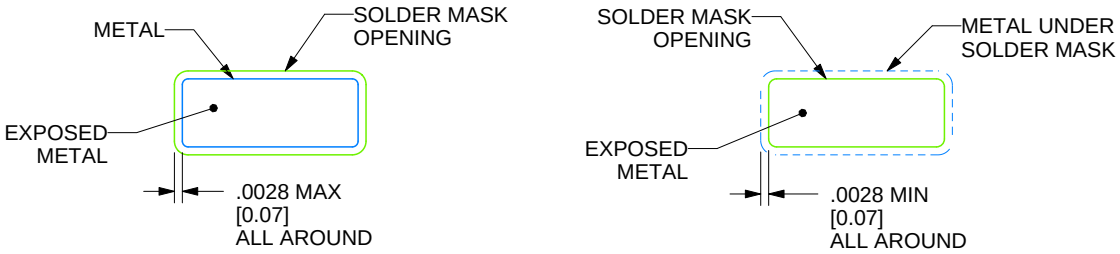


NOTES:

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.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:8X



SOLDER MASK DETAILS

4214825/C 02/2019

NOTES: (continued)

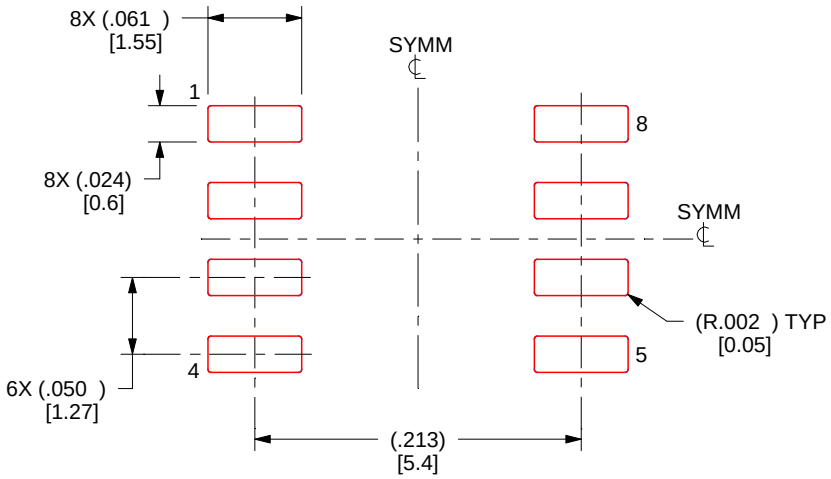
6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

D0008A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



SOLDER PASTE EXAMPLE
BASED ON .005 INCH [0.125 MM] THICK STENCIL
SCALE:8X

4214825/C 02/2019

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.

重要声明和免责声明

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