

## Features

- Compliant to LIN 2.0, LIN 2.1, LIN 2.2, LIN 2.2A and ISO 17987-4 Electrical Physical Layer (EPL) Specification
- Compliant to SAE J2602 LIN Network for Vehicle Applications
- Support LIN Data Rates up to 20 Kbps
- Wide  $V_{BAT}$  Input Voltage Range Supports 5.5 V to 40 V
- Low-current Standby Mode and Sleep Mode with Bus Wake-up and Local Wake-up Capability
- Input Levels Compatible with 3.3-V and 5-V MCU Interface
- System-level Power Control with INH Pin
- Ideal Passive Behavior to LIN Bus when Unpowered
- Integrated Pull-up Resistor for LIN Slave Applications
- Protection Feature:
  - Bus Pin IEC 61000-4-2 ESD Protection  $\pm 15$  kV
  - Bus Fault Tolerant:  $\pm 45$  V
  - $V_{BAT}$  Undervoltage Protection
  - TXD Dominant Time-out Function
  - Thermal Shutdown Protection
- Available in SOP8 Package and Leadless DFN3X3-8 Package with Improved Automated Optical Inspection (AOI) Capability
- AEC-Q100 Qualified for Automotive Applications, Grade 1

## Applications

- Automotive and Transportation
- Body Electronics / Lighting
- Power Train / Chassis
- Infotainment / Cluster
- ADAS / Safety

## Description

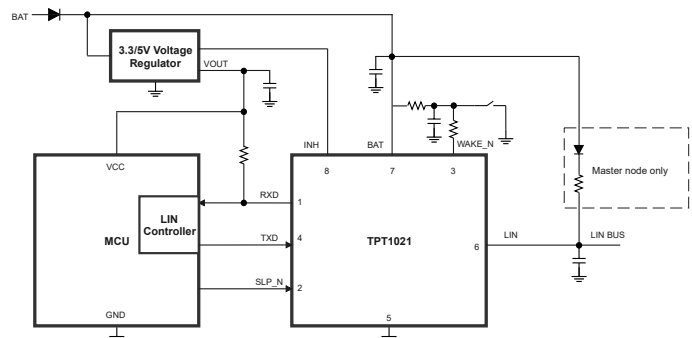
The TPT1021EQ is a local interconnect network (LIN) physical layer transceiver that is compliant with ISO 17987-4, SAE J2602 and LIN 2.0, LIN 2.1, LIN 2.2, and LIN 2.2A physical layer standards. LIN is a low-speed universal asynchronous receiver transmitter (UART) communication protocol that supports automotive in-vehicle sub-networks.

The device supports LIN networks up to 20 Kbps with the enhanced timing margin. The device converts the transmitted data received at the TXD with the optimized slew rate to minimize the electromagnetic emission (EME) and reports the state of the LIN bus at the RXD.

As designed, the device features overvoltage and loss of ground protection from  $-45$  V to  $+45$  V, over-temperature shutdown. The device has low-current standby and sleep mode with LIN BUS wake-up and local wake-up capability via the WAKE\_N pin. The INH pin of the device is used to control voltage regulation to reduce system-level power consumption. The device integrates a pull high resistor for LIN slave applications and ESD protection which allows applications to operate with a reduced dependence on external components. Additionally, all devices include many protection features to enhance the device and network robustness.

The TPT1021EQ is available in SOP8 and DFN3X3-8 packages and is AEC-Q100 qualified for automotive applications.

## Typical Application Circuit



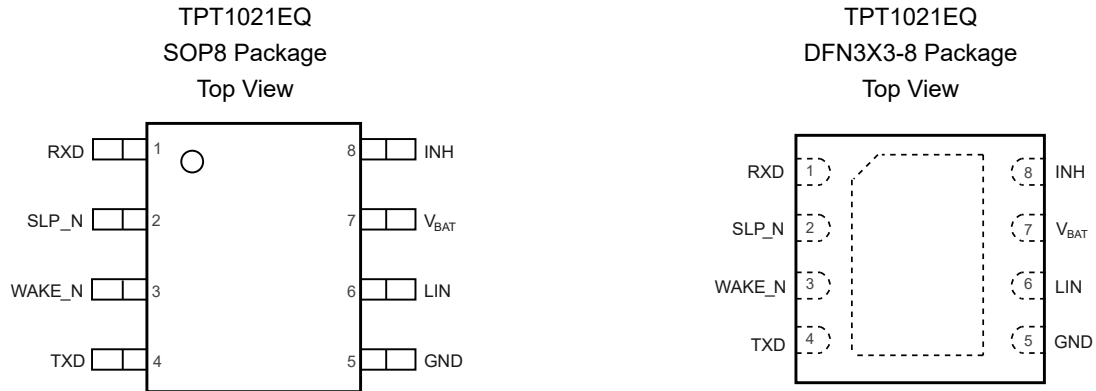
## Table of Contents

<b>Features</b> .....	<b>1</b>
<b>Applications</b> .....	<b>1</b>
<b>Description</b> .....	<b>1</b>
<b>Typical Application Circuit</b> .....	<b>1</b>
<b>Revision History</b> .....	<b>3</b>
<b>Pin Configuration and Functions</b> .....	<b>4</b>
<b>Specifications</b> .....	<b>5</b>
Absolute Maximum Ratings <sup>(1)</sup> .....	5
ESD (Electrostatic Discharge Protection).....	5
Recommended Operating Conditions.....	6
Thermal Information.....	6
Electrical Characteristics.....	7
Duty Cycles.....	10
AC Timing Requirements.....	11
<b>Parameter Measurement Information</b> .....	<b>12</b>
Test Circuit.....	12
Parameter Diagram.....	12
<b>Detailed Description</b> .....	<b>14</b>
Overview.....	14
Functional Block Diagram.....	14
Feature Description.....	14
Device Operating Modes.....	14
Protection Features.....	16
<b>Application and Implementation</b> .....	<b>18</b>
Typical Application.....	18
<b>Tape and Reel Information</b> .....	<b>19</b>
<b>Package Outline Dimensions</b> .....	<b>20</b>
SOP8.....	20
DFN3X3-8.....	21
<b>Order Information</b> .....	<b>22</b>
<b>IMPORTANT NOTICE AND DISCLAIMER</b> .....	<b>23</b>

## Revision History

Date	Revision	Notes
2022-12-05	Rev.Pre.0	Initial version
2024-10-05	Rev.A.0	Released version
2025-05-07	Rev.A.1	Added test condition for Normal mode dominant I <sub>BAT</sub>

## Pin Configuration and Functions



**Table 1. Pin Functions: TPT1021Q**

Pin		I/O	Description
No.	Name		
1	RXD	Output	LIN receives data output
2	SLP_N	Input	Sleep mode control input, active low
3	WAKE_N	HV Input	Local wake-up Input, active low
4	TXD	Input	LIN transmits data input
5	GND	GND	Ground
6	LIN	BUS I/O	LIN Bus input/output line
7	VBAT	Power	High voltage power supply from the battery
8	INH	HV Output	Inhibit output to control external voltage regulators

**Automotive Fault Protected LIN Transceiver with WAKE and INH**
**Specifications**
**Absolute Maximum Ratings <sup>(1)</sup>**

Parameter		Conditions	Min	Max	Unit
V <sub>BAT</sub>	Battery Supply Voltage Range		-0.3	45	V
V <sub>TXD</sub>	Pin TXD Voltage Range		-0.3	7	V
V <sub>RXD</sub>	Pin RXD Voltage Range		-0.3	7	V
V <sub>SLP_N</sub>	Pin SLP_N Voltage Range		-0.3	7	V
V <sub>WAKE_N</sub>	Pin WAKE_N Voltage Range		-0.3	45	V
V <sub>INH</sub>	Pin INH Voltage Range		-0.3	45	V
V <sub>LIN</sub>	Pin LIN Voltage Range	With respect to GND	-45	45	V
T <sub>J</sub>	Junction Temperature <sup>(2)</sup>		-40	150	°C
T <sub>STG</sub>	Storage Temperature		-55	150	°C

(1) Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to any Absolute Maximum Rating condition for extended periods may affect device reliability and lifetime.

**ESD (Electrostatic Discharge Protection)**

Parameter		Condition	Min	Max	Unit
V <sub>ESD</sub>	Electrostatics Discharge <sup>(1)(2)</sup>	IEC61000-4-2 (150 pF, 330 Ω discharge circuit), contact discharge on LIN, WAKE_N, INH Pins	-15	15	kV
		Human Body Model (HBM) on LIN, WAKE_N, INH pins	-15	15	kV
		Human Body Model (HBM) on any other pins	-6	6	kV
		Charged Device Model (CDM) on all pins	-1.5	1.5	kV
V <sub>TRAN</sub>	Transient Immunity ISO 7637-2 on Bus Pins	Pulse1	-100		V
		Pulse2a		75	V
		Pulse3a	-150		V
		Pulse3b		100	V

(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.

### Recommended Operating Conditions

	Parameter	Min	Max	Unit
V <sub>BAT</sub>	Battery Power Supply	5.5	40	V
V <sub>LIN</sub>	LIN Bus Input Voltage	0	40	V
V <sub>WAKE_N</sub>	WAKE_N Pin Input Voltage	0	40	V
V <sub>LOGIC</sub>	Logic Pin Voltage	0	5.25	V
T <sub>J</sub>	Operating Virtual Junction Temperature Range	-40	150	°C

### Thermal Information

Package Type	$\theta_{JA}$	$\theta_{JC}$	Unit
SOP8	118	48	°C/W
DFN3x3-8	51	23	°C/W

**Automotive Fault Protected LIN Transceiver with WAKE and INH**
**Electrical Characteristics**

All test conditions:  $V_{BAT} = 5.5\text{ V to }40\text{ V}$ ,  $R_L = 500\ \Omega$ ,  $T_J = -40^\circ\text{C to }150^\circ\text{C}$ , typical values are tested at  $V_{BAT} = 12\text{ V}$ , unless otherwise noted.

Parameter		Conditions	Min	Typ	Max	Unit
<b>Pin VBAT</b>						
$V_{TH\_VBAT\_L}$	Low Level of VBAT UVLO Threshold Voltage		3.50	4.30		V
$V_{TH\_VBAT\_H}$	High Level of VBAT UVLO Threshold Voltage			4.45	5.20	V
$V_{HYS\_VBAT}$	Hysteresis Voltage on Power-on Reset <sup>(1)</sup>			0.15		V
$I_{BAT}$	Sleep Mode Supply Current	$V_{LIN} = V_{BAT}$ ; $V_{WAKE\_N} = V_{BAT}$ ; $V_{TXD} = 0\text{ V}$ ; $V_{SLP\_N} = 0\text{ V}$		5.9	11	$\mu\text{A}$
	Standby Mode Supply Current	Recessive; $V_{INH} = V_{BAT}$ ; $V_{LIN} = V_{BAT}$ ; $V_{WAKE\_N} = V_{BAT}$ ; $V_{TXD} = 5\text{ V}$ ; $V_{SLP\_N} = 0\text{ V}$		21	30	$\mu\text{A}$
		Dominant; $V_{INH} = V_{BAT}$ ; $V_{LIN} = 0\text{ V}$ ; $V_{WAKE\_N} = V_{BAT}$ ; $V_{TXD} = 0\text{ V}$ ; $V_{SLP\_N} = 0\text{ V}$		440	1900	$\mu\text{A}$
	Normal Mode Supply Current	Recessive; $V_{INH} = V_{BAT}$ ; $V_{LIN} = V_{BAT}$ ; $V_{WAKE\_N} = V_{BAT}$ ; $V_{TXD} = 5\text{ V}$ ; $V_{SLP\_N} = 5\text{ V}$		157	280	$\mu\text{A}$
		Dominant; $V_{BAT} = 12\text{ V}$ ; $V_{INH} = 12\text{ V}$ ; $V_{LIN} = 0\text{ V}$ ; $V_{WAKE\_N} = 12\text{ V}$ ; $V_{TXD} = 0\text{ V}$ ; $V_{SLP\_N} = 5\text{ V}$		1.6	4	mA
<b>Pin TXD</b>						
$V_{IH}$	High-Level Input Voltage		2		7	V
$V_{IL}$	Low-Level Input Voltage		-0.3		0.8	V
$V_{HYS\_TXD}$	Hysteresis Voltage on Pin TXD		50	200	400	mV
$R_{PD\_TXD}$	Pin TXD Pull down Resistance	$V_{TXD} = 5\text{ V}$	140	500	1200	k $\Omega$
$I_{IL}$	Low-Level Input Current	$V_{TXD} = 0\text{ V}$	-5		5	$\mu\text{A}$
$I_{OL}$	Low-Level Output Current	Local wake-up request; Standby mode; $V_{WAKE\_N} = 0\text{ V}$ ; $V_{LIN} = V_{BAT}$ ; $V_{TXD} = 0.4\text{ V}$	1.5	3.5		mA
<b>Pin SLP_N</b>						
$V_{IH}$	High-Level Input Voltage		2		7	V
$V_{IL}$	Low-Level Input Voltage		-0.3		0.8	V

**Automotive Fault Protected LIN Transceiver with WAKE and INH**

Parameter		Conditions	Min	Typ	Max	Unit
V <sub>HYS_SLP_N</sub>	Hysteresis Voltage on Pin SLP_N		50	200	400	mV
R <sub>PD_SLP_N</sub>	Pin SLP_N Pull-down Resistance	V <sub>TXD</sub> = 5 V	140	500	1200	kΩ
I <sub>IL</sub>	Low-Level Input Current	V <sub>TXD</sub> = 0 V	-5		5	μA
<b>Pin RXD</b>						
I <sub>OL</sub>	Low-Level Output Current	Normal mode; V <sub>LIN</sub> = 0 V, V <sub>RXD</sub> = 0.4 V	1.5	4.2		mA
I <sub>LH</sub>	High-Level Leakage Current	Normal mode; V <sub>LIN</sub> = V <sub>BAT</sub> , V <sub>RXD</sub> = 5 V	-5	0	5	μA
<b>Pin WAKE_N</b>						
V <sub>IL</sub>	Low-Level Input Voltage		-0.3		V <sub>BAT</sub> - 3.3	V
I <sub>PU_L</sub>	Low-Level Pull-up Current	V <sub>WAKE_N</sub> = 0 V	-30	-12	-1	μA
I <sub>IH</sub>	High-Level Leakage Current		-5	0	5	μA
<b>Pin INH</b>						
ΔV <sub>INH</sub>	High-Level voltage drop INH with respect to V <sub>BAT</sub>	I <sub>INH</sub> = -0.5mA		0.7	1	V
I <sub>LH</sub>	High-Level Leakage Current	Sleep mode; V <sub>INH</sub> = 0 V ;	-5	0	5	μA
<b>Pin LIN</b>						
I <sub>BUS_LIM</sub>	Dominant Output Current Limitation	V <sub>BAT</sub> = V <sub>LIN</sub> = 18V; V <sub>TXD</sub> = 0 V	40		160	mA
R <sub>PU</sub>	Pull-up Resistance	Sleep mode; V <sub>SLP_N</sub> = 0 V	50	160	250	kΩ
I <sub>BUS_PAS_REC</sub>	Receiver Recessive Input Leakage Current	V <sub>BAT</sub> = 5.5 V; V <sub>LIN</sub> = 27 V; V <sub>TXD</sub> = 5 V			20	μA
I <sub>BUS_PAS_DOM</sub>	Receiver Dominant Input Leakage Current	Normal mode; V <sub>BAT</sub> = 12 V; V <sub>LIN</sub> = 0 V; V <sub>TXD</sub> = 5 V	-600			μA
V <sub>SerDiode</sub>	Voltage Drop at the Serial Diode <sup>(1)</sup>	Pull-up path with R <sub>SLAVE</sub> ; I <sub>SerDiode</sub> = 10 μA	0.4		1	V
I <sub>BUS_NO_GND</sub>	Ground Loss Bus Current	V <sub>BAT</sub> = 40 V; V <sub>LIN</sub> = 0 V	-750		10	μA
I <sub>BUS_NO_BAT</sub>	Battery Loss Bus Current	V <sub>BAT</sub> = 0 V; V <sub>LIN</sub> = 40 V			20	μA
V <sub>BUS_DOM</sub>	Receiver Dominant				0.4 x V <sub>BAT</sub>	V
V <sub>BUS_REC</sub>	Receiver Recessive		0.6 x V <sub>BAT</sub>			V
V <sub>BUS_CNT</sub>	Receiver Center Voltage		0.475 x V <sub>BAT</sub>	0.5 x V <sub>BAT</sub>	0.525 x V <sub>BAT</sub>	V
V <sub>HYS</sub>	Receiver Hysteresis Voltage				0.175 x V <sub>BAT</sub>	V
R <sub>SLAVE</sub>	Slave Resistance	Between LIN and V <sub>BAT</sub> ; V <sub>BAT</sub> = 12 V; V <sub>LIN</sub> = 0 V	20	30	47	kΩ
C <sub>LIN</sub>	Pin LIN Capacitance <sup>(1)</sup>				30	pF
V <sub>O_REC</sub>	Recessive Output Voltage	Normal mode; V <sub>TXD</sub> = V <sub>CC</sub> ;	0.85 x V <sub>BAT</sub>			V



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**Automotive Fault Protected LIN Transceiver with WAKE and INH**

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Parameter		Conditions	Min	Typ	Max	Unit
V <sub>O_DOM</sub>	Dominant Output Voltage	Normal mode; V <sub>TXD</sub> = 0 V;			1.4	V
<b>Temperature Detection</b>						
T <sub>J_SD</sub>	Thermal Shutdown Temperature <sup>(1)</sup>		160	180	200	°C
T <sub>J_SD_HYS</sub>	Thermal Shutdown Junction Hysteresis <sup>(1)</sup>			20		°C

(1) The data is based on bench tests and design simulations.

**Automotive Fault Protected LIN Transceiver with WAKE and INH**
**Duty Cycles**

All test conditions:  $V_{BAT} = 5.5\text{ V to }40\text{ V}$ ,  $R_L = 500\ \Omega$ ,  $T_J = -40^\circ\text{C to }150^\circ\text{C}$ , see [Figure 2](#), unless otherwise noted.

Parameter		Conditions	Min	Typ	Max	Unit
D1	Duty cycle 1; $D1 = t_{BUS\_REC\_MIN} / 2 \times t_{BIT}$	$V_{TH\_REC\_MAX} = 0.744 \times V_{BAT}$ ; $V_{TH\_DOM\_MAX} = 0.581 \times V_{BAT}$ ; 20 kbps; $t_{BIT} = 50\ \mu\text{s}$ ; $7\text{ V} \leq V_{BAT} \leq 40\text{ V}$	0.396			
D1	Duty cycle 1; $D1 = t_{BUS\_REC\_MIN} / 2 \times t_{BIT}$	$V_{TH\_REC\_MAX} = 0.744 \times V_{BAT}$ ; $V_{TH\_DOM\_MAX} = 0.581 \times V_{BAT}$ ; 20 kbps; $t_{BIT} = 50\ \mu\text{s}$ ; $5.5\text{ V} \leq V_{BAT} < 7\text{ V}$	0.396			
D2	Duty cycle 2; $D2 = t_{BUS\_REC\_MAX} / 2 \times t_{BIT}$	$V_{TH\_REC\_MIN} = 0.422 \times V_{BAT}$ ; $V_{TH\_DOM\_MIN} = 0.284 \times V_{BAT}$ ; 20 kbps; $t_{BIT} = 50\ \mu\text{s}$ ; $7.6\text{ V} \leq V_{BAT} \leq 40\text{ V}$			0.581	
D2	Duty cycle 2; $D2 = t_{BUS\_REC\_MAX} / 2 \times t_{BIT}$	$V_{TH\_REC\_MIN} = 0.464 \times V_{BAT}$ ; $V_{TH\_DOM\_MIN} = 0.312 \times V_{BAT}$ ; 20 kbps; $t_{BIT} = 50\ \mu\text{s}$ ; $5.5\text{ V} \leq V_{BAT} < 7.6\text{ V}$			0.581	
D3	Duty cycle 3; $D3 = t_{BUS\_REC\_MIN} / 2 \times t_{BIT}$	$V_{TH\_REC\_MAX} = 0.778 \times V_{BAT}$ ; $V_{TH\_DOM\_MAX} = 0.616 \times V_{BAT}$ ; 10.4 kbps; $t_{BIT} = 96\ \mu\text{s}$ ; $7\text{ V} \leq V_{BAT} \leq 40\text{ V}$	0.417			
D3	Duty cycle 3; $D3 = t_{BUS\_REC\_MIN} / 2 \times t_{BIT}$	$V_{TH\_REC\_MAX} = 0.778 \times V_{BAT}$ ; $V_{TH\_DOM\_MAX} = 0.616 \times V_{BAT}$ ; 10.4 kbps; $t_{BIT} = 96\ \mu\text{s}$ ; $5.5\text{ V} \leq V_{BAT} < 7\text{ V}$	0.417			
D4	Duty cycle 4; $D4 = t_{BUS\_REC\_MAX} / 2 \times t_{BIT}$	$V_{TH\_REC\_MIN} = 0.389 \times V_{BAT}$ ; $V_{TH\_DOM\_MIN} = 0.251 \times V_{BAT}$ ; 10.4 kbps; $t_{BIT} = 96\ \mu\text{s}$ ; $7.6\text{ V} \leq V_{BAT} \leq 40\text{ V}$			0.590	
D4	Duty cycle 4; $D4 = t_{BUS\_REC\_MAX} / 2 \times t_{BIT}$	$V_{TH\_REC\_MIN} = 0.389 \times V_{BAT}$ ; $V_{TH\_DOM\_MIN} = 0.251 \times V_{BAT}$ ; 10.4 kbps; $t_{BIT} = 96\ \mu\text{s}$ ; $5.5\text{ V} \leq V_{BAT} < 7.6\text{ V}$			0.590	

**Automotive Fault Protected LIN Transceiver with WAKE and INH**
**AC Timing Requirements**

All test conditions:  $V_{BAT} = 5.5\text{ V to }40\text{ V}$ ,  $R_L = 500\ \Omega$ ,  $T_J = -40^\circ\text{C to }150^\circ\text{C}$ , typical values are tested at  $V_{BAT} = 12\text{ V}$ , unless otherwise noted.

Parameter	Conditions	Min	Typ	Max	Unit
$t_F$	LIN Bus Fall Time $C_{BUS} = 1\text{ nF}$ , $R_{BUS} = 1\text{ k}\Omega$ ; $C_{BUS} = 6.8\text{ nF}$ , $R_{BUS} = 660\ \Omega$ ; $C_{BUS} = 10\text{ nF}$ , $R_{BUS} = 500\ \Omega$ ;			22.5	$\mu\text{s}$
$t_R$	LIN Bus Rise Time $C_{BUS} = 1\text{ nF}$ , $R_{BUS} = 1\text{ k}\Omega$ ; $C_{BUS} = 6.8\text{ nF}$ , $R_{BUS} = 660\ \Omega$ ; $C_{BUS} = 10\text{ nF}$ , $R_{BUS} = 500\ \Omega$ ;			22.5	$\mu\text{s}$
$\Delta t_{(R-F)}$	Difference between LIN Bus Rise-and-Fall Time $V_{BAT} = 7.3\text{ V}$	-5		5	$\mu\text{s}$
$t_{TX\_PD}$	Transmitter Propagation Delay Rising and falling			6	$\mu\text{s}$
$t_{TX\_SYM}$	Transmitter Propagation Delay Symmetry	-3		3	$\mu\text{s}$
$t_{RX\_PD}$	Receiver Propagation Delay Rising and falling			6	$\mu\text{s}$
$t_{RX\_SYM}$	Receiver Propagation Delay Symmetry	-2		2	$\mu\text{s}$
$t_{WAKE\_DOM\_LIN}$	LIN Dominant Wake-up Time Sleep mode	30	80	150	$\mu\text{s}$
$t_{WAKE\_DOM\_WAKE\_N}$	Pin WAKE_N Dominant Wake-up Time Sleep mode	7	25	50	$\mu\text{s}$
$t_{GOTONORM}$	Go-to-Normal Time Mode change time from Sleep, Power-on, Standby mode into Normal mode	2	5	10	$\mu\text{s}$
$t_{INITNORM}$	Normal Mode Initialization Time <sup>(1)</sup>	5	12	20	$\mu\text{s}$
$t_{GOTOSLEEP}$	Go-to-Normal Time Mode change time from Normal to Sleep mode	2	5	10	$\mu\text{s}$
$t_{TO\_DOM\_TXD}$	TXD dominant time-out time $V_{TXD} = 0\text{ V}$	27	43	90	ms

(1) The data is based on bench tests and design simulations.

### Parameter Measurement Information

#### Test Circuit

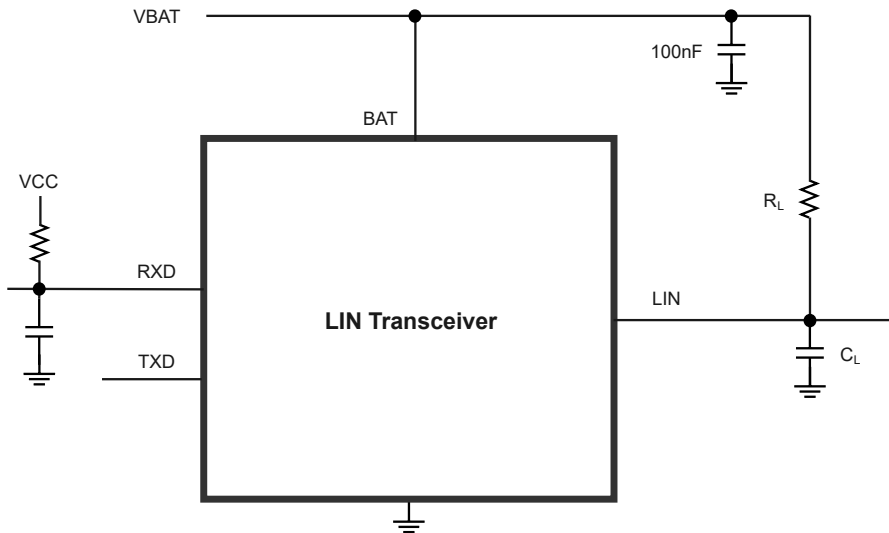


Figure 1. LIN Transceiver Timing Parameter Test Circuit

#### Parameter Diagram

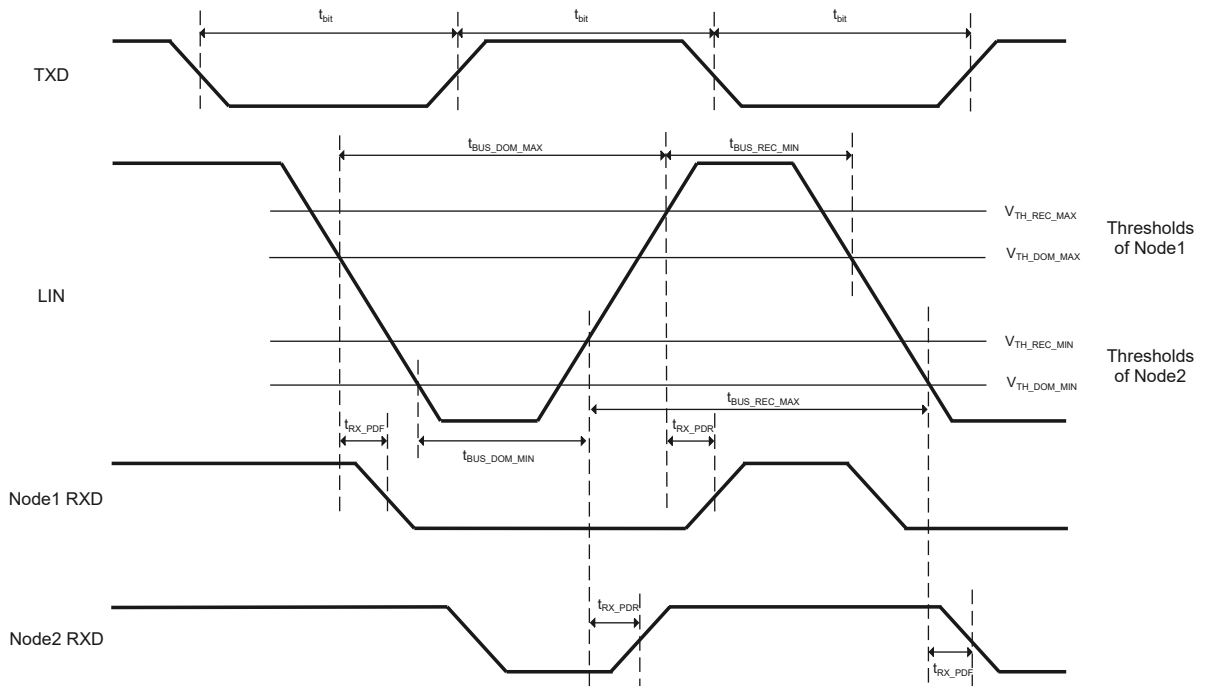
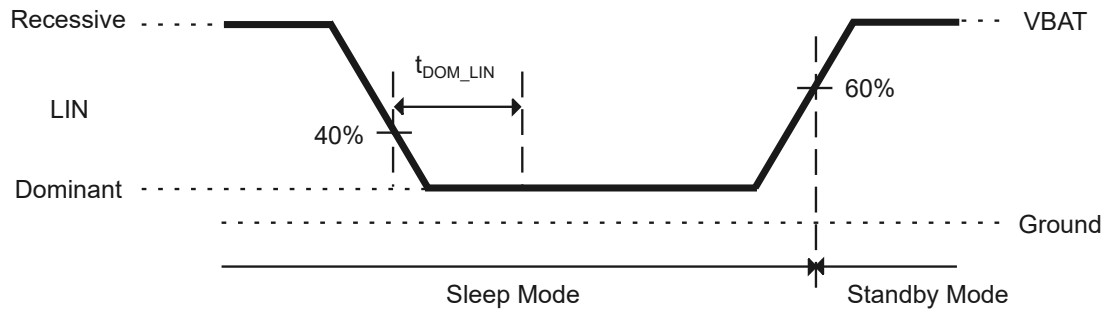


Figure 2. LIN Transceiver Timing Diagram

**Automotive Fault Protected LIN Transceiver with WAKE and INH****Figure 3. Remote Wake-up Diagram**

## Detailed Description

### Overview

The TPT1021EQ is a local interconnect network (LIN) physical layer transceiver that is compliant with ISO 17987-4, SAE J2602 and LIN 2.0, LIN 2.1, LIN 2.2, and LIN 2.2A physical layer standards. LIN is a low-speed universal asynchronous receiver transmitter (UART) communication protocol that supports automotive in-vehicle sub-networks. The device supports LIN networks up to 20 Kbps with an enhanced timing margin. The device converts the transmitted data received at the TXD with the optimized slew rate to minimize the electromagnetic emission (EME) and reports the state of the LIN bus at the RXD. As designed, the device features overvoltage and loss of ground protection from -45 V to +45 V, over-temperature shutdown. The device has low-current standby and sleep mode with LIN BUS wake-up and local wake-up capability via the WAKE\_N pin. The INH pin of the device is used to control voltage regulation to reduce system-level power consumption. The device integrates a pull high resistor for LIN slave applications and ESD protection which allows applications to operate with a reduced dependence on external components. Additionally, all devices include many protection features to enhance the device and network robustness. The TPT1021EQ is available in SOP-8 and DFN3X3-8 packages and is AEC-Q100 qualified for automotive applications.

### Functional Block Diagram

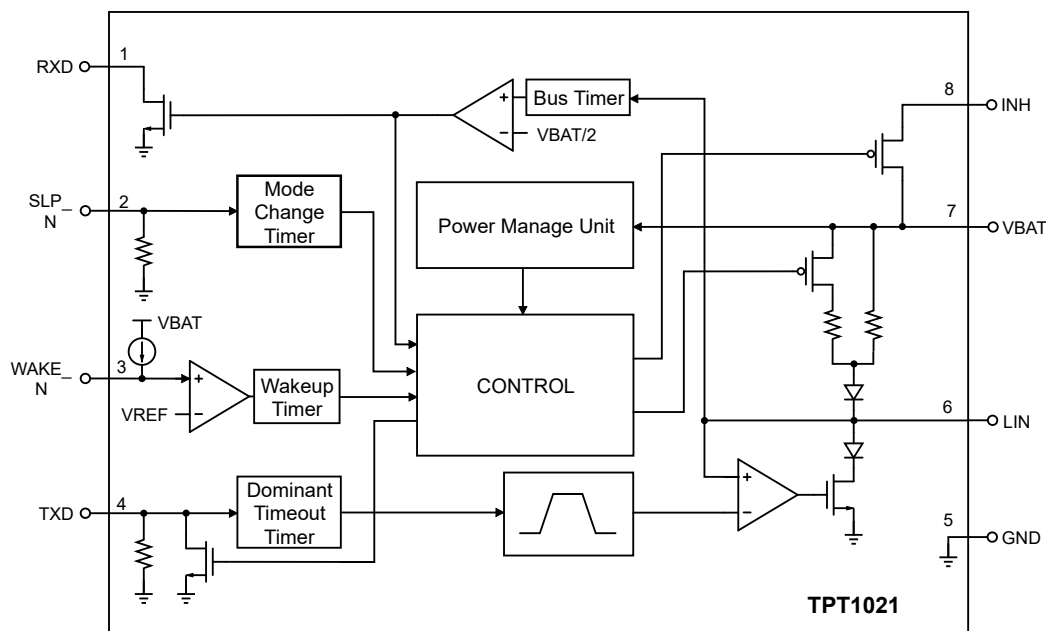
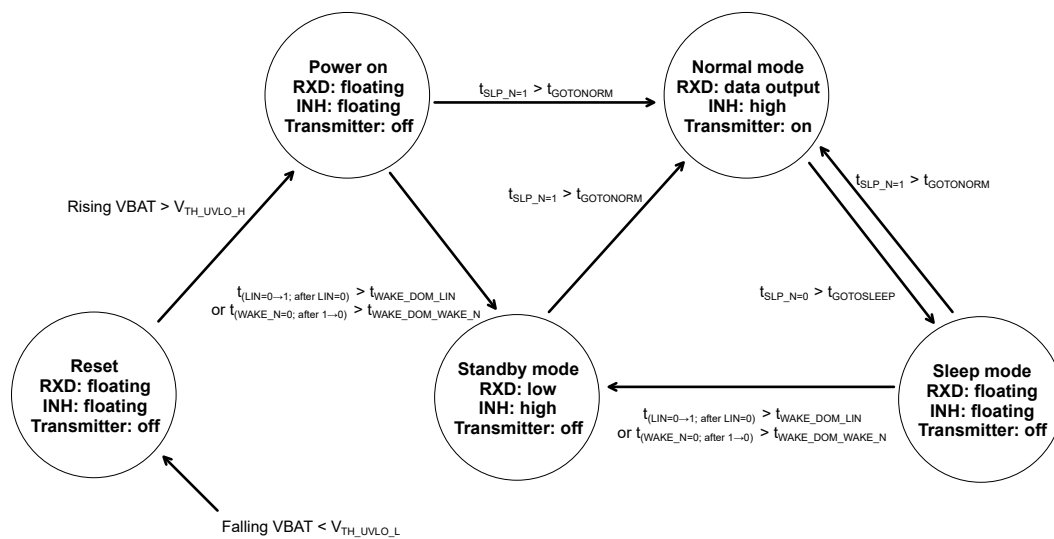


Figure 4. Functional Block Diagram

### Feature Description

#### Device Operating Modes

The device supports modes for Normal mode, Power-on mode, Standby mode, and Sleep mode. The figure below shows the state diagram.

**Automotive Fault Protected LIN Transceiver with WAKE and INH**

**Figure 5. Functional Block Diagram**
**Table 2. Function Table**

Mode	SLP_N	TXD	RXD	INH	Transmitter	Comments
Normal	High	High: recessive state Low: dominant state	High: recessive state Low: dominant state	High	Normal	
Sleep	Low	Weak pull-down	Floating	Floating	Off	No wake-up event detected
Standby	Low	Weak pull-down if remote wake-up; strong pull-down if local wake-up	Low	High	Off	Wake-up event detected
Power-on	Low	Weak pull-down	Floating	High	Off	

**Normal Mode**

In Normal mode, the device can transmit and receive data through the LIN bus line. The receiver detects the data stream at the LIN bus input pin and transfers it to the microcontroller via the RXD pin. On the bus, a HIGH level corresponds to a recessive state, while a LOW level represents a dominant state. The receiver incorporates a voltage-dependent threshold with hysteresis and an integrated filter to suppress noise on the bus.

The transmit data stream from the protocol controller at the TXD input is converted by the transmitter into a bus signal with optimized slew rate and wave shaping, aiming to minimize electromagnetic emissions (EME). The LIN bus output pin is pulled HIGH through an internal slave termination resistor. For master applications, an external resistor in series with a diode should be connected between pin INH or VBAT and pin LIN.

**Sleep Mode**

The device offers an energy-efficient mode known as the power-saving mode. Despite its extremely low current consumption, the device retains the capability to be remotely awakened via the LIN pin, locally awakened via the WAKE\_N pin, or directly activated through the SLP\_N pin. Input filters are incorporated at the receiver (LIN), WAKE\_N pin, and SLP\_N pin to prevent undesired wake-up events caused by automotive transients or electromagnetic interference (EMI).

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## Automotive Fault Protected LIN Transceiver with WAKE and INH

To initiate Sleep mode from Normal mode, a falling edge on the SLP\_N pin is required. In order to successfully enter Sleep mode (INH pin becomes floating), the sleep command (SLP\_N pin set to LOW) must be sustained for a minimum duration of  $t_{\text{gotosleep}}$ .

During Sleep mode, the internal slave termination between the LIN and VBAT pins is disabled to minimize power dissipation if the LIN pin is short-circuited to ground. Only a weak pull-up is present between the LIN and VBAT pins.

### Standby Mode

Whenever a local or remote wake-up occurs while the device is in Sleep mode, Standby mode is automatically activated. These wake-up events trigger the activation of pin INH and enable the slave termination resistor at the LIN pin. Consequently, the voltage regulator and microcontroller can be powered on due to the HIGH condition of the pin INH.

Standby mode is indicated by a low level on the RXD pin, which can serve as an interrupt for the microcontroller.

During Standby mode (with pin SLP\_N still low), the state of the TXD pin (weak pull-down or strong pull-down) indicates the source of the wake-up: a weak pull-down for a remote wake-up request and a strong pull-down for a local wake-up request.

### Wake-up

When VBAT voltage exceeds the undervoltage threshold voltage, the device transitions into Power-on mode. In this mode, despite being powered up and INH being high, both the transmitter and receiver remain inactive. If SLP\_N is HIGH for a duration greater than  $t_{\text{GOTONORM}}$ , the device enters Normal mode.

To wake up a device that is in Sleep mode, there are three methods:

Remote wake-up through the LIN bus by transmitting a dominant bus state sustained for a duration of at least  $t_{\text{WAKE\_DOM\_LIN}}$  then followed by a rising edge.

Local wake-up is achieved by a negative edge signal at the WAKE\_N pin and is sustained low for a duration of at least  $t_{\text{WAKE\_DOM\_WAKE\_N}}$ . This transition triggers the wake-up event and brings the device out of Sleep mode.

Mode change by setting the SLP\_N pin to a HIGH level. This change in pin state signals the device to exit Sleep mode and enter Normal mode.

### Wake-up Source Recognition

The device is capable of distinguishing between a local wake-up request, initiated on pin WAKE\_N, and a remote wake-up request through a dominant bus state. A local wake-up request activates the wake-up source flag, which can be accessed on pin TXD during Standby mode. If an external pull-up resistor is connected to pin TXD, a HIGH level indicates a remote wake-up request (with a weak pull-down at pin TXD), while a LOW level indicates a local wake-up request (with a strong pull-down at pin TXD, considerably stronger than the external pull-up resistor).

Both the wake-up request flag (indicated on pin RXD) and the wake-up source flag (indicated on pin TXD) reset immediately after the MCU sets pin SLP\_N to a HIGH state.

## Protection Features

### TXD Dominant Time-out

The device detects TXD dominant time-out and prevents a permanent low on the TXD pin driving the LIN bus into permanent dominant blocking the LIN bus network. If the TXD remains low for longer than  $t_{\text{TXD\_DTO}}$ , the transmitter is disabled until the fault flag has been cleared.

### Under-voltage Lockout (UVLO)

The device integrates under-voltage to detect and lockout circuit of the supply terminal to keep the device in protected mode if the supply voltage drops below the threshold until the supply voltage is higher than the UVLO threshold. This protects the device and system during undervoltage events on supply terminals.



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**Automotive Fault Protected LIN Transceiver with WAKE and INH****Over-Temperature Protection (OTP)**

The output drivers are protected against over-temperature conditions. If the virtual junction temperature exceeds the shutdown junction temperature  $T_{J\_SD}$ , the output drivers are disabled until the virtual junction temperature falls below  $T_{J\_SD\_R}$  and TXD becomes recessive again. Including the TXD condition ensures that output driver oscillation due to temperature drift is avoided.

**Fail-safe Features**

An internal pull-down to GND on the TXD pin to establish a predetermined level in case the TXD pin is disconnected.

An internal pull-down to GND on the SLP\_N pin to establish a predetermined level in case the SLP\_N pin is disconnected.

The RXD pin is set to floating when the VBAT pin is unpowered.

The current limit is applied to the LIN transmitter output to protect the LIN bus from short circuits to VBAT or GND.

VBAT and GND loss will not impact the LIN bus or the MCU. No reverse current flows from the bus into the LIN pin. The internal integrated LIN slave termination resistor maintains the current path from VBAT to LIN. Disconnecting the LIN transceiver from the power supply does not affect the LIN bus.

## Application and Implementation

Note

Information in the following application sections is not part of the 3PEAK's component specification and 3PEAK does not warrant its accuracy or completeness. 3PEAK's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

### Typical Application

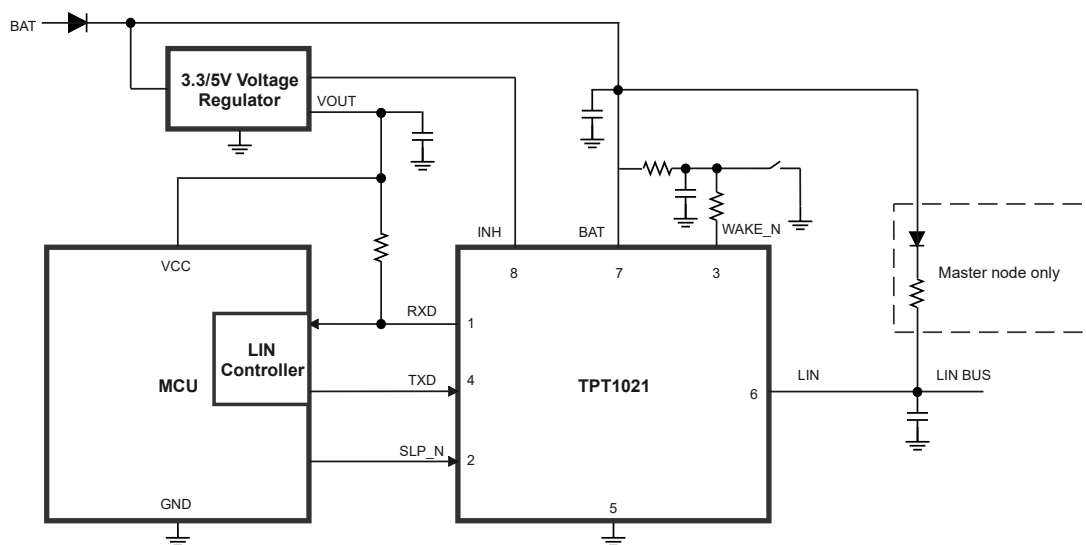
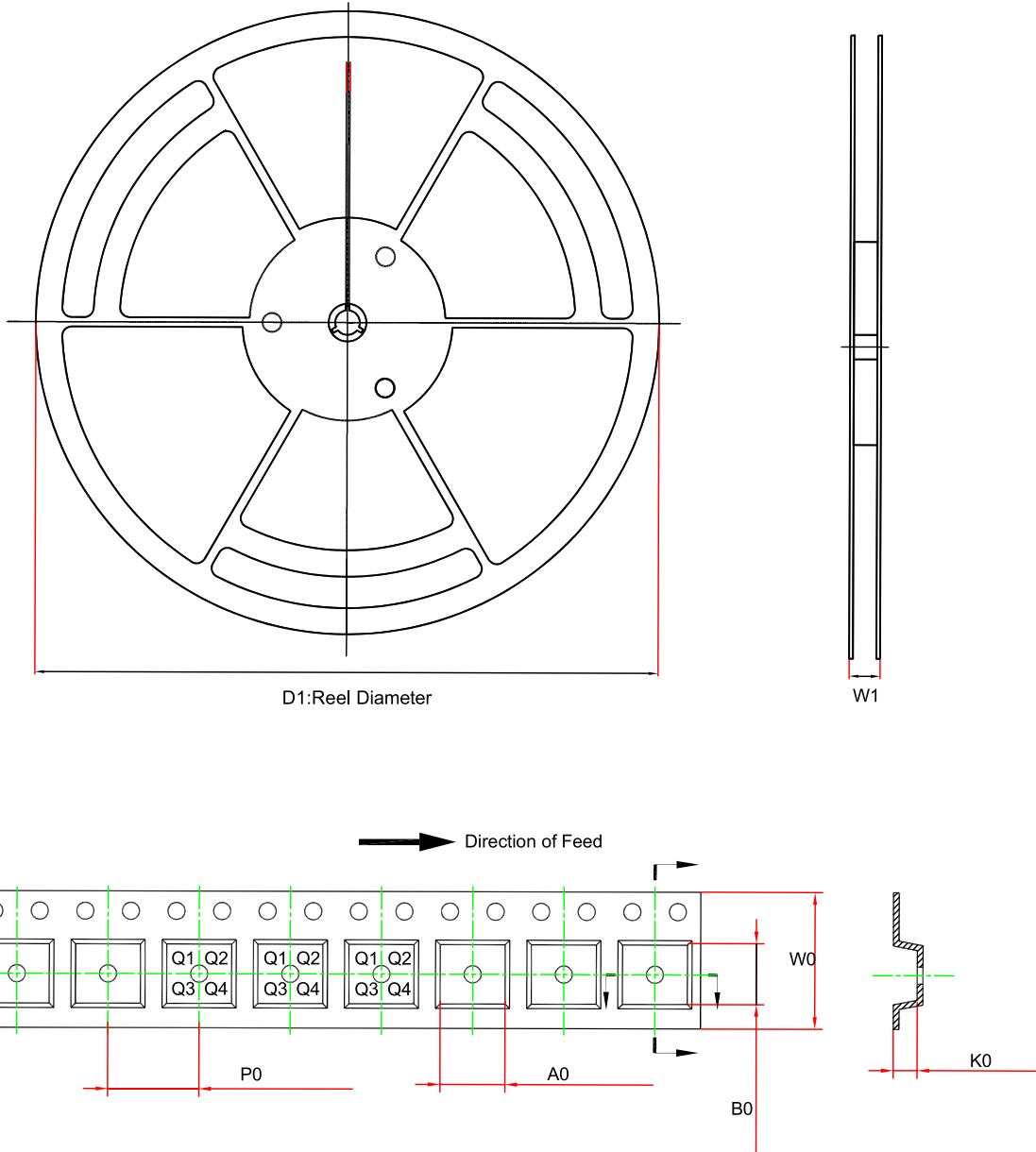


Figure 6. Typical Application Circuit

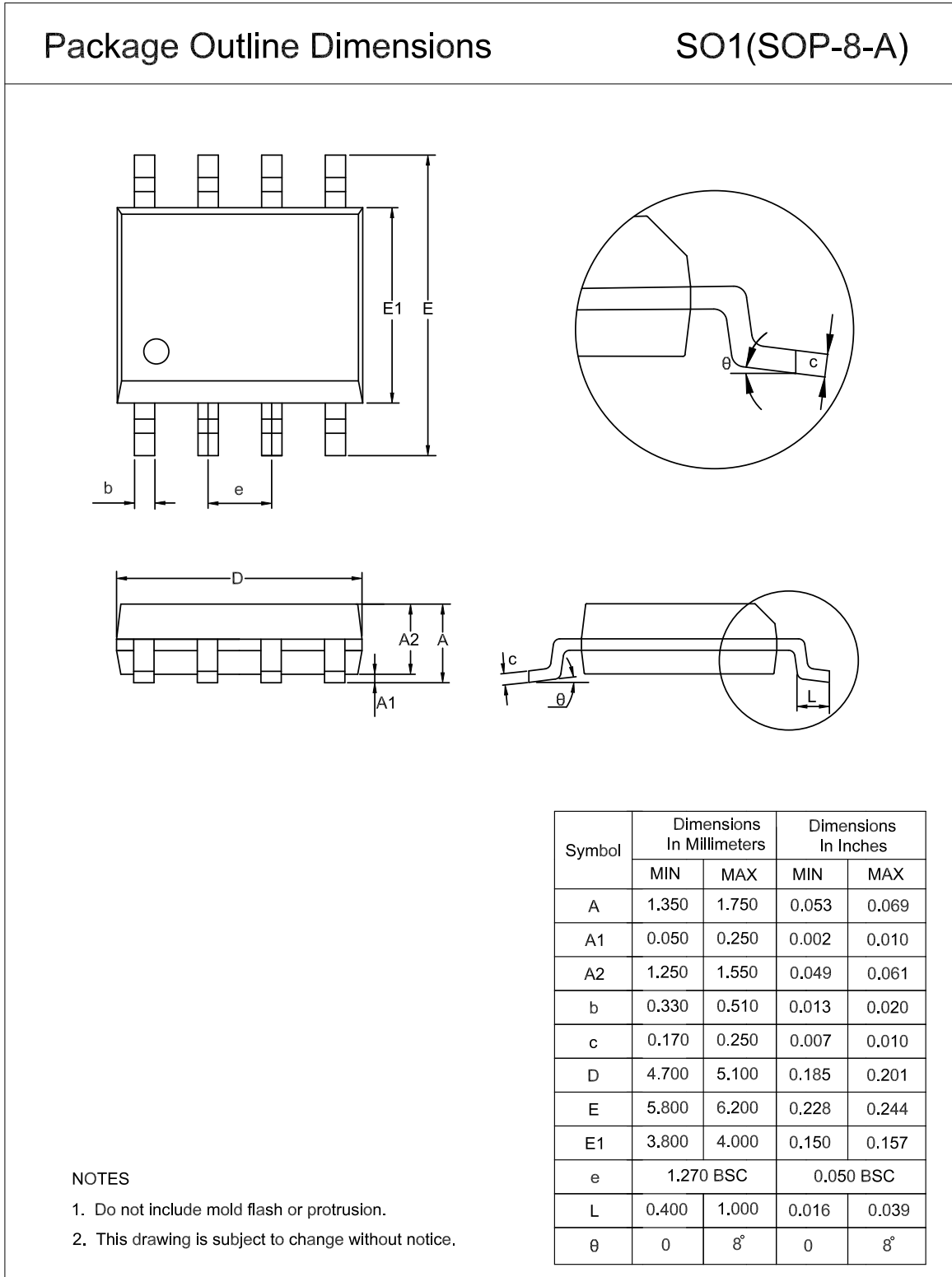
### Tape and Reel Information



Order Number	Package	D1 (mm)	A0 (mm)	K0(mm)	W0 (mm)	W1 (mm)	B0 (mm)	P0 (mm)	Pin1 Quadrant
TPT1021EQ-SO1R-S	SOP8	330	6.5	2	12	17.6	5.4	8	Q1
TPT1021EQ-DFCR-S	DFN3x3-8	330	3.3	1.1	12	17.6	3.3	8	Q1

Package Outline Dimensions

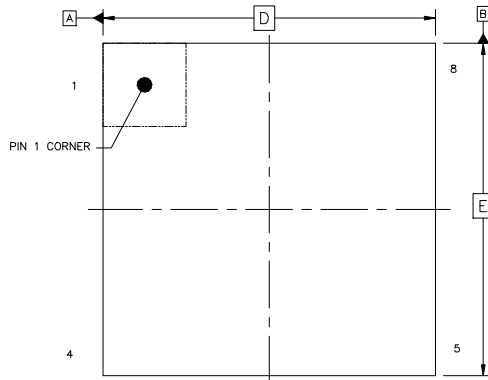
SOP8



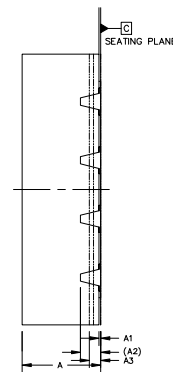
DFN3X3-8

Package Outline Dimensions

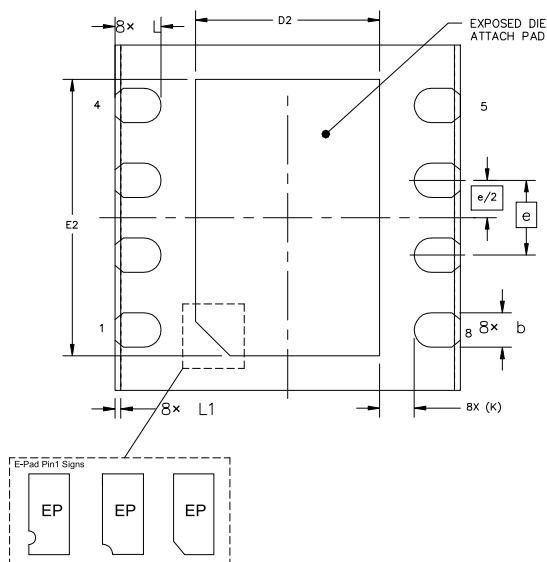
DFC(DFN3X3-8-WET-H)



TOP VIEW



SIDE VIEW



BOTTOM VIEW

NOTES

1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.
3. The many types of E-pad Pin1 signs may appear in the product.

Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.800	0.900	0.031	0.035
A1	0.000	0.050	0.000	0.002
A2	0.150	0.250	0.006	0.010
A3	0.080	0.180	0.003	0.007
D	2.900	3.100	0.114	0.122
D2	1.500	1.700	0.059	0.067
E	2.900	3.100	0.114	0.122
b	0.250	0.350	0.010	0.014
E2	2.300	2.500	0.091	0.098
e	0.650 BSC		0.026 BSC	
L	0.350	0.450	0.014	0.018
L1	0.010	0.090	0.0004	0.004
K	0.300 REF		0.012 REF	

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**Automotive Fault Protected LIN Transceiver with WAKE and INH****Order Information**

Order Number	Operating Temperature Range	Package	Marking Information	MSL	Transport Media, Quantity	Eco Plan
TPT1021EQ-SO1R-S	-40 to 125°C	SOP8	1021Q	1	Tape and Reel, 4000	Green
TPT1021EQ-DFCR-S	-40 to 125°C	DFN3x3-8	1021Q	1	Tape and Reel, 4000	Green

**Green:** 3PEAK defines "Green" to mean RoHS compatible and free of halogen substances.

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