Features

- Bidirectional Translator of I²C Applications and SMBus Compatible
- Support Fast-mode Plus, up to 1-Mbps Data Rate
- High-Impedance SCL1, SDA1, SCL2, and SDA2 Pins for EN = LOW
- 1-V Pre-Charge on All SDA and SCL Lines Prevents Corruption during Live Board Insertion
- Operating Power Supply Range from 2.3 V to 5.5 V
- Low I_{CC}Chip Shutdown Current: 0.3 μA (typ)
- Powered-Off High-Impedance I²C Pins
- Built-in ΔV/Δt Rise Time Accelerator
- ACK Error Protection to Avoid Direction Switching Error
- ESD Protection:
  - 7-kV Human-Body Model
  - 1.5-kV Charged-Device Model

Applications

- Servers/Storages
- Enterprise Switching
- Telecom Switching Equipment and Base Stations
- Industrial Automation Equipment

Description

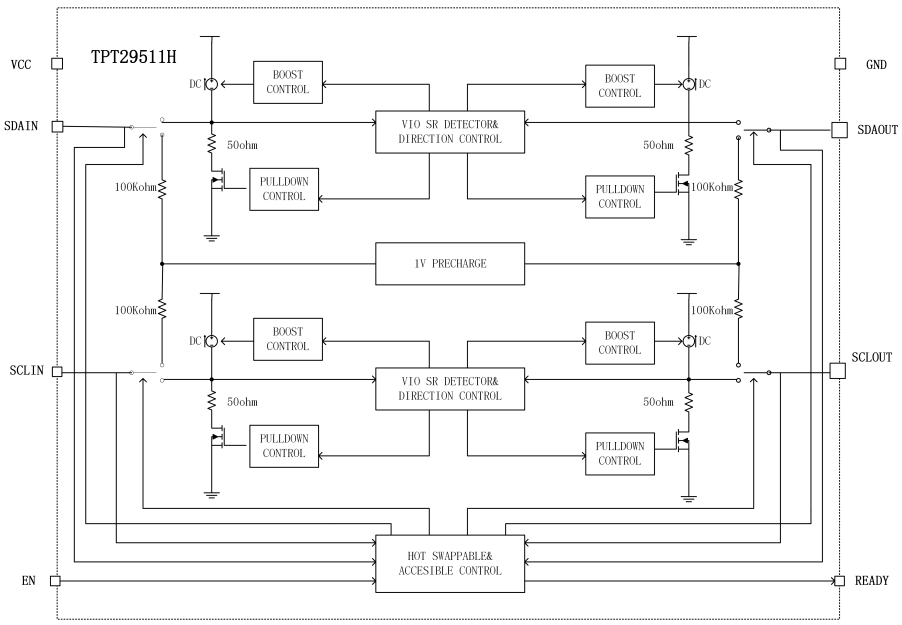
The TPT29511H device is a dual bidirectional I²C and SMBus hot-swap buffer with an enable (EN) input, and works from 2.3 V to 5.5 V V_{CC}, which supports IO cards live insertion and removal from the backplane. The control circuit prevents the backplane-side I²C lines (in) from the other card-side I²C lines (out) until a stop command or bus idle condition occurs on the backplane without bus contention on the card. When the connection is made, the TPT29511H provides bidirectional buffering, keeping the backplane and card capacitances isolated.

The TPT29511H rise time accelerator circuitry allows the use of weaker DC pull-up currents while also meeting rise time requirements (ΔV/Δt > 0.6 V/us).

The TPT29511H incorporates a digital enable input pin, which enables the device when asserted high and forces the device into a low current mode when asserted low, and an open-drain ready output pin, which indicates that the backplane and card sides are connected (high) or not (low).

TPT29511H is available in the MSOP8 package, and is characterized from −40°C to +125°C.

Functional Block Diagram



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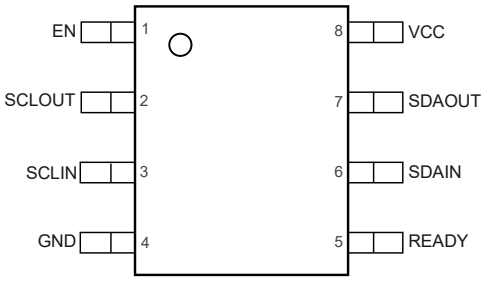
Revision History

Date	Revision	Notes
2023-12-05	Rev.A.0	Released version

Pin Configuration and Functions

TPT29511H
SOP8 Package
Top View



TPT29511H
MSOP8 Package
Top View

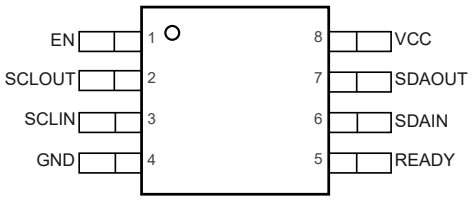


Table 1. Pin Functions: TPT29511H

Pin		I/O	Description
No.	Name		
1	EN	I	Active-high chip enable pin. If EN is low, the device is in a low current mode.
2	SCLOUT	I/O	Serial clock output to and from the SCL bus on the card
3	SCLIN	I/O	Serial clock input to and from the SCL bus on the backplane
4	GND	−	Ground.
5	READY	O	Open-drain output which pulls LOW when SDAIN and SCLIN are disconnected from SDAOUT and SCLOUT, and goes HIGH when the two sides are connected
6	SDAIN	I/O	Serial data input to and from the SDA bus on the backplane
7	SDAOUT	I/O	Serial data output to and from the SDA bus on the card
8	VCC	−	Power supply

Specifications

Absolute Maximum Ratings (1)

Parameter		Min	Max	Unit
V_{CC}	Power Supply	−0.5	+7	V
IO PIN	SDAIN, SCLIN, SDAOUT, SCLOUT, EN, READY	−0.5	+7	V
I_{IK}	Input Clamp Current		−50	mA
I_{OK}	Output Clamp Current		−50	mA
I_O	Continuous Output Current		±50	mA
I_{CC}	Continuous Current through VCC or GND		±100	mA
T_J	Maximum Junction Temperature		150	°C
T_{STG}	Storage Temperature Range	−65	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.
(2) This data was taken with the JEDEC low effective thermal conductivity test board.
(3) This data was taken with the JEDEC standard multilayer test boards.

ESD, Electrostatic Discharge Protection

Parameter		Condition	Minimum Level	Unit
HBM	Human Body Model ESD	ANSI/ESDA/JEDEC JS-001 (1)	7	kV
CDM	Charged Device Model ESD	ANSI/ESDA/JEDEC JS-002 (2)	1.5	kV

(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_{CC}	Supply Voltage		2.3	5.5	V
V_I	Input Voltage Range	EN input	0	5.5	V
V_{IO}	Input/output Voltage Range	SDAIN, SCLIN, SDAOUT, SCLOUT	0	5.5	V
V_O	Output Voltage Range	READY	0	5.5	V
T_A	Ambient Temperature		−40	125	°C

Thermal Information

Package Type	θ_{JA}	θ_{JC}	Unit
MSOP8	205	44	°C/W
SOP8	160	40	°C/W

Electrical Characteristics

All test conditions: V_{CC} = 3.3 V, T_A = +25°C, unless otherwise noted.

Parameter		Conditions	Min	Typ	Max	Unit
Power Supply						
I_{CC}	Supply Current	V_{CC} = 5.5 V SDAIN, SCLIN = 0 V SDAOUT, SCLOUT = 10k R_{PU}		4	6	mA
I_{SD}	Supply Current in Shutdown Mode through the V_{CC} Pin	EN = 0 V, SDAIN, SCLIN, SDAOUT, SCLOUT = 0 V or V_{CC}, READY pin = Hi-Z EN pulled low after bus connection event (disable pre-charge)		0.3	4	μA
UVLO(1)	Under Voltage Lockout (rising)	EN = V_{CC} READY = 10 kΩ to V_{CC}		2.15		V
	Under Voltage Lockout (falling)			2		
DC Electrical Characteristics						
V_{PRE}	Pre-charge Voltage	SDA, SCL = Hi-Z	0.8	1	1.2	V
I_{PU}	RTA pull-up Current(1)	Position transition on SDA, SCL $V_{SDA/SCL}$ > 0.8 V, Slew rate = 1.25 V/μs. V_{CC} = 3.3 V		5		mA
I_{LI}	Input Pin Leakage	SDA/SCL pins = V_{CC}, or 0 V, EN = 0 V	−1		1	μA
V_{OS}	Input-output Offset Voltage (SCLIN to SCLOUT, SCLOUT to SCLIN and SDAIN to SDAOUT, SDAOUT to SDAIN)	R_{PU} for SDA/SCL = 10 kΩ	50	105	175	mV
I_{I_RDY}	Ready Pin Leakage	EN = V_{CC}, READY = V_{CC}, Bus connected	−2		2	μA
V_{IH}	High-level Input Voltage		0.7 × V_{CC}		V_{CC}	V
V_{IL}	Low-level Input Voltage	EN	0		0.3 × V_{CC}	V
V_{OL_IO}	Low-level Output Voltage	SDAIN, SCLIN, SDAOUT, SCLOUT, I_{OL} = 3 mA, V_{IN} = 0 V		0.25	0.4	V
V_{OL_READY}	Low-level Output Voltage	Power on, READY = L, I_{OL} = 3 mA			0.4	V
		Power off, R_{PU} = 10kΩ to 3.3 V		0.6	0.7	V
$C_{IN(EN)}$	EN input Capacitance(1)	V_{EN} = 0 V or V_{CC}, f = 400 kHz		3		pF
$C_{IO(READY)}$	READY Output Capacitance(1)	V_{READY} = 0 V or V_{CC}, f = 400 kHz		3		pF
$C_{IO(SDA/SCL)}$	SDA/SCL Pin Capacitance(1)	V_{PIN} = 0 V or V_{CC}, f = 400 kHz		5		pF

(1) Test data based on bench test and design simulation; NOT test in production.

AC Electrical Characteristics

All test conditions: V_{CC} = 3.3 V, T_A = +25°C, unless otherwise noted.

Parameter		Conditions	Min	Typ	Max	Unit
Start-up Switching						
t_{EN}	Time from V_{POR} to Digital being Ready	V_{CC} transition from 0 V to V_{CC}, Time from V_{POR} to earliest stop bit recognized	50	105	200	μs
t_{IDLE}	Bus Idle Time to READY Active	SDA, SCL = 10 kΩ to V_{CC} EN = V_{CC} Measured at 0.5 × V_{CC}	50	100	200	μs
$t_{DISABLE}$	Time from EN High to Low to READY Low	SDA, SCL = 10 kΩ to V_{CC} READY = 10 kΩ to V_{CC} Measured at 0.5 × V_{CC}		25	200	ns
t_{STOP}	SDAIN to READY Delay after Stop Condition	SDA, SCL = 10 kΩ to V_{CC} READY = 10 kΩ to V_{CC} Measured at 0.5 × V_{CC}		1.2	2	μs
t_{READY}	SCLOUT/SDAOUT to READY	SDA, SCL = 10 kΩ to V_{CC} READY = 10 kΩ to V_{CC} Measured at 0.5 × V_{CC}		1.2	2	μs
t_{PLH}	Low to High Propagation Delay (1)	R_{PU} for SDA/SCL = 10 kΩ C_L = 100 pF per pin Measured at 0.5 × V_{CC}		4.5	– (1)	ns
t_{PHL}	High to Low Propagation Delay	R_{PU} for SDA/SCL = 10 kΩ C_L = 100 pF per pin Measured at 0.5 × V_{CC}		66	150	ns

(1) t_{PLH} typ data based on bench test and design simulation, the max value depends on the input source and cannot test in the FT.

AC Electrical Characteristics (continued)

All test conditions: V_{CC} = 3.3 V, T_A = +25°C, unless otherwise noted. (1)

Parameter		Conditions	Min	Typ	Max	Unit
Timing characteristics (only reference to I²C 400 kHz) (1)						
f_{SCL_MAX}	Maximum SCL Clock Frequency (1)		400			kHz
t_{BUF}	Bus Free Time between a STOP and START Condition		1.3			μs
$t_{HD;STA}$	Hold Time for a Repeated START Condition		0.6			μs
$t_{SU;STA}$	Set-up Time for a Repeated START Condition		0.6			μs
$t_{SU;STO}$	Set-up Time for a STOP Condition		0.6			μs
$t_{HD;DAT}$	Data Hold Time		0			ns
$t_{SU;DAT}$	Data set-up Time		100			ns
t_{LOW}	LOW Period of the SCL Clock		1.3			μs
t_{HIGH}	HIGH Period of the SCL Clock		0.6			μs
t_F	Fall Time of both SDA and SCL Signals (2)		5+ 0.1*Cb		300	ns
t_R	Rise Time of both SDA and SCL Signals (2)		20 +0.1*Cb		300	ns

(1) All timing characteristics should reference to I²C standard @400 kHz, all parameters in table are NOT test in production.
(2) t_F is 6 ns on bench test, and Cb is total capacitance of one bus line in pF.

Typical Performance Characteristics

All test conditions: V_{IN} =5 V, V_A =+ 25°C, unless otherwise noted.

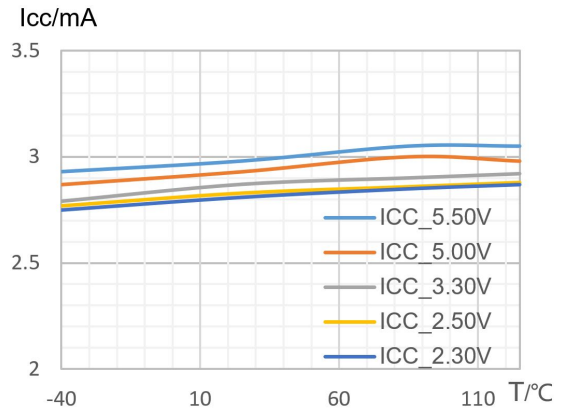


Figure 1. I_{CC} versus Temperature

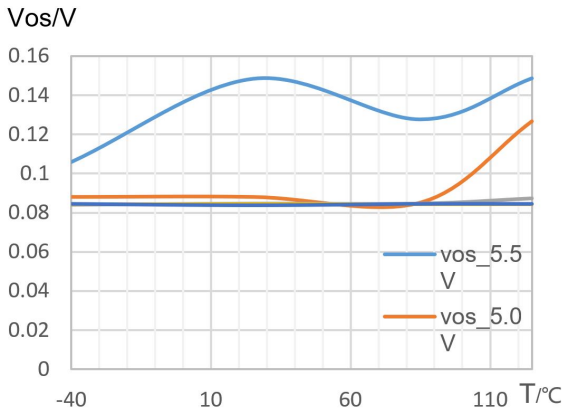


Figure 2. V_{os} versus Temperature

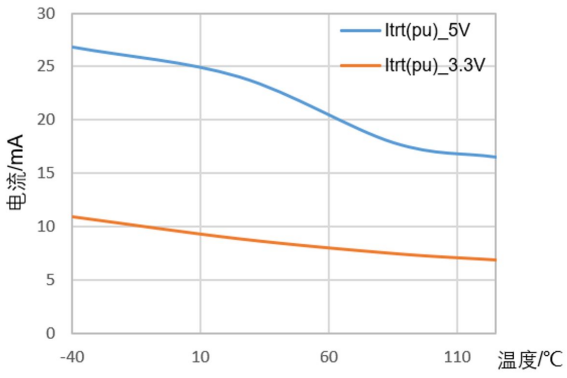


Figure 3. $I_{trt(pu)}$ versus Temperature

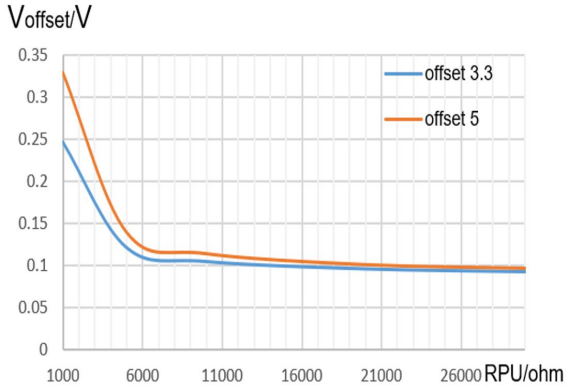


Figure 4. V_{os} versus Rpu

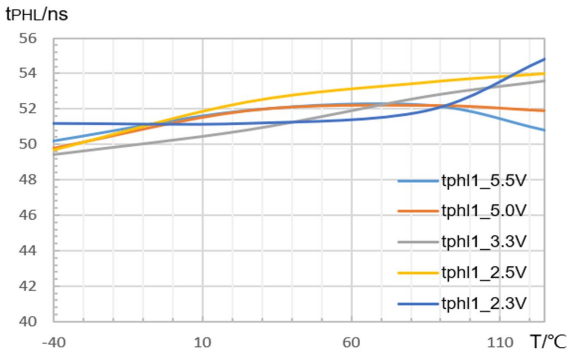


Figure 5. t_{PHL}versus Temperature

Test Circuitry

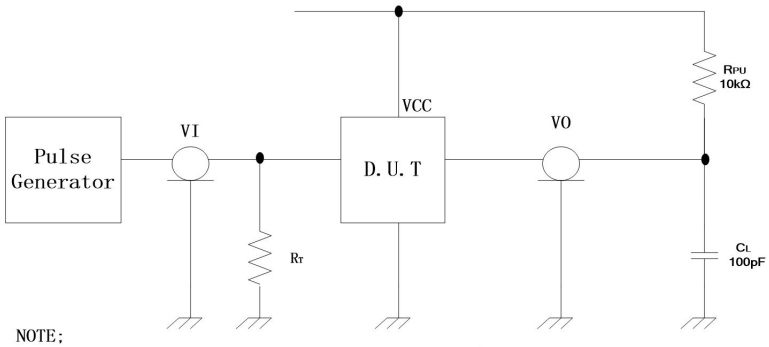


Figure 6. Test Circuitry of TPT29511H

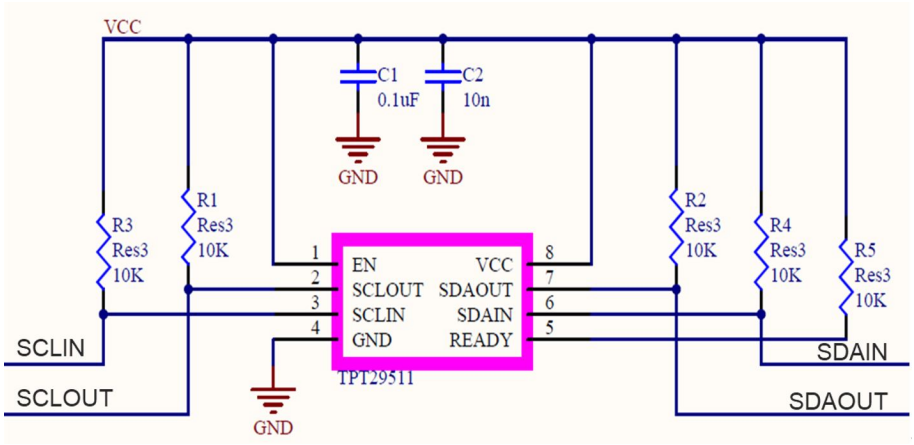


Figure 7. Reference Circuitry of TPT29511H

Test Timing Diagrams

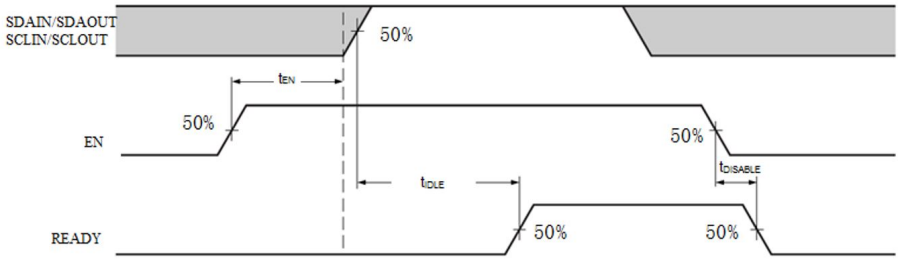


Figure 8. Timing for t_{EN}, t_{IDLE}, $t_{DISABLE}$

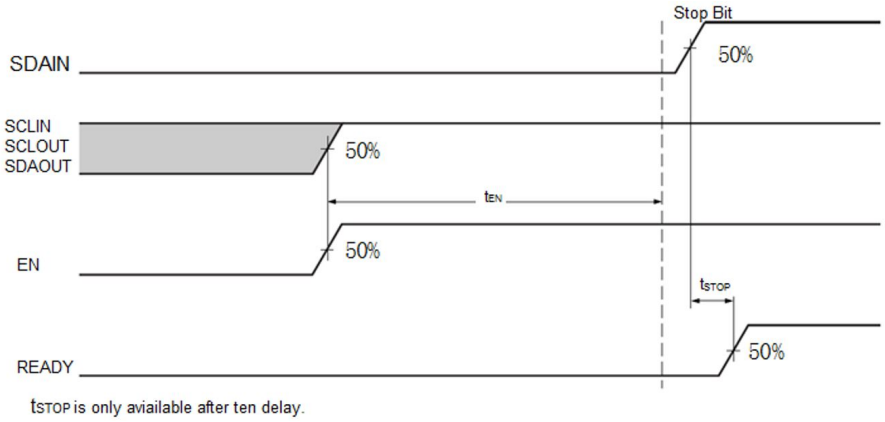


Figure 9. Timing for t_{STOP}

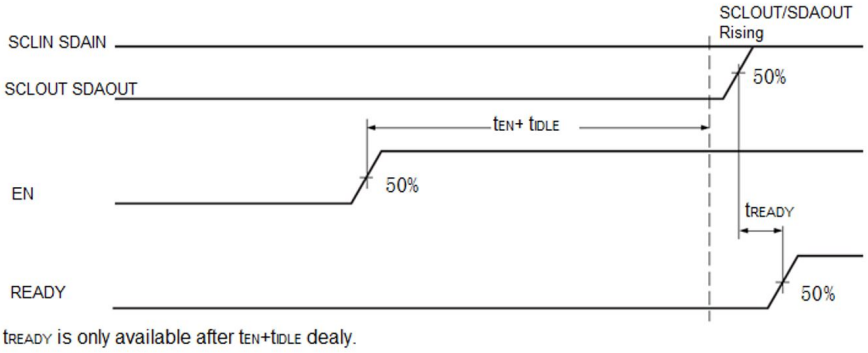


Figure 10. Timing for t_{READY}

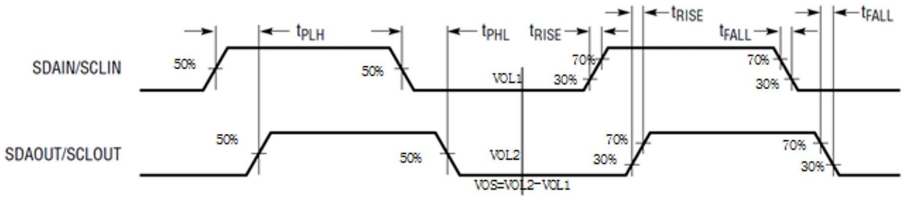


Figure 11. Timing for t_{PHL}, t_{PLH}, t_R, t_F, V_{OS}

Detailed Description

Overview

The TPT29511H device is a dual bidirectional I^2C and SMBus Hot-swap buffer with an enable (EN) input, and works from 2.3 V to 5.5 V V_{CC}, which supports IO cards live insertion and removal from the backplane. The control circuit prevents the backplane-side I^2C lines (in) from the other card-side I^2C lines (out) until a stop command or bus idle condition occurs on the backplane without bus contention on the card. When the connection is made, the TPT29511H provides bidirectional buffering, keeping the backplane and card capacitances isolated.

The TPT29511H rise time accelerator circuitry allows the use of weaker DC pull-up currents while also meeting rise time requirements ($\Delta V/\Delta t$ > 0.6 V/us).

The TPT29511H incorporates a digital enable input pin, which enables the device when asserted high and forces the device into a low current mode when asserted low, and an open-drain ready output pin, which indicates that the backplane and card sides are connected (high) or not (low).

Functional Block Diagram

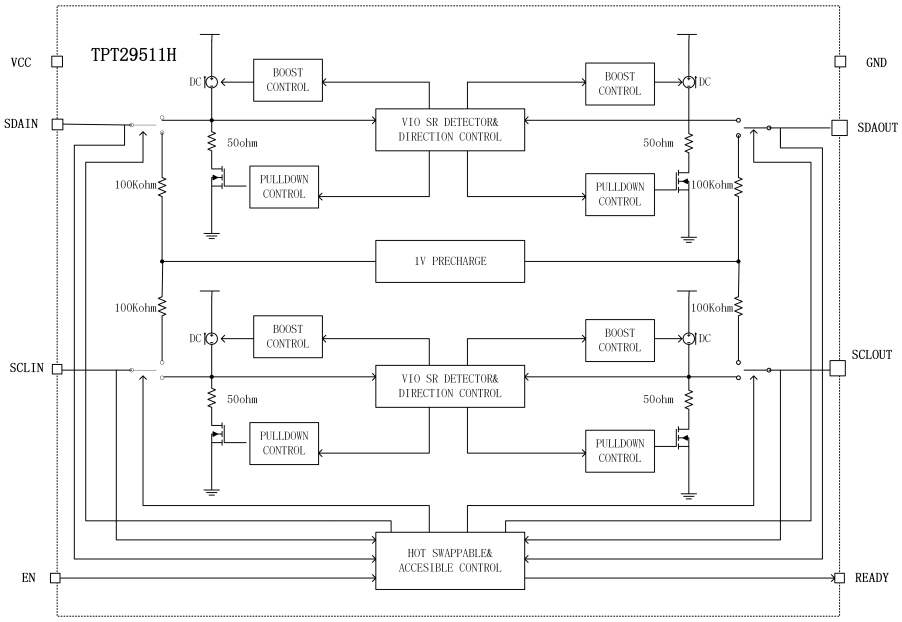


Figure 12. Functional Block Diagram

Feature Description

Enable (EN)

The device is in an active mode as pin EN is at high-voltage level. If EN is low, the device is in a low current mode.

Under-Voltage Lockout (UVLO)

The device uses an under-voltage lockout circuit to keep the device in shutdown mode until the supply voltage is higher than the UVLO threshold.

Over-Voltage Protection (OVP)

The device uses an over-voltage protection circuit to prevent the device from damage when the supply voltage is higher than the OVP threshold.

READY

The output pin will go HIGH to indicate that SDAIN and SCLIN are connected from SDAOUT and SCLOUT. And pull LOW when two sides are disconnected. The pin is driven by an open-drain pull-down capable of sinking 6 mA while holding 0.4 V on the pin. A 10-kΩ resistor is suggested connecting to VCC to provide the pull-up status.

Rise Time Accelerators

During positive bus transitions a 5-mA current source is switched on to quickly slew the SDA and SCL lines HIGH once the input level of 0.8 V for the TPT29511H is exceeded. The rising edge rate should be at least 0.6 V/μs to guarantee the accelerators turned on. The built-in $\Delta V/\Delta t$ rise time accelerators on all SDA and SCL lines requires the bus pull-up voltage and supply voltage (VCC) to be the same. If $\Delta V/\Delta t$ rise time accelerator < 0.2 V/μs, the time accelerators will stop to avoid the ack error.

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.

Application Information

The TPT29511H device is a dual bidirectional I²C and SMBus Hot-swap buffer, which supports IO cards live insertion and removal from backplane, such as the application in Servers/Storages and Enterprise Switching.

Typical Application

The following figures show the typical application schematics.

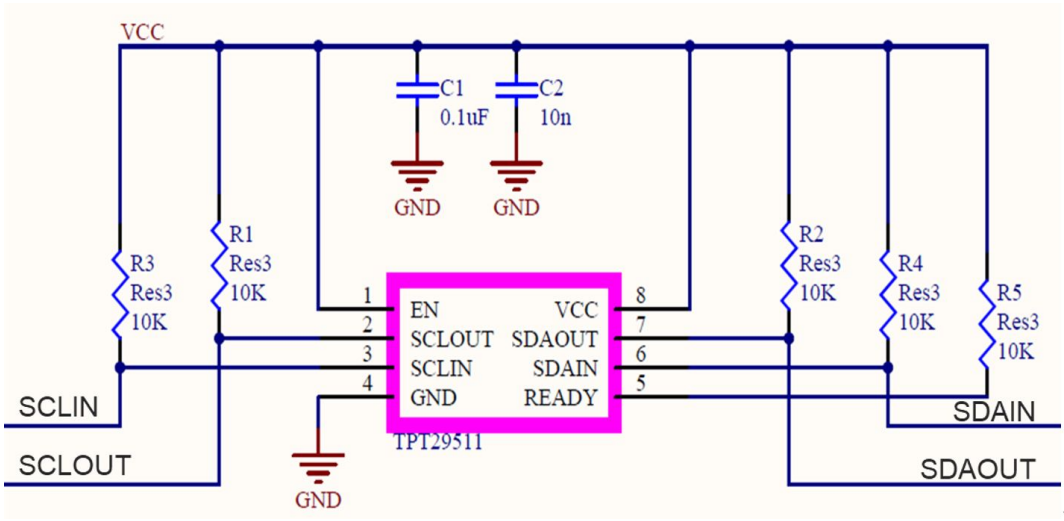


Figure 13. Reference Circuitry of TPT29511H

Layout

Layout Example

Reflections and matching are closely related to loop antenna theory, but different enough to warrant their own discussion. When a PCB trace turns a corner at a 90° angle, a reflection can occur. This is primarily due to the change in width of the trace. At the apex of the turn, the trace width is increased to 1.414 times its width. This change in width upsets the transmission line characteristics, especially the distributed capacitance and self-inductance of the trace, thus resulting in the reflection. Not all PCB traces can be straight, so they will have to turn corners. Figure 14 shows progressively better techniques of rounding corners. Only the last example (BEST) maintains constant trace width and minimizes reflections.

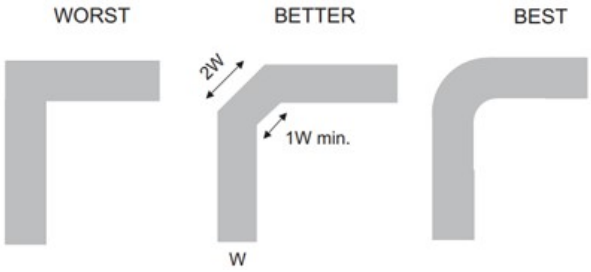
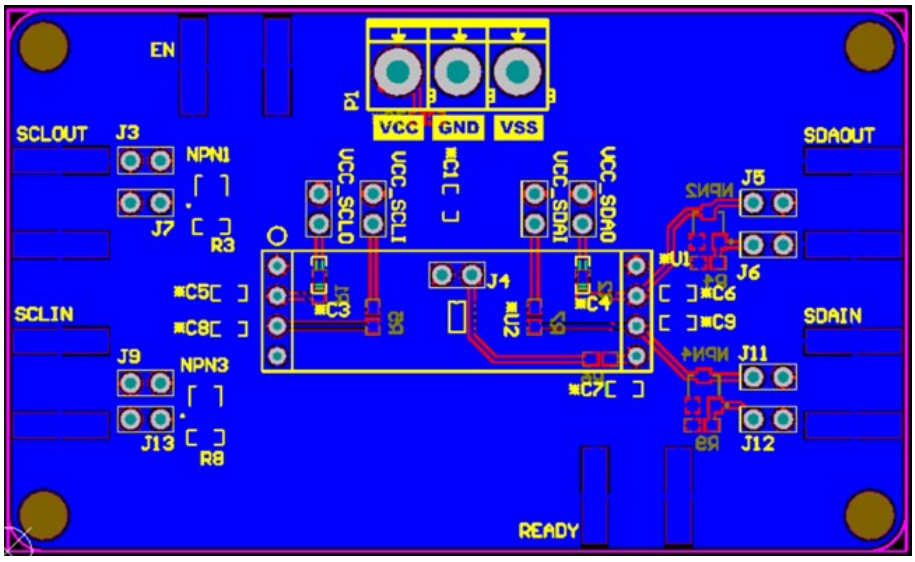
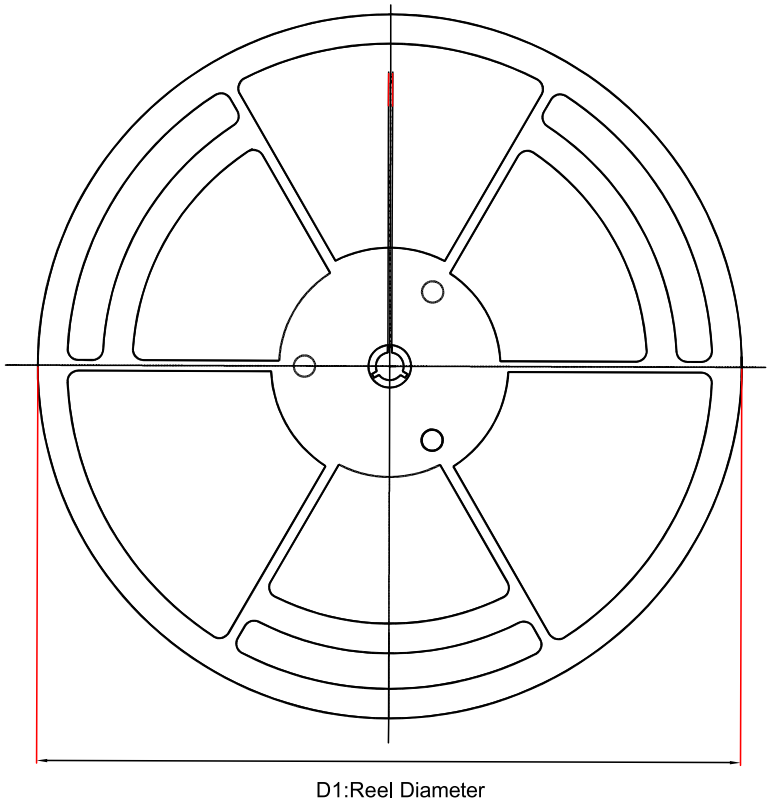


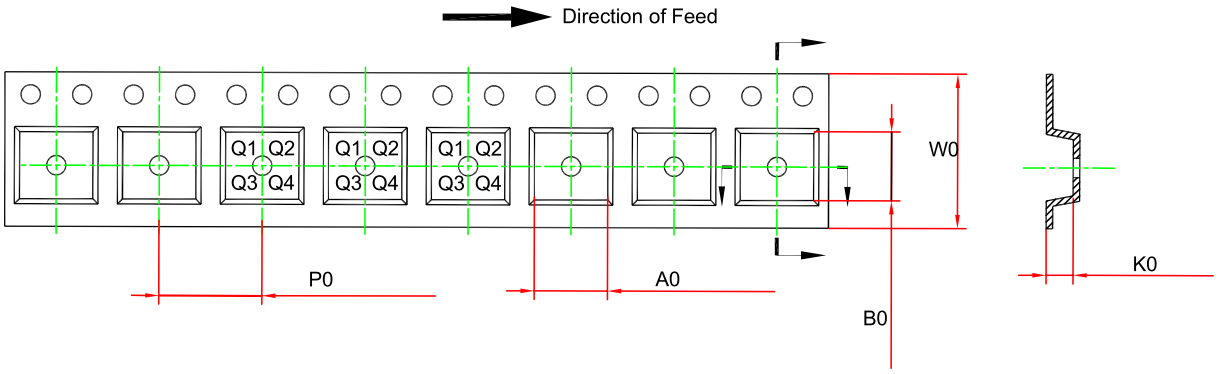
Figure 14. Trace Example

Route high-speed signals using a minimum of vias and corners which reduces signal reflections and impedance changes. When a via must be used, increase the clearance size around it to minimize its capacitance. Each via introduces discontinuities in the signal's transmission line and increases the chance of picking up interference from the other layers of the board. Be careful when designing test points, through-hole pins are not recommended at high frequencies.



Tape and Reel Information



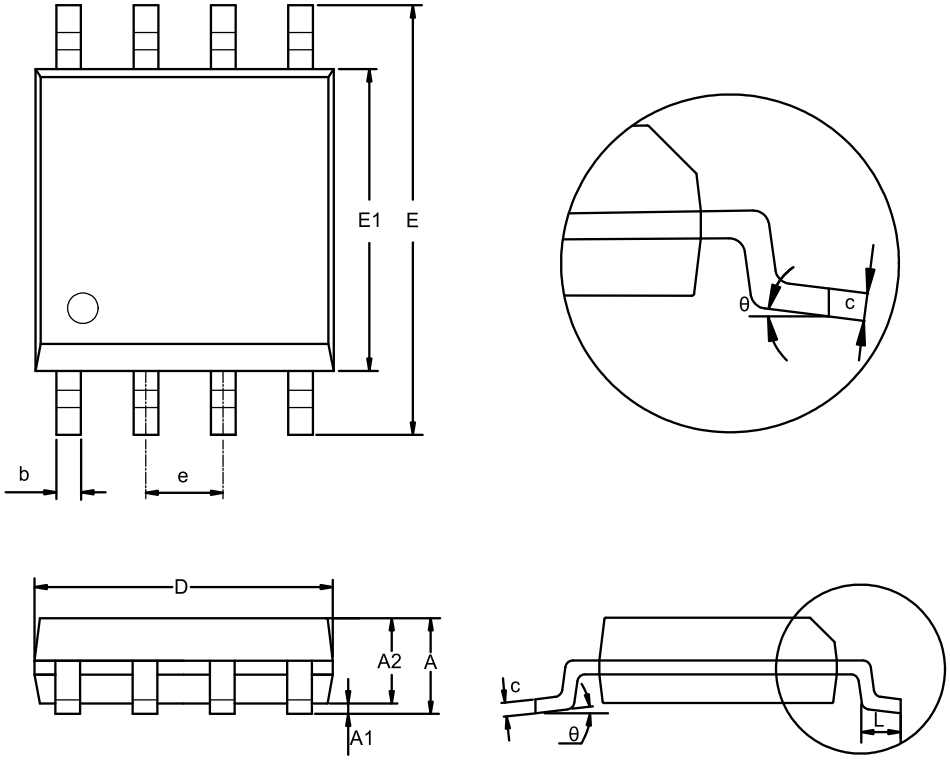


Order Number	Package	D1 (mm)	W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	W0 (mm)	Pin1 Quadrant
TPT29511H-VS1R	MSOP8	330.0	17.6	5.4	3.3	1.3	8.0	12.0	Q1

Package Outline Dimensions

MSOP8

Package Outline Dimensions VS1(MSOP-8-A)



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.800	1.100	0.031	0.043
A1	0.020	0.150	0.001	0.006
A2	0.750	0.950	0.030	0.037
b	0.250	0.380	0.010	0.015
c	0.090	0.230	0.004	0.009
D	2.900	3.100	0.114	0.122
E	4.700	5.100	0.185	0.201
E1	2.900	3.100	0.114	0.122
e	0.650 BSC		0.026 BSC	
L	0.400	0.800	0.016	0.031
θ	0	8°	0	8°

NOTES

1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.

Order Information

Order Number	Operating Temperature Range	Package	Marking Information	MSL	Transport Media, Quantity	Eco Plan
TPT29511H-VS1R	−40 to 125°C	MSOP8	9511H	MSL3	Tape and Reel, 3000	Green

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

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