TCA9511A Hot Swappable I²C Bus and SMBus Buffer

1 Features

- Supports bidirectional data transfer of I²C bus signals
- Operating power-supply voltage range of 2.3 V to 5.5 V
- T_A ambient air temperature range of -40 °C to 125 °C
- 1-V Precharge on all SDA and SCL lines prevents corruption during live insertion
- Accommodates standard mode and fast mode I²C devices
- Supports clock stretching, arbitration and synchronization
- Powered-off high-impedance I²C pins

2 Applications

- Servers
- Enterprise Switching
- Telecom switching equipment
- Base stations
- Industrial automation equipment

3 Description

The TCA9511A is a hot-swappable I²C bus buffer that supports I/O card insertion into a live backplane without corruption of the data and clock buses. Control circuitry prevents the backplane-side I²C lines (in) from being connected to the 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, this device provides bidirectional buffering, keeping the backplane and card capacitances separated. During insertion, the SDA and SCL lines are pre-charged to 1 V to minimize the current required to charge the parasitic capacitance of the device.

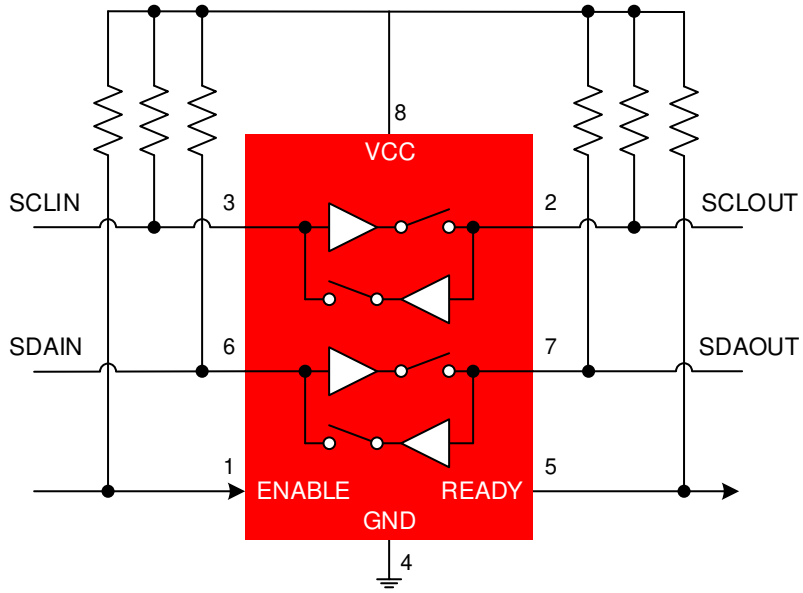
When the I²C bus is idle, the TCA9511A can be put into shutdown mode by setting the EN pin low, reducing power consumption. When EN is pulled high, the TCA9511A resumes normal operation. It also includes an open drain READY output pin, which indicates that the backplane and card sides are connected together. When READY is high, the SDAIN and SCLIN are connected to SDAOUT and SCLOUT. When the two sides are disconnected, READY is low.

Device information(1)

PART NUMBER	PACKAGE	BODY SIZE (NOM)
TCA9511A	VSSOP (8)	3.00 mm × 3.00 mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.

Simplified Schematic



An IMPORTANT NOTICE at the end of this data sheet addresses availability, warranty, changes, use in safety-critical applications, intellectual property matters and other important disclaimers. PRODUCTION DATA.

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4 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision A (December 2019) to Revision B	Page
• Changed pin 7 From: SDAOUTL To: SDAOUT	3
• Changed text From: "pulled to roughly 160 mV." To: "pulled to roughly 150 mV" in the *Bus active* section	11
• Changed the device number of Figure 14 to TCA9511A	18

Changes from Original (October 2019) to Revision A	Page
• Changed the device status From: *Advanced Information* To: *Production* data	1

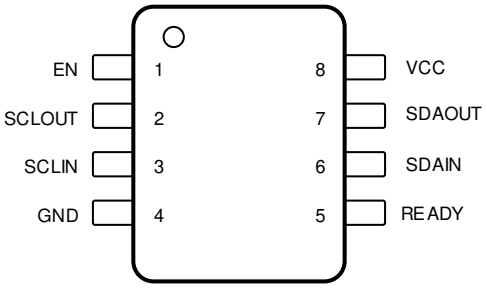
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5 Device Comparison Table

PART NUMBER	STUCK BUS RECOVERY
TCA9511A	No
TCA4307	Yes

6 Pin Configuration and Functions

DGK Package
8-Pin VSSOP
Top View



Not to scale

Pin functions

PIN		I/O	DESCRIPTION
NAME	NO.		
EN	1	I	Active-high chip enable pin. If EN is low, the TCA9511A is in a low current mode. It also disables the rise-time accelerators, disables the bus pre-charge circuitry, drives READY low, isolates SDAIN from SDAOUT and isolates SCLIN from SCLOUT. EN should be high (at VCC) for normal operation. Connect EN to VCC if this feature is not being used.
SCLOUT	2	I/O	Serial clock output. Connect this pin to the SCL bus on the card.
SCLIN	3	I/O	Serial clock input. Connect this pin to the SCL bus on the backplane.
GND	4	-	Supply ground
READY	5	O	Connection flag/rise-time accelerator control. Ready is low when either EN is low or the start-up sequence has not been completed. READY goes high when EN is high and start-up is complete. Connect a 10-kΩ resistor from this pin to V_{CC} to provide the pull-up current.
SDAIN	6	I/O	Serial data input. Connect this pin to the SDA bus on the backplane.
SDAOUT	7	I/O	Serial data output. Connect this pin to the SDA bus on the card.
VCC	8	-	Supply Power. Main input power supply from backplane. This is the supply voltage for the devices on the backplane I^2C buses. Connect pull-up resistors from SDAIN and SCLIN (and also from SDAOUT and SCLOUT) to this supply. Place a bypass capacitor of at least 0.01 μF close to this pin for best results.

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7 Specifications

7.1 Absolute Maximum Ratings

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

			MIN	MAX	UNIT
Input Voltage	VCC		–0.5	7	V
	SDAIN, SCLIN, SDAOUT, SCLOUT		–0.5	7	V
	EN, READY		–0.5	7	V
I_{IK}	Input clamp current	$V_I < 0$		–50	mA
I_{OK}	Output clamp current	$V_O < 0$		–50	mA
I_O	Continuous output current	SDAIN, SDAOUT, SCLIN, SCLOUT, EN, READY		±50	mA
I_{CC}	Continuous current through VCC or GND			±100	mA
T_J	Maximum junction temperature			130	°C
T_{stg}	Storage temperature		–65	150	°C

(1) Stresses beyond those listed under *Absolute Maximum Rating* 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 Condition*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

7.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001, allpins(1)	±1500	V
		Charged device model (CDM), per JEDEC specificationJESD22-C101, all pins(2)	±1000	

(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

7.3 Recommended Operating Conditions

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

			MIN	MAX	UNIT
V_{CC}	Supply voltage		2.3	5.5	V
V_I	Input voltage range	EN input	0	5.5	
V_{IO}	Input/output voltage range	SDAIN, SCLIN, SDAOUT, SCLOUT	0	5.5	
V_O	Output voltage range	READY	0	5.5	
T_A	Ambient temperature		–40	125	°C

7.4 Thermal Information

THERMAL METRIC(1)		TCA9511 DGK 8	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance	177.1	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	64.5	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	99.6	°C/W
Ψ_{JT}	Junction-to-top characterization parameter	9.5	°C/W
Ψ_{JB}	Junction-to-board characterization parameter	97.9	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	N/A	°C/W

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

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7.5 Electrical Characteristics

over operating free-air temperature range (unless otherwise noted). Typical specifications are at T_A = 25 °C, V_{CC} = 3.3 V, unless otherwise noted.

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
POWER SUPPLY						
I_{CC}	Supply current	VCC = 5.5V SDAIN, SCLIN = 0V SDAOUT, SCLOUT = 10k R_{PU}		3.5	6	mA
I_{SD}	Supply current in shutdown mode through the V_{CC} pin(1)	EN = 0 V SDAIN, SCLIN, SDAOUT, SCLOUT = 0V or V_{CC} READY pin = Hi-Z EN pulled low after bus connection event (disable precharge)		5	30	µA
UVLO	Under voltage lockout (rising)	EN = V_{CC} READY = 10 kΩ to V_{CC}		2.1		V
	Under voltage lockout (falling)			2		V
START-UP CIRCUITRY						
V_{PRE}	Pre-charge voltage	SDA, SCL = Hi-Z	0.8	1	1.2	V
RISE-TIME ACCELERATORS						
I_{PU}	RTA pull-up current(2)	Position transition on SDA, SCL $V_{SDA/SCL}$ = 0.6 V, Slew rate = 1.25 V/µs. VCC = 3.3 V	2	5		mA
INPUT-OUTPUT CONNECTION						
I_{LI}	Input pin leakage	SDA/SCL pins = 90% V_{CC}, EN = V_{CC}, GND SDA/SCL pins = 10% V_{CC}, EN = GND	-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	100	mV
I_{I_RDY}	Ready pin leakage	EN = VCC, READY = V_{CC}, Bus connected	-1		1	µA
DIGITAL IO THRESHOLD						
V_{IH}	High-level input voltage	EN	0.7 × V_{CC}		V_{CC}	V
V_{IL}	Low-level input voltage	EN	0		0.3 × V_{CC}	
V_{OL}	Low-level output voltage	SDAIN, SCLIN, SDAOUT, SCLOUT I_{OL} = 4 mA V_{IN} = 0.1 V		0.15	0.4	
		READY I_{OL} = 3 mA	0		0.4	
DYNAMIC CHARACTERISTICS						
$C_{IN\ (EN)}$	EN input capacitance	V_{EN} = 0 V or V_{CC} f = 400 kHz		1.6	4	pF
$C_{IO\ (READY)}$	READY output capacitance	V_{READY} = 0 V or V_{CC} f = 400 kHz		7	10	
$C_{IO\ (SDA/SCL)}$	SDA/SCL pin capacitance	V_{PIN} = 0 V or V_{CC} f = 400 kHz		5	10	

(1) In shutdown mode there will also be current flowing from V_{CC} through the ready pin as this pin is pulled down to indicate the bus is disconnected.
(2) Determined by design, not tested in production.

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7.6 Timing Requirements

		MIN	NOM	MAX	UNIT
f_{SCL_MAX}	Maximum SCL clock frequency	400			kHz
t_{BUF} (1)	Bus free time between a STOP and START condition	1.3			µs
$t_{HD;STA}$ (1)	Hold time for a repeated START condition	0.6			µs
$t_{SU;STA}$ (1)	Set-up time for a repeated START condition	0.6			µs
$t_{SU;STO}$ (1)	Set-up time for a STOP condition	0.6			µs
$t_{HD;DAT}$ (1)	Data hold time	0			ns
$t_{SU;DAT}$ (1)	Data set-up time	100			ns
t_{LOW} (1)	LOW period of the SCL clock	1.3			µs
t_{HIGH} (1)	HIGH period of the SCL clock	0.6			µs
t_f (1)	Fall time of both SDA and SCL signals	20 × (V_{CC}/5.5 V)		300	ns
t_r (1)	Rise time of both SDA and SCL signals	20 × (V_{CC}/5.5 V)		300	ns

(1) These are system-level timing specs and are dependent upon bus capacitance and pull up resistor value. It is up to the system designer to ensure they are met

7.7 Switching Characteristics

over operating free-air temperature range (unless otherwise noted). Typical specifications are at T_A = 25 °C, V_{CC} = 3.3 V, unless otherwise noted.

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
START-UP CIRCUITRY						
$t_{PRECHARGE}$	Time from V_{CC} to precharge enabled	SDA,SCL = Hi-Z EN = V_{CC}, GND		15	60	µs
t_{EN}	Time from V_{POR} to digital being ready	VCC transition from 0V to V_{CC} Time from V_{PORR} to earliest stop bit recongized		35	95	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}		95	150	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}		30	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}		0.8	1.5	µs
INPUT-OUTPUT CONNECTION						
t_{PLZ}	Low to high propagation delay	R_{PU} for SDA/SCL = 10 kΩ $_C$L = 100 pF per pin Measured at 0.5 × VCC		0	10	ns
t_{PZL}	High to low propagation delay	R_{PU} for SDA/SCL = 10 kΩ $_C$L = 100 pF per pin Measured at 0.5 × VCC		70	150	ns

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7.8 Typical Characteristics

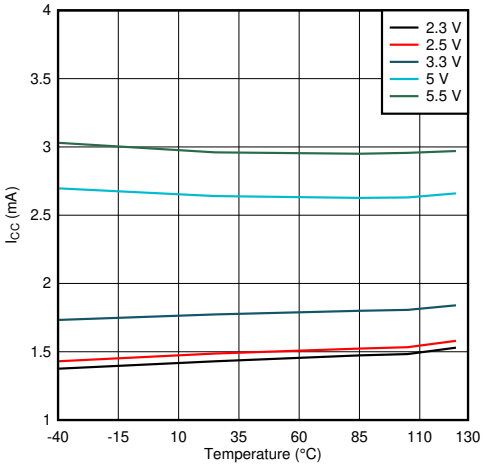


Figure 1. I_{CC} vs Temperature (For V_{CC})

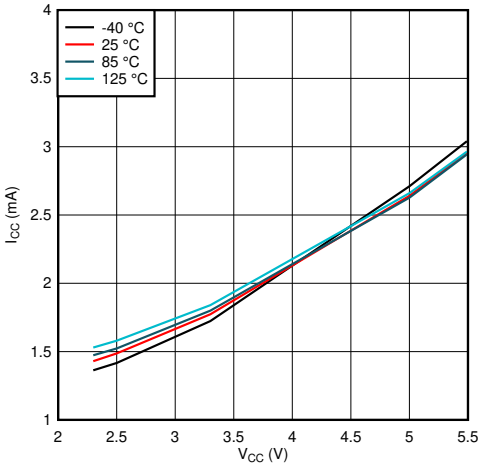


Figure 2. I_{CC} vs V_{CC} (For T_A)

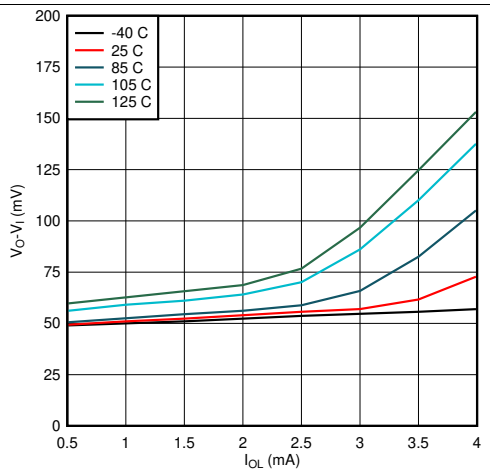


Figure 3. V_{OS} vs I_{OL} (V_{CC} = 2.3 V)

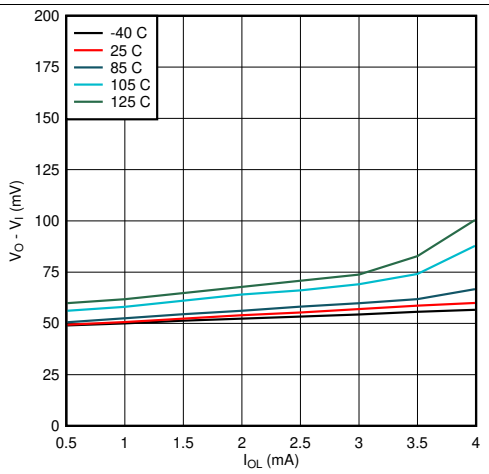


Figure 4. V_{OS} vs I_{OL} (V_{CC} = 3.3 V)

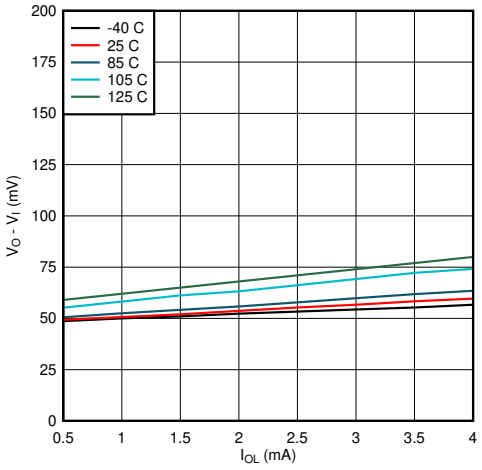


Figure 5. V_{OS} vs I_{OL} (V_{CC} = 5.5 V)

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8 Parameter Measurement Information

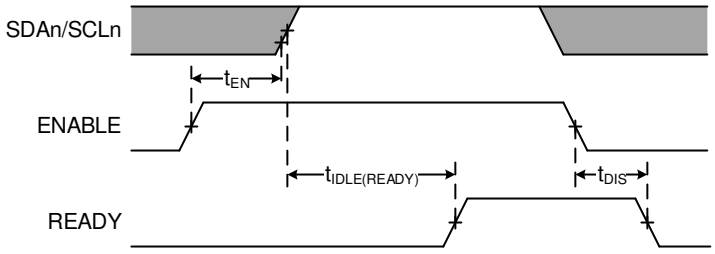


Figure 6. Timing for t_{EN}, $t_{IDLE(READY)}$, and t_{DIS}

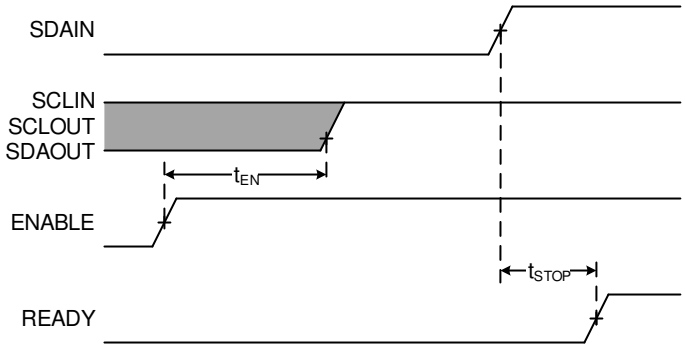


Figure 7. Timing for t_{STOP}

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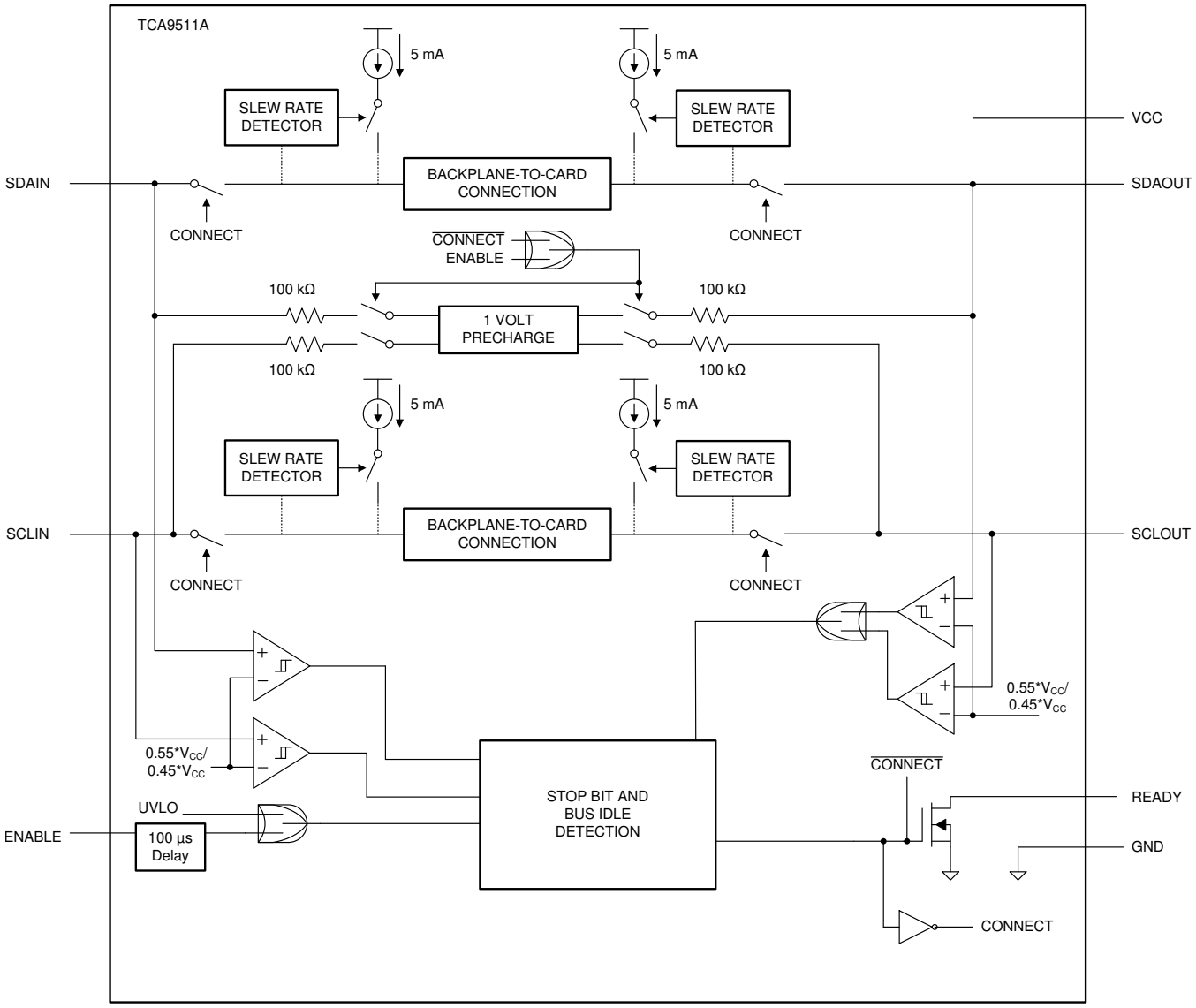
9 Detailed Description

9.1 Overview

The TCA9511A is a hot-swappable I^2C bus buffer that supports I/O card insertion into a live backplane without corruption of the data and clock buses. Control circuitry prevents the backplane from being connected to the card until a stop command or bus idle condition occurs on the backplane without bus contention on the card. When the connection is made, this device provides bidirectional buffering, keeping the backplane and card capacitances isolated. During insertion, the SDA and SCL lines are pre-charged to 1 V to minimize the current required to charge the parasitic capacitance of the device.

When the I2C bus is idle, the TCA9511A is put into shutdown mode by setting the EN pin low. When EN is high, the TCA9511A resumes normal operation. It also includes an open drain READY output pin, which indicates that the backplane and card sides are connected together. When READY is high, the SDAIN and SCLIN are connected to SDAOUT and SCLOUT. When the two sides are disconnected, READY is low.

9.2 Functional block diagram



9.3 Feature Description

9.3.1 Hot bus insertion

During a hot bus insertion event, the TCA9511A keeps the buses disconnected to ensure that no data corruption occurs on either bus. Once the buses are idle, the TCA9511A connects the buses and READY goes high.

9.3.2 Pre-charge voltage

Both the SDA and SCL pins feature a 1-V pre-charge circuit through an internal 100 kΩ resistor prior to the pins being connected to an I^2C bus. This feature helps minimize disruptions as a result of a hot bus insertion event.

9.3.3 Rise time accelerators

The TCA9511A features a rise time accelerator (RTA) on all I^2C pins that during a positive bus transition, switchs on a current source to quickly slew the bus pins high. This allows the use of weaker pull-up resistors.

9.3.4 Bus ready output indicator

The READY pin is an open drain output that provides an indicator to whether the buses are connected and ready for traffic. This pin is pulled low when the connection between IN/OUT is high impedance. Once the bus is idle and the connection between IN/OUT is made, the READY pin is released and pulled high by an external pull-up resistor, signaling that it is ready for traffic.

9.3.5 Powered-off high impedance for I2C and I/O pins

When the supply voltage is below the UVLO threshold, the I^2C and digital I/O pins are a high impedance state to prevent leakage currents from flowing through the device. When the EN pin is taken low, the device enters an isolation state and present a high impedance on all bus pins, and pull READY pin low.

9.3.6 Supports clock stretching and arbitration

The TCA9511A supports full clock stretching, and arbitration without lock up.

9.4 Device Functional Modes

9.4.1 Start-up and precharge

When the TCA9511A first receives power on the VCC pin, either during power-up or during live insertion, it starts in an under voltage lockout (UVLO) state, ignoring any activity on the SDA and SCL pins until V_{CC} rises above UVLO.

Once the ENABLE pin has been high long enough to complete the initialization state, the ‘Stop Bit and Bus Idle’ detect circuit is enabled and the device enters the bus idle state.

When V_{CC} rises above UVLO, the precharge circuitry will activate, which biases the bus pins on both sides to about 1 V through an internal 100 kΩ resistor.

9.4.2 Bus idle

After the Stop Bit and Bus Idle detect circuits are enabled the device enters the bus idle state. The pre-charge circuitry becomes active and forces 1 V through 100 kΩ nominal resistors to the SCL and SDA pins. The pre-charge circuitry minimizes the voltage differential seen by the SCL/SDA pins during a hot insertion event. This minimizes the amount of disturbance seen by the I/O card.

The device waits for the SDAIN and SCLIN pins to be high for the bus idle time or a STOP condition is observed on the SDAIN and SCLIN pins. The SDAOUT and SCLOUT pins must be high and the SDAIN and SCLIN pins must meet 1 of the 2 qualifiers (idle timer or a STOP condition) before connecting SDAIN to SDAOUT and SCLIN to SCLOUT. Once the bus connections have been made, the pre-charge circuitry is disabled and the device enters the bus active state.

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Device Functional Modes (continued)

9.4.3 Bus active

In the bus active mode, the I^2C IN and OUT pins are connected, and the input is passed bi-directionally from IN/OUT side of the bus to the OUT/IN side respectively. The buses remain connected until the EN pin is taken low.

When the bus is connected, the driven-low side of the device is reflected on the opposite side, but with a small offset voltage. For example, if the input is pulled low to 100 mV, the output side will be pulled to roughly 150 mV. This offset allows the device to determine which side is currently being driven and avoid getting stuck low.

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10 Application and Implementation

NOTE

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

10.1 Application Information

10.2 Typical Application

The typical application is to place the TCA9511A on the card that is being inserted or connected to a live bus, rather than being placed on the live bus. The reason for this is to provide maximum benefit by ensuring that the bus stays disconnected until an idle condition or stop condition is seen.

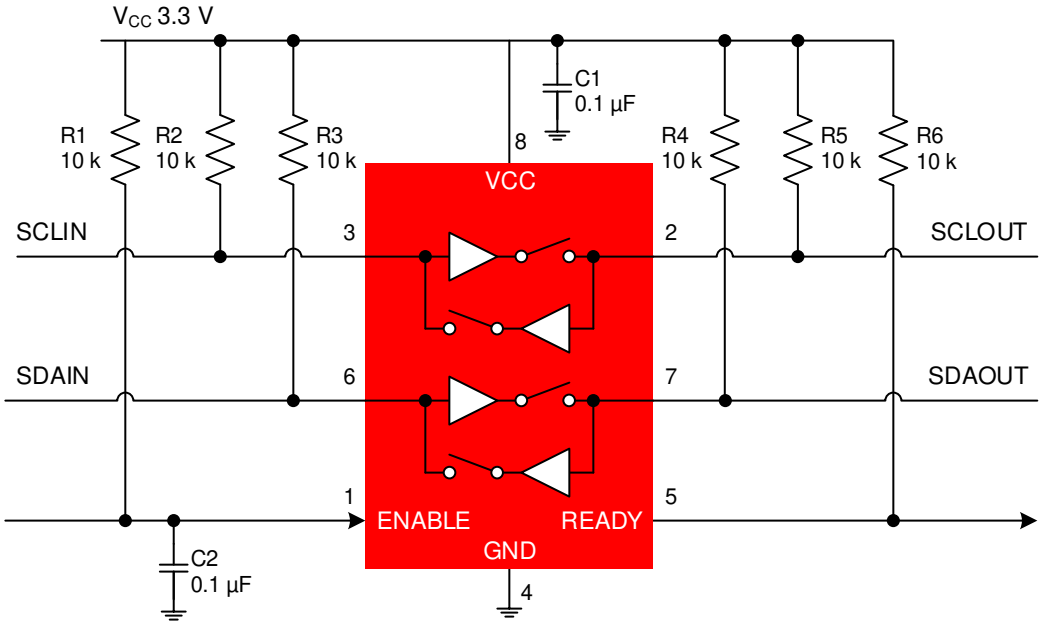


Figure 8. General Application Schematic

10.2.1 Design Requirements

10.2.1.1 Series connections

It is possible to have multiple buffers in series, but care must be taken when designing a system.

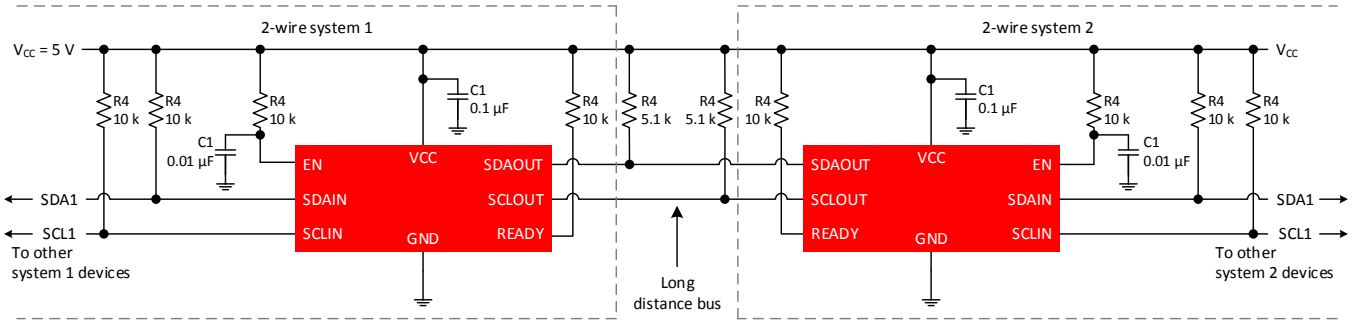


Figure 9. Series Buffer Connections

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Typical Application (continued)

Each buffer adds approximately 50 mV of offset. Maximum offset (V_{OFFSET}) should be considered. The low level at the signal origination end is dependent upon bus load. The I2C-bus specification requires that a 3 mA current produces no larger than a 0.4 V V_{OL}. As an example, if the V_{OL} at the master is 0.1 V, and there are 4 buffers in series (each adding about 50 mV), then the V_{OL} at the farthest buffer is approximately 0.3 V. This device has a rise time accelerator (RTA) that activates at 0.6 V. With great care, a system with 4 buffers may work, but as the V_{OL} moves up, it may be possible to trigger the RTA, creating a false edge on the clock.

It is recommended to limit the number of buffers in series to two, and to keep the load light to minimize the offset.

Another special consideration of series connections is the effect on round-trip-delay. This is the sum of propagation delays through the buffers and any effects on rise time. It is possible that fast mode speeds (400 kHz) are not possible due to delays and bus loading.

10.2.1.2 Multiple connections to a common node

It is possible to have multiple buffers in connect to a common node, but care must be taken when designing a system.

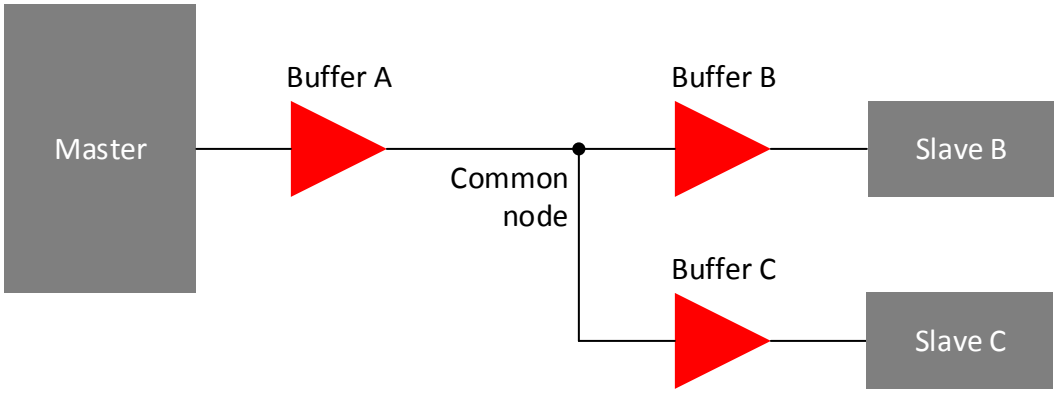


Figure 10. Connections to Common Node

Consider a system with three buffers connected to a common node and communication between the Master and Slave B that are connected at either end of buffer A and buffer B in series as shown in Figure 10. Consider if the V_{OL} at the input of buffer A is 0.3 V and the V_{OL} of Slave B (when acknowledging) is 0.36 V with the direction changing from Master to Slave B and then from Slave B to Master. Before the direction change the user should observe V_{IL} at the input of buffer A of 0.3 V and its output, the common node, is ~0.36 V. The output of buffer B and buffer C would be ~0.5 V, but Slave B is driving 0.4 V, so the voltage at Slave B is 0.4 V. The output of buffer C is ~0.5 V. When the Master pull-down turns off, the input of buffer A rises and so does its output, the common node, because it is the only part driving the node. The common node rises to 0.5 V before the buffer B output turns on, if the pull-up is strong the node may bounce. If the bounce goes above the threshold for the rising edge accelerator ~0.6 V, the accelerators on both buffer A and buffer C will fire, contending with the output of buffer B. The node on the input of buffer A goes high as will the input node of buffer C. After the common node voltage is stable for a while, the rising edge accelerators turn off, and the common node returns to ~0.5 V because the buffer B is still on. The voltage at both the Master and Slave C nodes then fall to ~0.6 V until Slave B turned off. This does not cause a failure on the data line as long as the return to 0.5 V on the common node (~0.56 V at the Master and Slave C) occurred before the data setup time. If this were the SCL line, the parts on buffer A and buffer C would see a false clock rather than a stretched clock, which causes a system error.

10.2.1.3 Propagation delays

The delay for a rising edge is determined by the combined pull-up current from the bus resistors and the rise time accelerator current source and the effective capacitance on the lines. If the pull-up currents are the same, any difference in rise time is directly proportional to the difference in capacitance between the two sides. The t_{PLH} may be negative if the output capacitance is less than the input capacitance and would be positive if the output capacitance is larger than the input capacitance, when the currents are the same.

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Typical Application (continued)

The t_{PHL} can never be negative because the output does not start to fall until the input is below 0.7 × V_{CC}, the output turn on has a non-zero delay, and the output has a limited maximum slew rate. Even if the input slew rate is slow enough that the output catches up, it would still lag the falling voltage of the input by the offset voltage. The maximum t_{PHL} occurs when the input is driven low with zero delay and the output is still limited by its turn-on delay and the falling edge slew rate.

10.2.2 Detailed Design Procedure

The system pull-up resistors must be strong enough to provide a positive slew rate of 1.25 V/µs on the SDA and SCL pins, in order to activate the boost pull-up currents during rising edges. Choose maximum resistor value using the formula given in Equation 1.

$$R \leq 800 \times 10^3 \left(\frac{V_{CC\,(MIN)} - 0.6}{C} \right) \quad (1)$$

where R is the pull-up resistor value in Ω, $V_{CC(MIN)}$ is the minimum V_{CC} voltage in volts, and C is the equivalent bus capacitance in picofarads (pF).

In addition, regardless of the bus capacitance, always choose R_{PU} ≤ 65.7 kΩ for V_{CC} = 5.5 V, R_{PU} ≤ 45 kΩ for V_{CC} = 3.3 V, and R_{PU} ≤ 33 kΩ for V_{CC} = 2.5 V. The start-up circuitry requires logic HIGH voltages on SDAOUT and SCLOUT to connect the backplane to the card, and these pull-up values are needed to overcome the pre-charge voltage.

10.2.3 Application Curves

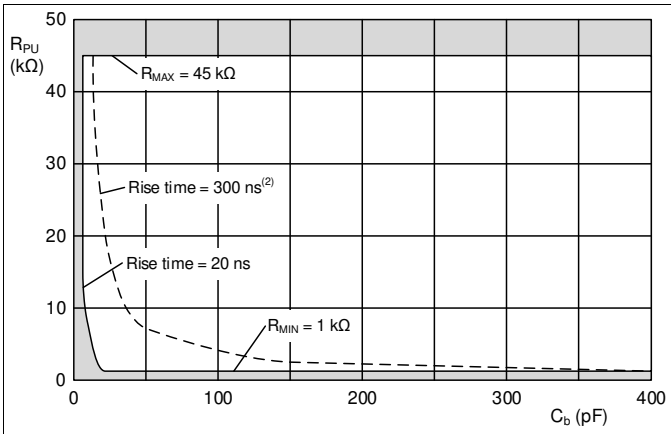


Figure 11. Example Bus Requirements for 3.3 V Systems

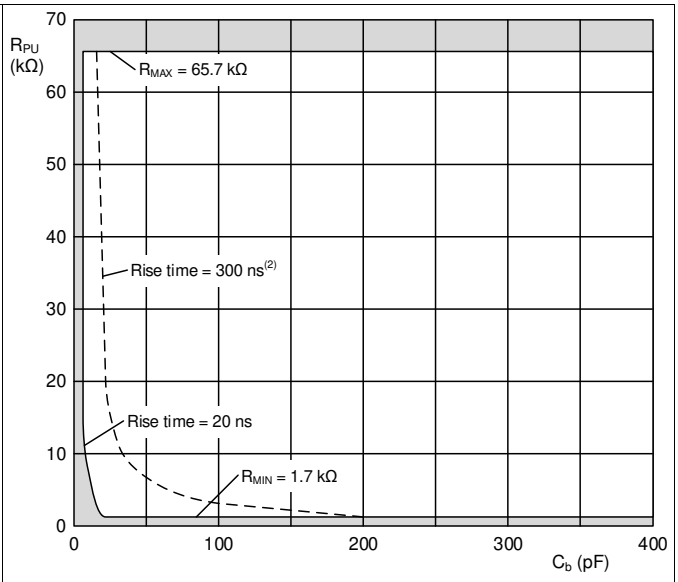


Figure 12. Example Bus Requirements for 5 V Systems

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10.3 Typical Application on a Backplane

As shown in Figure 13, the TCA9511A is used in a backplane connection. The TCA9511A is placed on the I/O peripheral card and connects the I^2C devices on the card to the backplane safely upon a hot insertion event. Note that if the I/O cards were plugged directly into the backplane, all of the backplane and card capacitances would add directly together, making rise time and fall time requirements difficult to meet. Placing a bus buffer on the edge of each card; however, isolates the card capacitance from the backplane. For a given I/O card, the TCA9511A drives the capacitance of everything on the card and the backplane must drive only the capacitance of the bus buffer, which is less than 10 pF, the connector, trace, and all additional cards on the backplane.

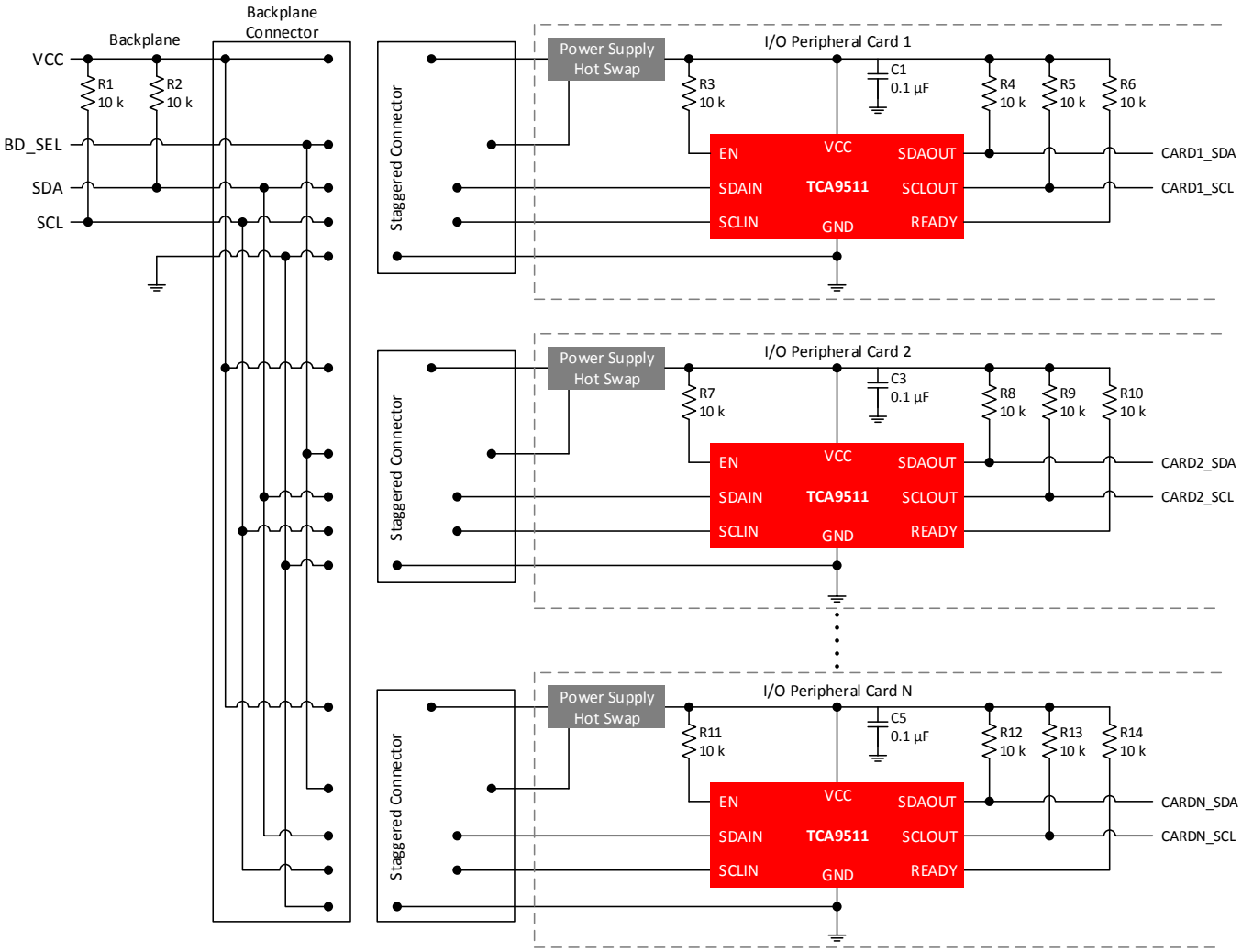


Figure 13. Backplane Application Schematic

10.3.1 Design Requirements

There are a few considerations when using these hot swap buffers. It is NOT recommended to place the TCA9511A on the backplane connector as it cannot isolate the cards from one another which will possibly result in disturbing on-going I^2C transactions. Instead, place the TCA9511A on the I/O peripheral card to maximize benefit.

10.3.2 Detailed Design Procedure

The design procedure is the same as outlined in Detailed Design Procedure.

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11 Power Supply Recommendations

11.1 Power supply best practices

In order for the pre-charge circuitry to dampen the effect of hot-swap insertion of the TCA9511A into an active I2C bus, V_{CC} must be applied before the SCL and SDA pins make contact to the main I2C bus. This is essential when the TCA9511A is placed on the add-on card circuit board, as in Typical Application on a Backplane. Although the pre-charge circuitry exists on both the -IN and -OUT side, the example in Typical Application on a Backplane shows SCLIN and SDAIN connecting to the main bus. The supply voltage to VCC can be applied early by ensuring that the VCC and GND pin contacts are physically longer than the contacts for the SCLIN and SDAIN pins. If a voltage supervisor will also be used to control the voltage supply on the add-on card, additional delay will exist before the 1 V pre-charge voltage is present on the SCL and SDA pins.

11.2 Power-on reset requirements

In order to ensure that the part starts up in the correct state, it is recommended that the power supply ramp rates meet the below requirements.

Table 1. Recommended supply ramp rates

Parameter			MIN	MAX	UNIT
t_{RT}	Rise rate		0.1	1000	ms
t_{FT}	Fall rate		0.1	1000	ms

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12 Layout

12.1 Layout Guidelines

For printed circuit board (PCB) layout of the TCA9511A, common PCB layout practices should be followed but additional concerns related to high-speed data transfer such as matched impedances and differential pairs are not a concern for I 2C signal speeds. In all PCB layouts, it is a best practice to avoid right angles in signal traces, to fan out signal traces away from each other upon leaving the vicinity of an integrated circuit (IC), and to use thicker trace widths to carry higher amounts of current that commonly pass through power and ground traces. By-pass and de-coupling capacitors are commonly used to control the voltage on the VCC pin, using a larger capacitor to provide additional power in the event of a short power supply glitch and a smaller capacitor to filter out high frequency ripple. These capacitors should be placed as close to the TCA9511A as possible. These best practices are shown in Layout Example.

The layout example provided in Layout Example shows a 4 layer board, which is preferable for boards with higher density signal routing. On a 4 layer PCB, it is common to route signals on the top and bottom layer, dedicate one internal layer to a ground plane, and dedicate the other internal layer to a power plane. In a board layout using planes or split planes for power and ground, vias are placed directly next to the surface mount component pad which needs to attach to V_{CC} or GND and the via is connected electrically to the internal layer or the other side of the board. Vias are also used when a signal trace needs to be routed to the opposite side of the board, shown in Figure 16 for the VCC side of the resistor connected to the EN pin; however, this routing and via is not necessary if V_{CC} and GND are both full planes as opposed to the partial planes depicted.

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12.2 Layout Example

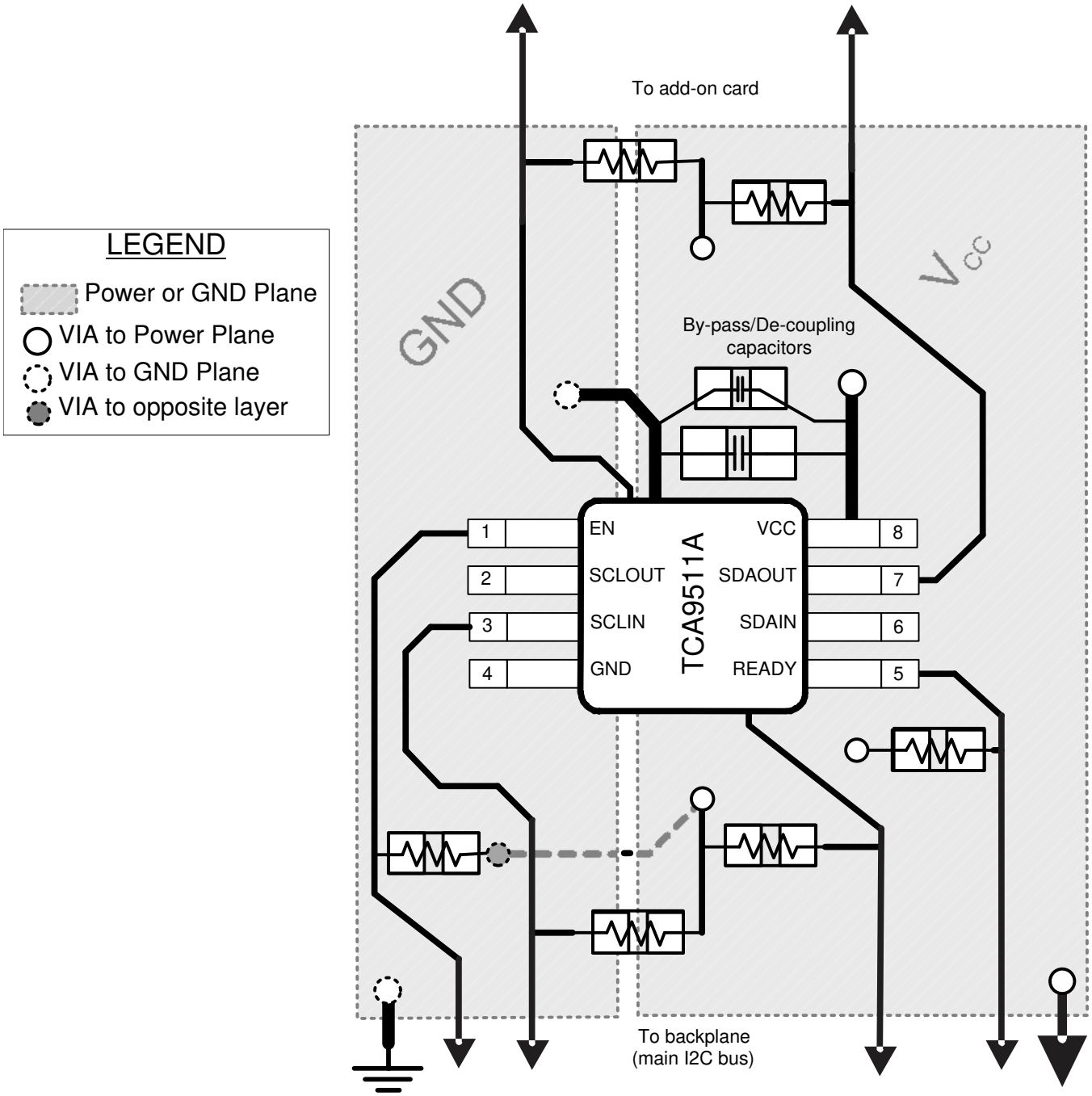


Figure 14. Layout example for TCA9511A

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13 Device and Documentation Support

13.1 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. In the upper right corner, click on *Alert me* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

13.2 Support Resources

TI E2E™ support forums are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

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13.3 Trademarks

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13.4 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.

13.5 Glossary

SLYZ022 — *TI Glossary*.

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

14 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.

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PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
TCA9511ADGKR	ACTIVE	VSSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	NIPDAUAG	Level-1-260C-UNLIM	-40 to 125	9511A	Samples

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

(2) **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.

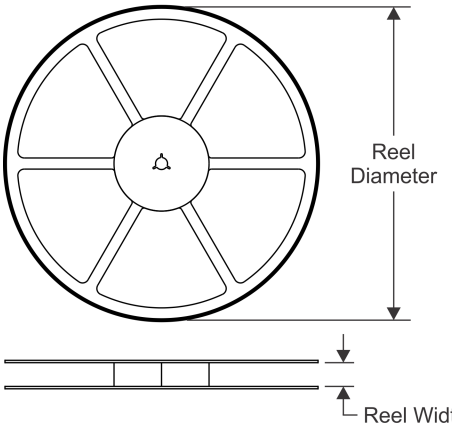
(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

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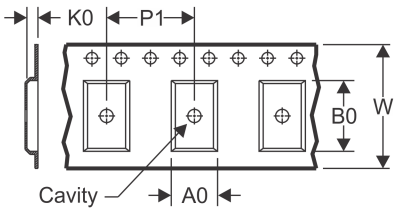
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TAPE AND REEL INFORMATION

REEL DIMENSIONS

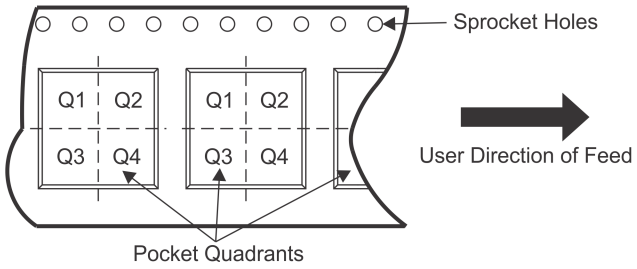


TAPE DIMENSIONS



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

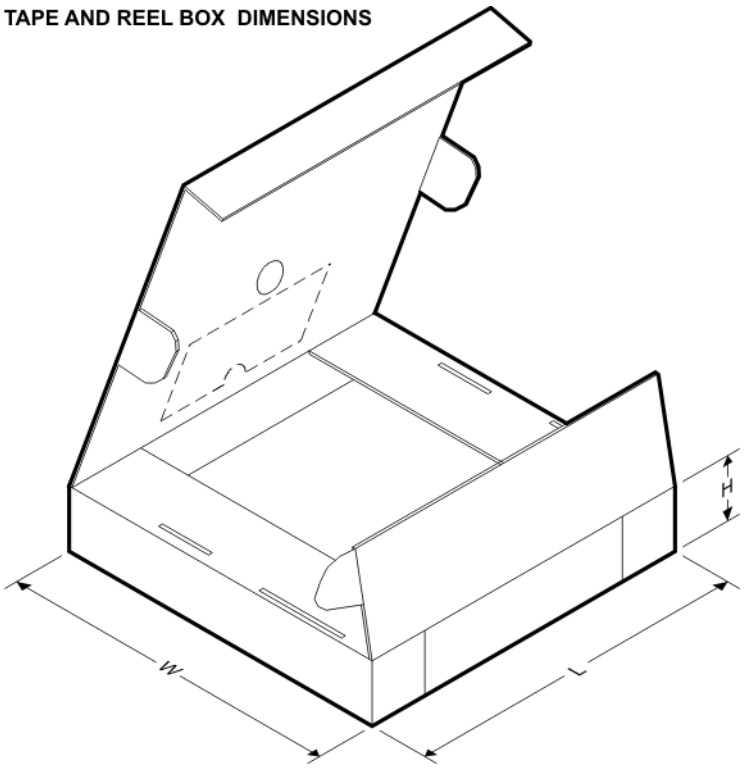
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
TCA9511ADGKR	VSSOP	DGK	8	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1

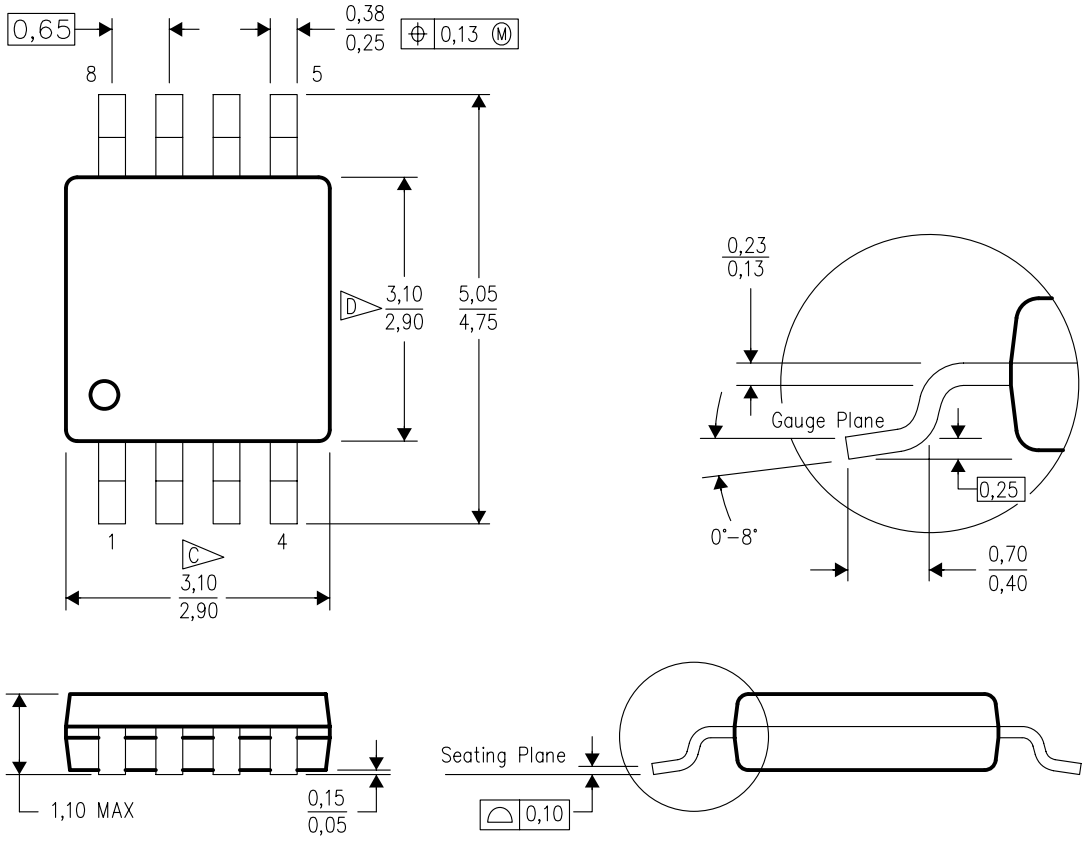
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TCA9511ADGKR	VSSOP	DGK	8	2500	364.0	364.0	27.0

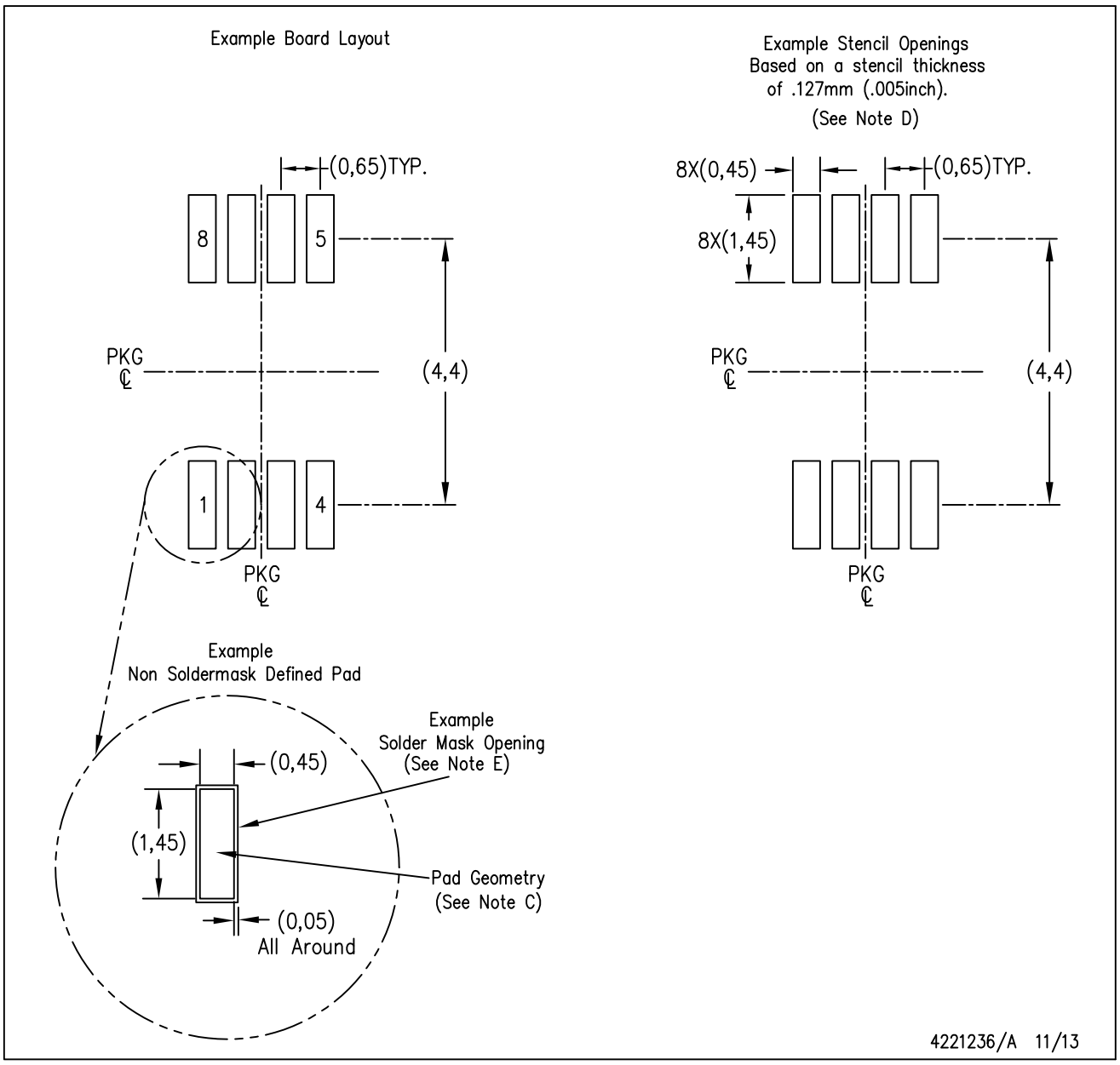
DGK (S–PDSO–G8) PLASTIC SMALL–OUTLINE PACKAGE



4073329/E 05/06

NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 per end.
D. Body width does not include interlead flash. Interlead flash shall not exceed 0.50 per side.
E. Falls within JEDEC MO–187 variation AA, except interlead flash.

DGK (S–PDSO–G8) PLASTIC SMALL OUTLINE PACKAGE



NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Publication IPC–7351 is recommended for alternate designs.
D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC–7525 for other stencil recommendations.
E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

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