PCA9515B Dual Bidirectional \(\text{i}^2\text{C}\) Bus and SMBus Repeater

1 Features
- Two-Channel Bidirectional Buffers
- \(\text{i}^2\text{C}\) Bus and SMBus Compatible
- Support for \(\text{i}^2\text{C}\) Standard Mode (100-kHz) and Fast Mode (400-kHz)
- Active-High Repeater-Enable Input
- Open-Drain \(\text{i}^2\text{C}\) Input and Output
- 5.5-V Tolerant \(\text{i}^2\text{C}\) Input and Output and Enable Input Support Mixed-Mode Signal Operation
- Lockup-Free Operation
- Accommodates Standard Mode, Fast Mode \(\text{i}^2\text{C}\) Devices, and Multiple Masters
- Supports Arbitration and Clock Stretching Across Repeater
- Powered-Off High-Impedance \(\text{i}^2\text{C}\) Pins
-Latch-Up Performance Exceeds 100-mA Per JESD 78, Class I
- ESD Protection Exceeds JESD 22
  – 2000-V Human-Body Model (A114-A)
  – 1000-V Charged-Device Model (C101)

2 Applications
- Servers
- Routers (Telecom Switching Equipment)
- Industrial Equipment
- Products with Many \(\text{i}^2\text{C}\) Slaves and Long PCB Traces

3 Description
The PCA9515B is a BiCMOS dual bidirectional buffer integrated circuit intended for \(\text{i}^2\text{C}\) bus and SMBus applications. The device contains two identical bidirectional open-drain buffer circuits that enables \(\text{i}^2\text{C}\) and similar bus systems to be extended (or add slaves) without degrading system performance. The dual bidirectional \(\text{i}^2\text{C}\) buffer is operational at 2.3 V to 3.6 V \(\text{V}_{\text{CC}}\).

The PCA9515B buffers both the serial data (SDA) and serial clock (SCL) signals on the \(\text{i}^2\text{C}\) bus, while retaining all the operating modes and features of the \(\text{i}^2\text{C}\) system. The device allows two buses, of 400-pF bus capacitance, to be connected in an \(\text{i}^2\text{C}\) application.

Device Information\(^{(1)}\)

<table>
<thead>
<tr>
<th>PART NUMBER</th>
<th>PACKAGE</th>
<th>BODY SIZE (NOM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCA9515B</td>
<td>VSSOP (8)</td>
<td>3.00 mm × 3.00 mm</td>
</tr>
</tbody>
</table>

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

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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 (May 2013) to Revision B Page

- Added Device Information table, ESD Ratings table, Feature Description section, Device Functional Modes, Application and Implementation section, Power Supply Recommendations section, Layout section, Device and Documentation Support section, and Mechanical, Packaging, and Orderable Information section. ........................................... 1
- Deleted the ordering information. See POA at the end of the datasheet. ........................................... 1

Changes from Original (March 2012) to Revision A Page

- Updated the $V_{OL}$ and $V_{OL} - V_{ILC}$ specifications.......................................................... 5
5 Pin Configuration and Functions

DGK Package
8-Pin VSSOP
Top View

NC 1   8   VCC
SCL0 2   7   SCL1
SDA0 3   6   SDA1
GND 4   5   EN

NC - No internal connection

Pin Functions

<table>
<thead>
<tr>
<th>PIN NO.</th>
<th>NAME</th>
<th>I/O</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>NC</td>
<td>—</td>
<td>No internal connection</td>
</tr>
<tr>
<td>2</td>
<td>SCL0</td>
<td>I/O</td>
<td>Serial clock bus 0</td>
</tr>
<tr>
<td>3</td>
<td>SDA0</td>
<td>I/O</td>
<td>Serial data bus 0</td>
</tr>
<tr>
<td>4</td>
<td>GND</td>
<td>—</td>
<td>Supply ground</td>
</tr>
<tr>
<td>5</td>
<td>EN</td>
<td>I</td>
<td>Active-high repeater enable input</td>
</tr>
<tr>
<td>6</td>
<td>SDA1</td>
<td>I/O</td>
<td>Serial data bus 1</td>
</tr>
<tr>
<td>7</td>
<td>SCL1</td>
<td>I/O</td>
<td>Serial clock bus 1</td>
</tr>
<tr>
<td>8</td>
<td>VCC</td>
<td>—</td>
<td>Supply power</td>
</tr>
</tbody>
</table>
6 Specifications

6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted) \(^{(1)}\)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Min</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>(V_{CC}) Supply voltage</td>
<td>–0.5</td>
<td>7</td>
<td>V</td>
</tr>
<tr>
<td>(V_I) Enable input voltage (^{(2)})</td>
<td>–0.5</td>
<td>7</td>
<td>V</td>
</tr>
<tr>
<td>(V_{IO}) (I^C) bus voltage (^{(2)})</td>
<td>–0.5</td>
<td>7</td>
<td>V</td>
</tr>
<tr>
<td>(I_{IK}) Input clamp current</td>
<td>(V_I &lt; 0)</td>
<td>–50</td>
<td>mA</td>
</tr>
<tr>
<td>(I_{OK}) Output clamp current</td>
<td>(V_O &lt; 0)</td>
<td>–50</td>
<td>mA</td>
</tr>
<tr>
<td>(I_O) Continuous output current</td>
<td>±50</td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td>Continuous current through (V_{CC}) or GND</td>
<td>±100</td>
<td>mA</td>
</tr>
<tr>
<td>(T_{stg}) Storage temperature</td>
<td>–65</td>
<td>150</td>
<td>°C</td>
</tr>
</tbody>
</table>

(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) The input negative-voltage and output voltage ratings may be exceeded if the input and output current ratings are observed.

6.2 ESD Ratings

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>(V_{(ESD)}) Electrostatic discharge</td>
<td>Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 (^{(1)})</td>
<td>±2000</td>
</tr>
<tr>
<td></td>
<td>Charged-device model (CDM), per JEDEC specification JESD22-C101 (^{(2)})</td>
<td>±1000</td>
</tr>
</tbody>
</table>

(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.

6.3 Recommended Operating Conditions

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Min</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>(V_{CC}) Supply voltage</td>
<td>2.3</td>
<td>3.6</td>
<td>V</td>
</tr>
<tr>
<td>(V_{IH}) High-level input voltage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SDA and SCL inputs</td>
<td>0.7 (\times V_{CC})</td>
<td>5.5</td>
<td>V</td>
</tr>
<tr>
<td>EN input</td>
<td>2</td>
<td>5.5</td>
<td></td>
</tr>
<tr>
<td>(V_{IL}) (^{(1)}) Low-level input voltage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SDA and SCL inputs</td>
<td>–0.5</td>
<td>0.3 (\times V_{CC})</td>
<td>V</td>
</tr>
<tr>
<td>EN input</td>
<td>–0.5</td>
<td>0.8</td>
<td></td>
</tr>
<tr>
<td>(V_{ILC}) (^{(1)}) SDA and SCL low-level input voltage contention</td>
<td>–0.5</td>
<td>0.4</td>
<td>V</td>
</tr>
<tr>
<td>(I_{OL}) Low-level output current</td>
<td>(V_{CC} = 2.3) V</td>
<td>6</td>
<td>mA</td>
</tr>
<tr>
<td>(V_{CC} = 3) V</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(T_A) Operating free-air temperature</td>
<td>–40</td>
<td>85</td>
<td>°C</td>
</tr>
</tbody>
</table>

(1) \(V_{IL}\) specification is for the EN input and the first low level seen by the SDAx and SCLx lines. \(V_{ILC}\) is for the second and subsequent low levels seen by the SDAx and SCLx lines. \(V_{ILC}\) must be at least 70 mV below \(V_{OL}\).

6.4 Thermal Information

<table>
<thead>
<tr>
<th>Thermal Metric (^{(1)})</th>
<th>PCA9515B DGK (VSSOP)</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>(R_{\theta JA}) Junction-to-ambient thermal resistance (^{(2)})</td>
<td>170.8</td>
<td>°C/W</td>
</tr>
<tr>
<td>(R_{\theta JC(top)}) Junction-to-case (top) thermal resistance</td>
<td>62.9</td>
<td>°C/W</td>
</tr>
<tr>
<td>(R_{\theta JB}) Junction-to-board thermal resistance</td>
<td>91.6</td>
<td>°C/W</td>
</tr>
<tr>
<td>(\Psi_{JT}) Junction-to-top characterization parameter</td>
<td>9.5</td>
<td>°C/W</td>
</tr>
<tr>
<td>(\Psi_{JB}) Junction-to-board characterization parameter</td>
<td>90.2</td>
<td>°C/W</td>
</tr>
</tbody>
</table>

(1) For more information about traditional and new thermal metrics, see the Semiconductor and IC Package Thermal Metrics application report, SPR4953.

(2) The package thermal impedance is calculated in accordance with JESD 51-7.
## 6.5 Electrical Characteristics

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

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>TEST CONDITIONS</th>
<th>$V_{CC}$</th>
<th>MIN</th>
<th>TYP(1)</th>
<th>MAX</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{IL}$</td>
<td>Input diode clamp voltage</td>
<td>$I_l = -18 , \text{mA}$</td>
<td>2.3 V to 3.6 V</td>
<td>$-1.2$</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>$V_{OL}$</td>
<td>Low-level output voltage</td>
<td>$I_{OL} = 20 , \mu\text{A} \text{ or } 6 , \text{mA}$</td>
<td>2.3 V to 3.6 V</td>
<td>0.47</td>
<td>0.52</td>
<td>0.6 V</td>
</tr>
<tr>
<td>$V_{OL} = V_{ILc}$</td>
<td>Low-level input voltage below</td>
<td>SDAX,</td>
<td>2.3 V to 3.6 V</td>
<td>120</td>
<td></td>
<td>mV</td>
</tr>
<tr>
<td></td>
<td>low-level output voltage</td>
<td>SCLX</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$I_{CC}$</td>
<td>Quiescent supply current</td>
<td></td>
<td>2.7 V</td>
<td>0.5</td>
<td>3</td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3.6 V</td>
<td>0.5</td>
<td>3</td>
<td>mA</td>
</tr>
<tr>
<td>$I_i$</td>
<td>Input current</td>
<td>SDAX,</td>
<td>2.3 V ± 0.2 V</td>
<td>45</td>
<td>82</td>
<td>130 ns</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SCLX</td>
<td>3.3 V ± 0.3 V</td>
<td>45</td>
<td>68</td>
<td>120 ns</td>
</tr>
<tr>
<td>$I_{off}$</td>
<td>Leakage current</td>
<td>SDAX,</td>
<td>2.5 V ± 0.2 V</td>
<td>33</td>
<td>113</td>
<td>190 ns</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SCLX</td>
<td>3.3 V ± 0.3 V</td>
<td>33</td>
<td>102</td>
<td>180 ns</td>
</tr>
<tr>
<td>$I_{i(ramp)}$</td>
<td>Leakage current during power</td>
<td>SDAX,</td>
<td>2.5 V ± 0.2 V</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>up</td>
<td>SCLX</td>
<td>3.3 V ± 0.3 V</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$C_{in}$</td>
<td>Input capacitance</td>
<td>EN</td>
<td>3.3 V</td>
<td>7</td>
<td>9</td>
<td>pF</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EN</td>
<td>3.3 V</td>
<td>7</td>
<td>9</td>
<td>pF</td>
</tr>
</tbody>
</table>

(1) All typical values are at nominal supply voltage ($V_{CC} = 2.5 \, \text{V or } 3.3 \, \text{V}$) and $T_A = 25^\circ \text{C}$.

## 6.6 Timing Requirements

over recommended operating free-air temperature range (unless otherwise noted) (see Figure 3)

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>FROM (INPUT)</th>
<th>TO (OUTPUT)</th>
<th>$V_{CC}$</th>
<th>MIN</th>
<th>TYP(1)</th>
<th>MAX</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>$t_{su}$</td>
<td>Setup time, $EN^+$ before Start condition</td>
<td></td>
<td>2.5 V ± 0.2 V</td>
<td>100</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3.3 V ± 0.3 V</td>
<td>100</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>$t_h$</td>
<td>Hold time, $EN^-$ after Stop condition</td>
<td></td>
<td>2.5 V ± 0.2 V</td>
<td>130</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3.3 V ± 0.3 V</td>
<td>100</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
</tbody>
</table>

## 6.7 Switching Characteristics

over recommended operating free-air temperature range, $C_L \leq 100 \, \text{pF}$ (unless otherwise noted)

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>FROM (INPUT)</th>
<th>TO (OUTPUT)</th>
<th>$V_{CC}$</th>
<th>MIN</th>
<th>TYP(1)</th>
<th>MAX</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>$t_{PZL}$</td>
<td>Propagation delay time(2)</td>
<td>SDA0, SCL0 or SDA1, SCL1</td>
<td>2.5 V ± 0.2 V</td>
<td>45</td>
<td>82</td>
<td>130</td>
<td>ns</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SDA0, SCL0 or SDA0, SCL0</td>
<td>3.3 V ± 0.3 V</td>
<td>45</td>
<td>68</td>
<td>120</td>
<td>ns</td>
</tr>
<tr>
<td>$t_{PLZ}$</td>
<td>Output transition time(2)</td>
<td>80%</td>
<td>2.5 V ± 0.2 V</td>
<td>57</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td></td>
<td>(SDAX, SCLx)</td>
<td>20%</td>
<td>3.3 V ± 0.3 V</td>
<td>58</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>$t_{OH}$</td>
<td></td>
<td></td>
<td>2.5 V ± 0.2 V</td>
<td>148</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3.3 V ± 0.3 V</td>
<td>147</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
</tbody>
</table>

(1) All typical values are at nominal supply voltage ($V_{CC} = 2.5 \, \text{V or } 3.3 \, \text{V}$) and $T_A = 25^\circ \text{C}$.
(2) Different load resistance and capacitance alter the RC time constant, thereby changing the propagation delay and transition times.
6.8 Typical Characteristics

![Graph 1](image1.png)  
**Figure 1.** Output Low Voltage ($V_{OL}$) vs. Output Low Current ($I_{OL}$) for SCL0 at Different $V_{CC}$

![Graph 2](image2.png)  
**Figure 2.** Output Low Voltage ($V_{OL}$) vs. Output Low Current ($I_{OL}$) for SCL0 at Different Temperatures for $V_{CC}=5\,V$
7 Parameter Measurement Information

![Diagram of test circuit and voltage waveforms](image)

**Figure 3. Test Circuit and Voltage Waveforms**

**A.** $R_T$ termination resistance should be equal to $Z_{OUT}$ of pulse generators.

**B.** $C_L$ includes probe and jig capacitance.

**C.** All input pulses are supplied by generators having the following characteristics: $PRR \leq 10$ MHz, $Z_O = 50$ Ω, slew rate $\geq 1$ V/ns.

**D.** The outputs are measured one at a time, with one transition per measurement.
8 Detailed Description

8.1 Overview

The PCA9515B is a BiCMOS dual bidirectional buffer integrated circuit intended for I^2C bus and SMBus applications. The device contains two identical bidirectional open-drain buffer circuits that enables I^2C and similar bus systems to be extended without degrading system performance. This device enables I^2C and similar bus systems to be extended (and add more slaves) without degradation of performance. The dual bidirectional I^2C buffer is operational at 2.3 V to 3.6 V V_{CC}.

The PCA9515B buffers both the serial data (SDA) and serial clock (SCL) signals on the I^2C bus, while retaining all the operating modes and features of the I^2C system. The device allows two buses, of 400-pF bus capacitance, to be connected in an I^2C application.

The I^2C bus capacitance limit of 400 pF restricts the number of slave devices and bus length. Using the PCA9515B, a system designer can capacitively isolate two halves of a bus, thus accommodating more I^2C devices and longer trace lengths.

The PCA9515B has an active-high enable (EN) input with an internal pull-up. This allows users to select when the repeater is active and isolate malfunctioning slaves on power-up reset. States should never be changed during an I^2C operation. Disabling during a bus operation will hang the bus and enabling part way through a bus cycle may confuse the I^2C parts being enabled. The EN input should only change state when the global bus and the repeater port are in an idle state to prevent system failures.

The PCA9515B can also be used to operate two buses, one at 5 V interface levels and the other at 3.3 V interface levels. The buses may also function at 400-kHz or 100-kHz operating frequency. If the two buses are operating at different frequencies, the 100-kHz bus must be isolated if the operation of the 400-kHz bus is required. If the master is running at 400-kHz, the maximum system operating frequency may be less than 400 kHz because of the delays added by the repeater.

The low level outputs for each internal buffer are approximately 0.5 V; however, the input voltage of each internal buffer must be 70 mV or more below the low level output when the output is driven low internally. This prevents a lockup condition from occurring when the input low condition is released.

Two or more PCA9515B devices cannot be used in series. Since there is no direction pin, different valid low-voltage levels are used to avoid lockup conditions between the input and the output of each repeater. A valid low, applied at the input of a PCA9515B, is propagated as a buffered low with a higher value on the enabled outputs. When this buffered low is applied to another PCA9515B-type device in series, the second device does not recognize it as a valid low and does not propagate it as a buffered low.

The device contains a power-up control circuit that sets an internal latch to prevent the output circuits from becoming active until V_{CC} is at a valid level (V_{CC} = 2.3 V).

As with the standard I^2C system, pullup resistors are required to provide the logic high levels on the buffered bus. The PCA9515B has standard open-collector configuration of the I^2C bus. The size of the pullup resistors depend on the system; however, each side of the repeater must have a pullup resistor. The device is designed to work with Standard Mode and Fast Mode I^2C devices in addition to SMBus devices. Standard Mode I^2C devices only specify a 3 mA termination current in a generic I^2C system where Standard Mode devices and multiple masters are possible. Under certain conditions, high termination currents can be used.
8.2 Functional Block Diagram

![Block Diagram](image)

**Figure 4. Logic Diagram (Positive Logic)**

8.3 Feature Description

8.3.1 Two-Channel Bidirectional Buffer

The PCA9515B is a two-channel bidirectional buffer for open-drain applications like I²C and SMBus.

8.3.2 Bidirectional Voltage-Level Translation

The PCA9515B allows bidirectional voltage-level translation (up-translation and down-translation) between low voltages (down to 2.3 V) and higher voltages (up to 5.5 V).

8.3.3 Active-High Enable Input

The PCA9515B has an active-high enable (EN) input with an internal pull-up to \( V_{CC} \). The enable input needs to be pulled to GND to disable the PCA9515B and isolate the I²C buses. Pulling-up the enable pin or floating the enable pin causes the PCA9515B to turn on and buffer the I²C bus.
8.4 Device Functional Modes

The PCA9515B has an active-high enable (EN) input with an internal pull-up to $V_{CC}$, which allows the user to select when the repeater is active. This can be used to isolate a badly behaved slave on power-up reset. It should never change state during an I2C operation, because disabling during a bus operation may hang the bus, and enabling part way through the bus cycles could confuse the I2C parts being enabled. The EN input should only change state when the global bus and repeater port are in the idle state to prevent system failures. Table 1 lists the PCA9515B functions.

<table>
<thead>
<tr>
<th>INPUT EN</th>
<th>FUNCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>Outputs disabled</td>
</tr>
<tr>
<td>H</td>
<td>$\text{SDA}_0 = \text{SDA}_1$, $\text{SCL}_0 = \text{SCL}_1$</td>
</tr>
</tbody>
</table>

Table 1. Function Table
9 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.

9.1 Application Information

The PCA9515B is typically used to buffer an I²C signal, isolating capacitance from two sides of the bus. This allows for longer traces and cables, and a more robust I²C communication. Typical Application section describes how the PCA9515B may be used to isolate a standard mode and fast mode I²C bus, to allow for faster communications when required, but maintaining compatibility with the slower standard mode slave device.

It is critical to keep the V_{OL} and V_{IL} requirements in mind when designing with buffers, especially when using multiple buffers/translators on the same node. Care must be taken to not violate the V_{IL} requirement of a buffer, otherwise I²C communication errors will occur. An example of this would be a buffer with a V_{OL} of ~0.5 V, and a device requires a V_{IL} of less than 0.4 V. Such a connection would result in the slave device being unable to recognize the output low signal as a valid low.

9.2 Typical Application

A typical application is shown in Figure 5. In this example, the system master is running on a 3.3 V I²C bus, while the slave is connected to a 5-V bus. Both buses run at 100 kHz, unless the slave bus is isolated. If the slave bus is isolated (by pulling the EN pin low), the master bus can run at 400 kHz. Master devices can be placed on either bus, the PCA9515B does not care which side the master is on. Decoupling capacitors are required, but are not shown in Figure 5 for simplicity.

Figure 5. Typical Application

9.2.1 Design Requirements

Table 2 lists the design requirements.

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input-side I²C signal</td>
<td>3.3 V</td>
</tr>
<tr>
<td>Output-side I²C signal</td>
<td>5 V</td>
</tr>
</tbody>
</table>
9.2.2 Detailed Design Procedure

The PCA9515B is 5.5 V tolerant, so it does not require any additional circuitry to translate between the different bus voltages. When one side of the PCA9515B is pulled low by a device on the I²C bus, a CMOS hysteresis-type input detects the falling edge and causes an internal driver on the other side to turn on, thus causing the other side also to go low. The side driven low by the PCA9515B typically is at \( V_{\text{OL}} = 0.5 \text{ V} \).

Figure 6 and Figure 7 show the waveforms that are seen in a typical application. If the bus master in Figure 5 writes to the slave through the PCA9515B, Bus 0 has the waveform shown in Figure 6. The waveform looks like a normal I²C transmission until the falling edge of the eighth clock pulse. At that point, the master releases the data line (SDA) while the slave pulls it low through the PCA9515B. Because the \( V_{\text{OL}} \) of the PCA9515B typically is around 0.5 V, a step in the SDA is seen. After the master has transmitted the ninth clock pulse, the slave releases the data line.

On the Bus 1 side of the PCA9515B, the clock and data lines have a positive offset from ground equal to the \( V_{\text{OL}} \) of the PCA9515B. After the eighth clock pulse, the data line is pulled to the \( V_{\text{OL}} \) of the slave device, which is very close to ground in the example.

9.2.3 Application Curves

![Figure 6. Bus 0 Waveforms](image)

![Figure 7. Bus 1 Waveforms](image)

10 Power Supply Recommendations

For \( V_{\text{CC}} \), a 2.3 V to 3.6 V power supply is required. Standard decoupling capacitors are recommended. These capacitors typically range from 0.1 \( \mu \text{F} \) to 1 \( \mu \text{F} \), but the ideal capacitance depends on the amount of noise from the power supply.
11 Layout

11.1 Layout Guidelines

For printed circuit board (PCB) layout of the PCA9515B, common PCB layout practices should be followed. 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 V\text{CC} pin, using a larger capacitor to provide additional power in the event of a short power supply glitch and a small capacitor to filter out high-frequency ripple. These decoupling capacitors should be placed as close to the V\text{CC} pin of PCA9515B as possible.

The layout example shown in Figure 8 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 one to 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\text{CC} or GND and the via is connected electrically to the internal layer on 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. This routing and via is not necessary if V\text{CC} and GND are both full planes as opposed to the partial planes depicted.

11.2 Layout Example

![Layout Schematic](Figure 8. Layout Schematic)
12 Device and Documentation Support

12.1 Documentation Support

12.1.1 Related Documentation
For related documentation see the following:

- *I2C Bus Pullup Resistor Calculation*, SLVA689
- *Maximum Clock Frequency of I2C Bus Using Repeaters*, SLVA695
- *Introduction to Logic*, SLVA700
- *Understanding the I2C Bus*, SLVA704

12.2 Community Resources
The following links connect to TI community resources. Linked contents are provided “AS IS” by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's Terms of Use.

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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 Glossary
*SLYZ022 — TI Glossary.*
This glossary lists and explains terms, acronyms, and definitions.

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

<table>
<thead>
<tr>
<th>Orderable Device</th>
<th>Status (1)</th>
<th>Package Type</th>
<th>Package Drawing</th>
<th>Pins</th>
<th>Package Qty</th>
<th>Lead finish/ Ball material</th>
<th>MSL Peak Temp (3)</th>
<th>Op Temp (°C)</th>
<th>Device Marking (4/5)</th>
<th>Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCA9515BDGKR</td>
<td>ACTIVE</td>
<td>VSSOP</td>
<td>DGK</td>
<td>8</td>
<td>2500</td>
<td>RoHS &amp; Green NIPDAU</td>
<td>NIPDAUAG</td>
<td>Level-1-260C-UNLIM</td>
<td>-40 to 85</td>
<td>(7SE, 7SF)</td>
</tr>
</tbody>
</table>

(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.

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**TAPE AND REEL INFORMATION**

<table>
<thead>
<tr>
<th>Device</th>
<th>Package Type</th>
<th>Package Drawing</th>
<th>Pins</th>
<th>SPQ</th>
<th>Reel Diameter (mm)</th>
<th>Reel Width W1 (mm)</th>
<th>A0 (mm)</th>
<th>B0 (mm)</th>
<th>K0 (mm)</th>
<th>P1 (mm)</th>
<th>W (mm)</th>
<th>Pin1 Quadrant</th>
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</thead>
<tbody>
<tr>
<td>PCA9515BDGKR</td>
<td>VSSOP</td>
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<td>8</td>
<td>2500</td>
<td>330.0</td>
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<td>5.3</td>
<td>3.4</td>
<td>1.4</td>
<td>8.0</td>
<td>12.0</td>
<td>Q1</td>
</tr>
</tbody>
</table>

*All dimensions are nominal*
### TAPE AND REEL BOX DIMENSIONS

*All dimensions are nominal

<table>
<thead>
<tr>
<th>Device</th>
<th>Package Type</th>
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<th>Width (mm)</th>
<th>Height (mm)</th>
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</thead>
<tbody>
<tr>
<td>PCA9515BDGKR</td>
<td>VSSOP</td>
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<td>8</td>
<td>2500</td>
<td>364.0</td>
<td>364.0</td>
<td>27.0</td>
</tr>
</tbody>
</table>
NOTES:

A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
  Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 per end.
  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.
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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