PCF8574 Remote 8-Bit I/O Expander for I²C Bus

1 Features
• Low Standby-Current Consumption of 10 μA Max
• I²C to Parallel-Port Expander
• Open-Drain Interrupt Output
• Compatible With Most Microcontrollers
• Latched Outputs With High-Current Drive Capability for Directly Driving LEDs
• Latch-Up Performance Exceeds 100 mA Per JESD 78, Class II

2 Applications
• Telecom Shelters: Filter Units
• Servers
• Routers (Telecom Switching Equipment)
• Personal Computers
• Personal Electronics
• Industrial Automation
• Products with GPIO-Limited Processors

3 Description
This 8-bit input/output (I/O) expander for the two-line bidirectional bus (I²C) is designed for 2.5-V to 6-V VCC operation.

The PCF8574 device provides general-purpose remote I/O expansion for most microcontroller families by way of the I²C interface [serial clock (SCL), serial data (SDA)].

The device features an 8-bit quasi-bidirectional I/O port (P0–P7), including latched outputs with high-current drive capability for directly driving LEDs. Each quasi-bidirectional I/O can be used as an input or output without the use of a data-direction control signal. At power on, the I/Os are high. In this mode, only a current source to VCC is active.

Device Information

<table>
<thead>
<tr>
<th>PART NUMBER</th>
<th>PACKAGE (PIN)</th>
<th>BODY SIZE (NOM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCF8574</td>
<td>TVSOP (20)</td>
<td>5.00 mm × 4.40 mm</td>
</tr>
<tr>
<td></td>
<td>SOIC (16)</td>
<td>10.30 mm × 7.50 mm</td>
</tr>
<tr>
<td></td>
<td>PDIP (16)</td>
<td>19.30 mm × 6.35 mm</td>
</tr>
<tr>
<td></td>
<td>TSSOP (20)</td>
<td>6.50 mm × 4.40 mm</td>
</tr>
<tr>
<td></td>
<td>QFN (16)</td>
<td>3.00 mm × 3.00 mm</td>
</tr>
<tr>
<td></td>
<td>VQFN (20)</td>
<td>4.50 mm × 3.50 mm</td>
</tr>
</tbody>
</table>

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

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.
4 Revision History

Changes from Revision I (November 2015) to Revision J

- Corrected part number in Device Information table

Changes from Revision H (January 2015) to Revision I

- Added Junction temperature to the Absolute Maximum Ratings
- Changed Supply Current (A) to Supply Current (µA) and \( f_{SCL} = 400 \text{ kHz} \) to \( f_{SCL} = 100 \text{ kHz} \) in Figure 1
- Changed Supply Current (A) to Supply Current (µA) in Figure 1
- Changed Supply Current (A) to Supply Current (µA) and \( f_{SCL} = 400 \text{ kHz} \) to \( f_{SCL} = 100 \text{ kHz} \) in Figure 3

Changes from Revision G (May 2008) to Revision H

- Added Applications, Device Information table, Pin Functions table, ESD Ratings table, Thermal Information table, Typical Characteristics, 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
- Deleted Ordering Information table
## 5 Pin Configuration and Functions

### Pin Functions

<table>
<thead>
<tr>
<th>NAME</th>
<th>RGT</th>
<th>RGY</th>
<th>DW or N</th>
<th>DESCRIPTION</th>
</tr>
</thead>
</table>
| A [0..2] | 2, 3, 4 | 6, 7, 9 | 1, 2, 3 | I
| GND | 9 | 15 | 8 | Ground |
| INT | 14 | 1 | 13 | O
| NC | - | 3, 8, 13, 18 | - | Do not connect |
| P[0..7] | 5, 6, 7, 8, 10, 11, 12, 13 | 10, 11, 12, 14, 16, 17, 19, 20 | 4, 5, 6, 7, 9, 10, 11, 12 | I/O
| SCL | 15 | 2 | 14 | I
| SDA | 16 | 4 | 15 | I/O
| VCC | 1 | 5 | 16 | Voltage supply |

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*Note: The table above lists the pin functions for the PCF8574 device.*
6 Specifications

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

<table>
<thead>
<tr>
<th></th>
<th>MIN</th>
<th>MAX</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>(V_{CC}) Supply voltage range</td>
<td>–0.5</td>
<td>7</td>
<td>V</td>
</tr>
<tr>
<td>(V_i) Input voltage range(^{(2)})</td>
<td>–0.5 (V_{CC} + 0.5)</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>(V_o) Output voltage range(^{(2)})</td>
<td>–0.5 (V_{CC} + 0.5)</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>(I_{\text{IK}}) Input clamp current</td>
<td>(V_i &lt; 0)</td>
<td>–20</td>
<td>mA</td>
</tr>
<tr>
<td>(I_{\text{OK}}) Output clamp current</td>
<td>(V_o &lt; 0)</td>
<td>–20</td>
<td>mA</td>
</tr>
<tr>
<td>(I_{\text{OL}}) Input/output clamp current</td>
<td>(V_o &lt; 0) or (V_o &gt; V_{CC})</td>
<td>±400</td>
<td>μA</td>
</tr>
<tr>
<td>(I_{\text{OL}}) Continuous output low current</td>
<td>(V_o = 0) to (V_{CC})</td>
<td>50</td>
<td>mA</td>
</tr>
<tr>
<td>(I_{\text{OL}}) Continuous output high current</td>
<td>(V_o = 0) to (V_{CC})</td>
<td>–4</td>
<td>mA</td>
</tr>
<tr>
<td>Continuous current through (V_{CC}) or GND</td>
<td>60</td>
<td>mA</td>
<td></td>
</tr>
<tr>
<td>(T_J) Junction temperature</td>
<td>150</td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td>(T_{\text{stg}}) Storage temperature range</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, and functional operation of the device at these or any other conditions beyond those indicated under Recommended Operating Conditions is not implied. 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>(V_{\text{ESD}}) Electrostatic discharge</th>
<th>VALUE</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001(^{(1)})</td>
<td>1500</td>
<td>V</td>
</tr>
<tr>
<td>Charged-device model (CDM), per JEDEC specification JESD22-C101(^{(2)})</td>
<td>2000</td>
<td>V</td>
</tr>
</tbody>
</table>

\(^{(1)}\) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process. Manufacturing with less than 500-V HBM is possible with the necessary precautions.

\(^{(2)}\) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process. Manufacturing with less than 250-V CDM is possible with the necessary precautions.

6.3 Recommended Operating Conditions

<table>
<thead>
<tr>
<th>(V_{CC}) Supply voltage</th>
<th>MIN</th>
<th>MAX</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>(V_{IH}) High-level input voltage</td>
<td>2.5</td>
<td>6</td>
<td>V</td>
</tr>
<tr>
<td>(V_{IL}) Low-level input voltage</td>
<td>(0.7 \times V_{CC})</td>
<td>(V_{CC} + 0.5)</td>
<td>V</td>
</tr>
<tr>
<td>(I_{\text{OH}}) High-level output current</td>
<td>–0.5</td>
<td>(0.3 \times V_{CC})</td>
<td>V</td>
</tr>
<tr>
<td>(I_{\text{OL}}) Low-level output current</td>
<td>–1</td>
<td>mA</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>

6.4 Thermal Information

<table>
<thead>
<tr>
<th>THERMAL METRIC(^{(1)})</th>
<th>PCF8574</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DGV</td>
</tr>
<tr>
<td></td>
<td>20 PINS</td>
</tr>
<tr>
<td>(\theta_{JA}) Junction-to-ambient thermal resistance</td>
<td>92</td>
</tr>
</tbody>
</table>

\(^{(1)}\) For more information about traditional and new thermal metrics, see the IC Package Thermal Metrics application report (SPRA953).
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>$V_{IH}$ Input diode clamp voltage</td>
<td>$I_i = -18$ mA</td>
<td>2.5 V to 6 V</td>
<td>1.2</td>
<td>1.3</td>
<td>2.4</td>
<td>V</td>
</tr>
<tr>
<td>$V_{POR}$ Power-on reset voltage $^{(2)}$</td>
<td>$V_i = V_{CC}$ or GND, $I_O = 0$</td>
<td>6 V</td>
<td>30</td>
<td>300</td>
<td>μA</td>
<td></td>
</tr>
<tr>
<td>$I_{OH}$ P port</td>
<td>$V_O = GND$</td>
<td>2.5 V to 6 V</td>
<td>2.5</td>
<td>1.6</td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td>$I_{OHIT}$ P port transient pullup current</td>
<td>High during acknowledge, $V_{OH} = GND$</td>
<td>2.5 V</td>
<td>$-1$</td>
<td></td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td>$I_{OL}$ SDA</td>
<td>$V_O = 0.4$ V</td>
<td>2.5 V to 6 V</td>
<td>3</td>
<td></td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td>$I_{OLP}$ P port</td>
<td>$V_O = 1$ V</td>
<td>5 V</td>
<td>10</td>
<td>25</td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td>$I_I$ INT, SDA</td>
<td>$V_i = V_{CC}$ or GND</td>
<td>2.5 V to 6 V</td>
<td>$-5$</td>
<td></td>
<td></td>
<td>μA</td>
</tr>
<tr>
<td>$I_{IHL}$ A0, A1, A2</td>
<td>$V_i \geq V_{CC}$ or $V_i \leq GND$</td>
<td>2.5 V to 6 V</td>
<td>$400$</td>
<td></td>
<td></td>
<td>μA</td>
</tr>
<tr>
<td>$I_{CC}$ Operating mode</td>
<td>$V_i = V_{CC}$ or GND, $I_O = 0$, $f_{SCL} = 100$ kHz</td>
<td>6 V</td>
<td>40</td>
<td>100</td>
<td></td>
<td>μA</td>
</tr>
<tr>
<td>$I_{CC}$ Standby mode</td>
<td>$V_i = V_{CC}$ or GND, $I_O = 0$</td>
<td>2.5 V to 6 V</td>
<td>1.5</td>
<td>7</td>
<td></td>
<td>pF</td>
</tr>
<tr>
<td>$C_{IN}$ SCL</td>
<td>$V_i = V_{CC}$ or GND</td>
<td>2.5 V to 6 V</td>
<td>3</td>
<td>7</td>
<td></td>
<td>pF</td>
</tr>
<tr>
<td>$C_{IO}$ SDA</td>
<td>$V_{IO} = V_{CC}$ or GND</td>
<td>2.5 V to 6 V</td>
<td>4</td>
<td></td>
<td></td>
<td>pF</td>
</tr>
</tbody>
</table>

$^{(1)}$ All typical values are at $V_{CC} = 5$ V, $T_A = 25^\circ$C.

$^{(2)}$ The power-on reset circuit resets the $I^2$C-bus logic with $V_{CC} < V_{POR}$ and sets all I/Os to logic high (with current source to $V_{CC}$).

6.6 $I^2C$ Interface Timing Requirements

over recommended operating free-air temperature range (unless otherwise noted) (see Figure 12)

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>FROM (INPUT)</th>
<th>TO (OUTPUT)</th>
<th>MIN</th>
<th>MAX</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>$t_{pv}$ Output data valid</td>
<td>SCL</td>
<td>P port</td>
<td>4</td>
<td></td>
<td>μs</td>
</tr>
<tr>
<td>$t_{su}$ Input data setup time</td>
<td>P port</td>
<td>SCL</td>
<td>0</td>
<td></td>
<td>μs</td>
</tr>
<tr>
<td>$t_{ih}$ Input data hold time</td>
<td>P port</td>
<td>SCL</td>
<td>4</td>
<td></td>
<td>μs</td>
</tr>
<tr>
<td>$t_{iv}$ Interrupt valid time</td>
<td>P port</td>
<td>INT</td>
<td>4</td>
<td></td>
<td>μs</td>
</tr>
<tr>
<td>$t_{ir}$ Interrupt reset delay time</td>
<td>SCL</td>
<td>INT</td>
<td>4</td>
<td></td>
<td>μs</td>
</tr>
</tbody>
</table>

6.7 Switching Characteristics

over recommended operating free-air temperature range, $C_L \leq 100$ pF (unless otherwise noted) (see Figure 13)

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>FROM (INPUT)</th>
<th>TO (OUTPUT)</th>
<th>MIN</th>
<th>MAX</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>$t_{pv}$ Output data valid</td>
<td>SCL</td>
<td>P port</td>
<td>4</td>
<td></td>
<td>μs</td>
</tr>
<tr>
<td>$t_{su}$ Input data setup time</td>
<td>P port</td>
<td>SCL</td>
<td>0</td>
<td></td>
<td>μs</td>
</tr>
<tr>
<td>$t_{ih}$ Input data hold time</td>
<td>P port</td>
<td>SCL</td>
<td>4</td>
<td></td>
<td>μs</td>
</tr>
<tr>
<td>$t_{iv}$ Interrupt valid time</td>
<td>P port</td>
<td>INT</td>
<td>4</td>
<td></td>
<td>μs</td>
</tr>
<tr>
<td>$t_{ir}$ Interrupt reset delay time</td>
<td>SCL</td>
<td>INT</td>
<td>4</td>
<td></td>
<td>μs</td>
</tr>
</tbody>
</table>

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6.8 Typical Characteristics

\( T_A = 25^\circ C \) (unless otherwise noted)

**Figure 1. Supply Current vs Temperature**

**Figure 2. Standby Supply Current vs Temperature**

**Figure 3. Supply Current vs Supply Voltage**

**Figure 4. I/O Sink Current vs Output Low Voltage**

**Figure 5. I/O Sink Current vs Output Low Voltage**

**Figure 6. I/O Sink Current vs Output Low Voltage**
Typical Characteristics (continued)

\[ T_A = 25^\circ C \text{ (unless otherwise noted)} \]

![Figure 7. I/O Output Low Voltage vs Temperature](image1)

![Figure 8. I/O Source Current vs Output High Voltage](image2)

![Figure 9. I/O Source Current vs Output High Voltage](image3)

![Figure 10. I/O Source Current vs Output High Voltage](image4)

![Figure 11. I/O High Voltage vs Temperature](image5)
7 Parameter Measurement Information

LOAD CIRCUIT

VCC

\[ R_L = 1 \text{k}\Omega \]

CL = 10 pF to 400 pF

\[ V_{CC} \]

\[ P_n \]

Load Circuit and Voltage Waveforms

2 Bytes for Complete Device Programming

Start Condition (S) | Start Condition (P) | Bit 7 (MSB) | Bit 6 | Bit 0 (LSB) (R/W) | Acknowledge (A) | Stop Condition (P)
--- | --- | --- | --- | --- | --- | ---

SCL

SDA

Stop Condition (P)

Acknowledge (A)

Stop Condition (P)

\[ 0.7 \times V_{CC} \]

\[ 0.3 \times V_{CC} \]

\[ 0.7 \times V_{CC} \]

\[ 0.3 \times V_{CC} \]

VOLTAGE WAVEFORMS

Figure 12. \( \text{I}^2\text{C} \) Interface Load Circuit and Voltage Waveforms
Parameter Measurement Information (continued)

Start Condition
Slave Address
R/W
Data From Port
Acknowledge From Slave
Data From Port
Acknowledge From Slave
Slave
Acknowledge
Unstable
Data
Last Stable Bit
SDA
Pn

Figure 13. Interrupt Voltage Waveforms

Figure 14. \textit{I}^2\textit{C} Write Voltage Waveforms
Parameter Measurement Information (continued)

![Load Circuits Diagram](image)

**Figure 15. Load Circuits**
8 Detailed Description

8.1 Overview

The PCF8574 device is an 8-bit I/O expander for the two-line bidirectional bus (I2C) designed for 2.5-V to 5.5-V \(V_{CC}\) operation. It provides general-purpose remote I/O expansion for most micro-controller families via the I2C interface (serial clock, SCL, and serial data, SDA, pins).

The PCF8574 device provides an open-drain output (\(\text{INT}\)) that can be connected to the interrupt input of a microcontroller. An interrupt is generated by any rising or falling edge of the port inputs in the input mode. After time, \(t_{iv}\), \(\text{INT}\) is valid. Resetting and reactivating the interrupt circuit is achieved when data on the port is changed to the original setting or data is read from, or written to, the port that generated the interrupt. Resetting occurs in the read mode at the acknowledge bit after the rising edge of the SCL signal, or in the write mode at the acknowledge bit after the high-to-low transition of the SCL signal. Interrupts that occur during the acknowledge clock pulse can be lost (or be very short) due to the resetting of the interrupt during this pulse. Each change of the I/Os after resetting is detected and, after the next rising clock edge, is transmitted as \(\text{INT}\). Reading from, or writing to, another device does not affect the interrupt circuit. This device does not have internal configuration or status registers. Instead, read or write to the device I/Os directly after sending the device address (see Figure 16 and Figure 17).

By sending an interrupt signal on this line, the remote I/O can inform the microcontroller if there is incoming data on its ports without having to communicate by way of the \(\text{I}^2\text{C}\) bus. Therefore, PCF8574 can remain a simple slave device.

An additional strong pullup to \(V_{CC}\) allows fast rising edges into heavily loaded outputs. This device turns on when an output is written high and is switched off by the negative edge of SCL. The I/Os should be high before being used as inputs.

8.2 Functional Block Diagram

8.2.1 Simplified Block Diagram of Device
Functional Block Diagram (continued)

8.2.2 Simplified Schematic Diagram of Each P-Port Input/Output

![Schematic Diagram of Each P-Port Input/Output](image.png)

8.3 Feature Description

8.3.1 I²C Interface

I²C communication with this device is initiated by a master sending a start condition, a high-to-low transition on the SDA I/O while the SCL input is high. After the start condition, the device address byte is sent, most-significant bit (MSB) first, including the data direction bit (R/W). This device does not respond to the general call address. After receiving the valid address byte, this device responds with an acknowledge, a low on the SDA I/O during the high of the acknowledge-related clock pulse. The address inputs (A0–A2) of the slave device must not be changed between the start and the stop conditions.

The data byte follows the address acknowledge. If the R/W bit is high, the data from this device are the values read from the P port. If the R/W bit is low, the data are from the master, to be output to the P port. The data byte is followed by an acknowledge sent from this device. If other data bytes are sent from the master, following the acknowledge, they are ignored by this device. Data are output only if complete bytes are received and acknowledged. The output data will be valid at time, t_{pv}, after the low-to-high transition of SCL and during the clock cycle for the acknowledge.

A stop condition, which is a low-to-high transition on the SDA I/O while the SCL input is high, is sent by the master.

8.3.2 Interface Definition

<table>
<thead>
<tr>
<th>BYTE</th>
<th>BIT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>7 (MSB)</td>
</tr>
<tr>
<td>I²C slave address</td>
<td>L</td>
</tr>
<tr>
<td>I/O data bus</td>
<td>P7</td>
</tr>
</tbody>
</table>

---

Submit Documentation Feedback
8.3.3 Address Reference

<table>
<thead>
<tr>
<th>INPUTS</th>
<th>I²C BUS SLAVE 8-BIT READ ADDRESS</th>
<th>I²C BUS SLAVE 8-BIT WRITE ADDRESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>A2 A1 A0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L L L</td>
<td>65 (decimal), 41 (hexadecimal)</td>
<td>64 (decimal), 40 (hexadecimal)</td>
</tr>
<tr>
<td>L L H</td>
<td>67 (decimal), 43 (hexadecimal)</td>
<td>66 (decimal), 42 (hexadecimal)</td>
</tr>
<tr>
<td>L H L</td>
<td>69 (decimal), 45 (hexadecimal)</td>
<td>68 (decimal), 44 (hexadecimal)</td>
</tr>
<tr>
<td>L H H</td>
<td>71 (decimal), 47 (hexadecimal)</td>
<td>70 (decimal), 46 (hexadecimal)</td>
</tr>
<tr>
<td>H L L</td>
<td>73 (decimal), 49 (hexadecimal)</td>
<td>72 (decimal), 48 (hexadecimal)</td>
</tr>
<tr>
<td>H L H</td>
<td>75 (decimal), 4B (hexadecimal)</td>
<td>74 (decimal), 4A (hexadecimal)</td>
</tr>
<tr>
<td>H H L</td>
<td>77 (decimal), 4D (hexadecimal)</td>
<td>76 (decimal), 4C (hexadecimal)</td>
</tr>
<tr>
<td>H H H</td>
<td>79 (decimal), 4F (hexadecimal)</td>
<td>78 (decimal), 4E (hexadecimal)</td>
</tr>
</tbody>
</table>

8.4 Device Functional Modes

Figure 16 and Figure 17 show the address and timing diagrams for the write and read modes, respectively.

Figure 16. Write Mode (Output)
Device Functional Modes (continued)

A. A low-to-high transition of SDA while SCL is high is defined as the stop condition (P). The transfer of data can be stopped at any moment by a stop condition. When this occurs, data present at the latest ACK phase is valid (output mode). Input data is lost.

Figure 17. Read Mode (Input)
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

Figure 18 shows an application in which the PCF8574 device can be used.

9.2 Typical Application

Figure 18. Application Schematic

(1) The SCL and SDA pins must be tied directly to VCC because if SCL and SDA are tied to an auxiliary power supply that could be powered on while VCC is powered off, then the supply current, ICC, will increase as a result.

A. Device address is configured as 0100000 for this example.
B. P0, P2, and P3 are configured as outputs.
C. P1, P4, and P5 are configured as inputs.
D. P6 and P7 are not used and must be configured as outputs.
Typical Application (continued)

9.2.1 Design Requirements

9.2.1.1 Minimizing $I_{CC}$ When I/Os Control LEDs

When the I/Os are used to control LEDs, normally they are connected to $V_{CC}$ through a resistor as shown in Figure 18. For a P-port configured as an input, $I_{CC}$ increases as $V_i$ becomes lower than $V_{CC}$. The LED is a diode, with threshold voltage $V_T$, and when a P-port is configured as an input the LED will be off but $V_i$ is a $V_T$ drop below $V_{CC}$.

For battery-powered applications, it is essential that the voltage of P-ports controlling LEDs is greater than or equal to $V_{CC}$ when the P-ports are configured as input to minimize current consumption. Figure 19 shows a high-value resistor in parallel with the LED. Figure 20 shows $V_{CC}$ less than the LED supply voltage by at least $V_T$. Both of these methods maintain the I/O $V_i$ at or above $V_{CC}$ and prevents additional supply current consumption when the P-port is configured as an input and the LED is off.

![Figure 19. High-Value Resistor in Parallel With LED](image1)

![Figure 20. Device Supplied by a Lower Voltage](image2)
Typical Application (continued)

9.2.2 Detailed Design Procedure

The pull-up resistors, $R_{pu}$, for the SCL and SDA lines need to be selected appropriately and take into consideration the total capacitance of all slaves on the I²C bus. The minimum pull-up resistance is a function of $V_{CC}$, $V_{OL(max)}$, and $I_{OL}$:

$$R_{p(min)} = \frac{V_{CC} - V_{OL(max)}}{I_{OL}}$$

(1)

The maximum pull-up resistance is a function of the maximum rise time, $t_r$ (300 ns for fast-mode operation, $f_{SCL} = 400$ kHz) and bus capacitance, $C_b$:

$$R_{p(max)} = \frac{t_r}{0.8473 \times C_b}$$

(2)

The maximum bus capacitance for an I²C bus must not exceed 400 pF for standard-mode or fast-mode operation. The bus capacitance can be approximated by adding the capacitance of the PCF8574 device, $C_i$ for SCL or $C_{io}$ for SDA, the capacitance of wires/connections/traces, and the capacitance of additional slaves on the bus.

9.2.3 Application Curves

Figure 21. Maximum Pull-Up resistance ($R_{p(max)}$)
vs Bus Capacitance ($C_b$)

Figure 22. Minimum Pull-Up Resistance ($R_{p(min)}$)
vs Pull-Up Reference Voltage ($V_{CC}$)
10 Power Supply Recommendations

10.1 Power-On Reset Requirements

In the event of a glitch or data corruption, the PCF8574 device can be reset to its default conditions by using the power-on reset feature. Power-on reset requires that the device go through a power cycle to be completely reset. This reset also happens when the device is powered on for the first time in an application.

The two types of power-on reset are shown in Figure 23 and Figure 24.

![Figure 23. VCC is Lowered Below 0.2 V or 0 V and Then Ramped Up to VCC](image)

![Figure 24. VCC is Lowered Below the POR Threshold, Then Ramped Back Up to VCC](image)

Table 1 specifies the performance of the power-on reset feature for PCF8574 for both types of power-on reset.

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNIT</th>
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<td>ms</td>
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<tr>
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<td>100</td>
<td>ms</td>
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<td>VCC_TRR_POR50</td>
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<td>ms</td>
<td></td>
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<td>VCC_GH</td>
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<td></td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>VCC_GW</td>
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<tr>
<td>VPORF</td>
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<td>V</td>
<td></td>
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<tr>
<td>VPORR</td>
<td>1.033</td>
<td>1.428</td>
<td>V</td>
<td></td>
</tr>
</tbody>
</table>

(1) TA = –40°C to 85°C (unless otherwise noted)
Glitches in the power supply can also affect the power-on reset performance of this device. The glitch width ($V_{CC\_GW}$) and height ($V_{CC\_GH}$) are dependent on each other. The bypass capacitance, source impedance, and device impedance are factors that affect power-on reset performance. Figure 25 and Table 1 provide more information on how to measure these specifications.

![Figure 25. Glitch Width and Glitch Height](image)

$V_{POR}$ is critical to the power-on reset. $V_{POR}$ is the voltage level at which the reset condition is released and all the registers and the \(^{2}\)C/SMBus state machine are initialized to their default states. The value of $V_{POR}$ differs based on the $V_{CC}$ being lowered to or from 0. Figure 26 and Table 1 provide more details on this specification.

![Figure 26. $V_{POR}$](image)
11 Layout

11.1 Layout Guidelines

For printed circuit board (PCB) layout of the PCF8574 device, 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 I2C 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 PCF8574 device as possible. These best practices are shown in Figure 27.

For the layout example provided in Figure 27, it would be possible to fabricate a PCB with only 2 layers by using the top layer for signal routing and the bottom layer as a split plane for power (VCC) and ground (GND). However, a 4 layer board 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 VCC 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, but this technique is not demonstrated in Figure 27.
11.2 Layout Example

Figure 27. Layout Example for PCF8574
12 Device and Documentation Support

12.1 Trademarks
All trademarks are the property of their respective owners.

12.2 Electrostatic Discharge Caution

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

12.3 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>Eco Plan (2)</th>
<th>Lead finish/ Ball material (6)</th>
<th>MSL Peak Temp (3)</th>
<th>Op Temp (°C)</th>
<th>Device Marking (4/5)</th>
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<td>NIPDAU</td>
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<td>-40 to 85</td>
<td>PF574</td>
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(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

**REEL DIMENSIONS**

- **Reel Diameter**
- **Reel Width (W1)**

**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**

- **Q1**
- **Q2**
- **Q3**
- **Q4**

*All dimensions are nominal

---

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# TAPE AND REEL BOX DIMENSIONS

*All dimensions are nominal

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</table>
TUBE

T - Tube height

L - Tube length

W - Tube width

B - Alignment groove width

*All dimensions are nominal

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NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm per side.
5. Reference JEDEC registration MO-153.
NOTES: (continued)

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

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.
Images above are just a representation of the package family, actual package may vary. Refer to the product data sheet for package details.
NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. The package thermal pad must be soldered to the printed circuit board for thermal and mechanical performance.
NOTES: (continued)

4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/slua271).

5. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.
NOTES: (continued)

6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
This image is a representation of the package family, actual package may vary. Refer to the product data sheet for package details.
NOTES:

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SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL

EXPOSED PAD 21
78% PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE
SCALE: 20X

NOTES: (continued)

6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
This image is a representation of the package family, actual package may vary. Refer to the product data sheet for package details.
NOTES:

1. All linear dimensions are in millimeters. Dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm, per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm, per side.
5. Reference JEDEC registration MS-013.
NOTES: (continued)

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

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate
design recommendations.

9. Board assembly site may have different recommendations for stencil design.
N (R-PDIP-T**) PLASTIC DUAL-IN-LINE PACKAGE

16 PINS SHOWN

PINS ** DIM A MAX A MIN MS-001 VARIATION

<table>
<thead>
<tr>
<th>Pins</th>
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NOTES:

A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Falls within JEDEC MS-001, except 18 and 20 pin minimum body length (Dim A).
D. The 20 pin end lead shoulder width is vendor option, either half or full width.
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