TEXAS INSTRUMENTS

PCA9557

SCPS133J −DECEMBER 2005−REVISED JUNE 2014

PCA9557 Remote 8-Bit I^{2}C and SMBus Low-Power I/O Expander With Reset and Configuration Registers

1 Features

- Low Standby Current Consumption of 1 µA Max
- I^{2}C to Parallel Port Expander
- Operating Power-Supply Voltage Range of 2.3 V to 5.5 V
- 5-V Tolerant I/O Ports
- 400-kHz Fast I^{2}C Bus
- Three Hardware Address Pins Allow for Use of up to Eight Devices on I^{2}C/SMBus
- Lower-Voltage Higher-Performance Migration Path for PCA9556
- Input/Output Configuration Register
- Polarity Inversion Register
- Active-Low Reset Input
- Internal Power-On Reset
- High-Impedance Open Drain on P0
- Power Up With All Channels Configured as Inputs
- No Glitch on Power Up
- Noise Filter on SCL/SDA Inputs
- Latched Outputs With High Current Drive Maximum Capability for Directly Driving LEDs
- Latch-Up Performance Exceeds 100 mA Per JESD 78, Class II
- ESD Protection Exceeds JESD 22
  - 2000-V Human-Body Model (A114-A)
  - 200-V Machine Model (A115-A)
  - 1000-V Charged-Device Model (C101)

2 Description

This 8-bit I/O expander for the two-line bidirectional bus (I^{2}C) is designed for 2.3-V to 5.5-V V_{CC} operation. The device provides general-purpose remote I/O expansion for most microcontroller families via the I^{2}C interface [serial clock (SCL) and serial data (SDA)].

The PCA9557 consists of one 8-bit configuration (input or output selection), input port, output port, and polarity inversion (active-high) registers. At power on, the I/Os are configured as inputs. However, the system master can enable the I/Os as either inputs or outputs by writing to the I/O configuration bits. The data for each input or output is kept in the corresponding input or output register. The polarity of the input port register can be inverted with the polarity inversion register. All registers can be read by the system master.

The device outputs (latched) have high-current drive capability for directly driving LEDs. The device has low current consumption.

Device Information[1]

PART NUMBEr	PACKAGE	BODY SIZE (NOM)
PCA9557	SSOP (16)	6.20 mm × 5.30 mm
	VQFN (16)	4.00 mm × 4.00 mm

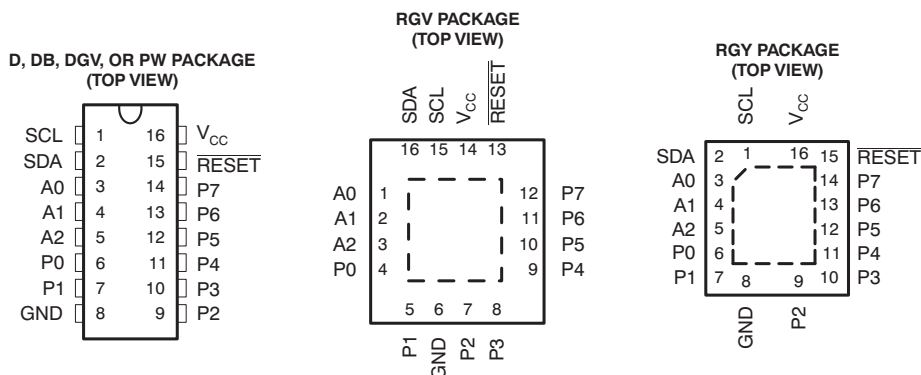(1) For all available packages, see the orderable addendum at the end of the datasheet.

D, DB, DGV, OR PW PACKAGE (TOP VIEW)

SCL	1	16	V_{CC}
SDA	2	15	$\overline{RESET}$
A0	3	14	P7
A1	4	13	P6
A2	5	12	P5
P0	6	11	P4
P1	7	10	P3
GND	8	9	P2

RGV PACKAGE (TOP VIEW)

RGY PACKAGE (TOP VIEW)

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3 Revision History

Changes from Revision I (June 2008) to Revision J   **Page**

- Added $\overline{\text{RESET}}$ Errata section. 14
- Added Power-On Reset Errata section. 22

Product Folder Links: *PCA9557*

4 Description (Continued)

The system master can reset the PCA9557 in the event of a timeout or other improper operation by asserting a low in the active-low reset (RESET) input. The power-on reset puts the registers in their default state and initializes the I²C/SMBus state machine. Asserting RESET causes the same reset/initialization to occur without depowering the part.

Three hardware pins (A0, A1, and A2) are used to program and vary the fixed I²C address, allowing up to eight devices to share the same I²C bus or SMBus.

5 Pin Configuration and Functions
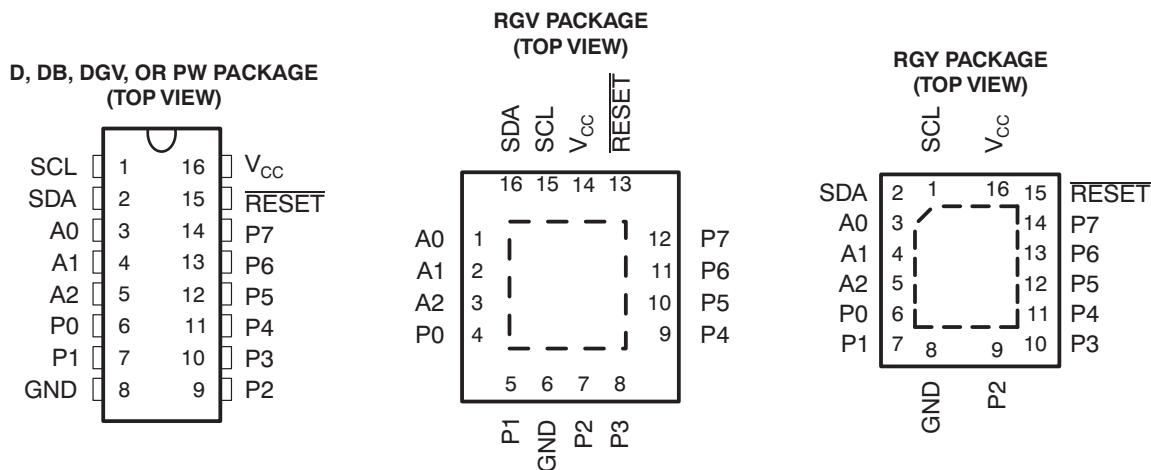
Pin Functions

PIN			DESCRIPTION
NAME	**QFN (RGY) SOIC (D), SSOP (DB), TSSOP (PW), AND TVSOP (DGV)**	**QFN (RGV)**	
SCL	1	15	Serial clock bus. Connect to V_{CC} through a pullup resistor.
SDA	2	16	Serial data bus. Connect to V_{CC} through a pullup resistor.
A0	3	1	Address input. Connect directly to V_{CC} or ground.
A1	4	2	Address input. Connect directly to V_{CC} or ground.
A2	5	3	Address input. Connect directly to V_{CC} or ground.
P0	6	4	P-port input/output. High impedance open-drain design structure. Connect to V_{CC} through a pullup resistor.
P1	7	5	P-port input/output. Push-pull design structure.
GND	8	6	Ground
P2	9	7	P-port input/output. Push-pull design structure.
P3	10	8	P-port input/output. Push-pull design structure.
P4	11	9	P-port input/output. Push-pull design structure.
P5	12	10	P-port input/output. Push-pull design structure.
P6	13	11	P-port input/output. Push-pull design structure.
P7	14	12	P-port input/output. Push-pull design structure.
RESET	15	13	Active-low reset input. Connect to V_{CC} through a pullup resistor if no active connection is used.
V_{CC}	16	14	Supply voltage

6 Specifications

6.1 Absolute Maximum Ratings[(1)]

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

			MIN	MAX	UNIT
V_{CC}	Supply voltage range		−0.5	6	V
V_I	Input voltage range[(2)]		−0.5	6	V
V_O	Output voltage range[(2)]		−0.5	6	V
I_{IK}	Input clamp current	$V_I < 0$		−20	mA
I_{OK}	Output clamp current	$V_O < 0$		−20	mA
I_{IOK}	Input/output clamp current	$V_O < 0$ or $V_O > V_{CC}$		−20	µA
I_{OL}	Continuous output low current	$V_O = 0$ to V_{CC}		50	mA
I_{OH}	Continuous output high current	$V_O = 0$ to V_{CC}		−50	mA
I_{CC}	Continuous current through GND			−250	mA
	Continuous current through V_{CC}			160	
θ_{JA}	Package thermal impedance[(3)]	D package		73	°C/W
		DB package		82	
		DGV package		120	
		PW package		108	
		RGV package		51	
		RGY package		47	

(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.
(3) The package thermal impedance is calculated in accordance with JESD 51-7.

6.2 Handling Ratings

			MIN	MAX	UNIT
T_{stg}	Storage temperature range		−65	150	°C
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001, all pins[(1)]	0	2000	V
		Charged device model (CDM), per JEDEC specification JESD22-C101, all pins[(2)]	0	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.

6.3 Recommended Operating Conditions

			MIN	MAX	UNIT
V_{CC}	Supply voltage		2.3	5.5	V
V_{IH}	High-level input voltage	SCL, SDA	$0.7 \times V_{CC}$	5.5	V
		A2–A0, P7–P0, $\overline{RESET}$	2	5.5	
V_{IL}	Low-level input voltage	SCL, SDA	−0.5	$0.3 \times V_{CC}$	V
		A2–A0, P7–P0, $\overline{RESET}$	−0.5	0.8	
I_{OH}	High-level output current	P7–P1		−10	mA
I_{OL}	Low-level output current	P7–P0		25	mA
T_A	Operating free-air temperature		−40	85	°C

6.4 Electrical Characteristics

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

PARAMETER		TEST CONDITIONS	V_{CC}	MIN	TYP[1]	MAX	UNIT
V_{IK}	Input diode clamp voltage	$I_I = -18$ mA	2.3 V to 5.5 V	−1.2			V
V_{POR}	Power-on reset voltage	$V_I = V_{CC}$ or GND, $I_O = 0$	V_{POR}		1.65	2.1	V
V_{OH}	P-port high-level output voltage[2]	$I_{OH} = -8$ mA	2.3 V	1.8			V
			3 V	2.6			
			4.5 V	3			
			4.75 V	4.1			
		$I_{OH} = -10$ mA	2.3 V	1.5			
			3 V	2.5			
			4.5 V	3			
			4.75 V	4			
I_{OL}	SDA	$V_{OL} = 0.4$ V	2.3 V to 5.5 V	3			mA
	P port[3]	$V_{OL} = 0.5$ V	2.3 V to 5.5 V	8	20		
		$V_{OL} = 0.55$ V		8	20		
		$V_{OL} = 0.7$ V		10	24		
I_{OH}	P port, except for P0[3]	$V_{OH} = 2.3$ V	2.3 V to 5.5 V	−4			mA
	P0[3]	$V_{OH} = 4.6$ V	4.6 V to 5.5 V			1	µA
		$V_{OH} = 3.3$ V	3.3 V to 5.5 V			1	
I_I	SCL, SDA	$V_I = V_{CC}$ or GND	2.3 V to 5.5 V			±1	µA
	A2–A0, $\overline{RESET}$					±1	
I_{IH}	P port	$V_I = V_{CC}$	2.3 V to 5.5 V			1	µA
I_{IL}	P port	$V_I = $ GND	2.3 V to 5.5 V			1	µA
I_{CC}	Operating mode	$V_I = V_{CC}$ or GND, $I_O = 0$, I/O = inputs, $f_{SCL} = 400$ kHz	5.5 V		19	25	µA
			3.6 V		12	22	
			2.7 V		8	20	
		$V_I = V_{CC}$ or GND, $I_O = 0$, I/O = inputs, $f_{SCL} = 100$ kHz	5.5 V		1.5	5	
			3.6 V		1	4	
			2.7 V		0.6	3	
	Standby mode	$V_I = V_{CC}$ or GND, $I_O = 0$, I/O = inputs, $f_{SCL} = 0$ kHz	5.5 V		0.25	1	
			3.6 V		0.25	0.9	
			2.7 V		0.2	0.8	
ΔI_{CC}	Additional current in Standby mode	One input at $V_{CC} - 0.6$ V, Other inputs at V_{CC} or GND	2.3 V to 5.5 V			0.2	mA
		Every LED I/O at $V_I = 4.3$ V, $f_{SCL} = 0$ kHz	5.5 V			0.4	
C_I	SCL	$V_I = V_{CC}$ or GND	2.3 V to 5.5 V		4	6	pF
C_{io}	SDA	$V_{IO} = V_{CC}$ or GND	2.3 V to 5.5 V		5.5	8	pF
	P port				7.5	9.5	

(1) All typical values are at nominal supply voltage (2.5-V, 3.3-V, or 5-V V_{CC}) and $T_A = 25°C$.
(2) The total current sourced by all I/Os must be limited to 85 mA per bit.
(3) Each I/O must be externally limited to a maximum of 25 mA, and the P port (P7–P0) must be limited to a maximum current of 200 mA.

Product Folder Links: PCA9557

6.5 I²C Interface Timing Requirements

over recommended operating free-air temperature range (unless otherwise noted) (see Figure 13)

		STANDARD MODE I²C BUS		FAST MODE I²C BUS		UNIT
		MIN	MAX	MIN	MAX	
t_{scl}	I²C clock frequency	0	100	0	400	kHz
t_{sch}	I²C clock high time	4		0.6		µs
t_{scl}	I²C clock low time	4.7		1.3		µs
t_{sp}	I²C spike time		50		50	ns
t_{sds}	I²C serial data setup time	250		100		ns
t_{sdh}	I²C serial data hold time	0		0		ns
t_{icr}	I²C input rise time		1000	$20 + 0.1C_b$ [1]	300	ns
t_{icf}	I²C input fall time		300	$20 + 0.1C_b$ [1]	300	ns
t_{ocf}	I²C output fall time, 10-pF to 400-pF bus		300	$20 + 0.1C_b$ [1]	300	ns
t_{buf}	I²C bus free time between Stop and Start	4.7		1.3		µs
t_{sts}	I²C Start or repeated Start condition setup time	4.7		0.6		µs
t_{sth}	I²C Start or repeated Start condition hold time	4		0.6		µs
t_{sps}	I²C Stop condition setup time	4		0.6		µs
$t_{vd(data)}$	Valid data time, SCL low to SDA output valid		1		0.9	µs
$t_{vd(ack)}$	Valid data time of ACK condition, ACK signal from SCL low to SDA (out) low		1		0.9	µs
C_b	I²C bus capacitive load		400		400	pF

(1) C_b = total capacitance of one bus line in pF

6.6 Reset Timing Requirements

over recommended operating free-air temperature range (unless otherwise noted) (see Figure 15)

		STANDARD MODE I²C BUS		FAST MODE I²C BUS		UNIT
		MIN	MAX	MIN	MAX	
t_W	Reset pulse duration[1]	16		16		ns
t_{REC}	Reset recovery time	0		0		ns
t_{RESET}	Time to reset[2]	400		400		ns

(1)   A pulse duration of 16 ns minimum must be applied to $\overline{RESET}$ to return the PCA9557 to its default state.
(2)   The PCA9557 requires a minimum of 400 ns to be reset.

6.7 Switching Characteristics

over recommended operating free-air temperature range (unless otherwise noted) (see Figure 13)

PARAMETER		FROM	TO	STANDARD MODE I²C BUS		FAST MODE I²C BUS		UNIT
				MIN	MAX	MIN	MAX	
t_{pv}	Output data valid	SCL	P0		250		250	ns
		SCL	P1–P7		200		200	
t_{ps}	Input data setup time	P port	SCL	0		0		ns
t_{ph}	Input data hold time	P port	SCL	200		200		ns

Product Folder Links: *PCA9557*
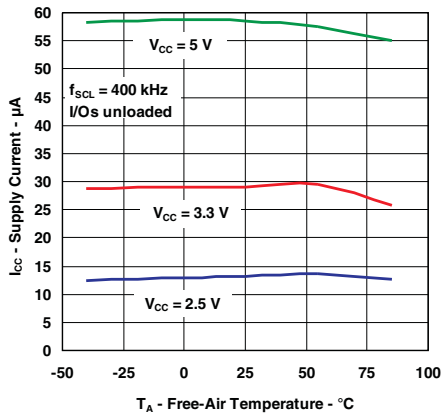
6.8 Typical Characteristics

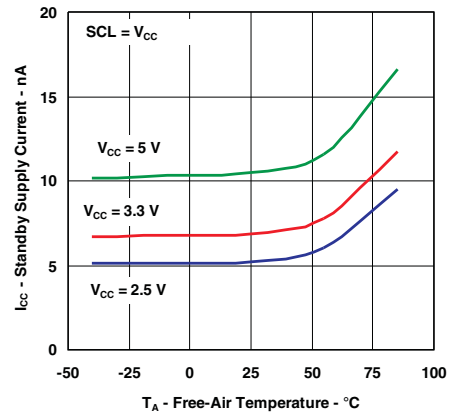Figure 1. Supply Current vs Temperature

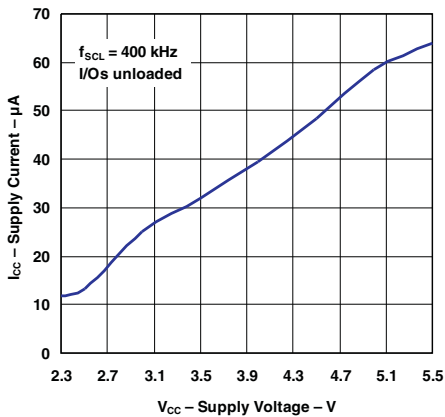Figure 2. Standby Supply Current vs Temperature
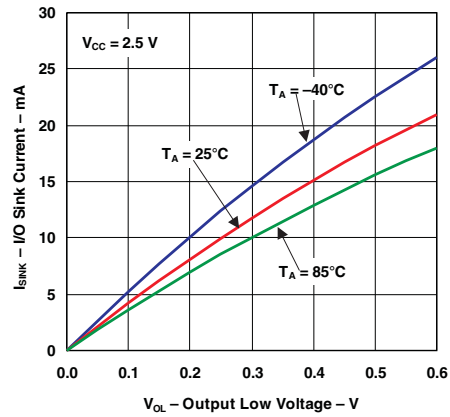

Figure 3. Supply Current vs Supply Voltage
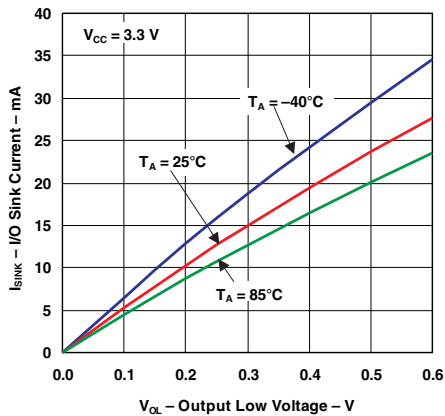

Figure 4. I/O Sink Current vs Output Low Voltage
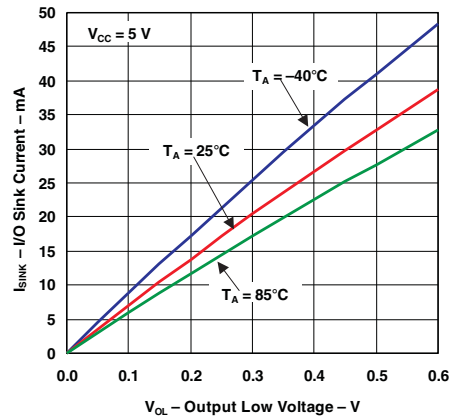

Figure 5. I/O Sink Current vs Output Low Voltage
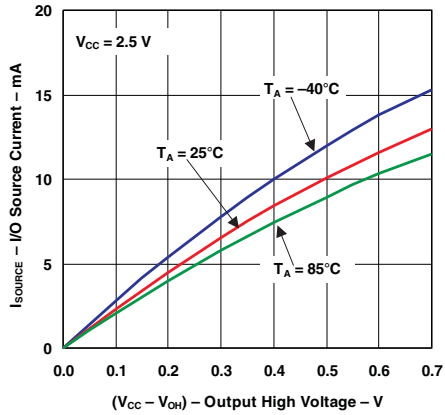

Figure 6. I/O Sink Current vs Output Low Voltage

Product Folder Links: PCA9557

Typical Characteristics (continued)

Figure 7. I/O Source Current vs Output High Voltage (P7–P1)
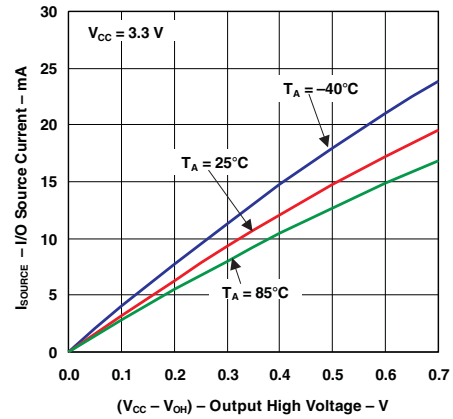
Figure 8. I/O Source Current vs Output High Voltage (P7–P1)
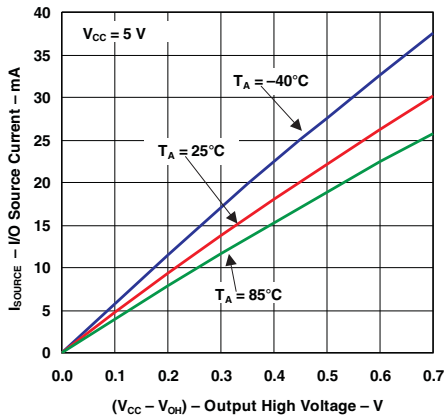
Figure 9. I/O Source Current vs Output High Voltage (P7–P1)
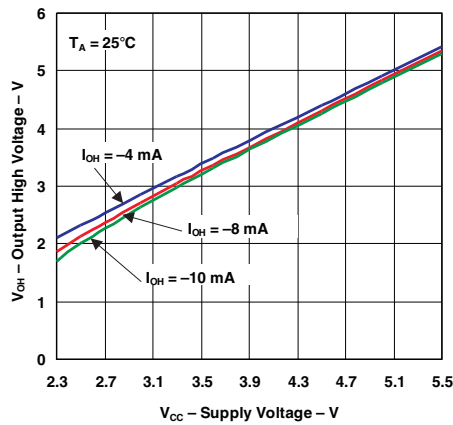
Figure 10. Output High Voltage vs Supply Voltage (P7–P1)
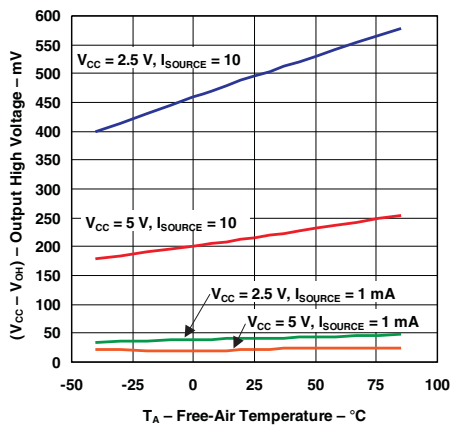
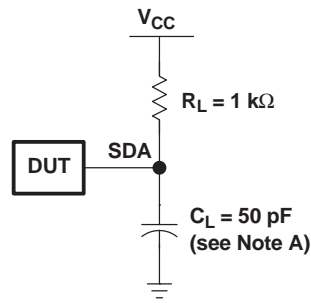**Figure 11. Output High Voltage vs Temperature (P7–P1)**
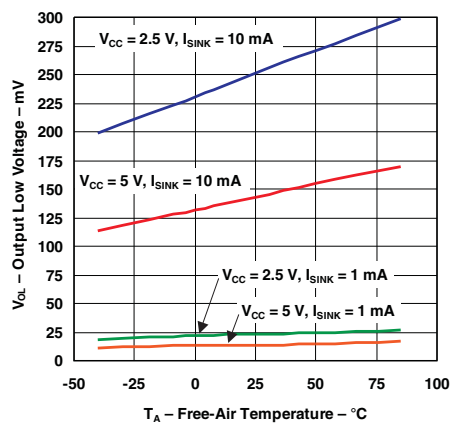
Figure 12. Output Low Voltage vs Temperature

Product Folder Links: *PCA9557*

7 Parameter Measurement Information

SDA LOAD CONFIGURATION

VOLTAGE WAVEFORMS
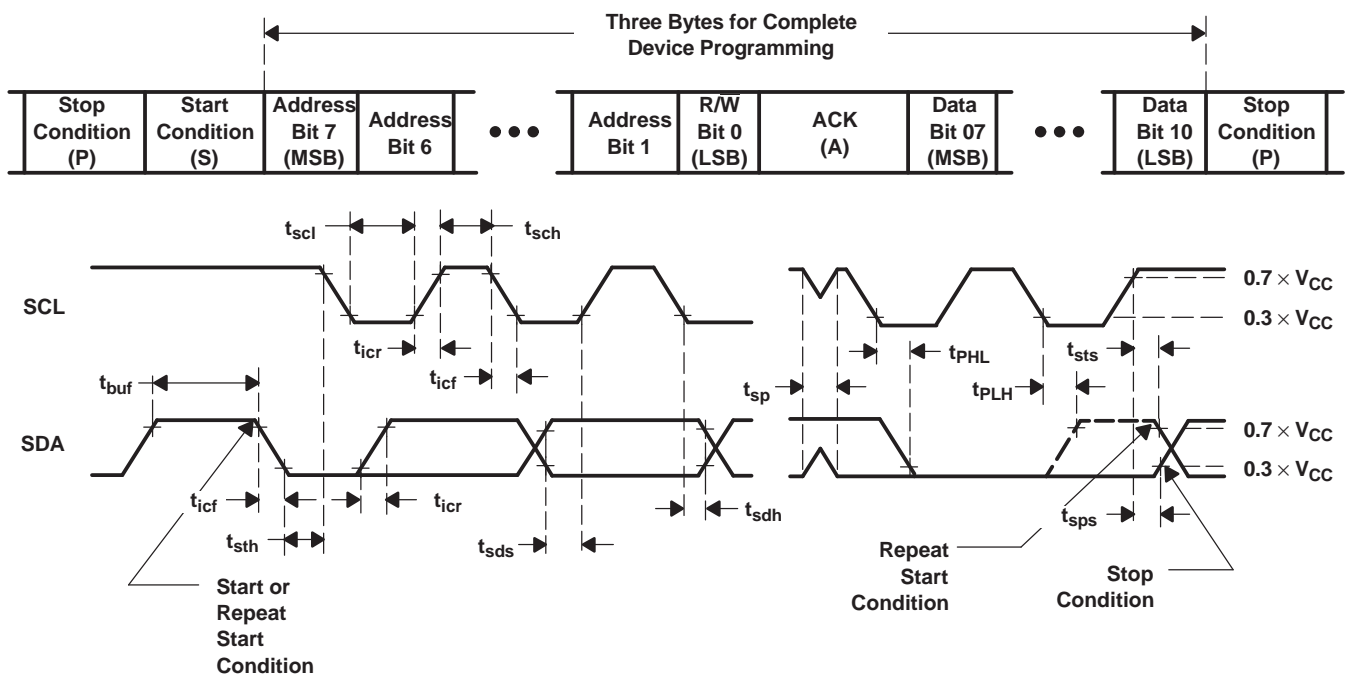
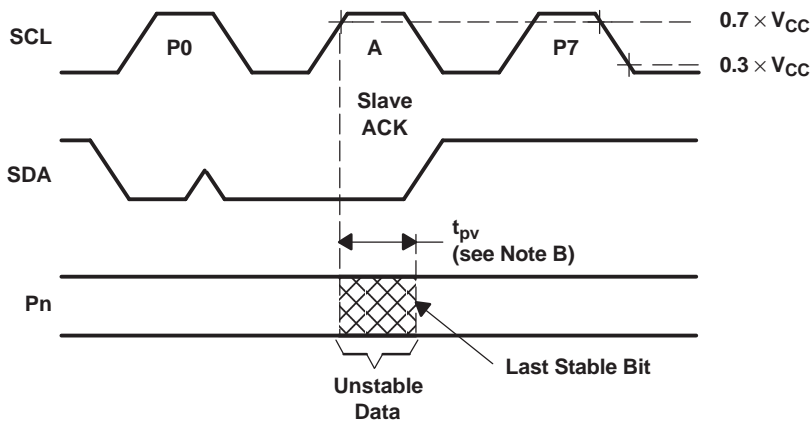| BYTE	DESCRIPTION
1	I^{2}C address
2, 3	P-port data

A. C$_L$ includes probe and jig capacitance.

B. All inputs are supplied by generators having the following characteristics: PRR ≤ 10 MHz, Z$_O$ = 50 Ω, t$_r$/t$_f$ ≤ 30 ns.

C. All parameters and waveforms are not applicable to all devices.

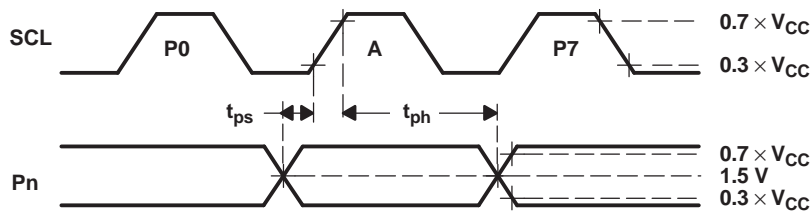**Figure 13. I^{2}C Interface Load Circuit And Voltage Waveforms**

Parameter Measurement Information (continued)
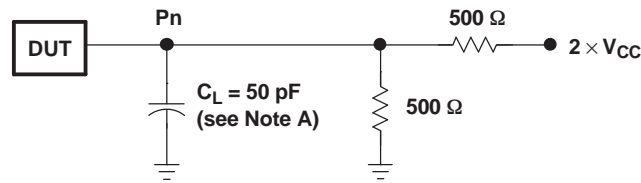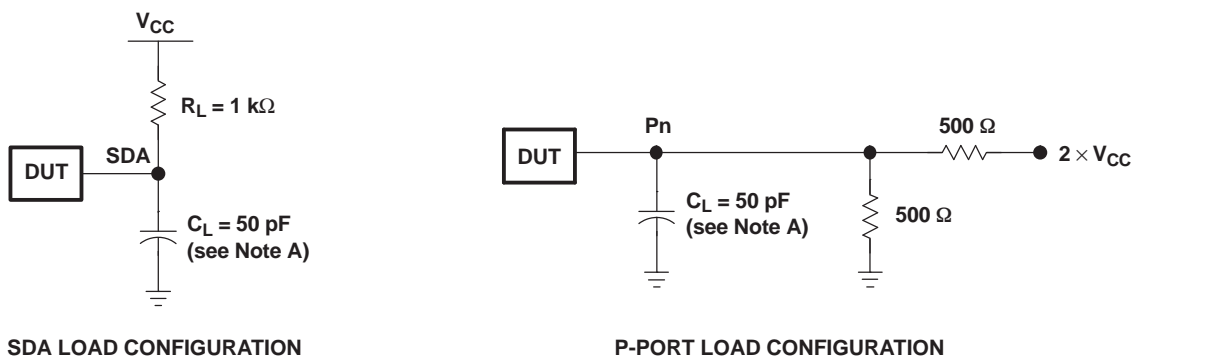

P-PORT LOAD CONFIGURATION

WRITE MODE (R/$\overline{W}$ = 0)

READ MODE (R/$\overline{W}$ = 1)

A. C_L includes probe and jig capacitance.

B. t_{pv} is measured from $0.7 \times V_{CC}$ on SCL to 50% I/O (Pn) output.

C.   All inputs are supplied by generators having the following characteristics: PRR ≤ 10 MHz, Z_O = 50 Ω, t_r/t_f ≤ 30 ns.

D.   The outputs are measured one at a time, with one transition per measurement.

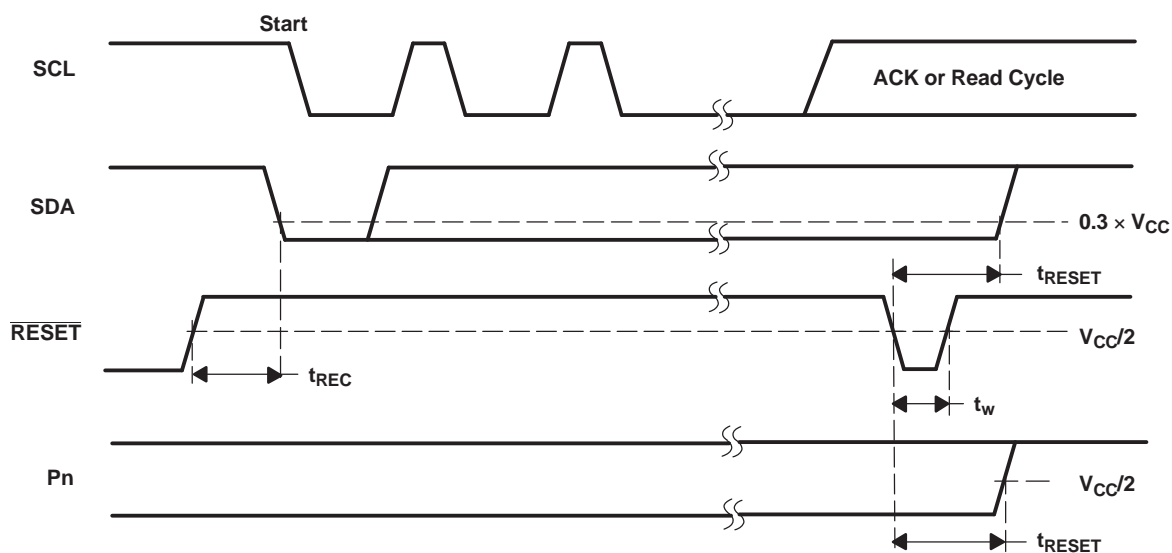E.   All parameters and waveforms are not applicable to all devices.

Figure 14. P-Port Load Circuit And Voltage Waveforms

Product Folder Links: *PCA9557*

Parameter Measurement Information (continued)


SDA LOAD CONFIGURATION

P-PORT LOAD CONFIGURATION

A. C_L includes probe and jig capacitance.

B. All inputs are supplied by generators having the following characteristics: PRR ≤ 10 MHz, Z_O = 50 Ω, t_r/t_f ≤ 30 ns.

C. I/Os are configured as inputs.

D. All parameters and waveforms are not applicable to all devices.

Figure 15. Reset Load Circuits And Voltage Waveforms
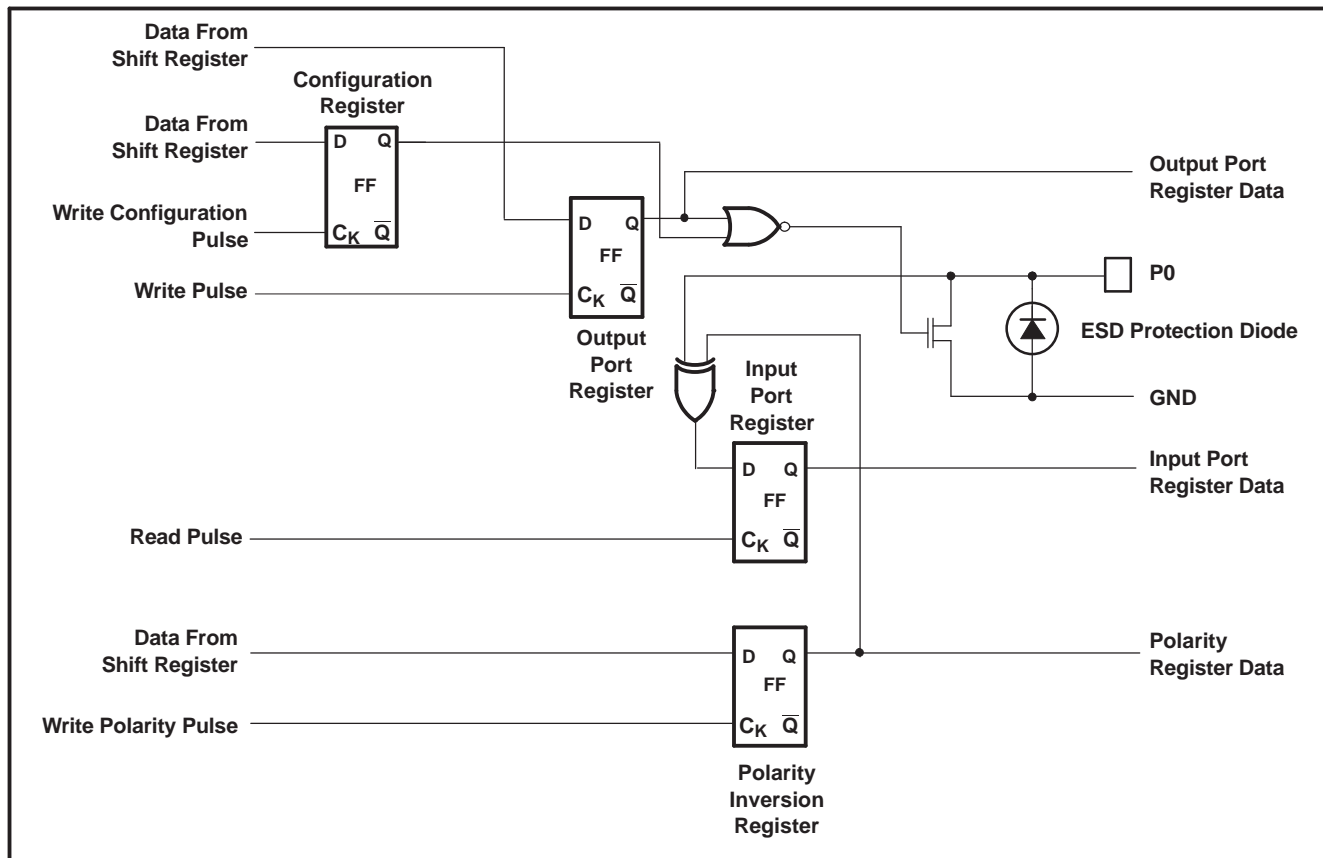
8 Detailed Description

8.1 Functional Block Diagram
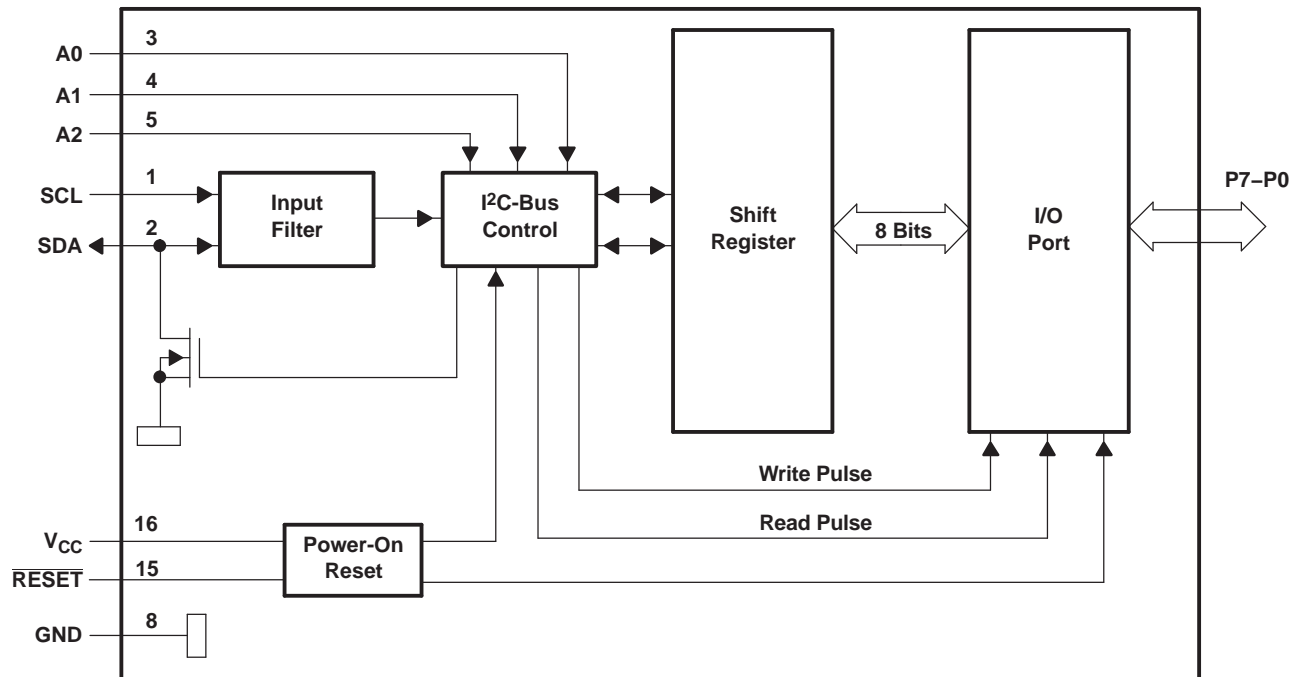
A. Pin numbers shown are for the D, DB, DGV, PW, and RGY packages.

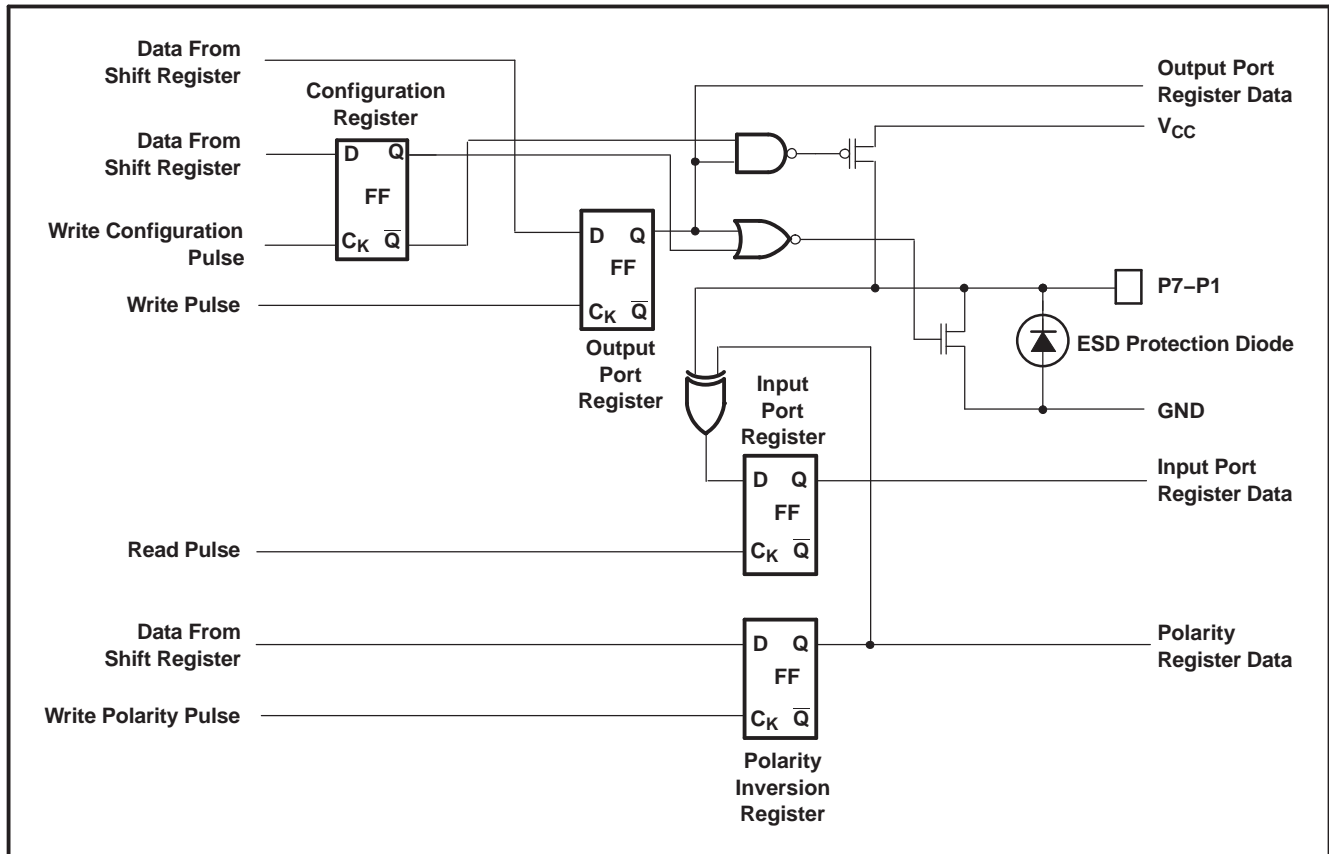B. All I/Os are set to inputs at reset.

Figure 16. Logic Diagram (Positive Logic)

Functional Block Diagram (continued)

A.   On power up or reset, all registers return to default values.

Figure 17. Simplified Schematic Diagram Of P0

Functional Block Diagram (continued)

A. On power up or reset, all registers return to default values.

Figure 18. Simplified Schematic Diagram Of P7−P1

8.2 Device Functional Modes

8.2.1 $\overline{\text{RESET}}$

A reset can be accomplished by holding the $\overline{\text{RESET}}$ pin low for a minimum of t_W. The PCA9557 registers and I^{2}C/SMBus state machine are held in their default states until $\overline{\text{RESET}}$ again is high. This input requires a pullup resistor to V_{CC} if no active connection is used.

8.2.1.1 $\overline{\text{RESET}}$ Errata

If $\overline{\text{RESET}}$ voltage set higher than VCC, current will flow from $\overline{\text{RESET}}$ pin to VCC pin.

System Impact

VCC will be pulled above its regular voltage level.

System Workaround

Design such that $\overline{\text{RESET}}$ voltage is same or lower than VCC.

Device Functional Modes (continued)

8.2.2 Power-On Reset

When power (from 0 V) is applied to V_{CC}, an internal power-on reset holds the PCA9557 in a reset condition until V_{CC} has reached V_{POR}. At that time, the reset condition is released, and the PCA9557 registers and I²C/SMBus state machine initialize to their default states. After that, V_{CC} must be lowered to below 0.2 V and back up to the operating voltage for a power-reset cycle. The $\overline{\text{RESET}}$ input can be asserted to reset the system, while keeping the V_{CC} at its operating level.

Refer to the *Power-On Reset Errata* section.

8.3 Programming

8.3.1 I²C Interface

The bidirectional I²C bus consists of the serial clock (SCL) and serial data (SDA) lines. Both lines must be connected to a positive supply through a pullup resistor when connected to the output stages of a device. Data transfer may be initiated only when the bus is not busy.

I²C communication with this device is initiated by a master sending a start condition, a high-to-low transition on the SDA input/output while the SCL input is high (see Figure 19). After the start condition, the device address byte is sent, most-significant bit (MSB) first, including the data direction bit (R/$\overline{\text{W}}$).

After receiving the valid address byte, this device responds with an acknowledge (ACK), a low on the SDA input/output during the high of the ACK-related clock pulse. The address (A2–A0) inputs of the slave device must not be changed between the start and the stop conditions.

On the I²C bus, only one data bit is transferred during each clock pulse. The data on the SDA line must remain stable during the high pulse of the clock period, as changes in the data line at this time are interpreted as control commands (start or stop) (see Figure 20).

A stop condition, a low-to-high transition on the SDA input/output while the SCL input is high, is sent by the master (see Figure 19).

Any number of data bytes can be transferred from the transmitter to the receiver between the Start and the Stop conditions. Each byte of eight bits is followed by one ACK bit. The transmitter must release the SDA line before the receiver can send an ACK bit. The device that acknowledges must pull down the SDA line during the ACK clock pulse, so that the SDA line is stable low during the high pulse of the ACK-related clock period (see Figure 21). When a slave receiver is addressed, it must generate an ACK after each byte is received. Similarly, the master must generate an ACK after each byte that it receives from the slave transmitter. Setup and hold times must be met to ensure proper operation.

A master receiver signals an end of data to the slave transmitter by not generating an acknowledge (NACK) after the last byte has been clocked out of the slave. This is done by the master receiver by holding the SDA line high. In this event, the transmitter must release the data line to enable the master to generate a stop condition.
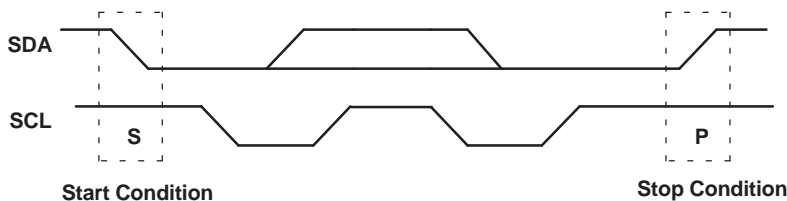

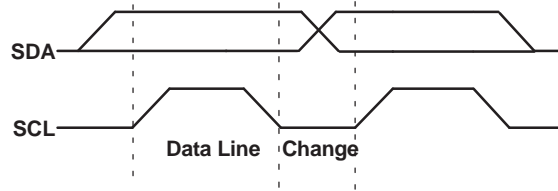**Figure 19. Definition Of Start And Stop Conditions**

Product Folder Links: *PCA9557*

Programming (continued)

Figure 20. Bit Transfer
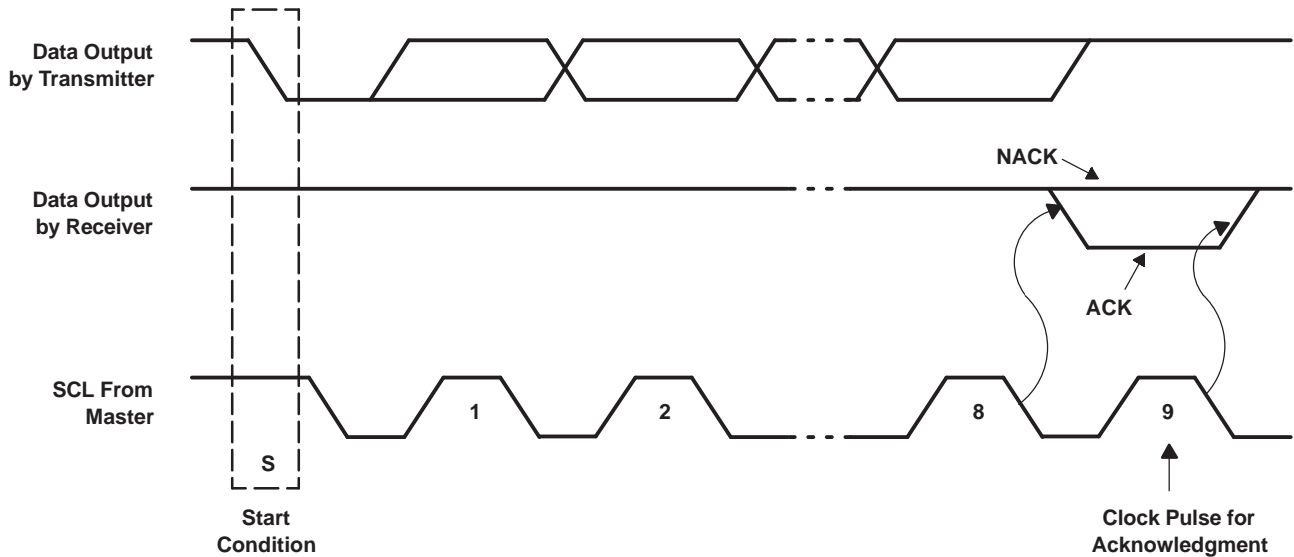
Figure 21. Acknowledgment On The I²C Bus

8.3.2 Register Map

Table 1. Interface Definition

BYTE	BIT							
	7 (MSB)	**6**	**5**	**4**	**3**	**2**	**1**	**0 (LSB)**
I²C slave address	L	L	H	H	A2	A1	A0	R/$\overline{W}$
Px I/O data bus	P7	P6	P5	P4	P3	P2	P1	P0

8.3.2.1 Device Address

The address of the PCA9557 is shown in Figure 22.
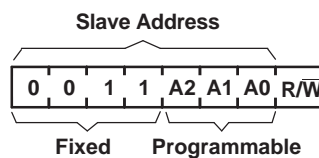
Figure 22. Pca9557 Address

Table 2. Address Reference

INPUTS			I²C BUS SLAVE ADDRESS
A2	A1	A0	
L	L	L	24 (decimal), 18 (hexadecimal)
L	L	H	25 (decimal), 19 (hexadecimal)
L	H	L	26 (decimal), 1A (hexadecimal)
L	H	H	27 (decimal), 1B (hexadecimal)
H	L	L	28 (decimal), 1C (hexadecimal)
H	L	H	29 (decimal), 1D (hexadecimal)
H	H	L	30 (decimal), 1E (hexadecimal)
H	H	H	31 (decimal), 1F (hexadecimal)

The last bit of the slave address defines the operation (read or write) to be performed. A high (1) selects a read operation, while a low (0) selects a write operation.

8.3.2.2 Control Register And Command Byte

Following the successful acknowledgment of the address byte, the bus master sends a command byte that is stored in the control register in the PCA9557. Two bits of this data byte state the operation (read or write) and the internal registers (input, output, polarity inversion or configuration) that will be affected. This register can be written or read through the I²C bus. The command byte is sent only during a write transmission.

Once a new command byte has been sent, the register that was addressed continues to be accessed by reads until a new command byte has been sent.

0	0	0	0	0	0	B1	B0
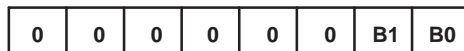
Figure 23. Control Register Bits

Table 3. Command Byte

CONTROL REGISTER BITS		COMMAND BYTE (HEX)	REGISTER	PROTOCOL	POWER-UP DEFAULT
B1	B0				
0	0	0x00	Input Port	Read byte	xxxx xxxx
0	1	0x01	Output Port	Read/write byte	0000 0000
1	0	0x02	Polarity Inversion	Read/write byte	1111 0000
1	1	0x03	Configuration	Read/write byte	1111 1111

Product Folder Links: PCA9557

8.3.2.3 Register Descriptions

The input port register (register 0) reflects the incoming logic levels of the pins, regardless of whether the pin is defined as an input or an output by the configuration register. It only acts on read operation. Writes to these registers have no effect. The default value, X, is determined by the externally applied logic level.

Before a read operation, a write transmission is sent with the command byte to signal the I²C device that the input port register will be accessed next.

Table 4. Register 0 (Input Port Register)

BIT	I7	I6	I5	I4	I3	I2	I1	I0
DEFAULT	X	X	X	X	X	X	X	X

The output port register (register 1) shows the outgoing logic levels of the pins defined as outputs by the configuration register. Bit values in this register have no effect on pins defined as inputs. In turn, reads from this register reflect the value that is in the flip-flop controlling the output selection, not the actual pin value.

Table 5. Register 1 (Output Port Register)

BIT	O7	O6	O5	O4	O3	O2	O1	O0
DEFAULT	0	0	0	0	0	0	0	0

The polarity inversion register (register 2) allows polarity inversion of pins defined as inputs by the configuration register. If a bit in this register is set (written with 1), the corresponding port pin's polarity is inverted. If a bit in this register is cleared (written with a 0), the corresponding port pin's original polarity is retained.

Table 6. Register 2 (Polarity Inversion Register)

BIT	N7	N6	N5	N4	N3	N2	N1	N0
DEFAULT	1	1	1	1	0	0	0	0

The configuration register (register 3) configures the directions of the I/O pins. If a bit in this register is set to 1, the corresponding port pin is enabled as an input with high impedance output driver. If a bit in this register is cleared to 0, the corresponding port pin is enabled as an output.

Table 7. Register 3 (Configuration Register)

BIT	C7	C6	C5	C4	C3	C2	C1	C0
DEFAULT	1	1	1	1	1	1	1	1

Product Folder Links: *PCA9557*

8.4 Bus Transactions

Data is exchanged between the master and PCA9557 through write and read commands.

8.4.1 Writes

Data is transmitted to the PCA9557 by sending the device address and setting the least-significant bit (LSB) to a logic 0 (see Figure 22 for device address). The command byte is sent after the address and determines which register receives the data that follows the command byte. There is no limitation on the number of data bytes sent in one write transmission (see Figure 24 and Figure 25).
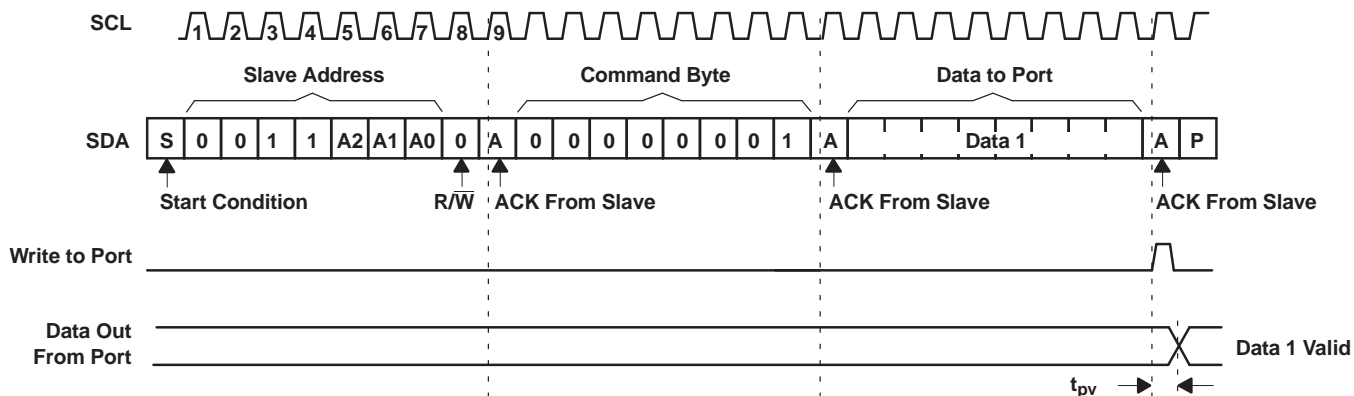
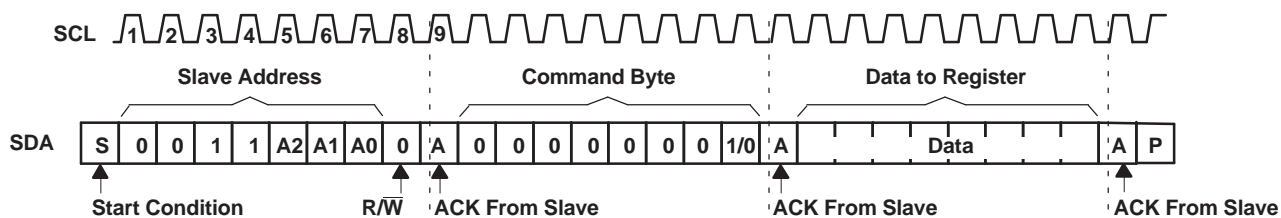**Figure 24. Write To Output Port Register**

Figure 25. Write To Configuration Or Polarity Inversion Registers

Bus Transactions (continued)

8.4.2 Reads

The bus master first must send the PCA9557 address with the LSB set to a logic 0 (see Figure 22 for device address). The command byte is sent after the address and determines which register is accessed. After a restart, the device address is sent again but, this time, the LSB is set to a logic 1. Data from the register defined by the command byte then is sent by the PCA9557 (see Figure 26 and Figure 27). After a restart, the value of the register defined by the command byte matches the register being accessed when the restart occurred. Data is clocked into the register on the rising edge of the ACK clock pulse. There is no limitation on the number of data bytes received in one read transmission, but when the final byte is received, the bus master must not acknowledge the data.
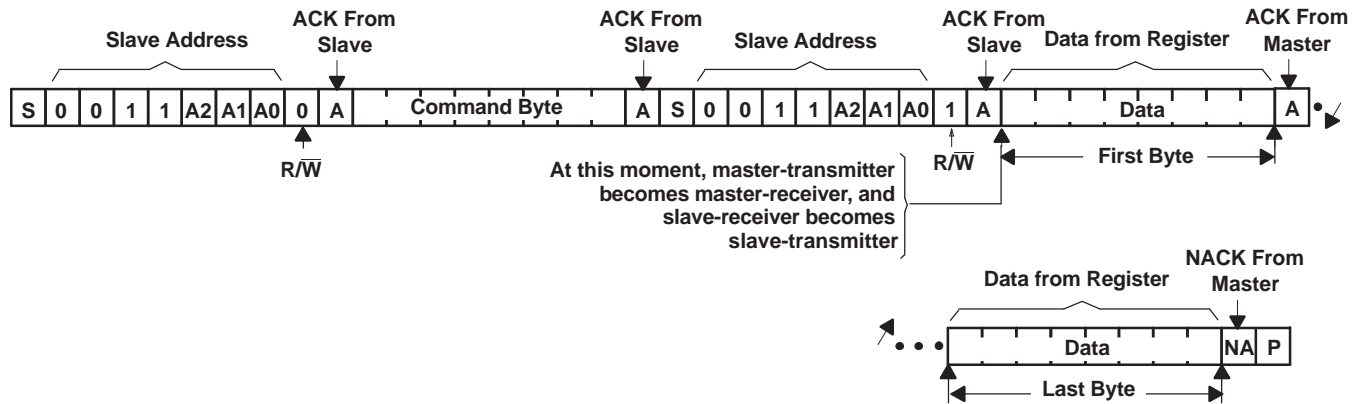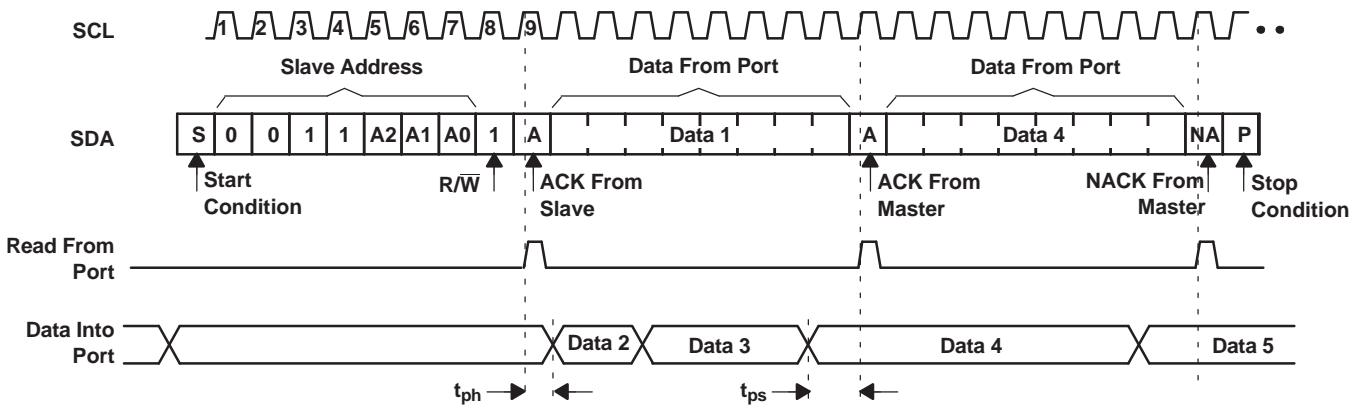
Figure 26. Read From Register

Figure 27. Read Input Port Register

A. This figure assumes the command byte has been previously programmed with 00h.

B. Transfer of data can be stopped at any moment by a stop condition. When this occurs, data present at the last acknowledge phase is valid (output mode). Input data is lost.

C. This figure eliminates the command byte transfer, a restart, and slave address call between the initial slave address call and actual data transfer from the P port (see Figure 26).
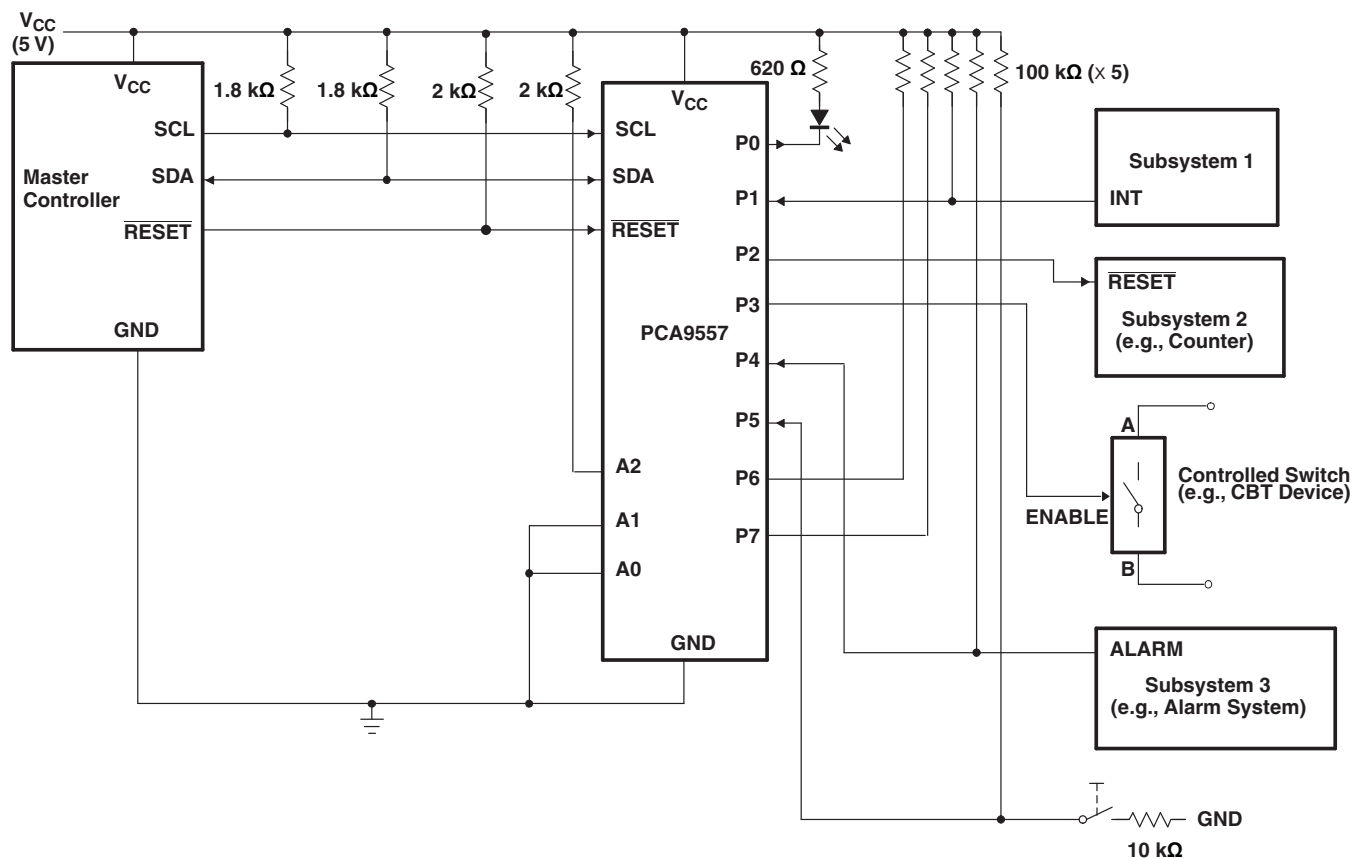
Product Folder Links: *PCA9557*

9 Application And Implementation

9.1 Application Information

9.2 Typical Application

Figure 28 shows an application in which the PCA9557 can be used.

A.   Device address is configured as 0011100 for this example.

B.   P1, P4, and P5 are configured as inputs.

C.   P0, P2, and P3 are configured as outputs.

D.   P6 and P7 are not used and must be configured as outputs.

Figure 28. Typical Application

9.2.1 Design Requirements

9.2.1.1 Minimizing I_{CC} When I/O Is Used To Control Led

When an I/O is used to control an LED, normally it is connected to V_{CC} through a resistor as shown in Figure 28. The LED acts as a diode so, when the LED is off, the I/O V_{IN} is about 1.2 V less than V_{CC}. The ΔI_{CC} parameter in *Electrical Characteristics* shows how I_{CC} increases as V_{IN} becomes lower than V_{CC}. Designs needing to minimize current consumption, such as battery power applications, should consider maintaining the I/O pins greater than or equal to V_{CC} when the LED is off.

Figure 29 shows a high-value resistor in parallel with the LED. Figure 30 shows V_{CC} less than the LED supply voltage by at least 1.2 V. Both of these methods maintain the I/O V_{IN} at or above V_{CC} and prevent additional supply-current consumption when the LED is off.

Typical Application (continued)
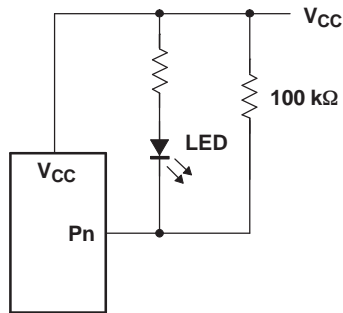
Figure 29. High-Value Resistor In Parallel With The Led
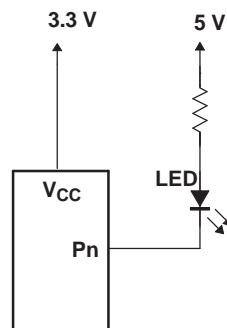
Figure 30. Device Supplied By A Low Voltage

10 Power Supply Recommendations

10.1 Power-On Reset Errata

A power-on reset condition can be missed if the VCC ramps are outside specification listed below.
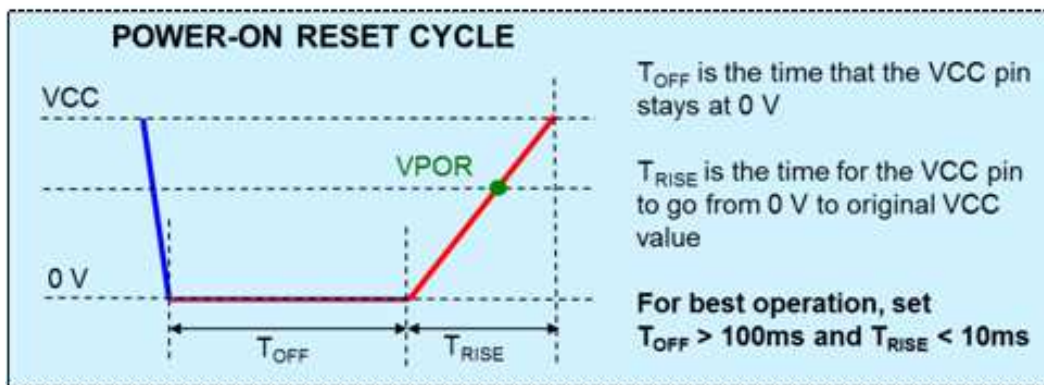
System Impact

If ramp conditions are outside timing allowances above, POR condition can be missed, causing the device to lock up.

Product Folder Links: *PCA9557*

11 Device and Documentation Support

11.1 Trademarks

All trademarks are the property of their respective owners.

11.2 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.

11.3 Glossary

SLYZ022 — *TI Glossary*.

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

12 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

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
PCA9557D	ACTIVE	SOIC	D	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	PCA9557	Samples
PCA9557DB	ACTIVE	SSOP	DB	16	80	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	PD557	Samples
PCA9557DBR	ACTIVE	SSOP	DB	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	PD557	Samples
PCA9557DGVR	ACTIVE	TVSOP	DGV	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	PD557	Samples
PCA9557DR	ACTIVE	SOIC	D	16	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	PCA9557	Samples
PCA9557DT	ACTIVE	SOIC	D	16	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	PCA9557	Samples
PCA9557PW	ACTIVE	TSSOP	PW	16	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	PD557	Samples
PCA9557PWR	ACTIVE	TSSOP	PW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	PD557	Samples
PCA9557PWRG4	ACTIVE	TSSOP	PW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	PD557	Samples
PCA9557PWT	ACTIVE	TSSOP	PW	16	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	PD557	Samples
PCA9557RGVR	ACTIVE	VQFN	RGV	16	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 85	PD557	Samples
PCA9557RGVRG4	ACTIVE	VQFN	RGV	16	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 85	PD557	Samples
PCA9557RGYR	ACTIVE	VQFN	RGY	16	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 85	PD557	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) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(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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In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

PACKAGE MATERIALS INFORMATION

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
PCA9557DBR	SSOP	DB	16	2000	330.0	16.4	8.2	6.6	2.5	12.0	16.0	Q1
PCA9557DGVR	TVSOP	DGV	16	2000	330.0	12.4	6.8	4.0	1.6	8.0	12.0	Q1
PCA9557DR	SOIC	D	16	2500	330.0	16.4	6.5	10.3	2.1	8.0	16.0	Q1
PCA9557DT	SOIC	D	16	250	330.0	16.4	6.5	10.3	2.1	8.0	16.0	Q1
PCA9557PWR	TSSOP	PW	16	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1
PCA9557PWT	TSSOP	PW	16	250	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1
PCA9557RGVR	VQFN	RGV	16	2500	330.0	12.4	4.25	4.25	1.15	8.0	12.0	Q2
PCA9557RGYR	VQFN	RGY	16	3000	330.0	12.4	3.8	4.3	1.5	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)
PCA9557DBR	SSOP	DB	16	2000	367.0	367.0	38.0
PCA9557DGVR	TVSOP	DGV	16	2000	367.0	367.0	35.0
PCA9557DR	SOIC	D	16	2500	367.0	367.0	38.0
PCA9557DT	SOIC	D	16	250	367.0	367.0	38.0
PCA9557PWR	TSSOP	PW	16	2000	367.0	367.0	35.0
PCA9557PWT	TSSOP	PW	16	250	367.0	367.0	35.0
PCA9557RGVR	VQFN	RGV	16	2500	367.0	367.0	35.0
PCA9557RGYR	VQFN	RGY	16	3000	367.0	367.0	35.0

D (R−PDSO−G16)   PLASTIC SMALL OUTLINE

0.394 (10,00)
0.386 (9,80)
⚠C

16   9

0.244 (6,20)
0.228 (5,80)

0.157 (4,00)
0.150 (3,80) ⚠D

1   8

Pin 1
Index Area

0.050 (1,27)

0.020 (0,51)
0.012 (0,31)

⊕ | 0.010 (0,25) Ⓜ

0.069 (1,75) Max

0.010 (0,25)
0.004 (0,10)

0.010 (0,25)
0.005 (0,13)

△ | 0.004 (0,10)

Gauge Plane

Seating Plane

0.010 (0,25)   0°−8°

0.050 (1,27)
0.016 (0,40)

4040047−6/M   06/11

NOTES: A. All linear dimensions are in inches (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 0.006 (0,15) each side.
      ⚠D. Body width does not include interlead flash. Interlead flash shall not exceed 0.017 (0,43) each side.
         E. Reference JEDEC MS−012 variation AC.

D (R−PDSO−G16)   PLASTIC SMALL OUTLINE

Example Board Layout
(Note C)

Stencil Openings
(Note D)

←─14x1,27

←16x0,55

←─14x1,27

16x1,50

5,40

5.40

Example
Non Soldermask Defined Pad

Example
Pad Geometry
(See Note C)

←─0,60

1,55

Example
Solder Mask Opening
(See Note E)

←─0,07

All Around

4211283−4/E 08/12

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.

PW (R−PDSO−G16)   PLASTIC SMALL OUTLINE

4040064−4/G 02/11

NOTES: A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M−1994.
         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 each side.
         D. Body width does not include interlead flash. Interlead flash shall not exceed 0,25 each side.
         E. Falls within JEDEC MO−153

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PW (R−PDSO−G16) PLASTIC SMALL OUTLINE

Example Board Layout
(Note C)

14x0,65

5,60

Example
Non Soldermask Defined Pad

Example
Pad Geometry
(See Note C)

0,35

1,60

0,07
All Around

Example
Solder Mask Opening
(See Note E)

Stencil Openings
(Note D)

16x0,30

14x0,65

16x1,55

5,60

4211284−3/G 08/15

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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DB (R-PDSO-G)**   **PLASTIC SMALL-OUTLINE**

28 PINS SHOWN

	PINS **	14	16	20	24	28	30	38
DIM								
A MAX		6,50	6,50	7,50	8,50	10,50	10,50	12,90
A MIN		5,90	5,90	6,90	7,90	9,90	9,90	12,30

4040065 /E 12/01

NOTES: A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion not to exceed 0,15.
D. Falls within JEDEC MO-150

RGV (S−PVQFN−N16)   PLASTIC QUAD FLATPACK NO−LEAD

PIN 1 INDEX AREA
TOP AND BOTTOM

THERMAL PAD

SIZE AND SHAPE
SHOWN ON SEPARATE SHEET
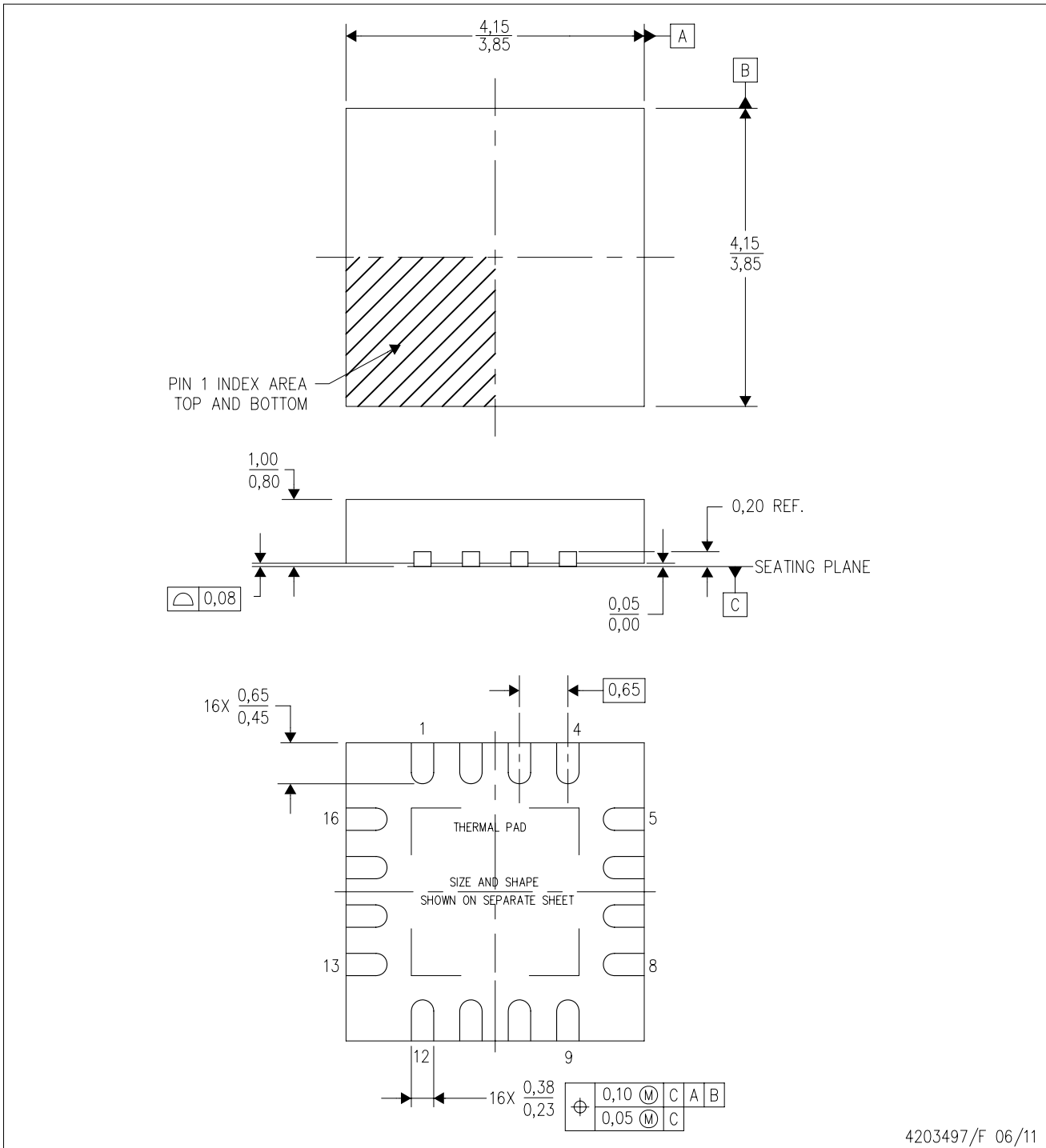
4203497/F 06/11

NOTES: A.   All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M−1994.
         B.   This drawing is subject to change without notice.
         C.   Quad Flatpack, No−leads (QFN) package configuration.
         D.   The package thermal pad must be soldered to the board for thermal and mechanical performance.
         E.   See the additional figure in the Product Data Sheet for details regarding the exposed thermal pad features and dimensions.
         F.   Falls within JEDEC MO−220.

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RGV (S−PVQFN−N16)   PLASTIC QUAD FLATPACK NO−LEAD

THERMAL INFORMATION

This package incorporates an exposed thermal pad that is designed to be attached directly to an external heatsink. The thermal pad must be soldered directly to the printed circuit board (PCB). After soldering, the PCB can be used as a heatsink. In addition, through the use of thermal vias, the thermal pad can be attached directly to the appropriate copper plane shown in the electrical schematic for the device, or alternatively, can be attached to a special heatsink structure designed into the PCB. This design optimizes the heat transfer from the integrated circuit (IC).

For information on the Quad Flatpack No−Lead (QFN) package and its advantages, refer to Application Report, QFN/SON PCB Attachment, Texas Instruments Literature No. SLUA271. This document is available at www.ti.com.

The exposed thermal pad dimensions for this package are shown in the following illustration.

Pin 1 indicator is electrically tied
to the exposed thermal pad
Pin 1 indicator metal feature may
not be present on some devices

0,18±0,05 (2 Places)

0,35±0,05 (2 Places)

Exposed Thermal Pad

2,16±0,10

2,16±0,10

Bottom View

Exposed Thermal Pad Dimensions

4206351−2/L 05/13

NOTE: All linear dimensions are in millimeters

RGV (S−PVQFN−N16)   PLASTIC QUAD FLATPACK NO−LEAD

Example Board Layout

Pin 1
Via Keep Out Area
0,72mm square

2x0,15

12x0,65

Note D

2,8

4,8

2,8

4,8

Non Solder Mask Defined Pad

Example
Solder Mask Opening
(Note F)

R0,175

Pad Geometry
(Note C)

1,0

0,07
all around

0,35

Example Stencil Design
0.125mm Stencil Thickness
(Note E)

16x0,3

12x0,65

16x0,95

R0,15

0,3

12x0,65

2,85   4,75

0,3

4x0,9

4x0,9

2,85

4,75

69% Printed Solder Coverage

Center Pad Layout
(Note D)

2,16

5x∅0,3

1,5

0,75

2,16

0,75

1,5

4208535/C   11/10

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.   This package is designed to be soldered to a thermal pad on the board. Refer to Application Note, QFN
              Packages, Texas Instruments Literature No. SLUA271, and also the Product Data Sheets
              for specific thermal information, via requirements, and recommended board layout. These documents are available at
              www.ti.com <http://www.ti.com>.
         E.   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 stencil design considerations.
         F.   Customers should contact their board fabrication site for solder mask tolerances.

RGY (R-PVQFN-N16)   PLASTIC QUAD FLATPACK NO-LEAD

$\frac{4,15}{3,85}$ A

B

15   10

16   9

$\frac{3,65}{3,35}$

1   8

Pin 1 Index Area
Top and Bottom

2   7

F

0,20 Nominal
Lead Frame

$\frac{1,00}{0,80}$

Seating Plane

0,08 C

$\frac{0,05}{0,00}$
Seating Height

C

2,50

0,50

16X $\frac{0,50}{0,30}$

2   7

1   THERMAL PAD   8

SIZE AND SHAPE
SHOWN ON SEPRATE SHEET

1,50

16   9

15   10

16X $\frac{0,30}{0,18}$

⊕ | 0,10 Ⓜ | C | A | B
  | 0,05 Ⓜ | C

Bottom View

4203539-3/I 06/2011

NOTES: A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
        B. This drawing is subject to change without notice.
        C. QFN (Quad Flatpack No-Lead) package configuration.
        D. The package thermal pad must be soldered to the board for thermal and mechanical performance.
        E. See the additional figure in the Product Data Sheet for details regarding the exposed thermal pad features and dimensions.
        F. Pin 1 identifiers are located on both top and bottom of the package and within the zone indicated.
            The Pin 1 identifiers are either a molded, marked, or metal feature.
        G. Package complies to JEDEC MO-241 variation BA.

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RGY (R—PVQFN—N16)   PLASTIC QUAD FLATPACK NO—LEAD

THERMAL INFORMATION

This package incorporates an exposed thermal pad that is designed to be attached directly to an external heatsink. The thermal pad must be soldered directly to the printed circuit board (PCB). After soldering, the PCB can be used as a heatsink. In addition, through the use of thermal vias, the thermal pad can be attached directly to the appropriate copper plane shown in the electrical schematic for the device, or alternatively, can be attached to a special heatsink structure designed into the PCB. This design optimizes the heat transfer from the integrated circuit (IC).

For information on the Quad Flatpack No—Lead (QFN) package and its advantages, refer to Application Report, QFN/SON PCB Attachment, Texas Instruments Literature No. SLUA271. This document is available at www.ti.com.

The exposed thermal pad dimensions for this package are shown in the following illustration.

Bottom View

Exposed Thermal Pad Dimensions

4206353—3/P 03/14

NOTE: All linear dimensions are in millimeters

RGY (R−PVQFN−N16)   PLASTIC QUAD FLATPACK NO−LEAD

Example Board Layout

Note D

4,80

4,30 2,60

2,55

1,50

2,05

0,85 X 16 PL.

0,28 X 16 PL.

10x0,50

Example Stencil Design
0.125mm Stencil Thickness
(Note E)

4,75

4,25 2,65

0,82

1,50

0,30 x 2 PL

1,07

0,80 x 16 PL.

0,23 x 16 PL.

10x0,50

67% solder coverage by printed
area on center thermal pad

Non Solder Mask
Defined Pad

Example
Solder Mask Opening
(Note F)

0,08

R0,14

0,85

0,07

0,28

All Around

Example
Pad Geometry
(Note C)

Example Via Layout Design
may vary depending on constraints
(Note D, F)

1,00

1,00

6xØ0,3

4208122−3/P 03/14

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. This package is designed to be soldered to a thermal pad on the board. Refer to Application Note, Quad Flat−Pack
            QFN/SON PCB Attachment, Texas Instruments Literature No. SLUA271, and also the Product Data Sheets
            for specific thermal information, via requirements, and recommended board layout.
            These documents are available at www.ti.com <http://www.ti.com>.
        E. 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 stencil design considerations.
        F. Customers should contact their board fabrication site for minimum solder mask web tolerances between signal pads.

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