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PCA9554
REMOTE 8-BIT I^{2}C AND SMBus I/O EXPANDER
WITH INTERRUPT OUTPUT AND CONFIGURATION REGISTERS
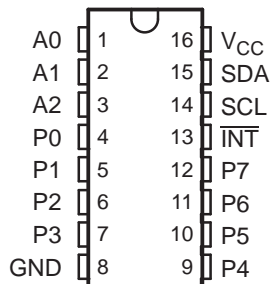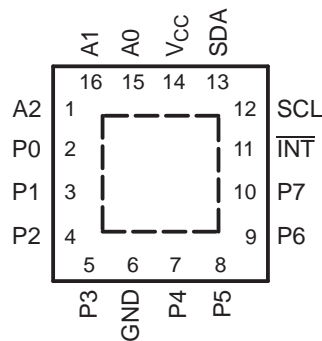SCPS128−JULY 2006

FEATURES

- **I^{2}C to Parallel Port Expander**
- **Open-Drain Active-Low Interrupt Output**
- **Operating Power-Supply Voltage Range of 2.3 V to 5.5 V**
- **5-V Tolerant I/Os**
- **400-kHz Fast I^{2}C Bus**
- **Three Hardware Address Pins Allow up to Eight Devices on the I^{2}C/SMBus**
- **Input/Output Configuration Register**
- **Polarity Inversion Register**
- **Internal Power-On Reset**

- **Power-Up With All Channels Configured as Inputs**
- **No Glitch On Power Up**
- **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)**
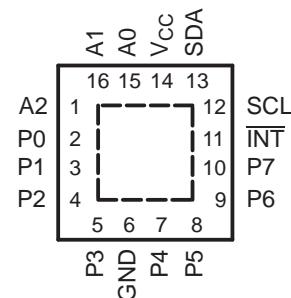 - **1000-V Charged-Device Model (C101)**

DB, DBQ, DGV, DW, OR PW PACKAGE
(TOP VIEW)

```
      A0 [ 1      16 ] V_CC
      A1 [ 2      15 ] SDA
      A2 [ 3      14 ] SCL
      P0 [ 4      13 ] INT
      P1 [ 5      12 ] P7
      P2 [ 6      11 ] P6
      P3 [ 7      10 ] P5
     GND [ 8       9 ] P4
```

RGV PACKAGE
(TOP VIEW)

```
        A1  A0  V_CC  SDA
        16  15  14  13
   A2 [ 1           12 ] SCL
   P0 [ 2           11 ] INT
   P1 [ 3           10 ] P7
   P2 [ 4            9 ] P6
         5   6   7   8
        P3  GND  P4  P5
```

RGT PACKAGE
(TOP VIEW)

```
        A1  A0  V_CC  SDA
        16  15  14  13
   A2 [ 1           12 ] SCL
   P0 [ 2           11 ] INT
   P1 [ 3           10 ] P7
   P2 [ 4            9 ] P6
         5   6   7   8
        P3  GND  P4  P5
```

DESCRIPTION/ORDERING INFORMATION

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. It provides general-purpose remote I/O expansion for most microcontroller families via the I^{2}C interface [serial clock (SCL), serial data (SDA)].

The PCA9554 consists of one 8-bit Configuration (input or output selection), Input, Output, and Polarity Inversion (active high or active low) registers. At power on, the I/Os are configured as inputs with a weak pullup to V_{CC}. 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 system master can reset the PCA9554 in the event of a timeout or other improper operation by utilizing the power-on reset feature, which puts the registers in their default state and initializes the I^{2}C/SMBus state machine.

The PCA9554 open-drain interrupt ($\overline{INT}$) output is activated when any input state differs from its corresponding Input Port register state and is used to indicate to the system master that an input state has changed.

$\overline{INT}$ can be connected to the interrupt input of a microcontroller. 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 via the I^{2}C bus. Thus, the PCA9554 can remain a simple slave device.

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

Three hardware pins (A0, A1, and A2) are used to program and vary the fixed I^{2}C address and allow up to eight devices to share the same I^{2}C bus or SMBus.

Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

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The PCA9554 is pin-to-pin and I^{2}C address compatible with the PCF8574. However, software changes are required, due to the enhancements in the PCA9554 over the PCF8574.

The PCA9554 and PCA9554A are identical except for their fixed I^{2}C address. This allows for up to 16 of these devices (eight of each) on the same I^{2}C/SMBus.

ORDERING INFORMATION

T$_A$	PACKAGE[1]		ORDERABLE PART NUMBER	TOP-SIDE MARKING
−40°C to 85°C	QFN – RGT	Reel of 3000	PCA9554RGTR	PREVIEW
		Reel of 250	PCA9554RGTT	
	QFN – RGV	Reel of 2500	PCA9554RGVR	PREVIEW
		Reel of 250	PCA9554RGVT	
	QSOP – DBQ	Tube of 75	PCA9554DBQ	PREVIEW
		Reel of 2500	PCA9554DBQR	
	SOIC – DW	Tube of 40	PCA9554DW	PREVIEW
		Reel of 2000	PCA9554DWR	
		Reel of 250	PCA9554DWT	
	SSOP – DB	Tube of 250	PCA9554DB	PD554
		Reel of 2000	PCA9554DBR	
	TSSOP – PW	Tube of 90	PCA9554PW	PD554
		Reel of 2000	PCA9554PWR	
	TVSOP – DGV	Reel of 2000	PCA9554DGVR	PD554

(1) Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at www.ti.com/sc/package.
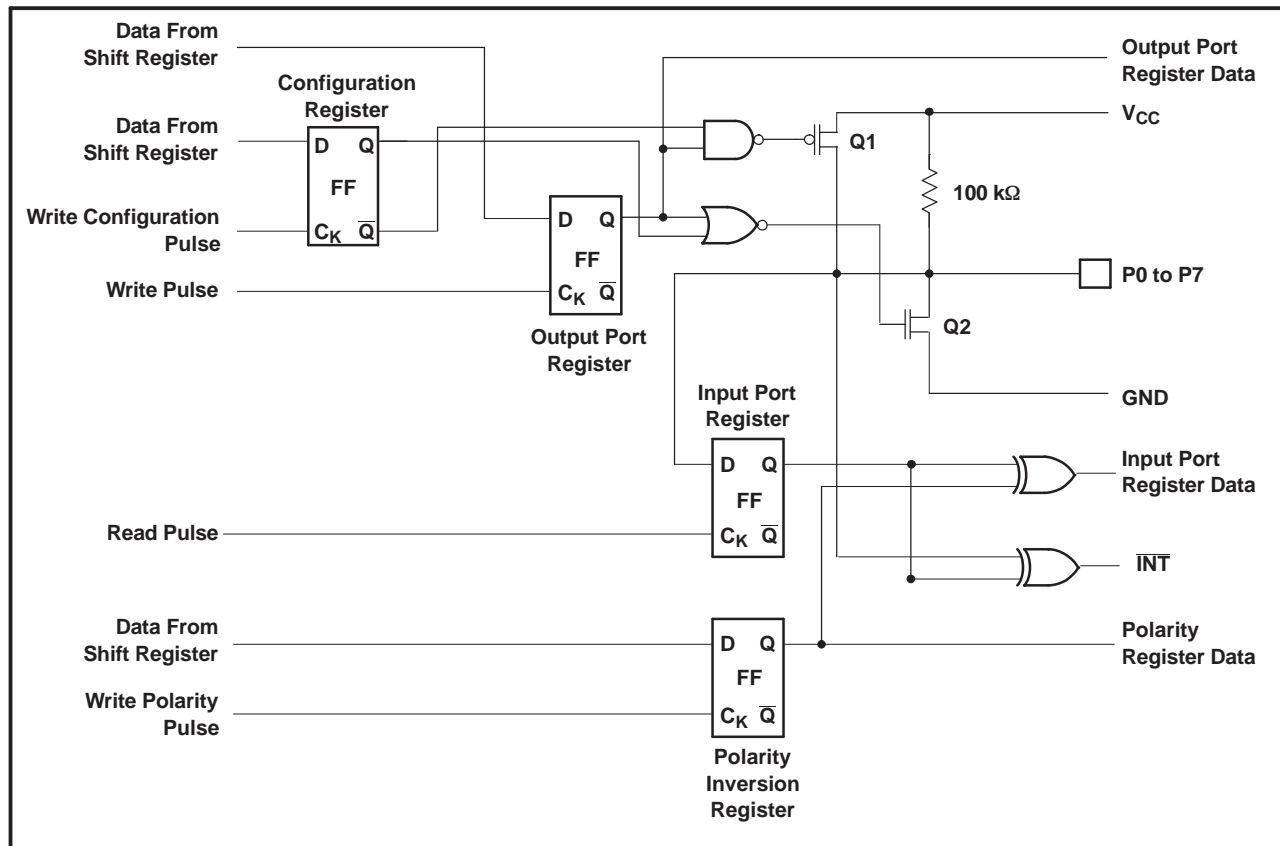
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TERMINAL FUNCTIONS

NO.		NAME	DESCRIPTION
QSOP (DBQ) SOIC (DW), SSOP (DB), TSSOP (PW), AND TVSOP (DGV)	QFN (RGT) AND QFN (RGV)		
1	15	A0	Address input. Connect directly to V$_{CC}$ or ground.
2	16	A1	Address input. Connect directly to V$_{CC}$ or ground.
3	1	A2	Address input. Connect directly to V$_{CC}$ or ground.
4	2	P0	P-port input/output
5	3	P1	P-port input/output
6	4	P2	P-port input/output
7	5	P3	P-port input/output
8	6	GND	Ground
9	7	P4	P-port input/output
10	8	P5	P-port input/output
11	9	P6	P-port input/output
12	10	P7	P-port input/output
13	11	$\overline{INT}$	Interrupt output. Connect to V$_{CC}$ through a pullup resistor.
14	12	SCL	Serial clock bus. Connect to V$_{CC}$ through a pullup resistor.
15	13	SDA	Serial data bus. Connect to V$_{CC}$ through a pullup resistor.
16	14	V$_{CC}$	Supply voltage

FUNCTIONAL BLOCK DIAGRAM
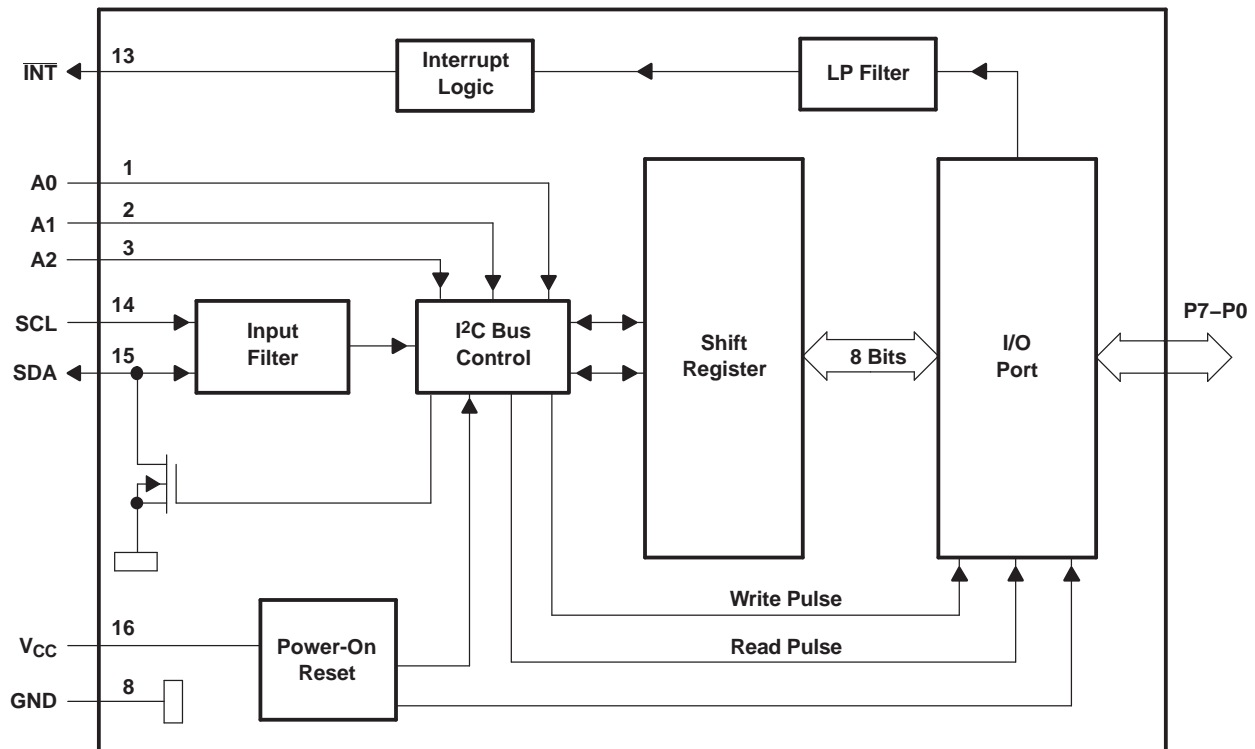
A.   Pin numbers shown are for the DB, DBQ, DGV, DW, N, or PW package.

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

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Simplified Schematic of P0 to P7

A. At power-on reset, all registers return to default values.

I/O Port

When an I/O is configured as an input, FETs Q1 and Q2 are off, which creates a high-impedance input with a weak pullup (100 kΩ typ) to V_{CC}. The input voltage may be raised above V_{CC} to a maximum of 5.5 V.

If the I/O is configured as an output, Q1 or Q2 is enabled, depending on the state of the output port register. In this case, there are low-impedance paths between the I/O pin and either V_{CC} or GND. The external voltage applied to this I/O pin should not exceed the recommended levels for proper operation.

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 1). After the start condition, the device address byte is sent, MSB first, including the data direction bit (R/$\overline{W}$).

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 inputs (A0–A2) 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 2).

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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 1).

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 3). 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 will signal 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.
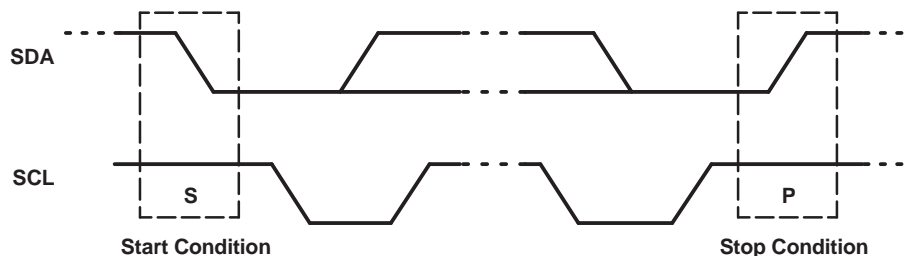

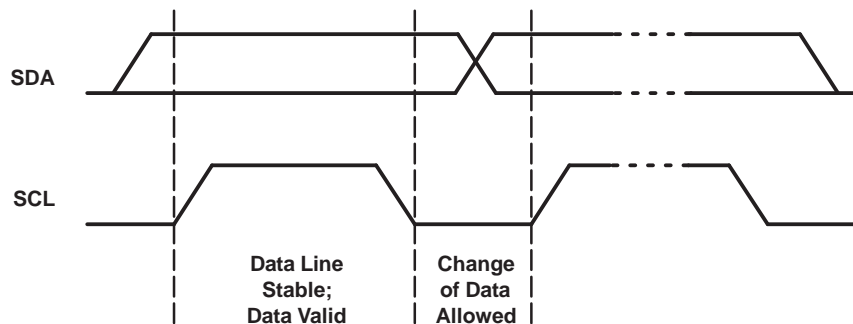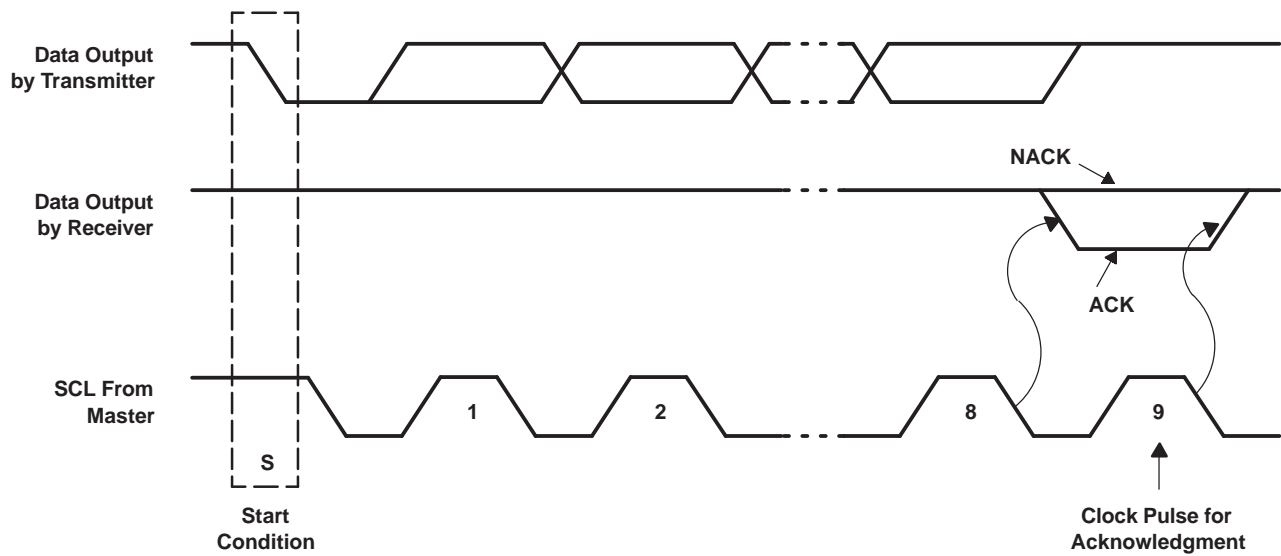**Figure 1. Definition of Start and Stop Conditions**

Figure 2. Bit Transfer

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Figure 3. Acknowledgment on the I^{2}C Bus

Interface Definition

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

Device Address

Figure 4 shows the address byte for the PCA9554.
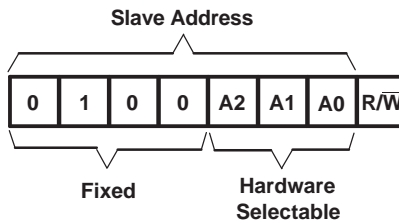
Figure 4. PCA9554 Address

Address Reference

INPUTS			I²C BUS SLAVE ADDRESS
A2	**A1**	**A0**	
L	L	L	32 (decimal), 20 (hexadecimal)
L	L	H	33 (decimal), 21 (hexadecimal)
L	H	L	34 (decimal), 22 (hexadecimal)
L	H	H	35 (decimal), 23 (hexadecimal)
H	L	L	36 (decimal), 24 (hexadecimal)
H	L	H	37 (decimal), 25 (hexadecimal)
H	H	L	38 (decimal), 26 (hexadecimal)
H	H	H	39 (decimal), 27 (hexadecimal)

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

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 PCA9554. Two bits of this command byte state the operation (read or write) and the internal register (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 command byte has been sent, the register that was addressed continues to be accessed by readsuntil a new command byte has been sent.
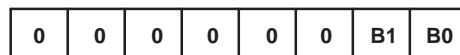

Figure 5. Control Register Bits

Command Byte

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

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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 indicate to the I²C device that the Input Port register will be accessed next.

Register 0 (Input Port Register) Table

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.

Register 1 (Output Port Register) Table

BIT	O7	O6	O5	O4	O3	O2	O1	O0
DEFAULT	1	1	1	1	1	1	1	1

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 polarity is inverted. If a bit in this register is cleared (written with a 0), the corresponding port pin's original polarity is retained.

Register 2 (Polarity Inversion Register) Table

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

Register 3 (Configuration Register) Table

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

Power-On Reset

When power (from 0 V) is applied to V_{CC}, an internal power-on reset holds the PCA9554 in a reset condition until V_{CC} has reached V_{POR}. At that point, the reset condition is released and the PCA9554 registers and I²C/SMBus state machine initialize to their default states. After that, V_{CC} must be lowered to below 0.2 V and then back up to the operating voltage for a power-reset cycle.

Interrupt Output (INT)

An interrupt is generated by any rising or falling edge of the port inputs in the input mode. After time t_{iv}, the signal INT is valid. Resetting the interrupt circuit is achieved when data on the port is changed to the original setting, and data is read from the port that generated the interrupt or in a Stop event. Resetting occurs in the read mode at the acknowledge (ACK) bit or not acknowledge (NACK) bit after the rising edge of the SCL signal. In a Stop event, INT is cleared after the rising edge of SDA. Interrupts that occur during the ACK or NACK 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 is transmitted as INT.

Reading from or writing to another device does not affect the interrupt circuit, and a pin configured as an output cannot cause an interrupt. Changing an I/O from an output to an input may cause a false interrupt to occur if the state of the pin does not match the contents of the Input Port register.

INT has an open-drain structure and requires a pullup resistor to V_{CC}.

Bus Transactions

Data is exchanged between the master and PCA9554 through write and read commands.

Writes

Data is transmitted to the PCA9554 by sending the device address and setting the least-significant bit to a logic 0 (see Figure 4 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.
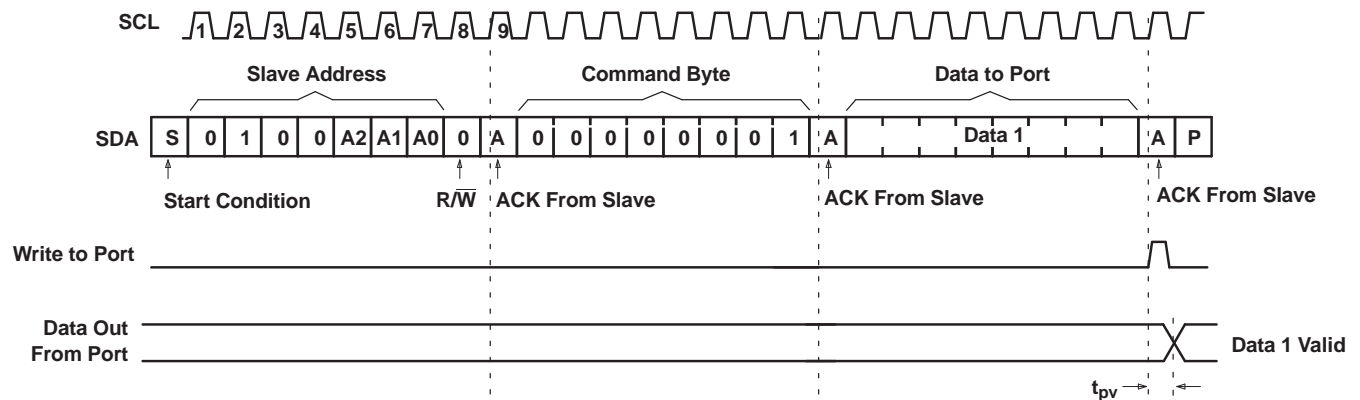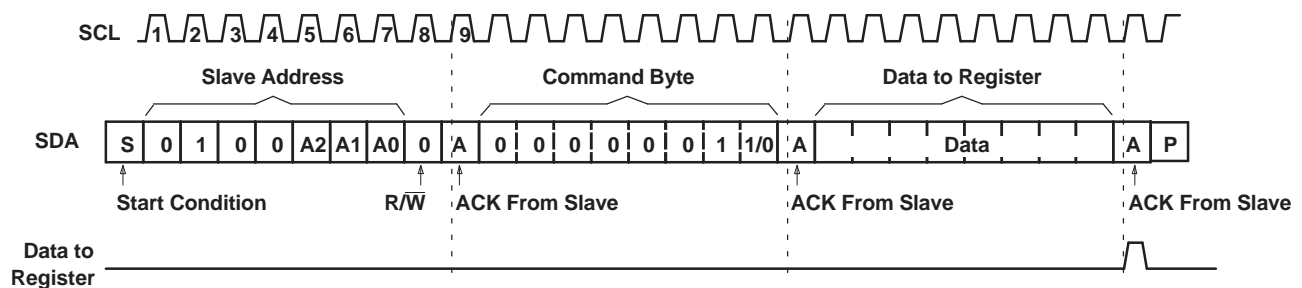

Figure 6. Write to Output Port Register

Figure 7. Write to Configuration or Polarity Inversion Registers

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Reads

The bus master first must send the PCA9554 address with the least-significant bit set to a logic 0 (see Figure 4 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 least-significant bit is set to a logic 1. Data from the register defined by the command byte then is sent by the PCA9554 (see Figure 8 and Figure 9). 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
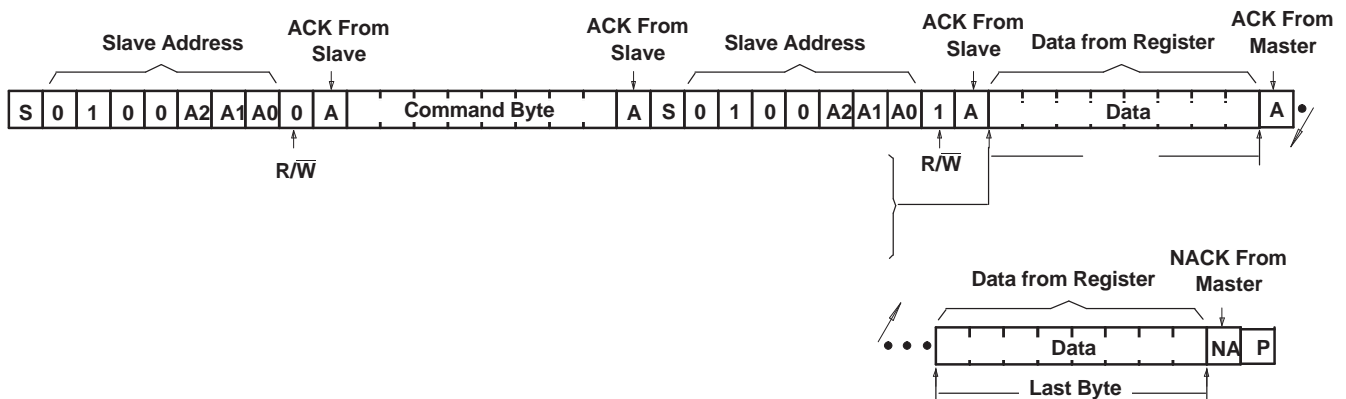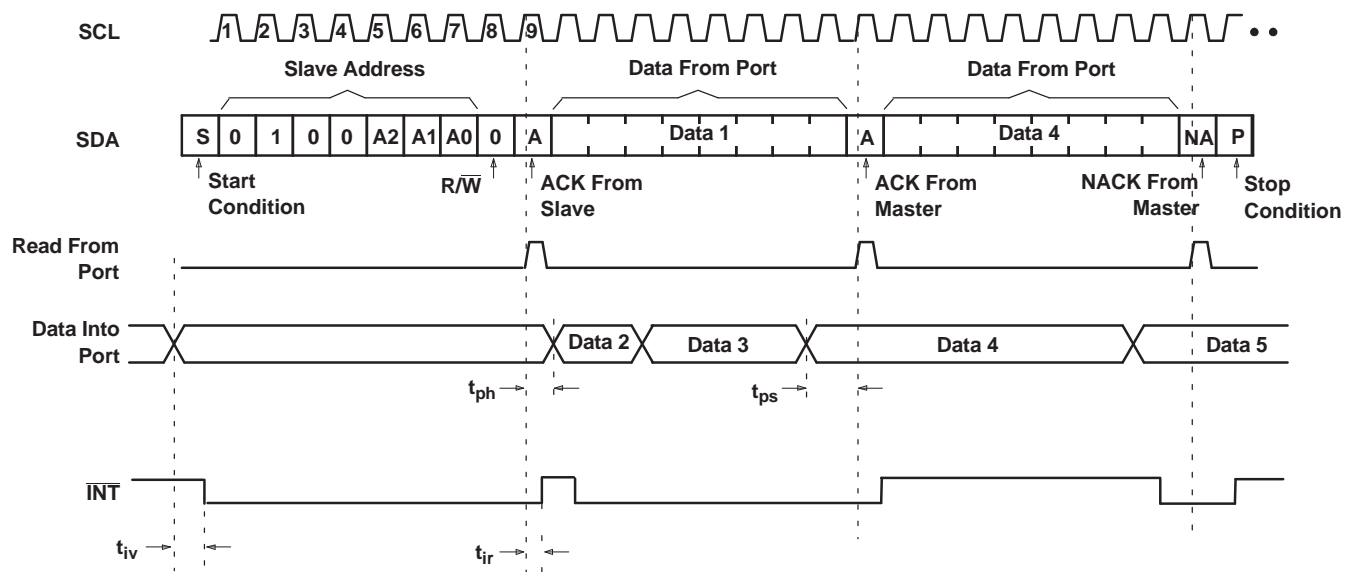
Figure 8. Read From Register

Figure 9. Read From Input Port Register

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

B. Transfer of data can be stopped at any moment by a Stop condition.

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 P port. See Figure 8 for these details.

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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	mA
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			−200	mA
	Continuous current through V_{CC}			160	mA
θ_{JA}	Package thermal impedance[3]	DB package		82	°C/W
		DBQ package		90	
		DGV package		120	
		DW package		57	
		N package		67	
		PW package		108	
		RGT package		TBD	
		RGV package		TBD	
T_{stg}	Storage temperature range		−65	150	°C

(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.

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

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Electrical Characteristics

over 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}		1.5	1.65	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	3.1			
			4.75 V	4.1			
		$I_{OH} = -10$ mA	2.3 V	1.7			
			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	8		mA
	P port[3]	$V_{OL} = 0.5$ V	2.3 V	8	10		
			3 V	8	14		
			4.5 V	8	17		
			4.75 V	8	35		
		$V_{OL} = 0.7$ V	2.3 V	10	13		
			3 V	10	19		
			4.5 V	10	24		
			4.75 V	10	45		
	$\overline{INT}$	$V_{OL} = 0.4$ V	2.3 V to 5.5 V	3	10		
I_I	SCL, SDA	$V_I = V_{CC}$ or GND	2.3 V to 5.5 V			±1	μA
	A2–A0					±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			−100	μA
I_{CC}	Operating mode	$V_I = V_{CC}$, $I_O = 0$, I/O = inputs, $f_{scl} = 400$ kHz, No load	5.5 V		104	175	μA
			3.6 V		50	90	
			2.7 V		20	65	
		$V_I = V_{CC}$, $I_O = 0$, I/O = inputs, $f_{scl} = 100$ kHz, No load	5.5 V		60	150	
			3.6 V		15	40	
			2.7 V		8	20	
	Standby mode	$V_I = $ GND, $I_O = 0$, I/O = inputs, $f_{scl} = 0$ kHz, No load	5.5 V		450	700	
			3.6 V		300	600	
			2.7 V		225	500	
		$V_I = V_{CC}$, $I_O = 0$, I/O = inputs, $f_{scl} = 0$ kHz, No load	5.5 V		0.25	1	
			3.6 V		0.2	0.9	
			2.7 V		0.1	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			1.5	mA
		Every LED I/O at $V_I = 4.3$ V, $f_{scl} = 0$ kHz	5.5 V			1	
C_i	SCL	$V_I = V_{CC}$ or GND	2.3 V to 5.5 V		4	5	pF
C_{io}	SDA	$V_{IO} = V_{CC}$ or GND	2.3 V to 5.5 V		5.5	6.5	pF
	P port				8	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.
(3) Each I/O must be externally limited to a maximum of 25 mA, and the P port (P0 to P7) must be limited to a maximum current of 100 mA.

I^{2}C Interface Timing Requirements

over operating free-air temperature range (unless otherwise noted) (see Figure 10)

			STANDARD MODE I^{2}C BUS		FAST MODE I^{2}C BUS		UNIT
			MIN	MAX	MIN	MAX	
t_{scl}	I^{2}C clock frequency		0	100	0	400	kHz
t_{sch}	I^{2}C clock high time		4		0.6		μs
t_{scl}	I^{2}C clock low time		4.7		1.3		μs
t_{sp}	I^{2}C spike time			50		50	ns
t_{sds}	I^{2}C serial-data setup time		250		100		ns
t_{sdh}	I^{2}C serial-data hold time		0		0		ns
t_{icr}	I^{2}C input rise time			1000	20 + 0.1C$_b$[1]	300	ns
t_{icf}	I^{2}C input fall time			300	20 + 0.1C$_b$[1]	300	ns
t_{ocf}	I^{2}C output fall time	10-pF to 400-pF bus		300	20 + 0.1C$_b$[1]	300	ns
t_{buf}	I^{2}C bus free time between stop and start		4.7		1.3		μs
t_{sts}	I^{2}C start or repeated start condition setup		4.7		0.6		μs
t_{sth}	I^{2}C start or repeated start condition hold		4		0.6		μs
t_{sps}	I^{2}C stop condition setup		4		0.6		μs
$t_{vd(data)}$	Valid data time	SCL low to SDA output valid	300		50		ns
$t_{vd(ack)}$	Valid data time of ACK condition	ACK signal from SCL low to SDA (out) low	0.3	3.45	0.1	0.9	μs
C_b	I^{2}C bus capacitive load			400		400	ns

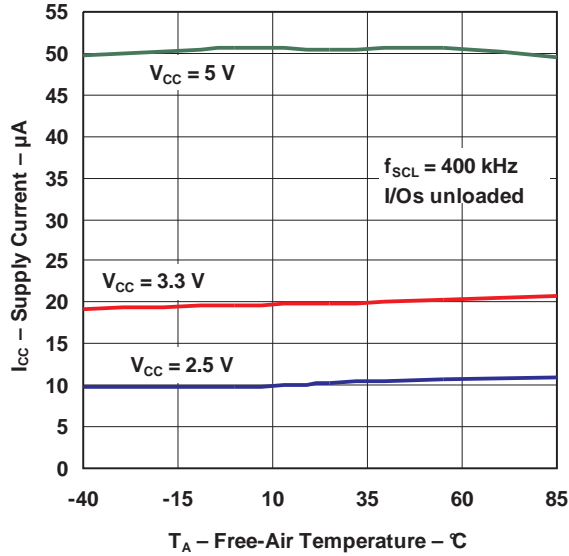(1) C_b = Total capacitive load of one bus in pF

Switching Characteristics

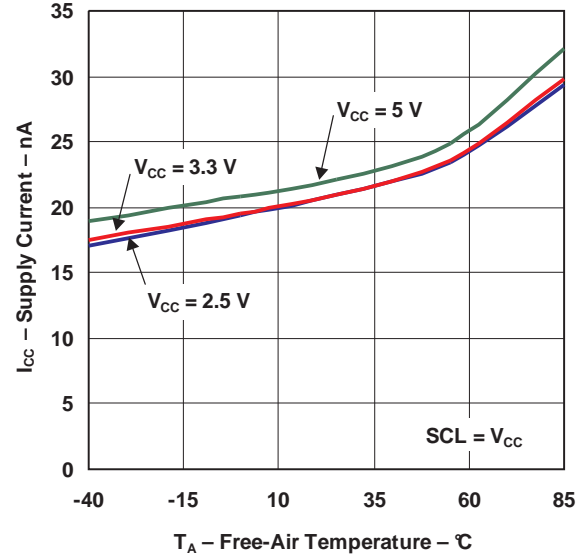over operating free-air temperature range (unless otherwise noted) (see Figure 11 and Figure 12)

	PARAMETER	FROM (INPUT)	TO (OUTPUT)	STANDARD MODE I^{2}C BUS		FAST MODE I^{2}C BUS		UNIT
				MIN	MAX	MIN	MAX	
t_{iv}	Interrupt valid time	P port	$\overline{INT}$		4		4	μs
t_{ir}	Interrupt reset delay time	SCL	$\overline{INT}$		4		4	μs
t_{pv}	Output data valid	SCL	P7–P0		200		200	ns
t_{ps}	Input data setup time	P port	SCL	100		100		ns
t_{ph}	Input data hold time	P port	SCL	1		1		μs

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TYPICAL CHARACTERISTICS

SUPPLY CURRENT
vs
TEMPERATURE

QUIESCENT SUPPLY CURRENT
vs
TEMPERATURE
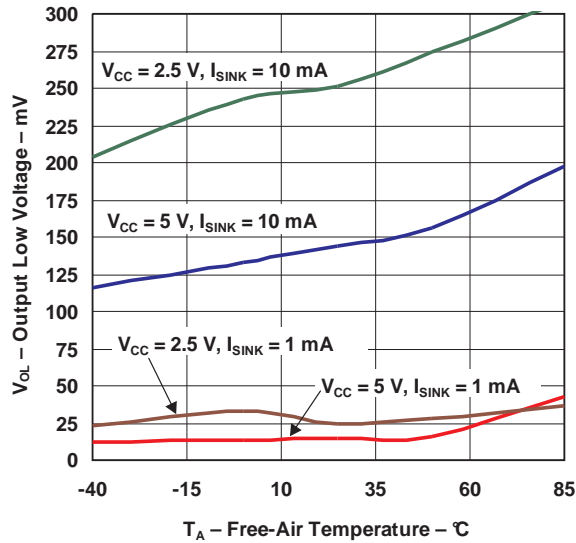

SUPPLY CURRENT
vs
SUPPLY VOLTAGE
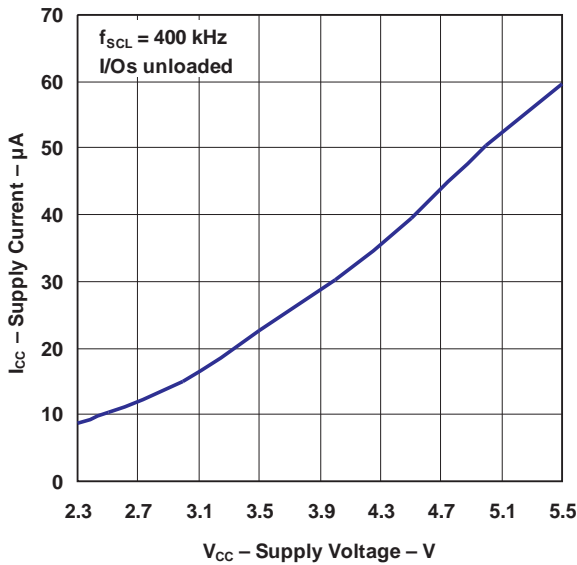
SUPPLY CURRENT
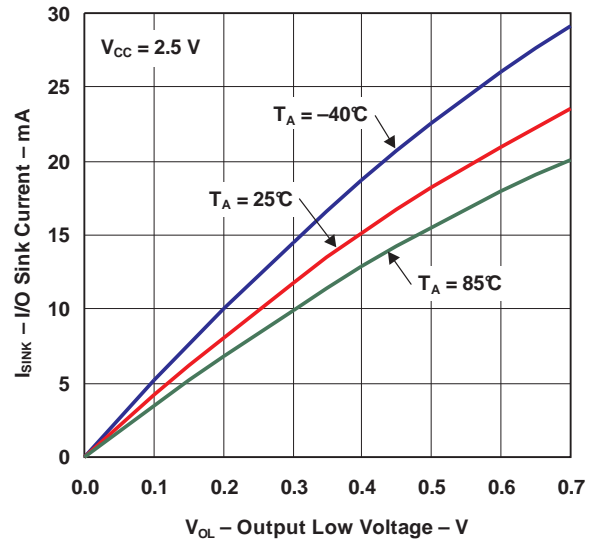**vs**
NUMBER OF I/Os HELD LOW
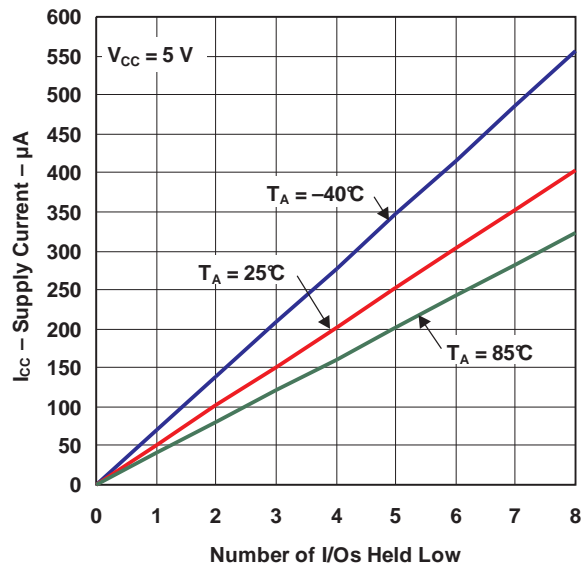
TYPICAL CHARACTERISTICS (continued)

I/O OUTPUT LOW VOLTAGE
vs
TEMPERATURE

I/O SINK CURRENT
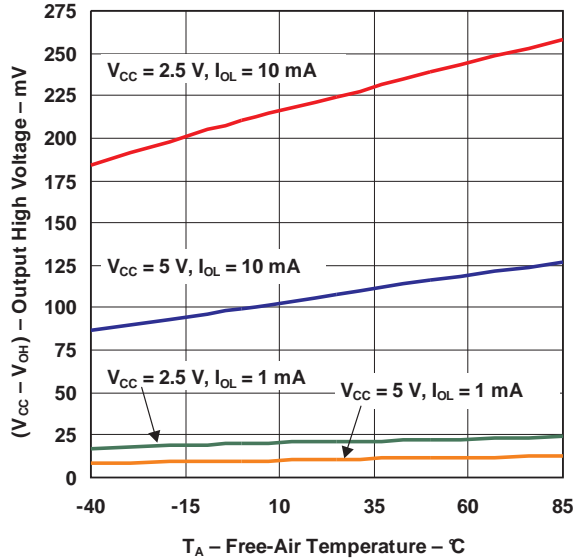**vs**
OUTPUT LOW VOLTAGE

I/O SINK CURRENT
vs
OUTPUT LOW VOLTAGE

I/O SINK CURRENT
vs
OUTPUT LOW VOLTAGE

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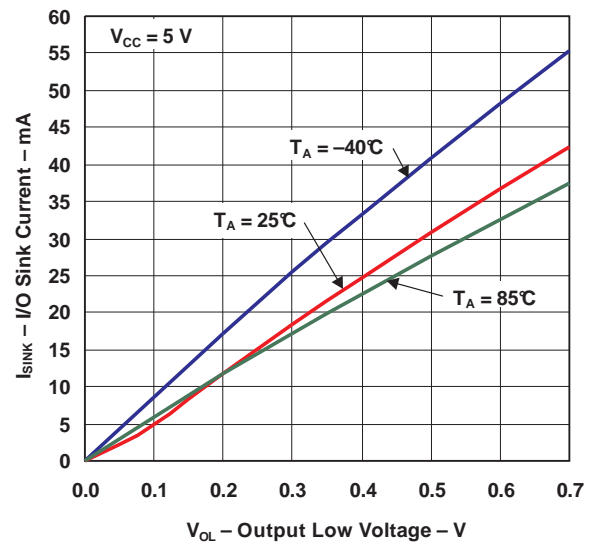
TYPICAL CHARACTERISTICS (continued)

I/O OUTPUT HIGH VOLTAGE
vs
TEMPERATURE

I/O SOURCE CURRENT
vs
OUTPUT HIGH VOLTAGE
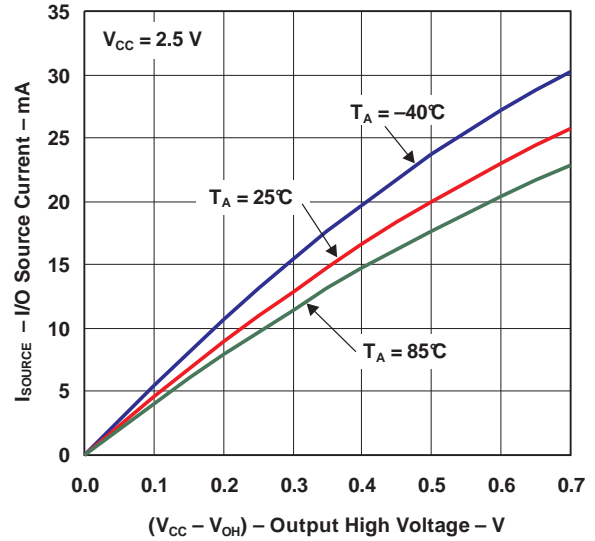
I/O SOURCE CURRENT
vs
OUTPUT HIGH VOLTAGE
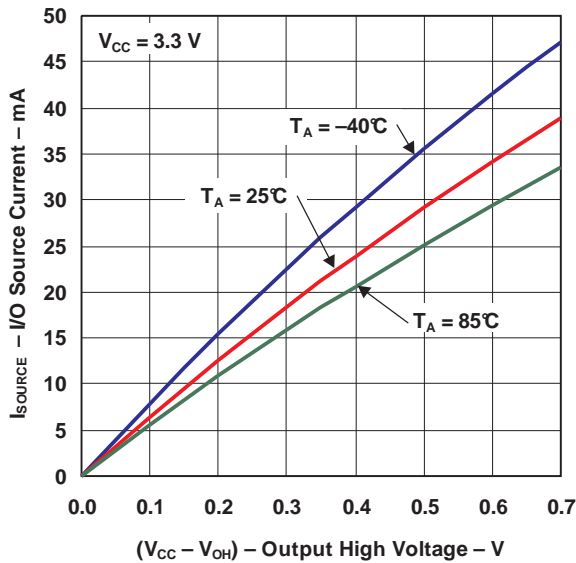
I/O SOURCE CURRENT
vs
OUTPUT HIGH VOLTAGE
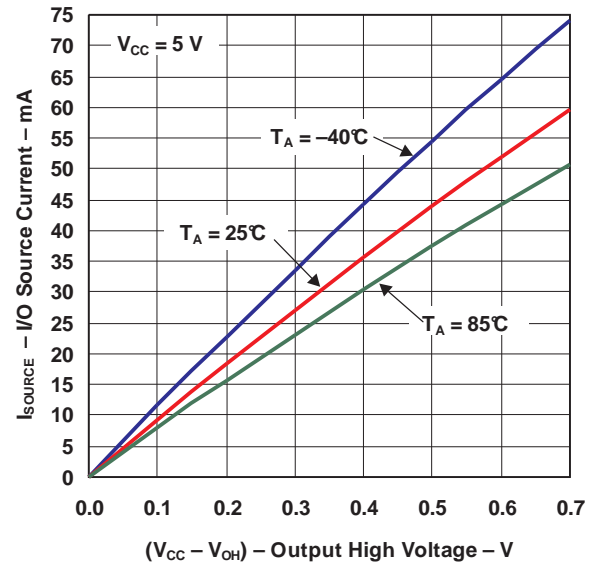
TYPICAL CHARACTERISTICS (continued)

OUTPUT HIGH VOLTAGE
vs
SUPPLY VOLTAGE

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PARAMETER MEASUREMENT INFORMATION

SDA LOAD CONFIGURATION

VOLTAGE WAVEFORMS

BYTE	DESCRIPTION
1	I²C 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.

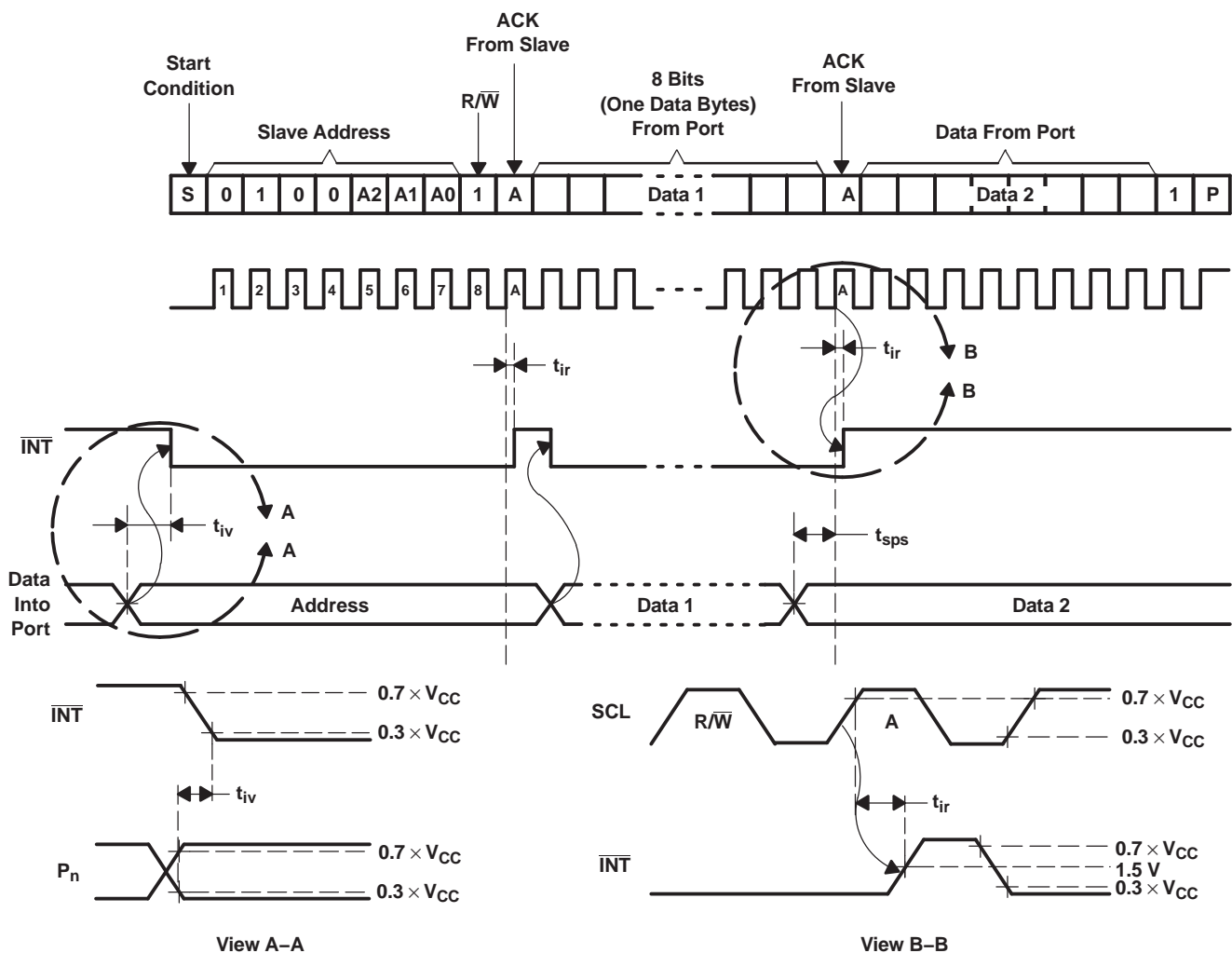**Figure 10. I²C Interface Load Circuit and Voltage Waveforms**
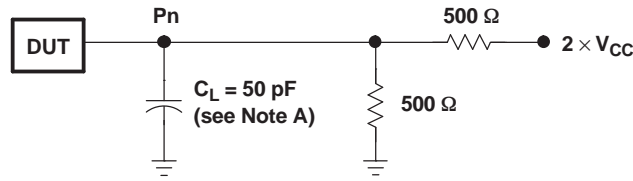
PARAMETER MEASUREMENT INFORMATION (continued)

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

Figure 11. Interrupt Load Circuit and Voltage Waveforms

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PARAMETER MEASUREMENT INFORMATION (continued)

P-PORT LOAD CONFIGURATION

WRITE MODE (R/$\overline{W}$ = 0)
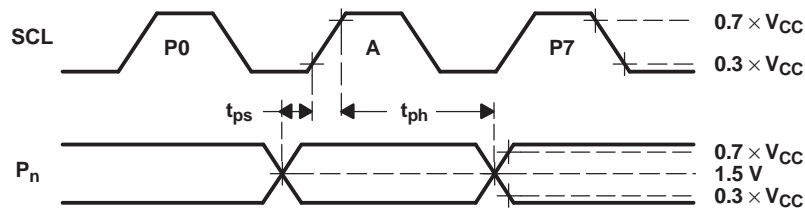
READ MODE (R/$\overline{W}$ = 1)

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 pin 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 12. P-Port Load Circuit and Voltage Waveforms
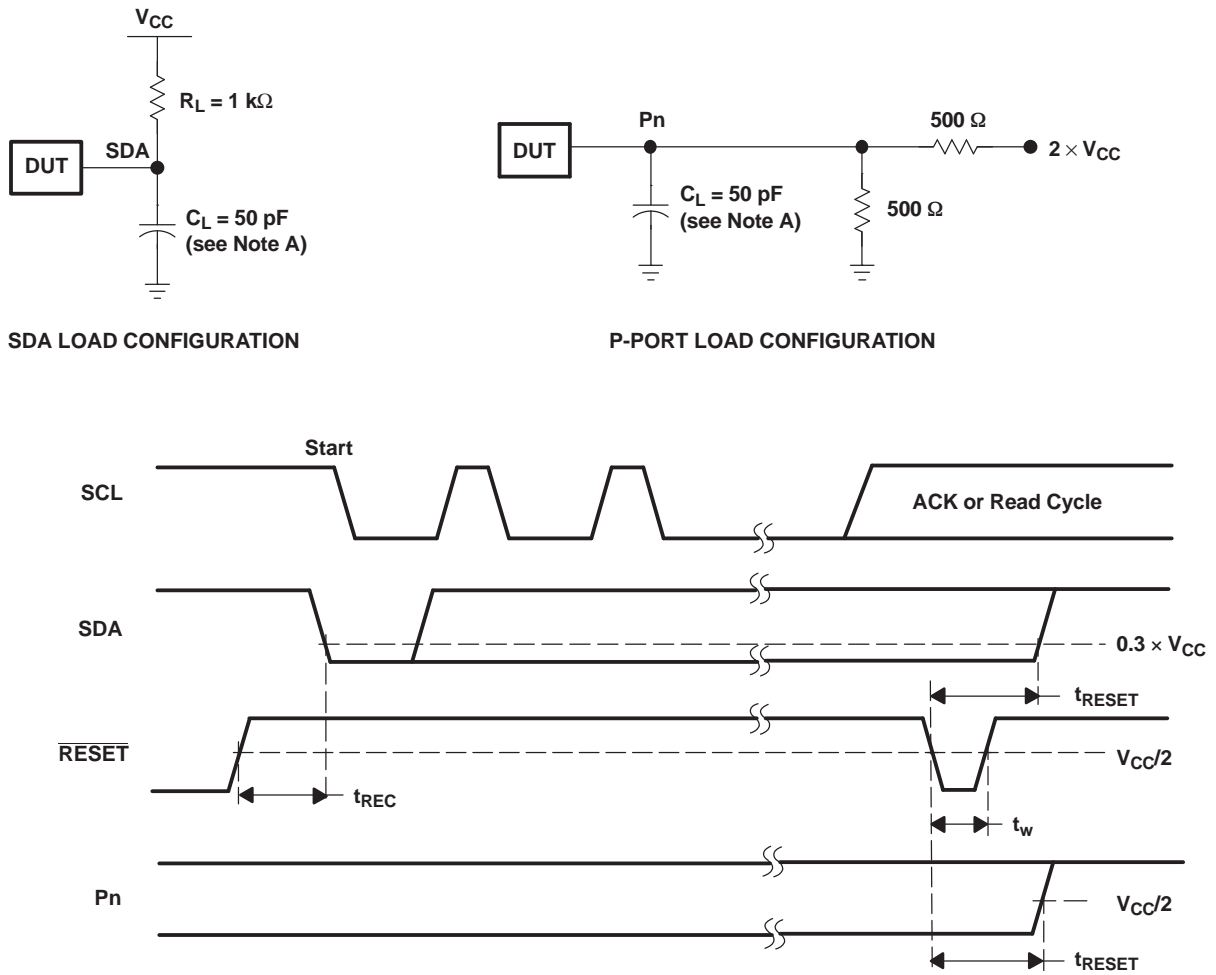
PARAMETER MEASUREMENT INFORMATION (continued)
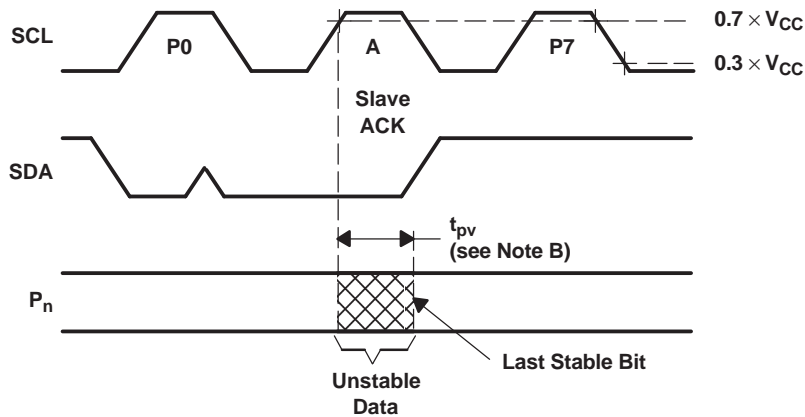

SDA LOAD CONFIGURATION

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

Figure 13. Reset Load Circuits and Voltage Waveforms

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APPLICATION INFORMATION

Figure 14 shows an application in which the PCA9554 can be used.
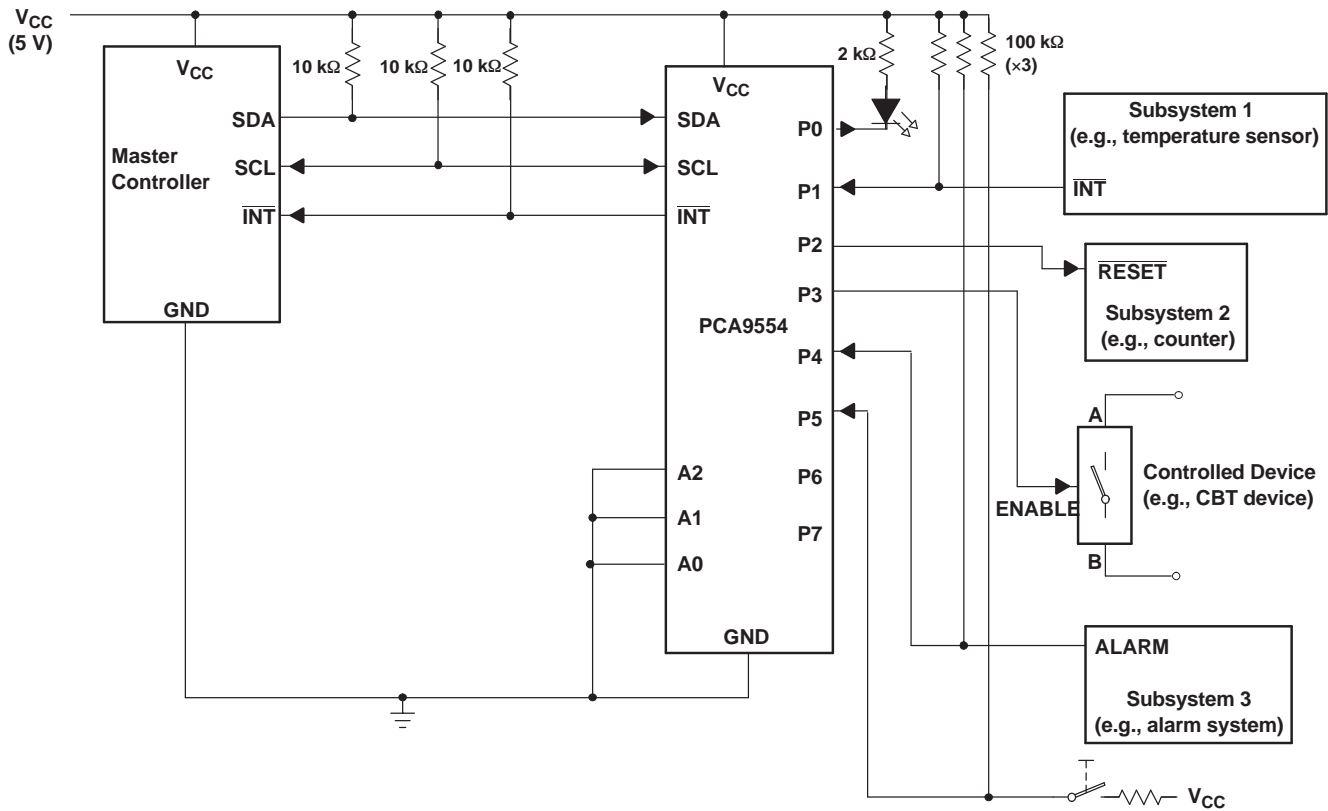
A. Device address is configured as 0100000 for this example.

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 and have internal 100-kΩ pullup resistors to protect them from floating.

Figure 14. Typical Application

APPLICATION INFORMATION (continued)

Minimizing I_{CC} When I/Os Control LEDs

When the I/Os are used to control LEDs, they are normally connected to V_{CC} through a resistor as shown in Figure 14. 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}. ΔI_{CC} in *Electrical Characteristics* shows how I_{CC} increases as V_{IN} becomes lower than V_{CC}.

For battery-powered applications, it is essential that the voltage of I/O pins is greater than or equal to V_{CC} when the LED is off to minimize current consumption. Figure 15 shows a high-value resistor in parallel with the LED. Figure 16 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.
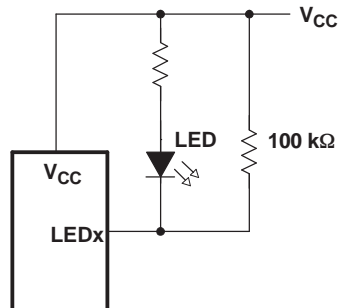

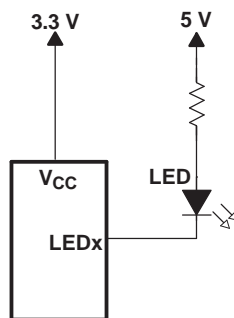**Figure 15. High-Value Resistor in Parallel With LED**

Figure 16. Device Supplied by a Lower Voltage

PACKAGING INFORMATION

Orderable Device	Status [1]	Package Type	Package Drawing	Pins	Package Qty	Eco Plan [2]	Lead/Ball Finish	MSL Peak Temp [3]
PCA9554DB	ACTIVE	SSOP	DB	16	80	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
PCA9554DBG4	ACTIVE	SSOP	DB	16	80	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
PCA9554DBR	ACTIVE	SSOP	DB	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
PCA9554DBRG4	ACTIVE	SSOP	DB	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
PCA9554DGVR	ACTIVE	TVSOP	DGV	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
PCA9554DGVRG4	ACTIVE	TVSOP	DGV	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
PCA9554DW	ACTIVE	SOIC	DW	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
PCA9554DWR	ACTIVE	SOIC	DW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
PCA9554PW	ACTIVE	TSSOP	PW	16	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
PCA9554PWG4	ACTIVE	TSSOP	PW	16	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
PCA9554PWR	ACTIVE	TSSOP	PW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
PCA9554PWRG4	ACTIVE	TSSOP	PW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM

[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.

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

24 PINS SHOWN

0,40

0,23 / 0,13   ⊕   0,07 Ⓜ

24   13

4,50 / 4,30   6,60 / 6,20

0,16 NOM

Gage Plane

0°–8°

0,25

0,75 / 0,50

1   12

A

1,20 MAX

0,15 / 0,05

Seating Plane

⌒ 0,08

PINS ** DIM	14	16	20	24	38	48	56
A MAX	3,70	3,70	5,10	5,10	7,90	9,80	11,40
A MIN	3,50	3,50	4,90	4,90	7,70	9,60	11,20

4073251/E 08/00

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 per side.
　　　　D. Falls within JEDEC: 24/48 Pins – MO-153
　　　　　　　　　　　　　　　　14/16/20/56 Pins – MO-194

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DW (R-PDSO-G16) PLASTIC SMALL-OUTLINE PACKAGE

0.413 (10,50)
0.398 (10,10)

16   9

0.419 (10,63)
0.393 (9,97)

0.299 (7,60)
0.291 (7,40)

1   8

Pin 1
Index Area

0.050 (1,27)

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

⊕ 0.010 (0,25) Ⓜ

0.104 (2,65) Max

0.012 (0,30)
0.004 (0,10)

0.013 (0,33)
0.008 (0,20)

Gauge Plane

0.004 (0,10)

Seating Plane

0.010 (0,25)   0°-8°

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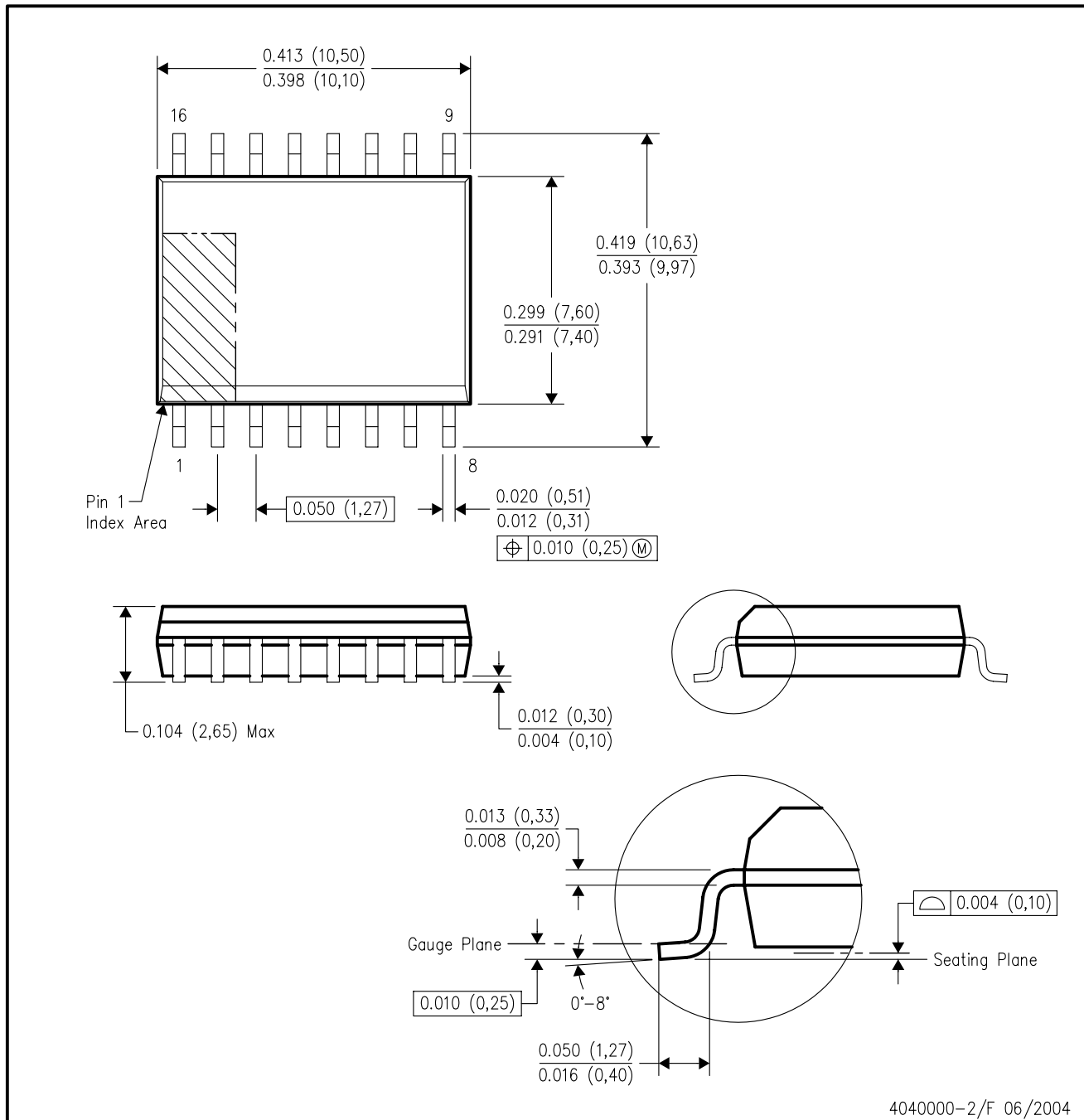0.016 (0,40)

4040000-2/F 06/2004

NOTES: A.   All linear dimensions are in inches (millimeters).
         B.   This drawing is subject to change without notice.
         C.   Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15).
         D.   Falls within JEDEC MS-013 variation AA.

MECHANICAL DATA

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

28 PINS SHOWN

DIM \ PINS **	14	16	20	24	28	30	38
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

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PW (R-PDSO-G**)　　　　　　　　　　　　　　　　**PLASTIC SMALL-OUTLINE PACKAGE**

14 PINS SHOWN

PINS ** DIM	8	14	16	20	24	28
A MAX	3,10	5,10	5,10	6,60	7,90	9,80
A MIN	2,90	4,90	4,90	6,40	7,70	9,60

4040064/F 01/97

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-153

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