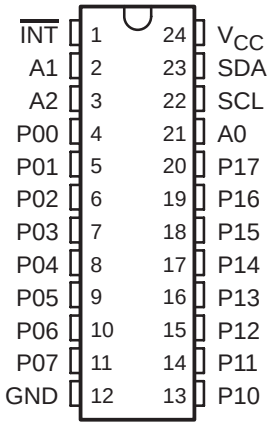
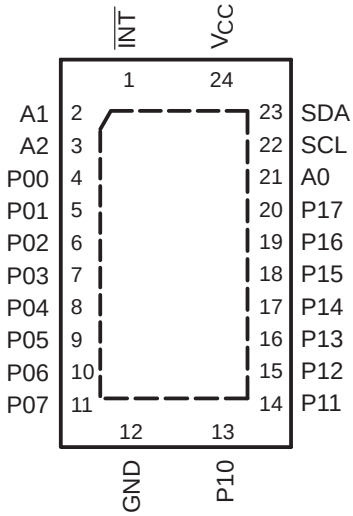
- **Low Standby-Current Consumption of 10 μA Maximum**
- **I²C to Parallel-Port Expander**
- **Open-Drain Interrupt Output**
- **Compatible With Most Microcontrollers**
- **400 kbit/s Fast I²C Bus**
- **Address by Three Hardware Address Pins for Use of Up To Eight Devices**
- **Latched Outputs With High-Current Drive Capability for Directly Driving LEDs**
- **Current Source to V_{CC} for Actively Driving a High at the Output**
- **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)**

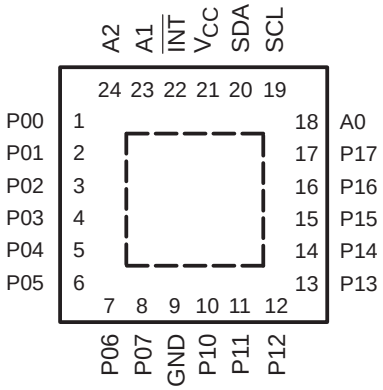
DB, DBQ, DGV, DW, OR PW PACKAGE
(TOP VIEW)



RHL PACKAGE
(TOP VIEW)



RGE PACKAGE
(TOP VIEW)



description/ordering information

This 16-bit I/O expander for the two-line bidirectional bus (I²C) is designed for 2.5-V to 5.5-V V_{CC} operation.

ORDERING INFORMATION

T_A	PACKAGE†		ORDERABLE PART NUMBER	TOP-SIDE MARKING
−40°C to 85°C	SSOP − DB	Reel of 2500	PCF8575DBR	PF575
		Reel of 250	PCF8575DBT	
	QSOP − DBQ	Reel of 2500	PCF8575DBQR	PCF8575
	TVSOP − DGV	Reel of 2000	PCF8575DGVR	PF575
	SOIC − DW	Tube of 25	PCF8575DW	PCF8575
		Reel of 2000	PCF8575DWR	
	TSSOP − PW	Tube of 60	PCF8575PW	PF575
		Reel of 1200	PCF8575PWR	
		Reel of 250	PCF8575PWT	
	QFN − RGE	Reel of 3000	PCF8575RGER	PF575
	QFN − RHL	Reel of 1000	PCF8575RHLR	PF575

† Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at www.ti.com/sc/package.

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.

description/ordering information (continued)

The PCF8575 provides general-purpose remote I/O expansion for most microcontroller families via the I^2C interface [serial clock (SCL), serial data (SDA)].

The device features a 16-bit quasi-bidirectional input/output (I/O) port (P07−P00; P17−P10), 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 (I_{OH}) to V_{CC} is active. An additional strong pullup to V_{CC} (I_{OHT}) 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. After power on, as all the I/Os are set high, all of them can be used as inputs. Any change in setting of the I/Os as either input or outputs can be done with the write mode. If a high is applied externally to an I/O that has been written earlier to low, a large current (I_{OL}) will flow to GND.

The PCF8575 provides an open-drain interrupt output ($\overline{INT}$), which 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}), the signal $\overline{INT}$ 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 (ACK) bit after the rising edge of the SCL signal or in the write mode at the ACK bit after the falling edge of the SCL signal. Interrupts that occur during the ACK 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 transmitted as $\overline{INT}$. Reading from or writing to another device does not affect the interrupt circuit.

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^2C bus. Thus, the PCF8575 can remain a simple slave device.

Every data transmission to or from the PCF8575 must consist of an even number of bytes. The first data byte in every pair refers to port 0 (P07−P00), and the second data byte in every pair refers to port 1 (P17−P10). To write to the ports (output mode), the master first addresses the slave device, setting the last bit of the byte containing the slave address to logic 0. The PCF8575 acknowledges, and the master sends the first data byte for P07−P00. After the first data byte is acknowledged by the PCF8575, the second data byte (P17−P10) is sent by the master. Once again, the PCF8575 acknowledges the receipt of the data, after which this 16-bit data is presented on the port lines.

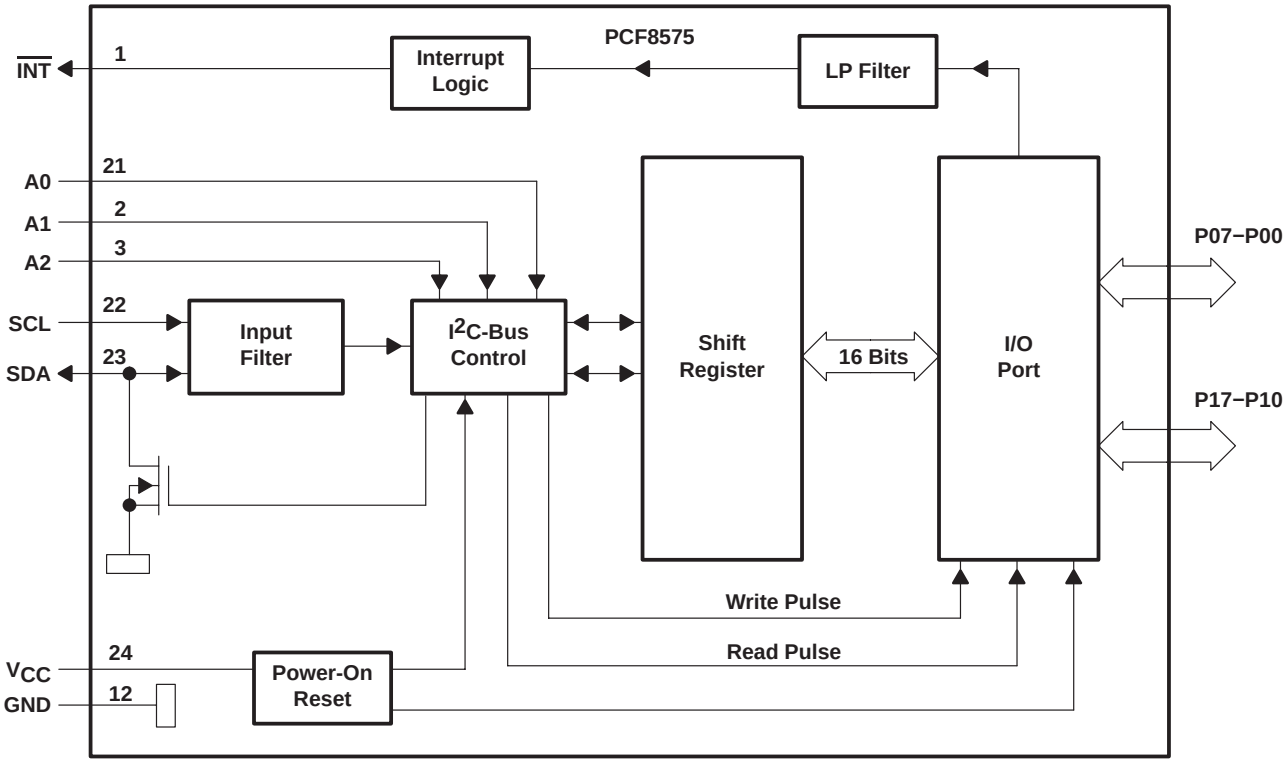
The number of data bytes that can be sent successively is not limited. After every two bytes, the previous data is overwritten. When the PCF8575 receives the pairs of data bytes, the first byte is referred to as P07−P00 and the second byte as P17−P10. The third byte is referred to as P07−P00, the fourth byte as P17−P10, and so on.

Before reading from the PCF8575, all ports desired as input should be set to logic 1. To read from the ports (input mode), the master first addresses the slave device, setting the last bit of the byte containing the slave address to logic 1. The data bytes that follow on the SDA are the values on the ports. If the data on the input port changes faster than the master can read, this data may be lost.

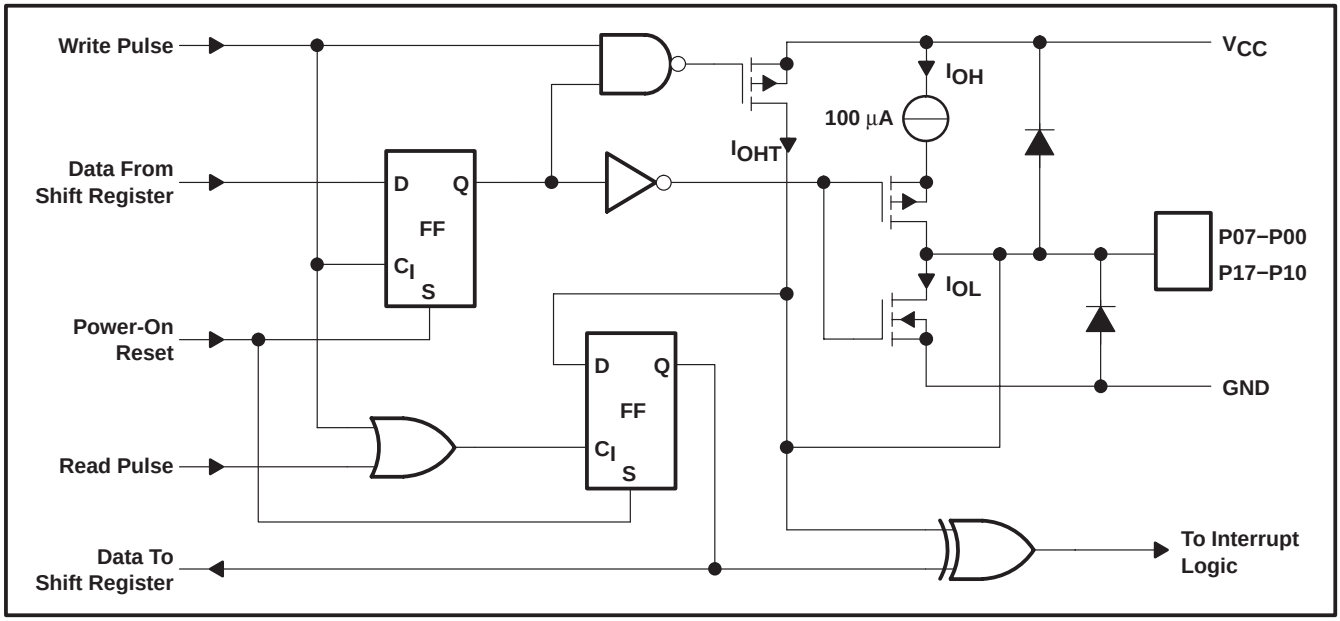
When power is applied to V_{CC}, an internal power-on reset holds the PCF8575 in a reset state until V_{CC} has reached V_{POR}. At that time, the reset condition is released, and the device's I^2C-bus state machine initializes the bus to its default state.

The hardware pins (A0, A1, and A2) are used to program and vary the fixed I^2C address and allow up to eight devices to share the same I^2C bus or SMBus. The fixed I^2C address of the PCF8575 is the same as the PCF8575C, PCF8574, PCA9535, and PCA9555, allowing up to eight of these devices, in any combination, to share the same I^2C bus or SMBus.

logic diagram (positive logic)



simplified schematic diagram of each P-port input/output



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 via 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/$\overline{W}$). This device does not respond to the general call address. After receiving the valid address byte, this device responds with an 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.

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

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).

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).

The number of data bytes transferred between the start and the stop conditions from transmitter to receiver is not limited. 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.

A slave receiver that is addressed must generate an ACK after the reception of each byte. Also, a master must generate an ACK after the reception of each byte that has been clocked out of the slave transmitter. The device that acknowledges has to 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). Setup and hold times must be taken into account.

A master receiver must signal an end of data to the transmitter by not generating an acknowledge (NACK)after the last byte that 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.

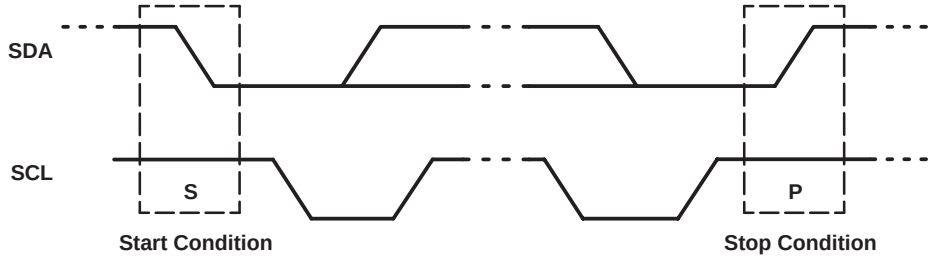


Figure 1. Definition of Start and Stop Conditions

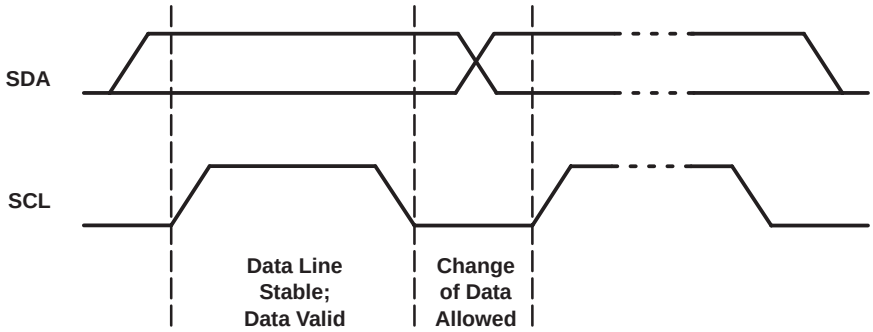


Figure 2. Bit Transfer

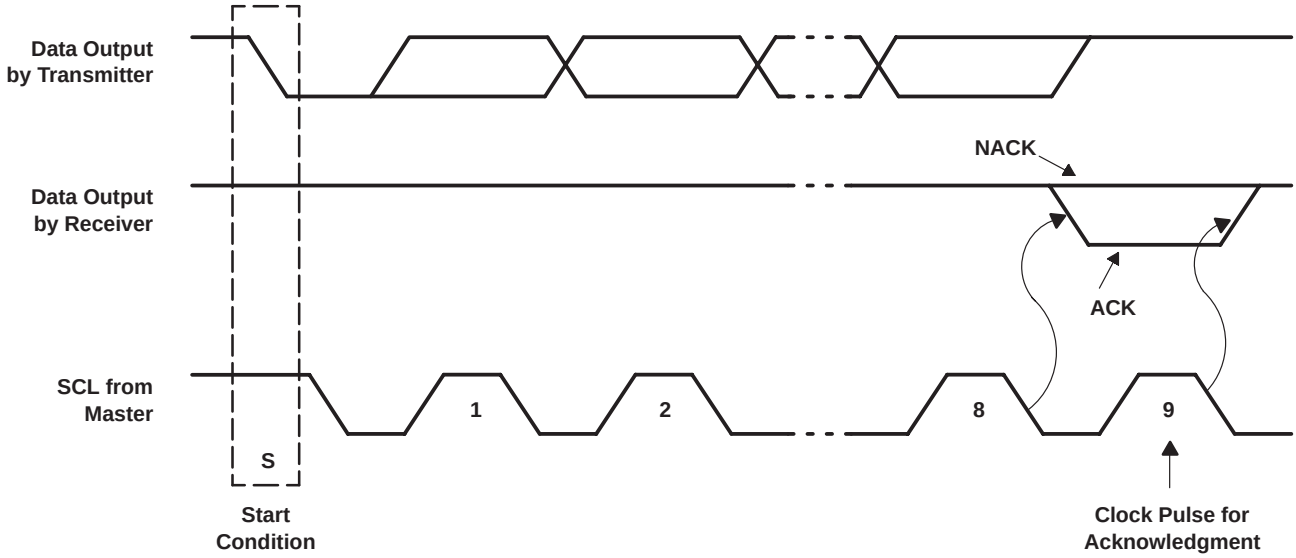


Figure 3. Acknowledgment on the I²C Bus

INTERFACE DEFINITION TABLE

BYTE	BIT							
	7 (MSB)	6	5	4	3	2	1	0 (LSB)
I²C slave address	L	H	L	L	A2	A1	A0	R/$\overline{W}$
P0x I/O data bus	P07	P06	P05	P04	P03	P02	P01	P00
P1x I/O data bus	P17	P16	P15	P14	P13	P12	P11	P10

Figures 4 and 5 show the address and timing diagrams for the write and read modes, respectively.

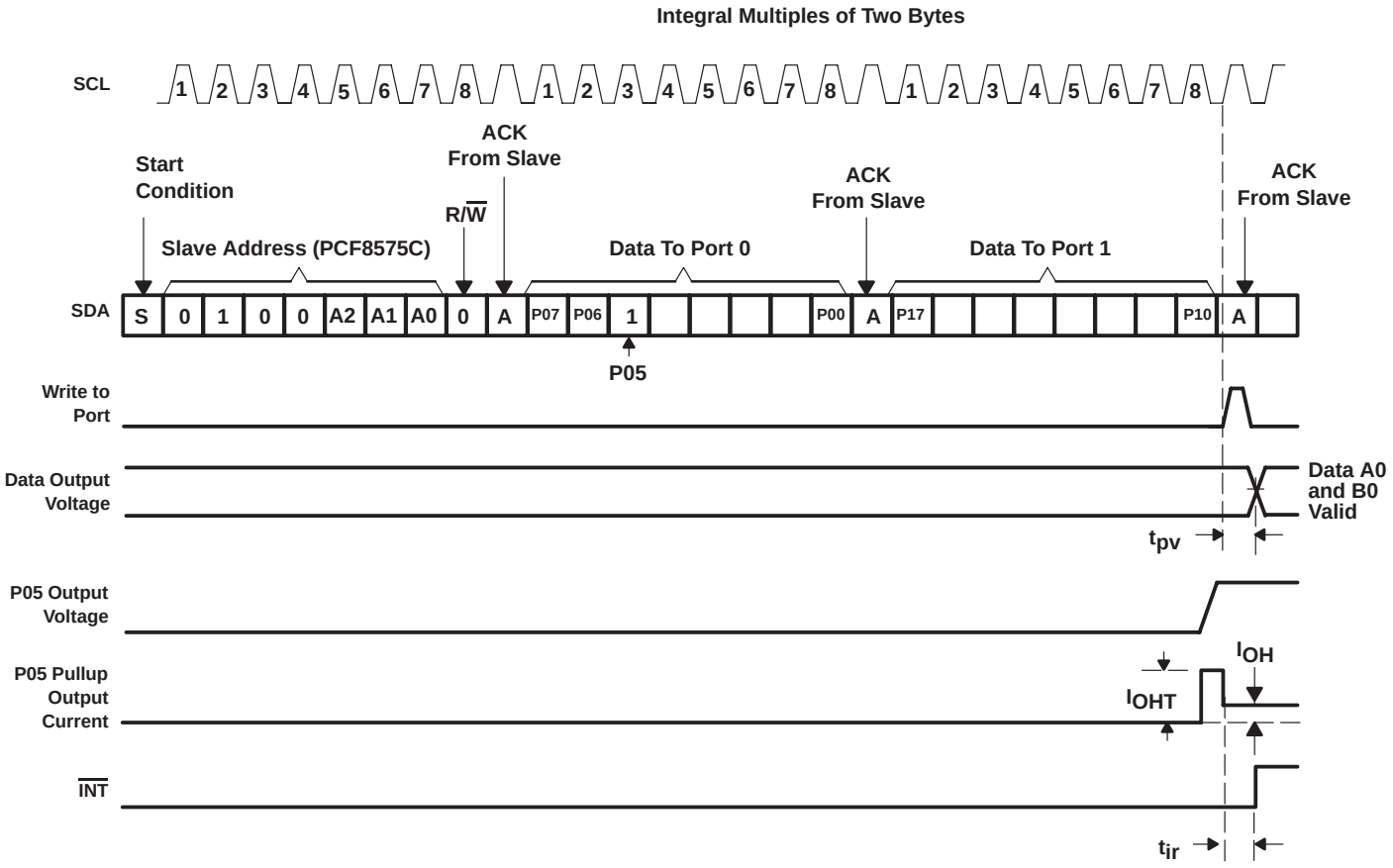
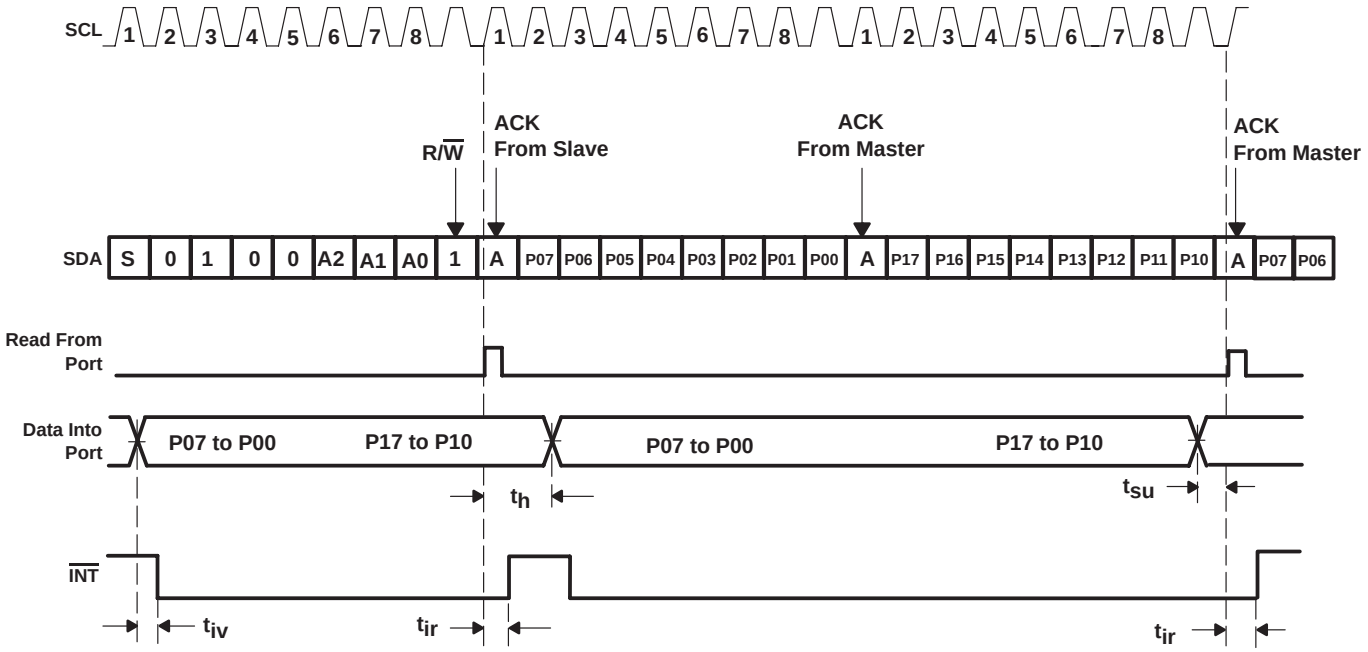


Figure 4. Write Mode (Output)



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 5. Read Mode (Input)

ADDRESS REFERENCE TABLE

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)

absolute maximum ratings over operating free-air temperature range (unless otherwise noted)†

Supply voltage range, V_{CC} . . . . . −0.5 V to 6.5 V
Input voltage range, V_I (see Note 1) . . . . . −0.5 V to V_{CC} + 0.5 V
Output voltage range, V_O (see Note 1) . . . . . −0.5 V to V_{CC} + 0.5 V
Input clamp current, I_{IK} (V_I < 0) . . . . . −20 mA
Output clamp current, I_{OK} (V_O < 0) . . . . . −20 mA
Input/Output clamp current, I_{OK} (V_O < 0 or V_O > V_{CC}) . . . . . −20 mA
Continuous output low current, I_{OL} (V_O = 0 to V_{CC}) . . . . . 50 mA
Continuous output high current, I_{OH} (V_O = 0 to V_{CC}) . . . . . −4 mA
Continuous current through V_{CC} or GND . . . . . ±100 mA
Package thermal impedance, θ_{JA} (see Note 2): DB package . . . . . 63°C/W
DBQ package . . . . . 61°C/W
DGV package . . . . . 86°C/W
DW package . . . . . 46°C/W
PW package . . . . . 88°C/W
RGE package . . . . . 53°C/W
RHL package . . . . . 43°C/W
Storage temperature range, T_{stg} . . . . . −65°C to 150°C

† 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.

NOTES: 1. The input negative-voltage and output voltage ratings may be exceeded if the input and output current ratings are observed.
2. The package thermal impedance is calculated in accordance with JESD 51-7.

recommended operating conditions

		MIN	MAX	UNIT
V_{CC}	Supply voltage	2.5	5.5	V
V_{IH}	High-level input voltage	0.7 × V_{CC}	V_{CC} + 0.5	V
V_{IL}	Low-level input voltage	−0.5	0.3 × V_{CC}	V
I_{OH}	P-port high-level output current		−1	mA
I_{OHT}	P-port transient pullup current		10	mA
I_{OL}	P-port low-level output current		25	mA
T_A	Operating free-air temperature	−40	85	°C

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

PARAMETER		TEST CONDITIONS	V_{CC}	MIN	TYP†	MAX	UNIT
V_{IK}	Input diode clamp voltage	I_I = −18 mA	2.5 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}		1.2	1.8	V
I_{OH}	P port	V_O = GND	2.5 V to 5.5 V	−30		−300	µA
I_{OHT}	P-port transient pullup current	High during ACK, V_{OH} = GND	2.5 V	−0.5	−1		mA
I_{OL}	SDA	V_{OL} = 0.4 V	2.5 V to 5.5 V	3			mA
	P port	V_{OL} = 0.4 V	2.5 V to 5.5 V	5	15		mA
		V_{OL} = 1 V		10	25		mA
	$\overline{INT}$	V_{OL} = 0.4 V	2.5 V to 5.5 V	1.6			mA
I_I	SCL, SDA	$V_I = V_{CC}$ or GND	2.5 V to 5.5 V			±5	µA
	A0, A1, A2					±1	µA
I_{IHL}	P port	$V_I \geq V_{CC}$ or $V_I \leq$ GND	2.5 V to 5.5 V			±400	µA
I_{CC}	Operating mode	$V_I = V_{CC}$ or GND, I_O = 0, f_{SCL} = 400 kHz	5.5 V		100	200	µA
			3.6 V		30	75	
			2.7 V		20	50	
	Standby mode	$V_I = V_{CC}$ or GND, I_O = 0 f_{SCL} = 0 kHz	5.5 V		2.5	10	
			3.6 V		2.5	10	
			2.7 V		2.5	10	
ΔI_{CC}	Supply current increase	One input at V_{CC} − 0.6, Other inputs at V_{CC} or GND	2.5 V to 5.5 V			200	µA
C_i	SCL	$V_I = V_{CC}$ or GND	2.5 V to 5.5 V		3	7	pF
C_{io}	SDA	$V_{IO} = V_{CC}$ or GND	2.5 V to 5.5 V		3	7	pF
	P port				4	10	

† All typical values are at nominal supply voltage (2.5-V, 3.3-V, or 5 V V_{CC}) and T_A = 25°C.
‡ The power-on reset circuit resets the I²C-bus logic with $V_{CC} < V_{POR}$ and sets all I/Os to logic high (with current source to V_{CC}).

I²C interface timing requirements over recommended operating free-air temperature range (unless otherwise noted) (see Figure 6)

			MIN	MAX	UNIT
f_{scl}	I²C clock frequency			400	kHz
t_{sch}	I²C clock high time		0.6		µs
t_{scl}	I²C clock low time		1.3		µs
t_{sp}	I²C spike time			50	ns
t_{sds}	I²C serial-data setup time		100		ns
t_{sdh}	I²C serial-data hold time		0		ns
t_{icr}	I²C input rise time		$20 + 0.1C_b$§	300	ns
t_{icf}	I²C input fall time		$20 + 0.1C_b$§	300	ns
t_{ocf}	I²C output fall time (10-pF to 400-pF bus)			300	ns
t_{buf}	I²C bus free time between stop and start		1.3		µs
t_{sts}	I²C start or repeated start condition setup		0.6		µs
t_{sth}	I²C start or repeated start condition hold		0.6		µs
t_{sps}	I²C stop condition setup		0.6		µs
t_{vd}	Valid-data time	SCL low to SDA output valid		1.2	µs
C_b	I²C bus capacitive load			400	pF

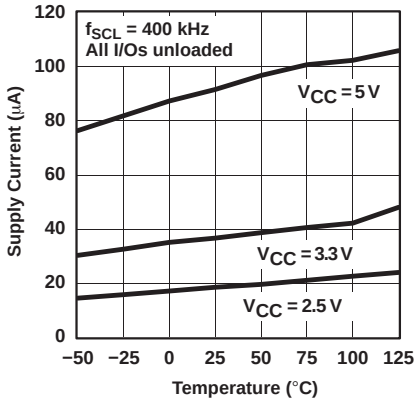
§ C_b = total bus capacitance of one bus line in pF

switching characteristics over recommended operating free-air temperature range, $C_L \leq 100$ pF (unless otherwise noted) (see Figures 7 and 8)

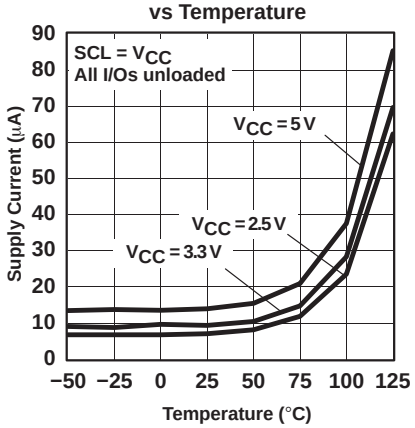
PARAMETER		FROM (INPUT)	TO (OUTPUT)	MIN	TYP	MAX	UNIT
t_{iv}	Interrupt valid time	P port	$\overline{INT}$			4	µs
t_{ir}	Interrupt reset delay time	SCL	$\overline{INT}$			4	µs
t_{pv}	Output data valid	SCL	P port			4	µs
t_{su}	Input data setup time	P port	SCL	0			µs
t_h	Input data hold time	P port	SCL	4			µs

TYPICAL OPERATING CHARACTERISTICS
T_A = 25°C (unless otherwise noted)

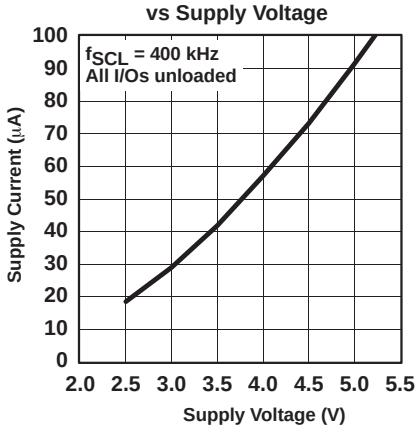
Supply Current vs Temperature



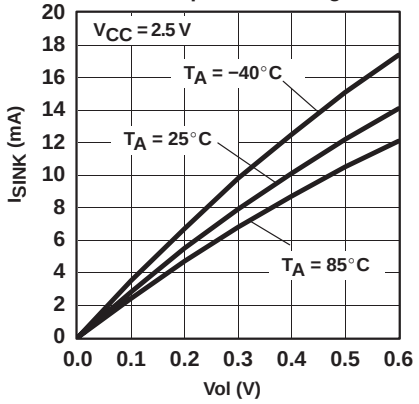
Standby Supply Current vs Temperature



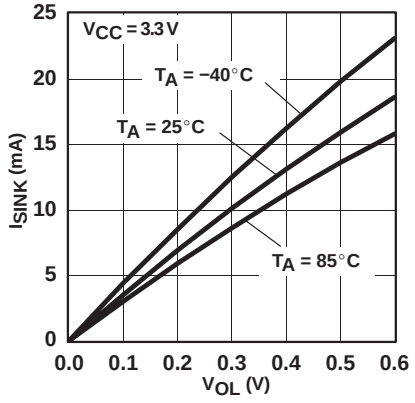
Supply Current vs Supply Voltage



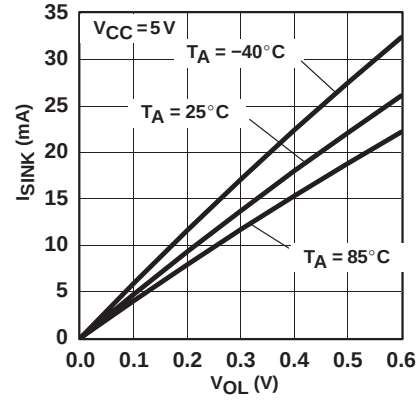
I/O Sink Current vs Output Low Voltage



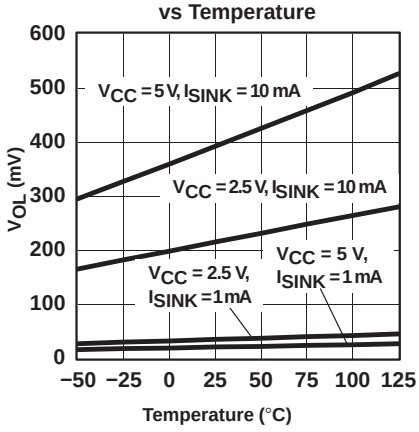
I/O Sink Current vs Output Low Voltage



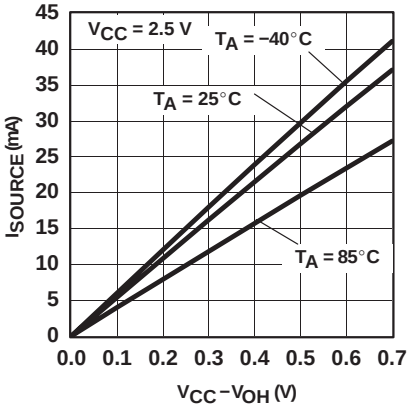
I/O Sink Current vs Output Low Voltage



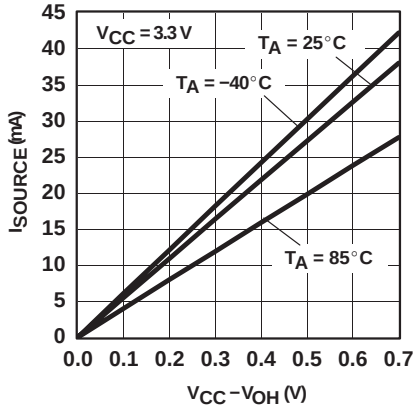
I/O Output Low Voltage vs Temperature



I/O Source Current vs Output High Voltage

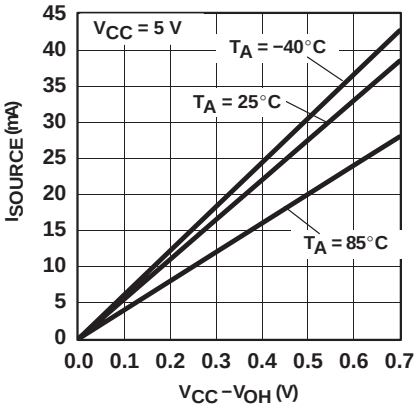


I/O Source Current vs Output High Voltage

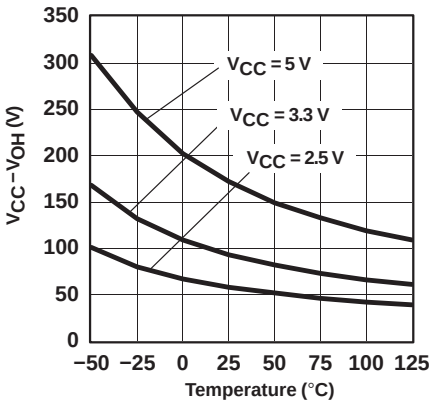


TYPICAL OPERATING CHARACTERISTICS
T_A = 25°C (unless otherwise noted) (continued)

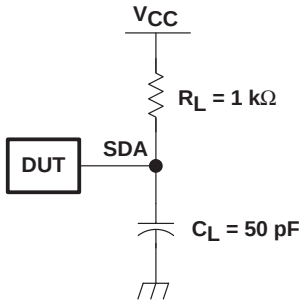
I/O Source Current vs Output High Voltage



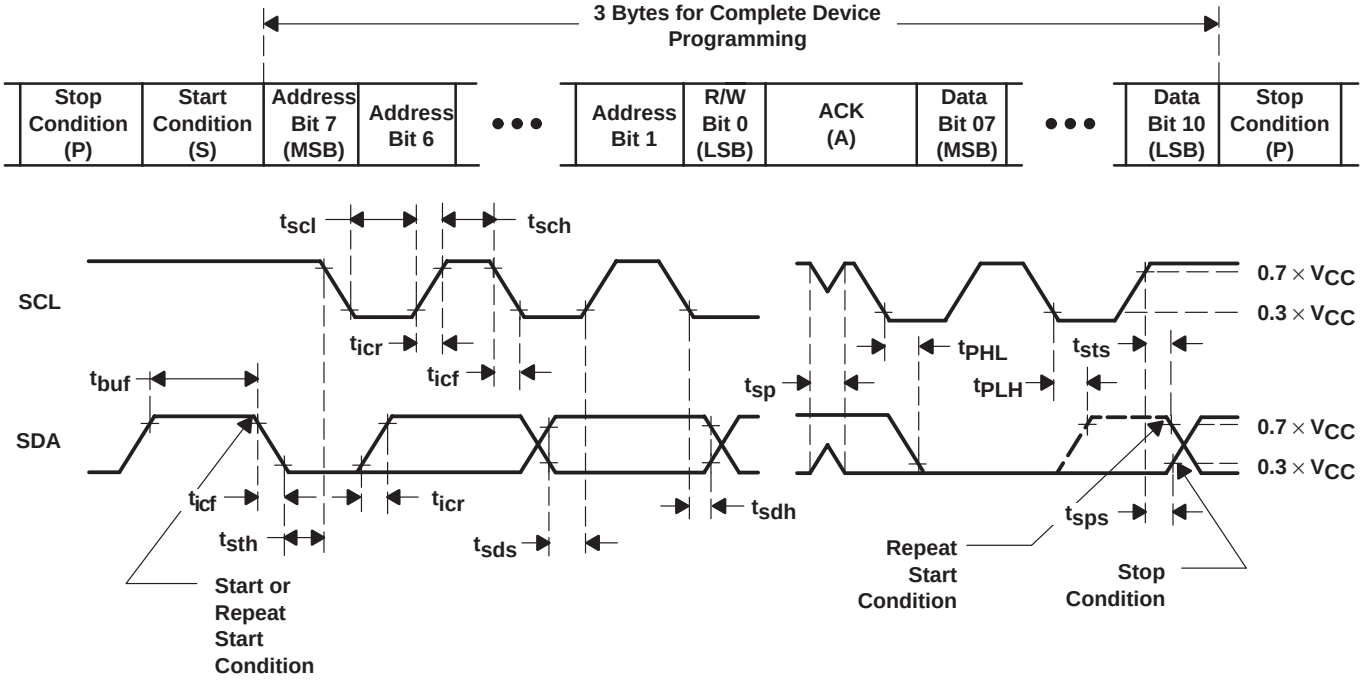
I/O High Voltage vs Temperature



PARAMETER MEASUREMENT INFORMATION



SDA LOAD CONFIGURATION

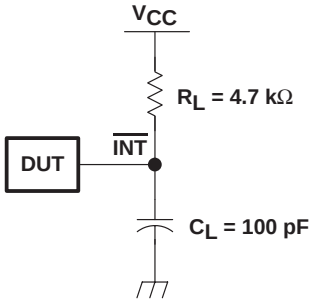


VOLTAGE WAVEFORMS

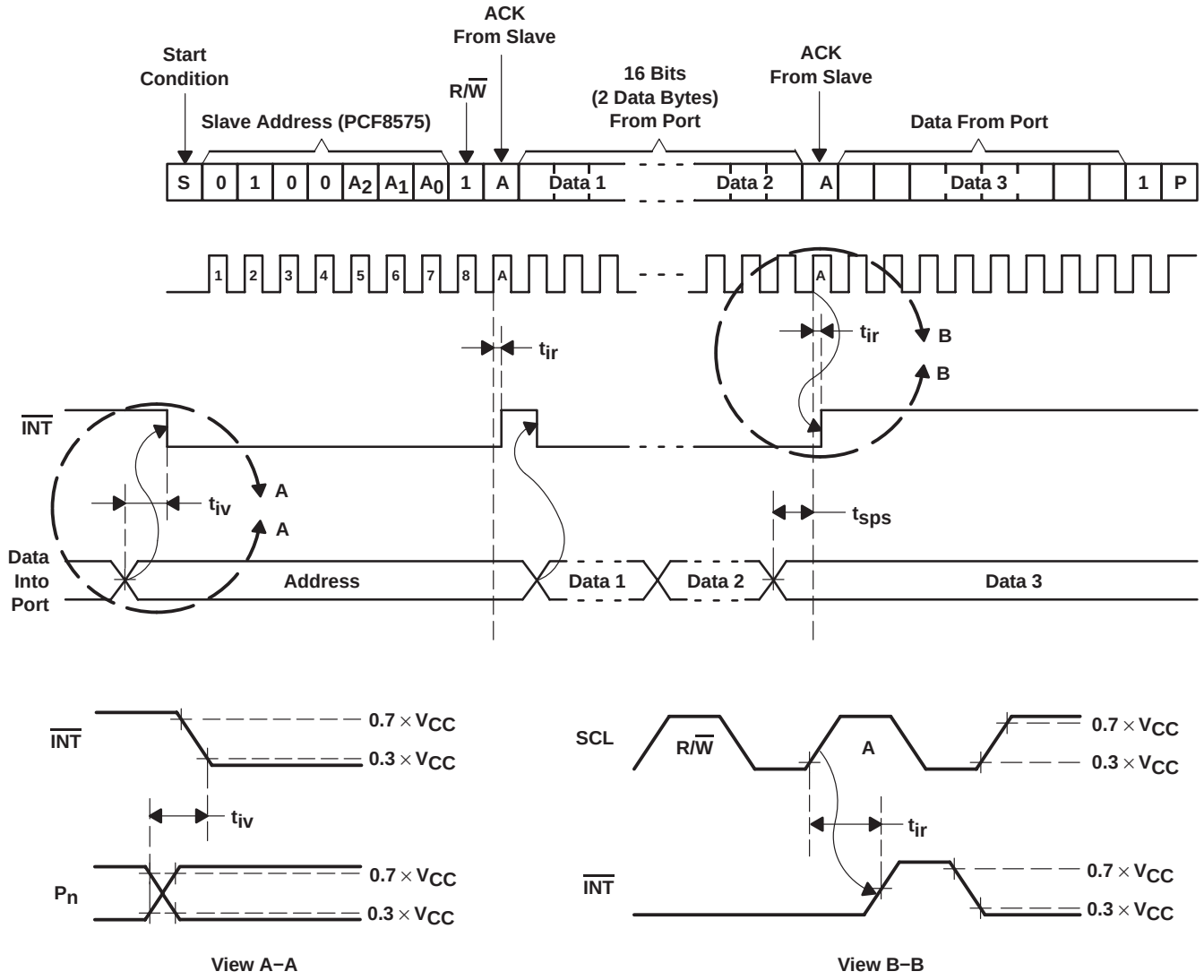
BYTE	DESCRIPTION
1	I2C address
2, 3	P port data

Figure 6. I2C Interface Load Circuit and Voltage Waveforms

PARAMETER MEASUREMENT INFORMATION



INTERRUPT LOAD CONFIGURATION

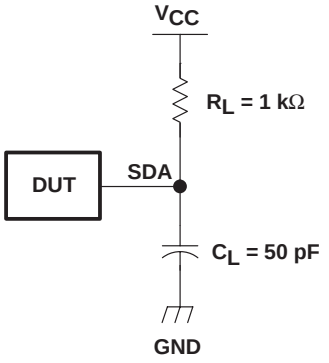


View A–A

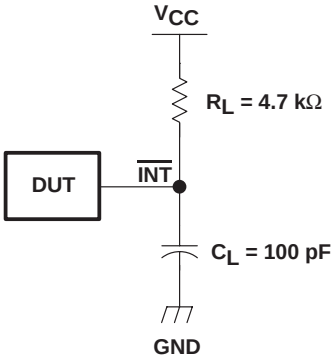
View B–B

Figure 7. Interrupt Load Circuits and Voltage Waveforms

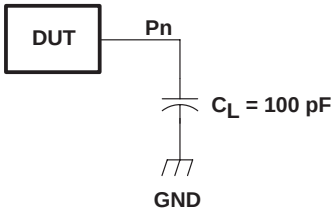
PARAMETER MEASUREMENT INFORMATION



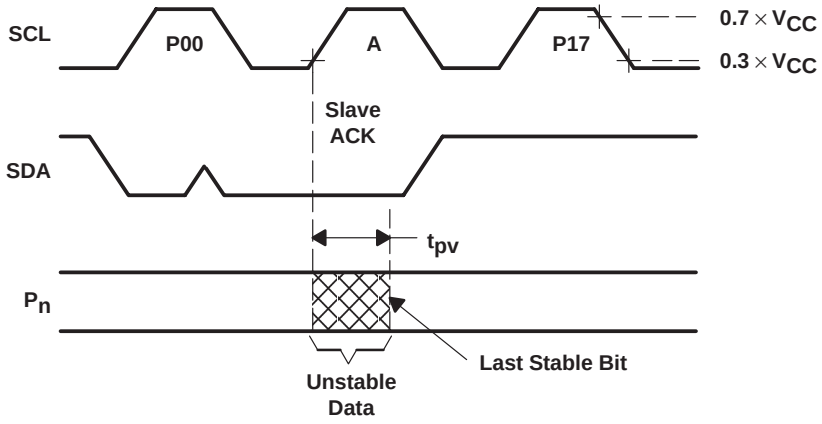
SDA LOAD CONFIGURATION



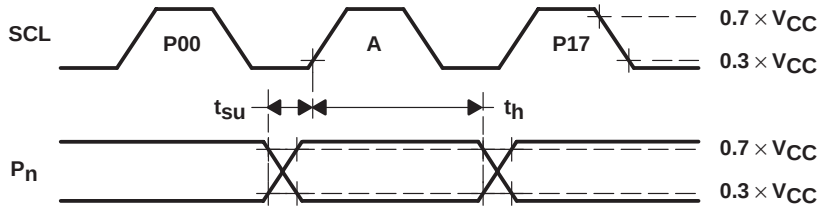
INTERRUPT LOAD CONFIGURATION



P-PORT LOAD CONFIGURATION



Write-Mode Timing (R/$\overline{W}$ = 0)

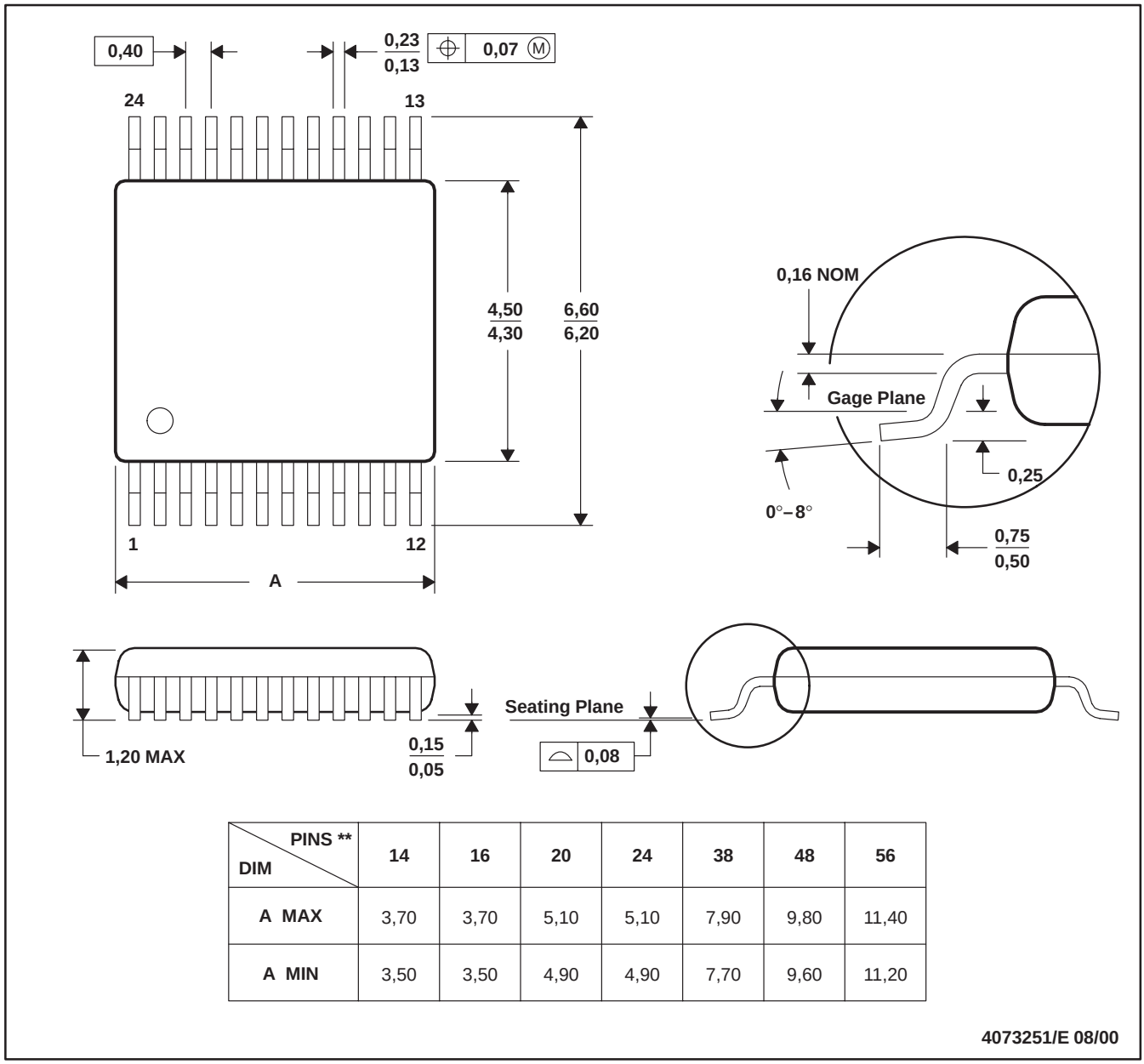


Read-Mode Timing (R/$\overline{W}$ = 1)

Figure 8. P-Port Timing Waveforms

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

24 PINS SHOWN

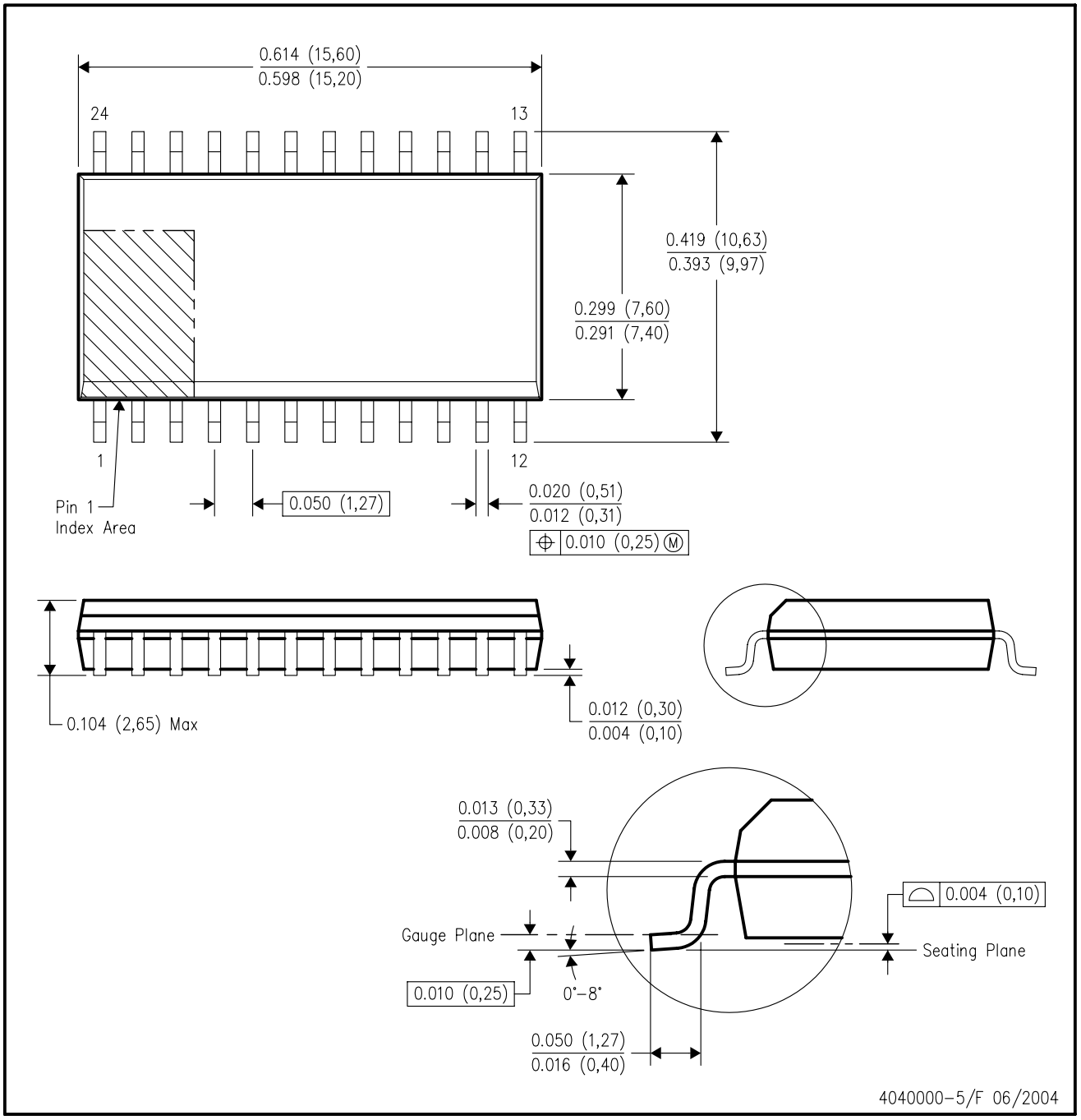


DIM \ PINS **	14	16	20	24	38	48	56
A MAX	3,70	3,70	5,10	5,10	7,90	9,80	11,40
A MIN	3,50	3,50	4,90	4,90	7,70	9,60	11,20

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

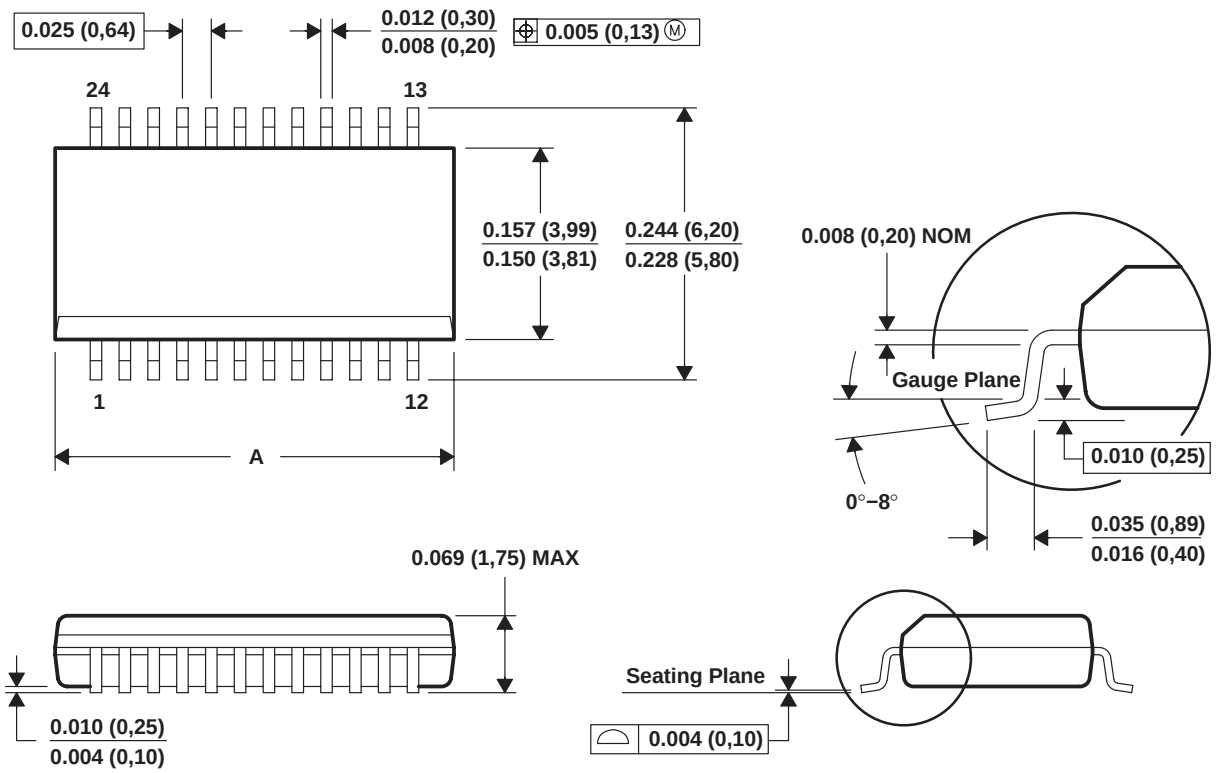
DW (R–PDSO–G24) PLASTIC SMALL–OUTLINE PACKAGE



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 AD.

MSOI004E JANUARY 1995 − REVISED MAY 2002

DBQ (R−PDSO−G)** **PLASTIC SMALL−OUTLINE PACKAGE**



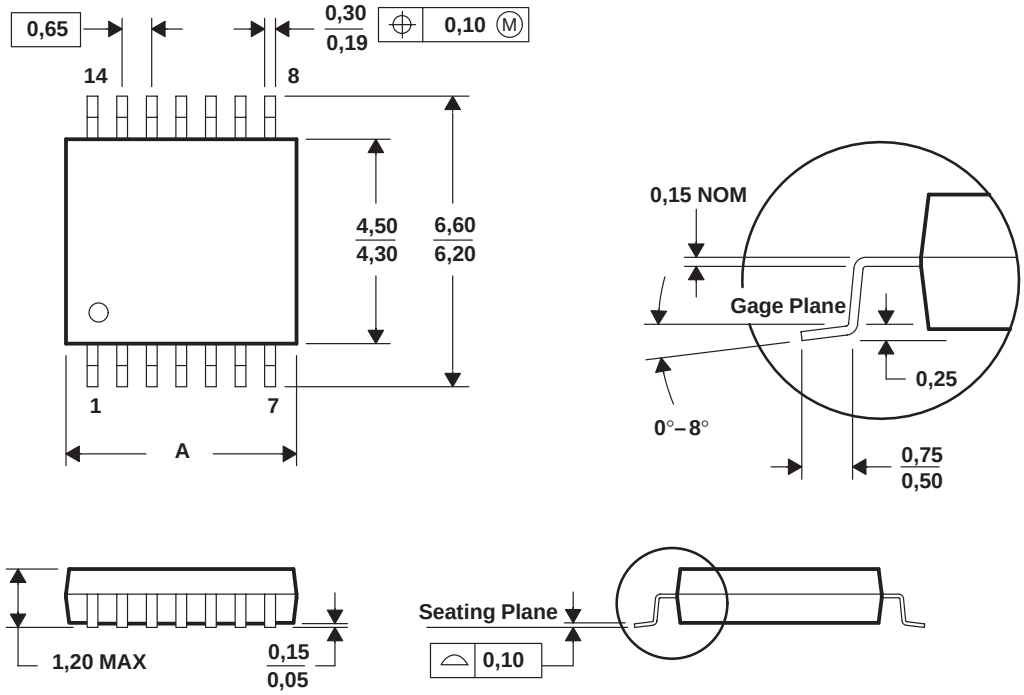
DIM \ PINS **	16	20	24	28
A MAX	0.197 (5,00)	0.344 (8,74)	0.344 (8,74)	0.394 (10,01)
A MIN	0.189 (4,80)	0.337 (8,56)	0.337 (8,56)	0.386 (9,80)
M0−137 VARIATION	AB	AD	AE	AF

4073301/F 02/2002

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 MO−137.

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

14 PINS SHOWN



DIM \ PINS **	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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