

# DATA SHEET



## **PCA9515A** I<sup>2</sup>C-bus repeater

Product data sheet  
Supersedes data of 2004 Jul 09

2004 Sep 29

# I<sup>2</sup>C-bus repeater

## PCA9515A

### DESCRIPTION

The PCA9515A is a CMOS integrated circuit intended for application in I<sup>2</sup>C and SMBus systems.

While retaining all the operating modes and features of the I<sup>2</sup>C system it permits extension of the I<sup>2</sup>C-bus by buffering both the data (SDA) and the clock (SCL) lines, thus enabling two buses of 400 pF.

The I<sup>2</sup>C-bus capacitance limit of 400 pF restricts the number of devices and bus length. Using the PCA9515A enables the system designer to isolate two halves of a bus, thus more devices or longer length can be accommodated. It can also be used to run two buses, one at 5 V and the other at 3.3 V or a 400 kHz and 100 kHz bus, where the 100 kHz bus is isolated when 400 kHz operation of the other is required.

**Two or more PCA9515As cannot be put in series.** The PCA9515A design does not allow this configuration. Since there is no direction pin, slightly different "legal" low voltage levels are used to avoid lock-up conditions between the input and the output. A "regular LOW" applied at the input of a PCA9515A will be propagated as a "buffered LOW" with a slightly higher value. When this "buffered LOW" is applied to another PCA9515A, PCA9516A, or PCA9518 in series, the second PCA9515A, PCA9516A, or PCA9518 will not recognize it as a "regular LOW" and will not propagate it as a "buffered LOW" again. The PCA9510/9511/9513/9514 and PCA9512 cannot be used in series with the PCA9515A, PCA9516A, or PCA9518 but can be used in series with themselves since they use shifting instead of static offsets to avoid lock-up conditions.

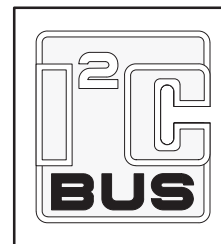
### FEATURES

- 2 channel, bi-directional buffer
- I<sup>2</sup>C-bus and SMBus compatible
- Active-HIGH repeater enable input
- Open-drain input/outputs
- Lock-up free operation
- Supports arbitration and clock stretching across the repeater
- Accommodates standard mode and fast mode I<sup>2</sup>C devices and multiple masters
- Powered-off high-impedance I<sup>2</sup>C pins
- Operating supply voltage range of 2.3 V to 3.6 V
- 5.5 V tolerant I<sup>2</sup>C and enable pins
- 0 to 400 kHz clock frequency<sup>1</sup>
- ESD protection exceeds 2000 V HBM per JESD22-A114, 200 V MM per JESD22-A115, and 1000 V CDM per JESD22-C101.
- Latch-up testing is done to JEDEC Standard JESD78 which exceeds 100 mA.
- Package offerings: SO and TSSOP (MSOP)

### ORDERING INFORMATION

PACKAGES	TEMPERATURE RANGE	ORDER CODE	TOPSIDE MARK	DRAWING NUMBER
8-pin plastic SO	−40 °C to +85 °C	PCA9515AD	PA9515A	SOT96-1
8-pin plastic TSSOP (MSOP)	−40 °C to +85 °C	PCA9515ADP	9515A	SOT505-1

Standard packing quantities and other packaging data are available at [www.standardproducts.philips.com/packaging](http://www.standardproducts.philips.com/packaging).



### PIN CONFIGURATION

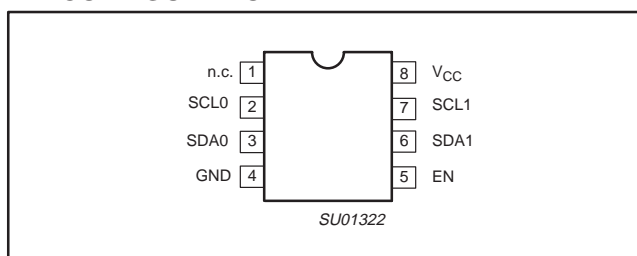


Figure 1. Pin configuration

### PIN DESCRIPTION

PIN	SYMBOL	FUNCTION
1	n.c.	No connection
2	SCL0	Serial clock bus 0
3	SDA0	Serial data bus 0
4	GND	Supply ground
5	EN	Active-HIGH repeater enable input
6	SDA1	Serial data bus 1
7	SCL1	Serial clock bus 1
8	V <sub>CC</sub>	Supply power

1. The maximum system operating frequency may be less than 400 kHz because of the delays added by the repeater.

I<sup>2</sup>C-bus repeater

## PCA9515A

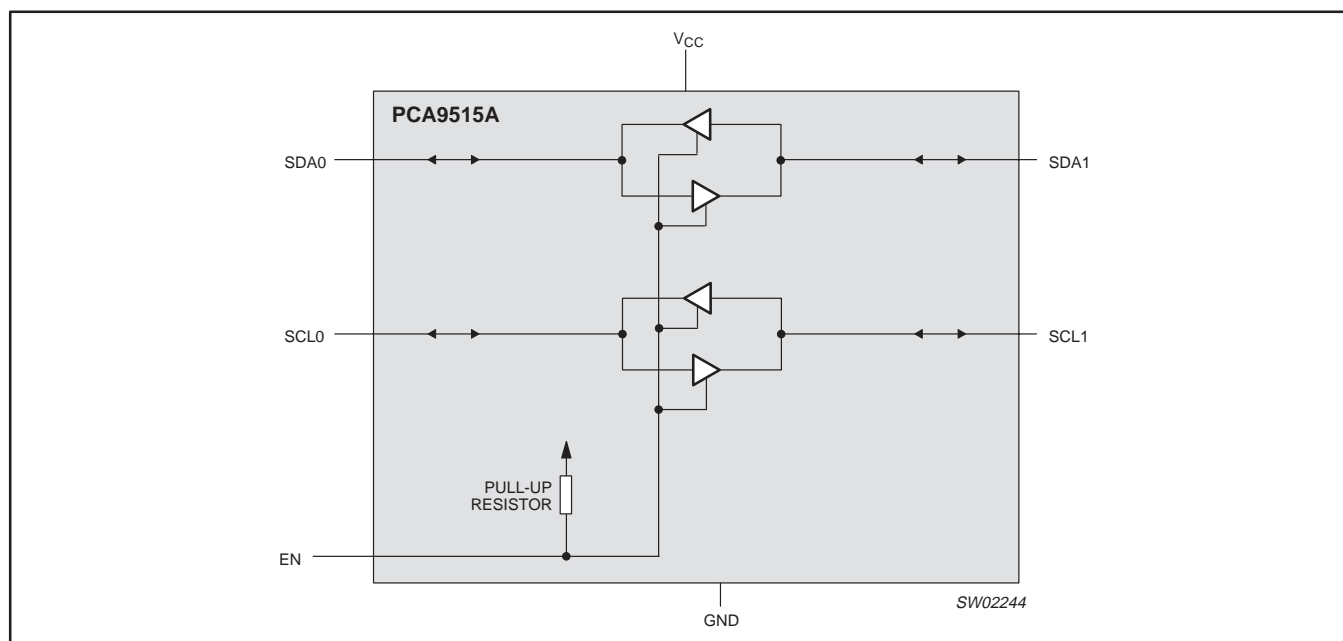


Figure 2. PCA9515A block diagram

The output pull-down of each internal buffer is set for approximately 0.5 V, while the input threshold of each internal buffer is set about 0.07 V lower, when the output is internally driven LOW. This prevents a lock-up condition from occurring.

### FUNCTIONAL DESCRIPTION

The PCA9515A integrated circuit contains two identical buffer circuits which enable I<sup>2</sup>C and similar bus systems to be extended without degradation of system performance.

The PCA9515A contains two bi-directional, open drain buffers specifically designed to support the standard LOW-level-contention arbitration of the I<sup>2</sup>C-bus. Except during arbitration or clock stretching, the PCA9515A acts like a pair of non-inverting, open drain buffers, one for SDA and one for SCL.

### Enable

The EN pin is active HIGH with an internal pull up and allows the user to select when the repeater is active. This can be used to isolate a badly behaved slave on power up until after the system power up reset. It should never change state during an I<sup>2</sup>C operation because disabling during a bus operation will hang the bus and enabling part way through a bus cycle could confuse the I<sup>2</sup>C parts being enabled.

The enable pin should only change state when the global bus and the repeater port are in an idle state to prevent system failures.

### I<sup>2</sup>C Systems

As with the standard I<sup>2</sup>C system, pull-up resistors are required to provide the logic HIGH levels on the Buffered bus. (Standard open-collector configuration of the I<sup>2</sup>C-bus). The size of these pull-up resistors depends on the system, but each side of the repeater must have a pull-up resistor. This part designed to work with standard mode and fast mode I<sup>2</sup>C devices in addition to SMBus devices. Standard mode I<sup>2</sup>C devices only specify 3 mA output drive, this limits the termination current to 3 mA in a generic I<sup>2</sup>C system where standard mode devices and multiple masters are possible. Under certain conditions higher termination currents can be used. Please see Application Note AN255 "I<sup>2</sup>C & SMBus Repeaters, Hubs and Expanders" for additional information on sizing resistors and precautions when using more than one PCA9515A/PCA9516A in a system or using the PCA9515A/16A in conjunction with the P82B96.

# I<sup>2</sup>C-bus repeater

## PCA9515A

### APPLICATION INFORMATION

A typical application is shown in Figure 3. In this example, the system master is running on a 3.3 V I<sup>2</sup>C-bus while the slave is connected to a 5 V bus. Both buses run at 100 kHz unless the slave bus is isolated and then the master bus can run at 400 kHz. Master devices can be placed on either bus.

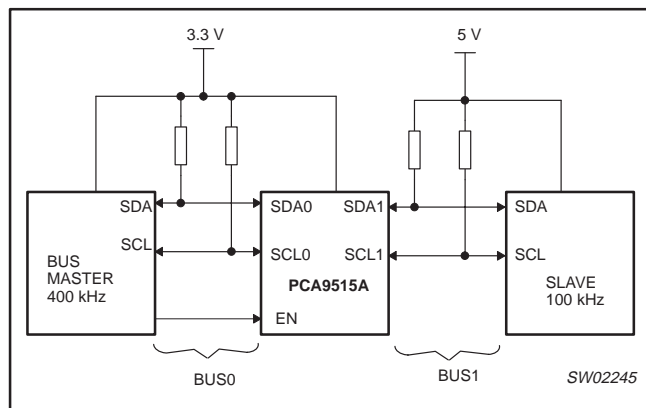


Figure 3. Typical application

The PCA9515A is 5 V tolerant so it does not require any additional circuitry to translate between the different bus voltages.

When one side of the PCA9515A is pulled LOW by a device on the I<sup>2</sup>C-bus, a CMOS hysteresis type input detects the falling edge and causes an internal driver on the other side to turn on, thus causing the other side to also go LOW. The side driven LOW by the PCA9515A will typically be at  $V_{OL} = 0.5$  V.

In order to illustrate what would be seen in a typical application, refer to Figures 4 and 5. If the bus master in Figure 3 were to write to the slave through the PCA9515A, we would see the waveform shown in Figure 4 on Bus 0. This looks like a normal I<sup>2</sup>C transmission until the falling edge of the 8<sup>th</sup> clock pulse. At that point, the master releases the data line (SDA) while the slave pulls it LOW through the PCA9515A. Because the  $V_{OL}$  of the PCA9515A is typically around 0.5 V, a step in the SDA will be seen. After the master has transmitted the 9<sup>th</sup> clock pulse, the slave releases the data line.

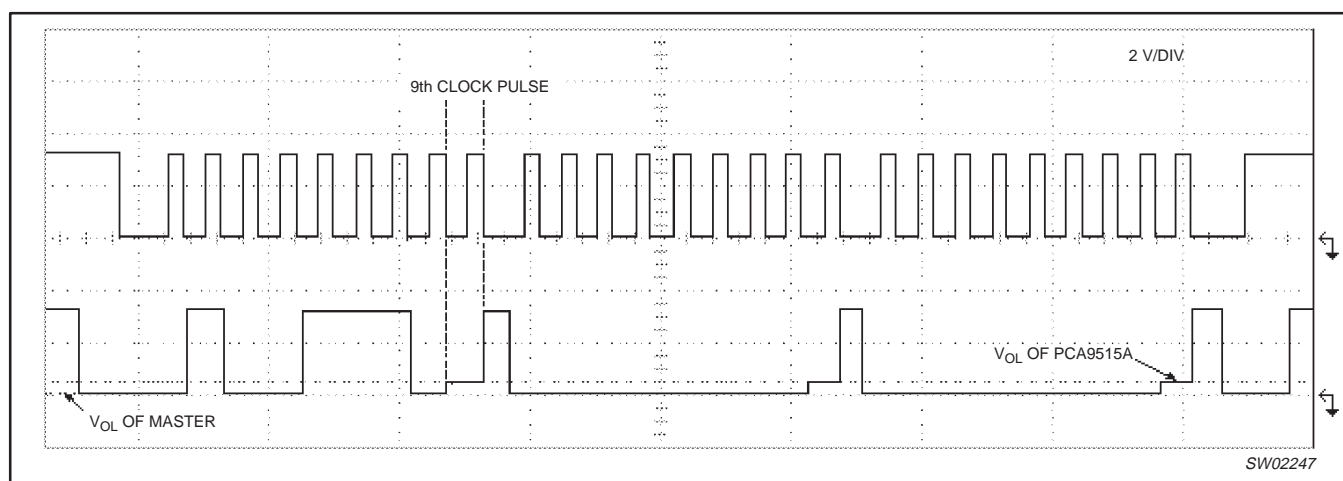


Figure 4. Bus 0 waveform

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## PCA9515A

On the Bus 1 side of the PCA9515A, the clock and data lines would have a positive offset from ground equal to the  $V_{OL}$  of the PCA9515A. After the 8<sup>th</sup> clock pulse, the data line will be pulled to the  $V_{OL}$  of the slave device that is very close to ground in our example.

It is important to note that any arbitration or clock stretching events on Bus 1 require that the  $V_{OL}$  of the devices on Bus 1 be 70 mV below the  $V_{OL}$  of the PCA9515A (see  $V_{OL} - V_{ilc}$  in the DC Characteristics section) to be recognized by the PCA9515A and then transmitted to Bus 0.

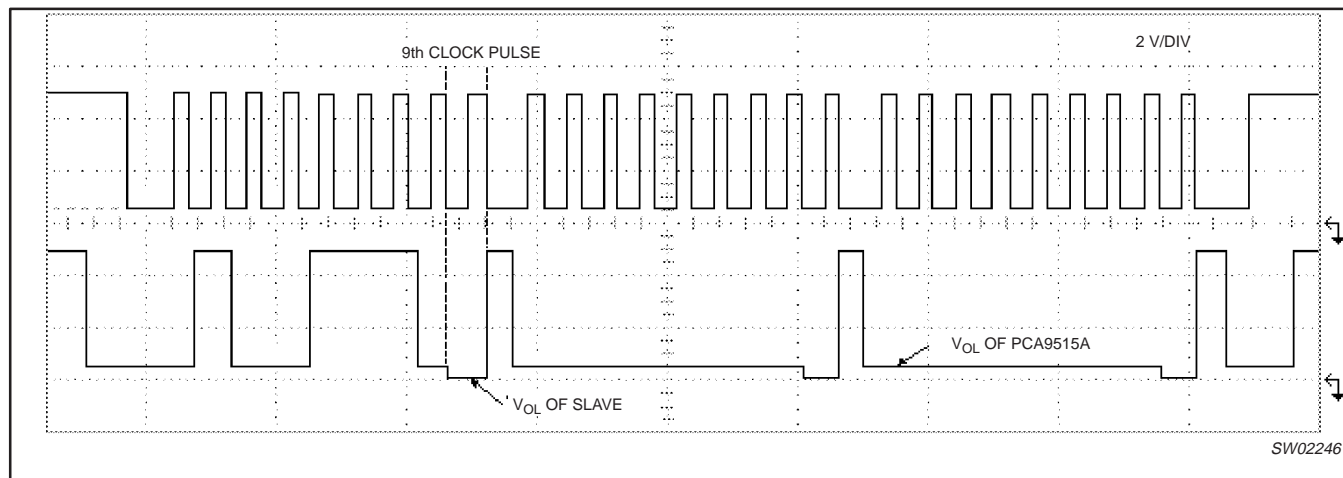


Figure 5. Bus 1 waveform

I<sup>2</sup>C-bus repeater

PCA9515A

## ABSOLUTE MAXIMUM RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134).

Voltages with respect to pin GND.

SYMBOL	PARAMETER	LIMITS		UNIT
		MIN.	MAX.	
V <sub>CC</sub> to GND	Supply voltage range V <sub>CC</sub>	−0.5	+7	V
V <sub>bus</sub>	Voltage range I <sup>2</sup> C-bus, SCL or SDA	−0.5	+7	V
I	DC current (any pin)	—	50	mA
P <sub>tot</sub>	Power dissipation	—	100	mW
T <sub>stg</sub>	Storage temperature range	−55	+125	°C
T <sub>amb</sub>	Operating ambient temperature range	−40	+85	°C

## DC ELECTRICAL CHARACTERISTICS

V<sub>CC</sub> = 3.0 V to 3.6 V; GND = 0 V; T<sub>amb</sub> = −40 to +85 °C; unless otherwise specified.

SYMBOL	PARAMETER	TEST CONDITIONS	LIMITS			UNIT
			MIN.	TYP. <sup>2</sup>	MAX.	
Supplies						
V <sub>CC</sub>	DC supply voltage		3.0	—	3.6	V
I <sub>CCH</sub>	Quiescent supply current, both channels HIGH	V <sub>CC</sub> = 3.6 V; SDAn = SCLn = V <sub>CC</sub>	—	0.8	5	mA
I <sub>CCL</sub>	Quiescent supply current, both channels LOW	V <sub>CC</sub> = 3.6 V; one SDA and one SCL = GND, other SDA and SCL open	—	1.7	5	mA
I <sub>CCLc</sub>	Quiescent supply current in contention	V <sub>CC</sub> = 3.6 V; SDAn = SCLn = GND	—	1.6	5	mA
Input SCL; input/output SDA						
V <sub>IH</sub>	HIGH-level input voltage		0.7 V <sub>CC</sub>	—	5.5	V
V <sub>IL</sub>	LOW-level input voltage (Note 1)		−0.5	—	0.3 V <sub>CC</sub>	V
V <sub>ILc</sub>	LOW-level input voltage contention (Note 1)		−0.5	—	0.4	V
V <sub>IK</sub>	Input clamp voltage	I <sub>I</sub> = −18 mA	—	—	−1.2	V
I <sub>LI</sub>	Input leakage current	V <sub>I</sub> = 3.6 V	−1	—	+1	μA
I <sub>IL</sub>	Input current LOW, SDA, SCL	V <sub>I</sub> = 0.2 V, SDA, SCL	—	—	5	μA
V <sub>OL</sub>	LOW-level output voltage	I <sub>OL</sub> = 20 μA or 6 mA	0.47	0.52	0.6	V
V <sub>OL</sub> −V <sub>ILc</sub>	LOW-level input voltage below output LOW level voltage	Guaranteed by design	—	—	70	mV
C <sub>I</sub>	Input capacitance	V <sub>I</sub> = 3 V or 0 V	—	6	7	pF
Enable						
V <sub>IL</sub>	LOW-level input voltage		−0.5	—	0.8	V
V <sub>IH</sub>	HIGH-level input voltage		2.0	—	5.5	V
I <sub>IL</sub>	Input current LOW, EN	V <sub>I</sub> = 0.2 V, EN	—	−10	−30	μA
I <sub>LI</sub>	Input leakage current		−1	—	1	μA
C <sub>I</sub>	Input capacitance	V <sub>I</sub> = 3.0 V or 0 V	—	6	7	pF

## NOTES:

1. V<sub>IL</sub> specification is for the first LOW level seen by the SDAx/SCLx lines. V<sub>ILc</sub> is for the second and subsequent LOW levels seen by the SDAx/SCLx lines.
2. Typical value taken at 3.3 V and 25 °C.
3. For operation between published voltage ranges, refer to worst case parameter in both ranges.

I<sup>2</sup>C-bus repeater

## PCA9515A

## DC ELECTRICAL CHARACTERISTICS

$V_{CC} = 2.3$  to  $2.7$  V;  $GND = 0$  V;  $T_{amb} = -40$  to  $+85$  °C; unless otherwise specified.

SYMBOL	PARAMETER	TEST CONDITIONS	LIMITS			UNIT
			MIN.	TYP. <sup>2</sup>	MAX.	
Supplies						
V <sub>CC</sub>	DC supply voltage		2.3	—	2.7	V
I <sub>CCH</sub>	Quiescent supply current, both channels HIGH	V <sub>CC</sub> = 2.7 V; SDAn = SCLn = V <sub>CC</sub>	—	0.8	5	mA
I <sub>CCL</sub>	Quiescent supply current, both channels LOW	V <sub>CC</sub> = 2.7 V; one SDA and one SCL = GND, other SDA and SCL open	—	1.6	5	mA
I <sub>CCLc</sub>	Quiescent supply current in contention	V <sub>CC</sub> = 2.7 V; SDAn = SCLn = GND	—	1.6	5	mA
Input SCL; input/output SDA						
V <sub>IH</sub>	HIGH-level input voltage		0.7 V <sub>CC</sub>	—	5.5	V
V <sub>IL</sub>	LOW-level input voltage (Note 1)		−0.5	—	0.3 V <sub>CC</sub>	V
V <sub>ILc</sub>	LOW-level input voltage contention (Note 1)		−0.5	—	0.4	V
V <sub>IK</sub>	Input clamp voltage	I <sub>I</sub> = −18 mA	—	—	−1.2	V
I <sub>LI</sub>	Input leakage current	V <sub>I</sub> = 2.7 V	−1	—	+1	μA
I <sub>IL</sub>	Input current LOW, SDA, SCL	V <sub>I</sub> = 0.2 V, SDA, SCL	—	—	10	μA
V <sub>OL</sub>	LOW-level output voltage	I <sub>OL</sub> = 20 μA or 6 mA	0.47	0.52	0.6	V
V <sub>OL</sub> −V <sub>ILc</sub>	LOW-level input voltage below output LOW level voltage	Guaranteed by design	—	—	70	mV
C <sub>I</sub>	Input capacitance	V <sub>I</sub> = 3 V or 0 V	—	6	7	pF
Enable						
V <sub>IL</sub>	LOW-level input voltage		−0.5	—	0.8	V
V <sub>IH</sub>	HIGH-level input voltage		2.0	—	5.5	V
I <sub>IL</sub>	Input current LOW, EN	V <sub>I</sub> = 0.2 V, EN	—	−10	−30	μA
I <sub>LI</sub>	Input leakage current		−1	—	1	μA
C <sub>I</sub>	Input capacitance	V <sub>I</sub> = 3.0 V or 0 V	—	6	7	pF

## NOTES:

- $V_{IL}$  specification is for the first LOW level seen by the SDAx/SCLx lines.  $V_{ILc}$  is for the second and subsequent LOW levels seen by the SDAx/SCLx lines.
- Typical value taken at 2.5 V and 25 °C.

I<sup>2</sup>C-bus repeater

## PCA9515A

## AC ELECTRICAL CHARACTERISTICS

 $V_{CC} = 2.3$  to  $2.7$  V

SYMBOL	PARAMETER	TEST CONDITIONS	LIMITS			UNIT
			MIN.	TYP. <sup>2</sup>	MAX.	
$t_{PHL}$	Propagation delay	Waveform 1	45	82	130	ns
$t_{PLH}$	Propagation delay	Waveform 1; Note 1	33	113	190	ns
$t_{THL}$	Transition time	Waveform 1	—	57	—	ns
$t_{TLH}$	Transition time	Waveform 1; Note 1	—	148	—	ns
$t_{SET}$	Enable to Start condition		100	—	—	ns
$t_{HOLD}$	Enable after Stop condition		130	—	—	ns

## NOTES:

1. Different load resistance and capacitance will alter the RC time constant, thereby changing the propagation delay and transition times.
2. Typical value taken at 2.5 V and 25 °C.

## AC ELECTRICAL CHARACTERISTICS

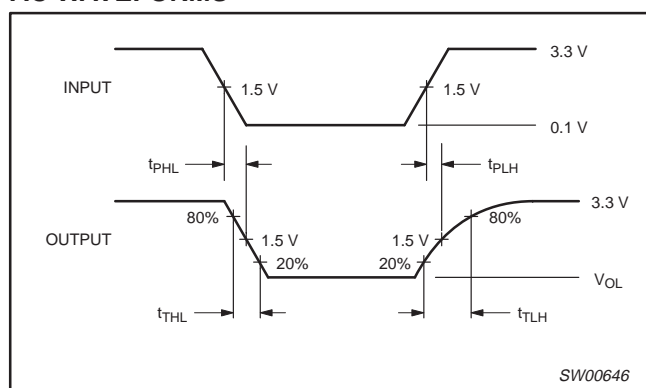
 $V_{CC} = 3.0$  to  $3.6$  V

SYMBOL	PARAMETER	TEST CONDITIONS	LIMITS			UNIT
			MIN.	TYP. <sup>2</sup>	MAX.	
$t_{PHL}$	Propagation delay	Waveform 1	45	68	120	ns
$t_{PLH}$	Propagation delay	Waveform 1; Note 1	33	102	180	ns
$t_{THL}$	Transition time	Waveform 1	—	58	—	ns
$t_{TLH}$	Transition time	Waveform 1; Note 1	—	147	—	ns
$t_{SET}$	Enable to Start condition		100	—	—	ns
$t_{HOLD}$	Enable after Stop condition		100	—	—	ns

## NOTES:

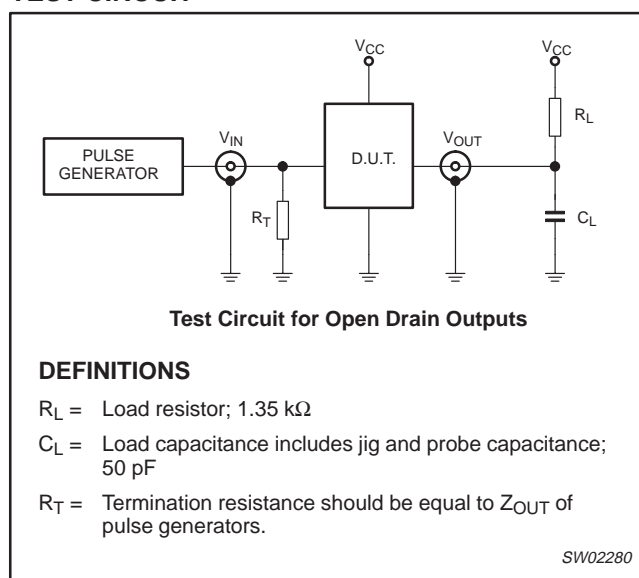
1. Different load resistance and capacitance will alter the RC time constant, thereby changing the propagation delay and transition times.
2. Typical value taken at 3.3 V and 25 °C.

## AC WAVEFORMS



Waveform 1.

## TEST CIRCUIT



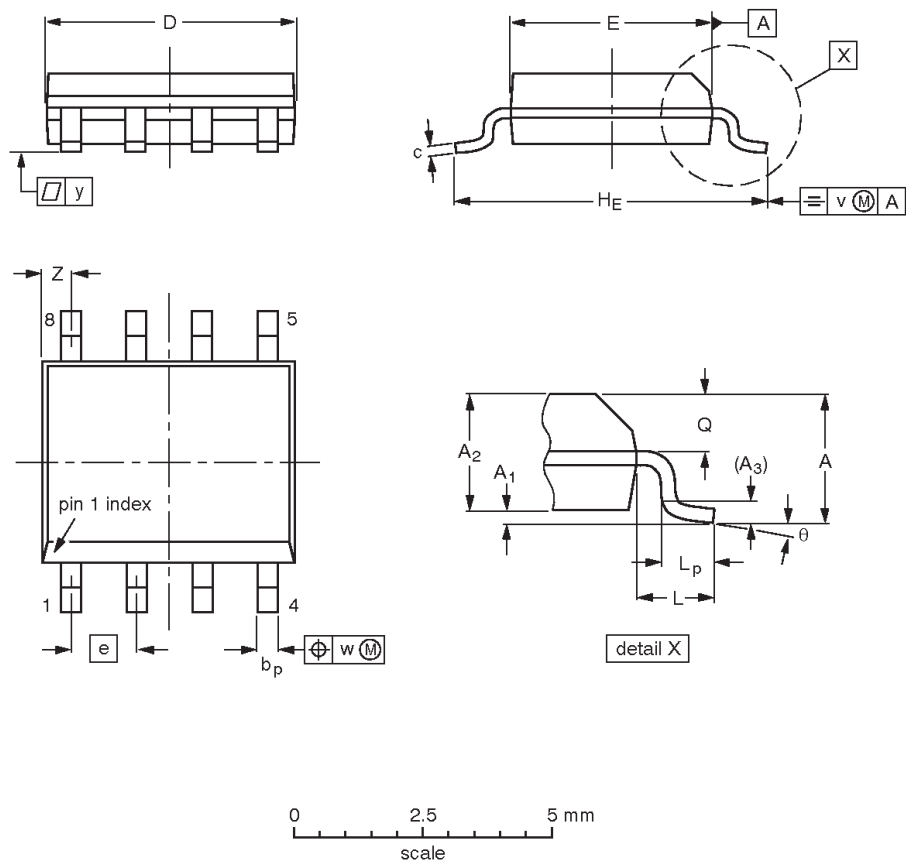


I<sup>2</sup>C-bus repeater

PCA9515A

SO8: plastic small outline package; 8 leads; body width 3.9 mm

SOT96-1



DIMENSIONS (inch dimensions are derived from the original mm dimensions)

UNIT	A max.	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	b <sub>p</sub>	c	D <sup>(1)</sup>	E <sup>(2)</sup>	e	H <sub>E</sub>	L	L <sub>p</sub>	Q	v	w	y	Z <sup>(1)</sup>	θ
mm	1.75	0.25 0.10	1.45 1.25	0.25	0.49 0.36	0.25 0.19	5.0 4.8	4.0 3.8	1.27	6.2 5.8	1.05	1.0 0.4	0.7 0.6	0.25	0.25	0.1	0.7 0.3	8° 0°
inches	0.069	0.010 0.004	0.057 0.049	0.01	0.019 0.014	0.0100 0.0075	0.20 0.19	0.16 0.15	0.05	0.244 0.228	0.041	0.039 0.016	0.028 0.024	0.01	0.01	0.004	0.028 0.012	

Notes

- 1. Plastic or metal protrusions of 0.15 mm (0.006 inch) maximum per side are not included.
- 2. Plastic or metal protrusions of 0.25 mm (0.01 inch) maximum per side are not included.

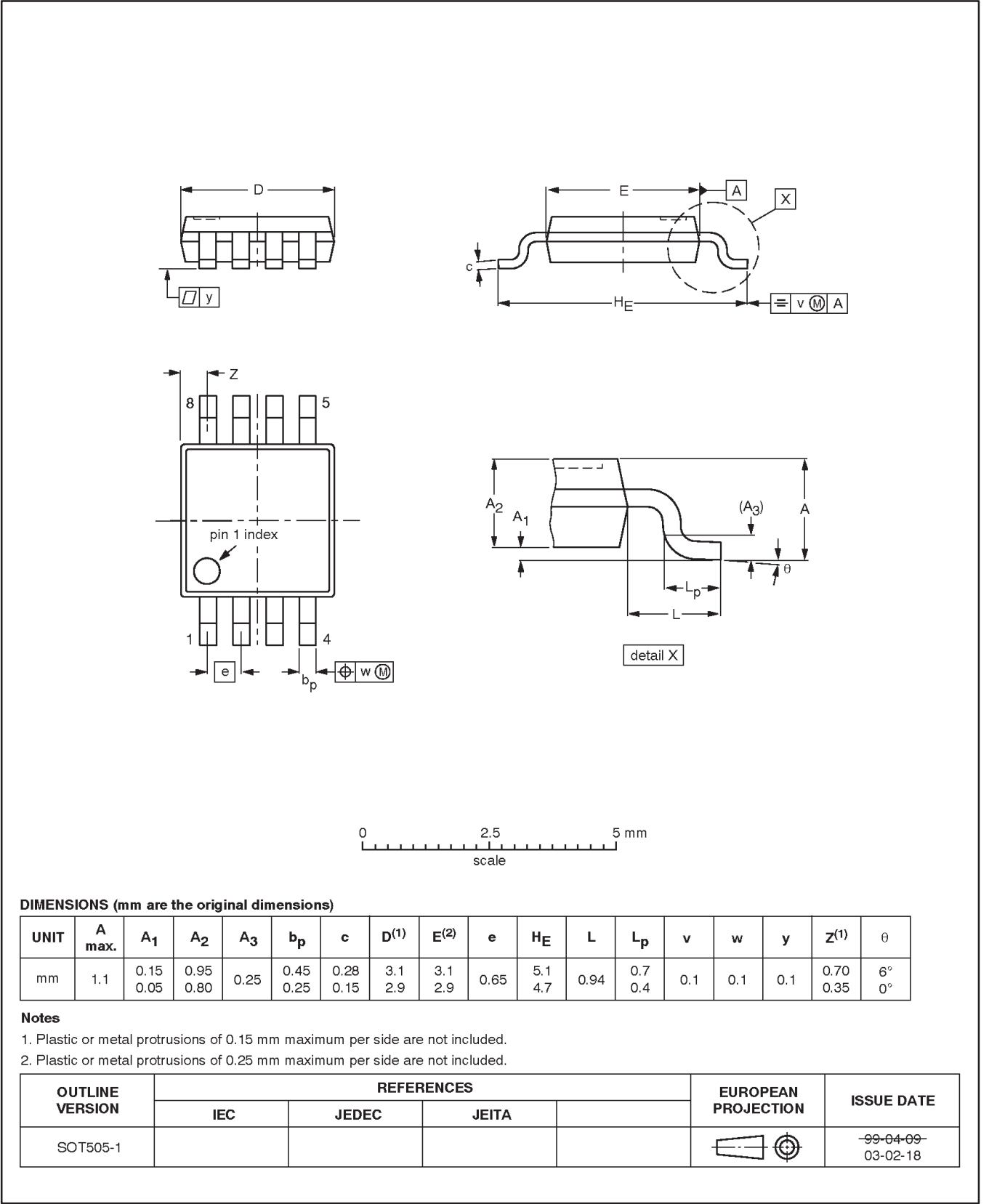
OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	JEITA			
SOT96-1	076E03	MS-012				-99-12-27 03-02-18

I<sup>2</sup>C-bus repeater

PCA9515A

TSSOP8: plastic thin shrink small outline package; 8 leads; body width 3 mm

SOT505-1



# I<sup>2</sup>C-bus repeater

PCA9515A

## REVISION HISTORY

Rev	Date	Description
_3	20040929	<b>Product data sheet (9397 750 14098). Supersedes data of 2004 Jul 09 (9397 750 13709).</b> Modifications: <ul style="list-style-type: none"><li>• 'Features' section on page 2, last bullet: add "(MSOP)"</li><li>• 'Ordering information' table on page 2: add "(MSOP)" to 8-pin plastic TSSOP</li></ul>
_2	20040709	<b>Product data sheet (9397 750 13709). Supersedes data of 2004 Jun 17 (9397 750 13237).</b>
_1	20040617	<b>Objective data sheet (9397 750 13237).</b>

I<sup>2</sup>C-bus repeater

PCA9515A



Purchase of Philips I<sup>2</sup>C components conveys a license under the Philips' I<sup>2</sup>C patent to use the components in the I<sup>2</sup>C system provided the system conforms to the I<sup>2</sup>C specifications defined by Philips. This specification can be ordered using the code 9398 393 40011.

## Data sheet status

Level	Data sheet status <sup>[1]</sup>	Product status <sup>[2] [3]</sup>	Definitions
I	Objective data sheet	Development	This data sheet contains data from the objective specification for product development. Philips Semiconductors reserves the right to change the specification in any manner without notice.
II	Preliminary data sheet	Qualification	This data sheet contains data from the preliminary specification. Supplementary data will be published at a later date. Philips Semiconductors reserves the right to change the specification without notice, in order to improve the design and supply the best possible product.
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[1] Please consult the most recently issued data sheet before initiating or completing a design.

[2] The product status of the device(s) described in this data sheet may have changed since this data sheet was published. The latest information is available on the Internet at URL <http://www.semiconductors.philips.com>.

[3] For data sheets describing multiple type numbers, the highest-level product status determines the data sheet status.

## Definitions

**Short-form specification** — The data in a short-form specification is extracted from a full data sheet with the same type number and title. For detailed information see the relevant data sheet or data handbook.

**Limiting values definition** — Limiting values given are in accordance with the Absolute Maximum Rating System (IEC 60134). Stress above one or more of the limiting values may cause permanent damage to the device. These are stress ratings only and operation of the device at these or at any other conditions above those given in the Characteristics sections of the specification is not implied. Exposure to limiting values for extended periods may affect device reliability.

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Document number:

9397 750 14098

*Let's make things better.*