DATA SHEET

PCA8581; PCA8581C
128 × 8-bit EEPROM with I²C-bus interface

Product specification
Supersedes data of July 1994
File under Integrated Circuits, IC12

1996 Aug 19

PHILIPS

128 × 8-bit EEPROM with I²C-bus interface PCA8581; PCA8581C

FEATURES

- Operating supply voltage:
  - 4.5 to 5.5 V (PCA8581)
  - 2.5 to 6.0 V (PCA8581C)
- Integrated voltage multiplier and timer for writing (no external components required)
- Automatic erase before write
- Low standby current; maximum 10 μA
- 8-byte page write mode
- Serial input/output bus (I²C-bus)
- Address by 3 hardware address pins
- Automatic word address incrementing
- Designed for minimum 10000 write cycles per byte
- 10 years minimum non-volatile data retention
- Infinite number of read cycles
- Pin and address compatibility to PCF8570, PCF8571 and PCF8582
- Operating temperature: –25 to +85 °C.

GENERAL DESCRIPTION

The PCA8581 and PCA8581C are low power CMOS EEPROMs with standard and wide operating voltages:

4.5 to 5.5 V (PCA8581)

2.5 to 6.0 V (PCA8581C).

In the following text, the generic term ‘PCA8581’ is used to refer to both types in all packages except when otherwise specified.

The PCA8581 is organized as 128 words of 8-bytes.

Addresses and data are transferred serially via a two-line bidirectional bus (I²C-bus). The built-in word address register is incremented automatically after each written or read data byte. All bytes can be read in a single operation. Up to 8 bytes can be written in one operation, reducing the total write time per byte. Three address pins, A0, A1 and A2 are used to define the hardware address, allowing the use of up to 8 devices connected to the bus without additional hardware.

QUICK REFERENCE DATA

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{DD}	supply voltage				
	PCA8581		4.5	5.5	V
	PCA8581C		2.5	6.0	V
I_{DD}	supply current (standby)	f_{SCL} = 0 Hz	–	10	μA
T_{amb}	operating ambient temperature		–25	+85	°C
T_{stg}	storage temperature	without EEPROM retention	–65	+150	°C
		with EEPROM retention	–65	+85	°C

ORDERING INFORMATION

TYPE NUMBER	PACKAGE			
	PINS	PIN POSITION	MATERIAL	CODE
PCA8581P	8	DIP	plastic	SOT97-1
PCA8581CP	8	DIP	plastic	SOT97-1
PCA8581T	8	SO8	plastic	SOT96-1
PCA8581CT	8	SO8	plastic	SOT96-1

BLOCK DIAGRAM

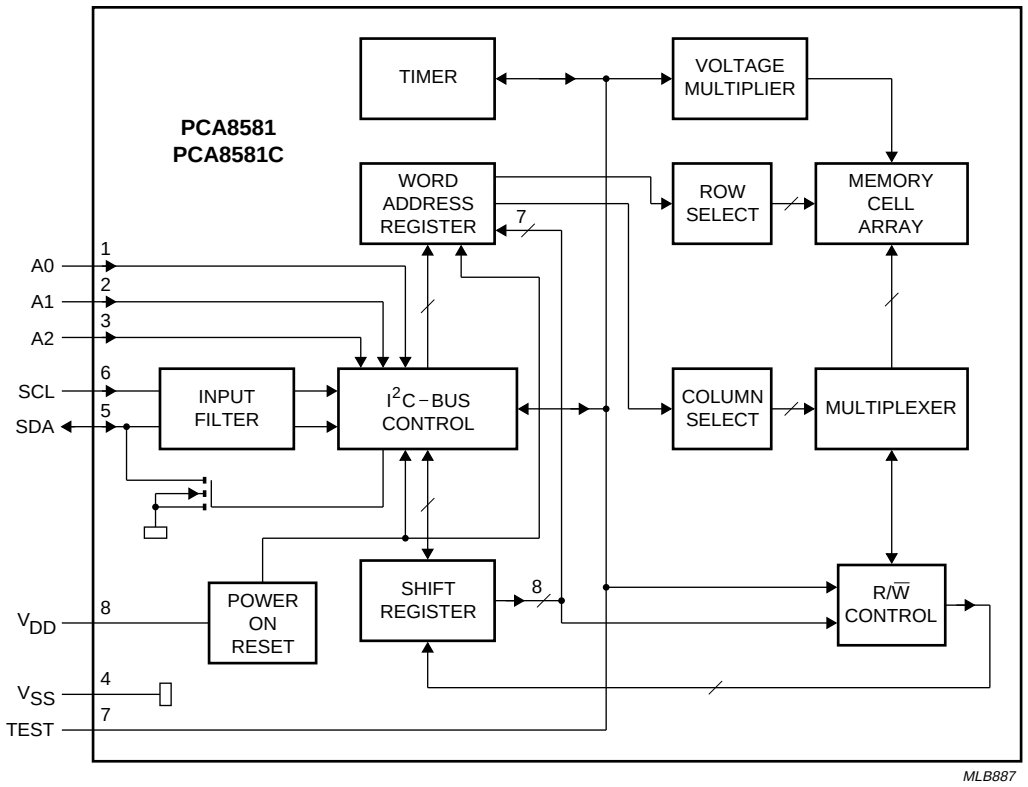


Fig.1 Block diagram.

PINNING

SYMBOL	PIN	DESCRIPTION
A0	1	hardware address input 0
A1	2	hardware address input 1
A2	3	hardware address input 2
V_{SS}	4	negative supply
SDA	5	serial data input/output
SCL	6	serial clock input
TEST	7	test output can be connected to V_{SS}, V_{DD} or left open-circuit
V_{DD}	8	positive supply

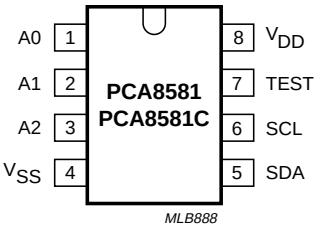


Fig.2 Pin configuration.

CHARACTERISTICS OF THE I²C-BUS

The I²C-bus is for bidirectional, two-line communication between different ICs or modules. The two lines are a serial data line (SDA) and a serial clock line (SCL). Both lines must be connected to a positive supply via a pull-up resistor. Data transfer may be initiated only when the bus is not busy.

Bit transfer

One data bit is transferred during each clock pulse. The data on the SDA line must remain stable during the HIGH period of the clock pulse as changes in the data line at this time will be interpreted as a control signal.

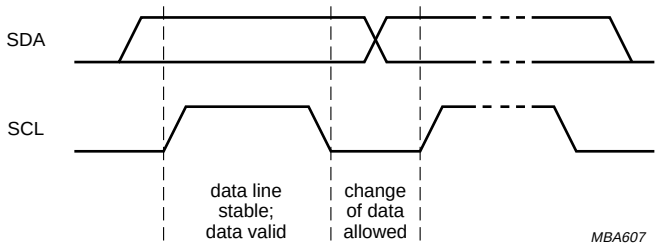


Fig.3 Bit transfer.

Start and stop conditions

Both data and clock lines remain HIGH when the bus is not busy. A HIGH-to-LOW transition of the data line, while the clock is HIGH is defined as the start condition (S). A LOW-to-HIGH transition of the data line while the clock is HIGH is defined as the stop condition (P).

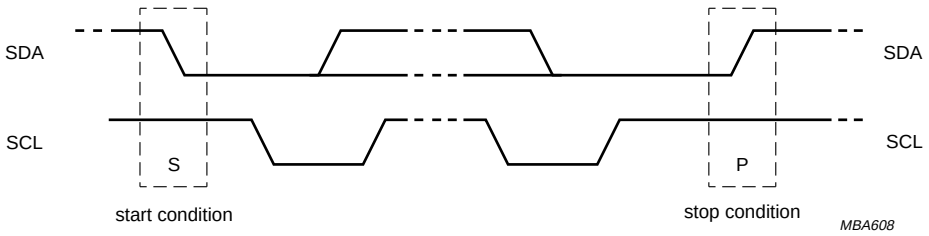


Fig.4 Definition of start and stop conditions.

System configuration

A device generating a message is a ‘transmitter’, a device receiving a message is the ‘receiver’. The device that controls the message is the ‘master’ and the devices which are controlled by the master are the ‘slaves’.

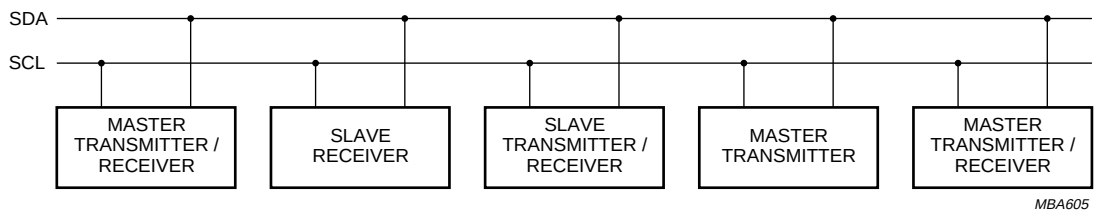


Fig.5 System configuration.

Acknowledge

The number of data bytes transferred between the start and stop conditions from transmitter to receiver is unlimited. Each byte of eight bits is followed by an acknowledge bit. The acknowledge bit is a HIGH level signal put on the bus by the transmitter during which time the master generates an extra acknowledge related clock pulse. A slave receiver which is addressed must generate an acknowledge after the reception of each byte. Also a master receiver must generate an acknowledge after the reception of each byte that has been clocked out of the slave transmitter.

The device that acknowledges must pull down the SDA line during the acknowledge clock pulse, so that the SDA line is stable LOW during the HIGH period of the acknowledge related clock pulse (set-up and hold times must be taken into consideration). A master receiver must signal an end of data to the transmitter by not generating an acknowledge on the last byte that has been clocked out of the slave. In this event the transmitter must leave the data line HIGH to enable the master to generate a stop condition.

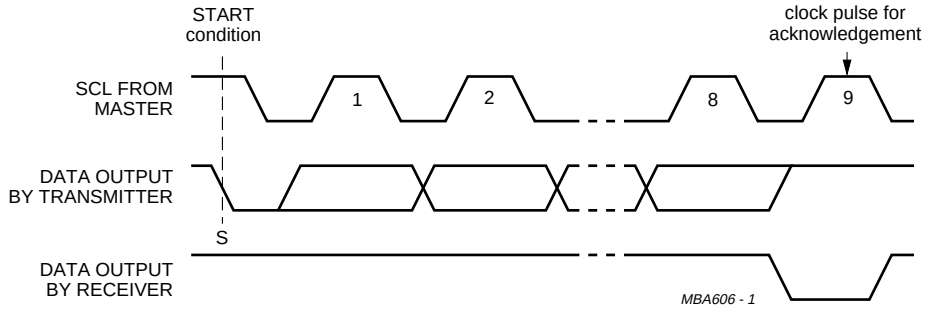


Fig.6 Acknowledgement on the I²C-bus.

I²C-bus protocol

Before any data is transmitted on the I²C-bus, the device which should respond is addressed first. The addressing is always carried out with the first byte transmitted after the start procedure. The I²C-bus configuration for the different PCA8581 WRITE and READ cycles is shown in Figs 7, 9 and 10.

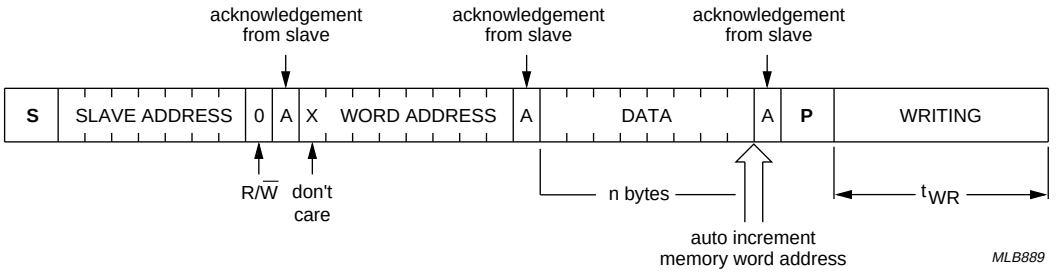
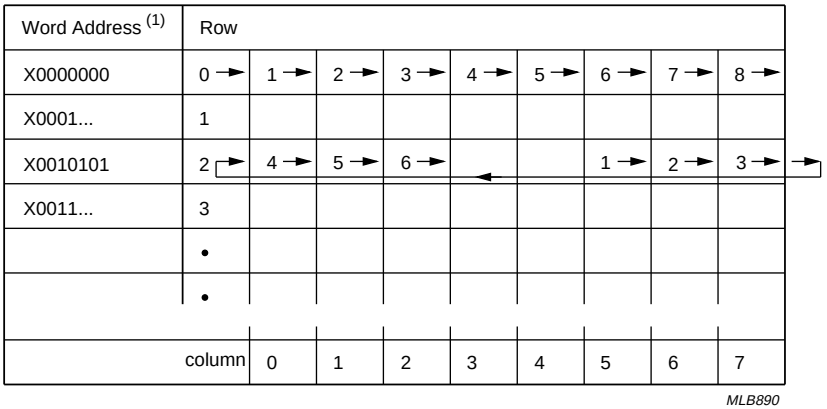


Fig.7 Master transmits to slave receiver (WRITE) mode.

After the word address, one-to-eight data bytes can be sent. The address is automatically incremented, but the four highest address bits (row) are internally latched. Therefore all bytes are written in the same row.

An example of writing eight bytes with word address X 0 0 0 0 0 0 0 and six bytes with word address X 0 0 1 0 1 0 1 is shown in Fig.8.



(1) X = don't care.

Fig.8 Writing eight and six bytes with different word addresses.

To transmit eight bytes in sequential order, begin with the lowest address bits 0 0 0. The data is written after a stop is detected. The data is only written if complete bytes have been received and acknowledged. Writing takes a time t_{WR} (6 to 10 ms) during which the device will not respond to its slave address. Note that to write the next row, a new write operation is required (start, slave address, row address, data and stop).

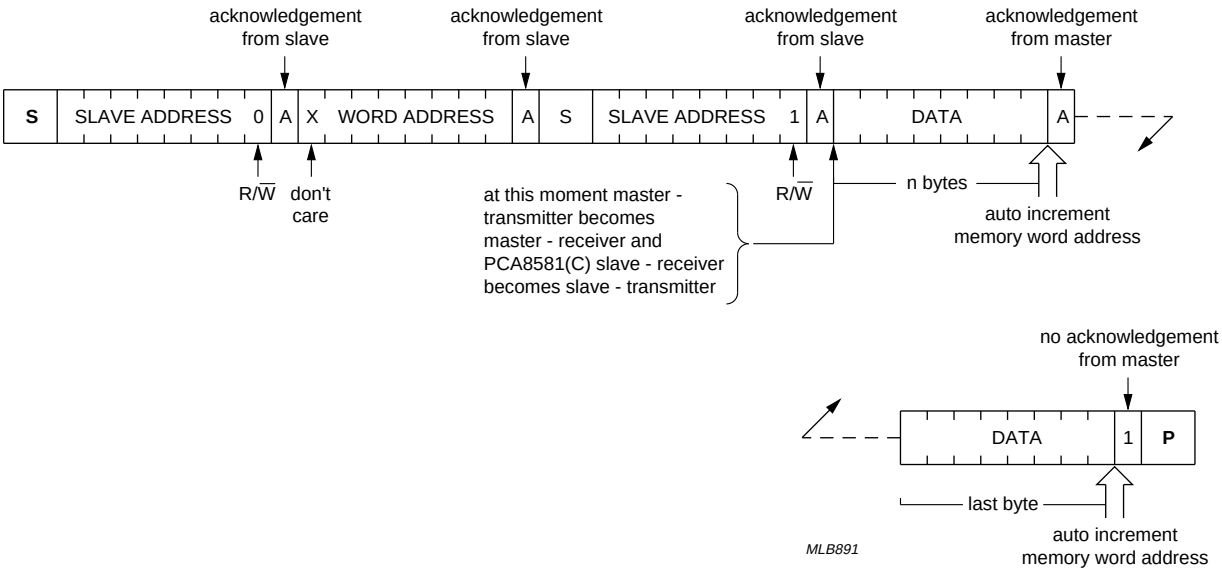


Fig.9 Master reads after setting word address (WRITE word address; READ data).

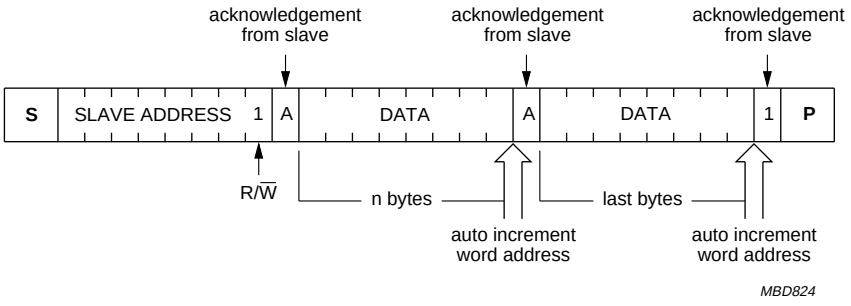


Fig.10 Master reads slave immediately after first byte (READ mode).

An unlimited number of data bytes can be read in one operation. The address is automatically incremented. If a read without setting the word address is performed after a write operation, the address pointer may point at a byte in the row after the previously written row. This occurs if, during writing, the three lowest address bits (column) rolled over.

LIMITING VALUES

In accordance with the Absolute Maximum Rating System (IEC 134).

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{DD}	supply voltage (pin 8)		–0.3	+7.0	V
V_I	input voltage (any input)	measured via a 500 Ω resistor	–0.8	V_{DD} + 0.8	V
I_I	DC input current		–	±10	mA
I_O	DC output current		–	±10	mA
P_{tot}	total power dissipation per package		–	150	mW
P_O	power dissipation per output		–	50	mW
T_{amb}	operating ambient temperature		–25	+85	°C
T_{stg}	storage temperature	without EEPROM retention	–65	+150	°C
		with EEPROM retention	–65	+85	°C

HANDLING

Inputs and outputs are protected against electrostatic discharge in normal handling. However, to be totally safe, it is desirable to take precautions appropriate to handling MOS devices (see *"Handling MOS Devices"*).

DC CHARACTERISTICS

V_{DD} = 2.5 to 6.0 V (PCA8581C); V_{DD} = 4.5 to 5.5 V (PCA8581); V_{SS} = 0 V; T_{amb} = –25 to +85 °C; note 1; unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
Supply						
V_{DD}	supply voltage					
	PCA8581C		2.5	–	6.0	V
	PCA8581		4.5	–	5.5	V
I_{DD}	supply current					
	standby mode	f_{SCL} = 0 Hz; V_{IL} = 0 V; V_{IH} = V_{DD}	–	–	10	µA
	during read cycle	f_{SCL} = 100 Hz; V_{IL} = 0 V; V_{IH} = V_{DD}	–	–	400	µA
	during write cycle	V_{IL} = 0 V; V_{IH} = V_{DD}	–	–	1000	µA
Inputs A0, A1, A2, SDA and SCL						
V_{IL}	LOW level input voltage		–	–	$0.3V_{DD}$	V
V_{IH}	HIGH level input voltage		$0.7V_{DD}$	–	–	V
I_{LI}	input leakage current	V_I = V_{DD} or V_{SS}	–	–	1	µA
C_I	input capacitance	V_I = V_{SS}	–	–	7	pF
Output SDA						
I_{OL}	LOW level output current	V_{OL} = 0.4 V	3	–	–	mA
Erase/write data						
t_{WR}	write time		–	7	10	ms
t_{RET}	data retention time		10	–	–	years

Note

1. The PCA8581C is guaranteed to be programmed with all locations ‘FF’ (hexadecimal) provided the device has been stored within the temperature limits –65 to +85 °C.

AC CHARACTERISTICS

All timing values are valid within the operating supply voltage and ambient temperature range and reference to V_{IL} and V_{IH} with an input voltage swing of V_{SS} to V_{DD}.

SYMBOL	PARAMETER	MIN.	TYP.	MAX.	UNIT
I²C-bus timing (see Fig.11; note 1)					
f_{SCL}	SCL clock frequency	–	–	100	kHz
t_{SP}	tolerable spike width on bus	–	–	100	ns
t_{BUF}	bus free time	4.7	–	–	µs
$t_{SU;STA}$	start condition set-up time	4.7	–	–	µs
$t_{HD;STA}$	start condition hold time	4.0	–	–	µs
t_{LOW}	SCL LOW time	4.7	–	–	µs
t_{HIGH}	SCL HIGH time	4.0	–	–	µs
t_r	SCL and SDA rise time	–	–	1.0	µs
t_f	SCL and SDA fall time	–	–	0.3	µs
$t_{SU;DAT}$	data set-up time	250	–	–	ns
$t_{HD;DAT}$	data hold time	0	–	–	ns
$t_{VD;DAT}$	SCL LOW to data out valid	–	–	3.4	µs
$t_{SU;STO}$	stop condition set-up time	4.0	–	–	µs

Note

1. A detailed description of the I²C-bus specification, with applications, is given in brochure *"The I²C-bus and how to use it"*. This brochure may be ordered using the code 9398 393 40011.

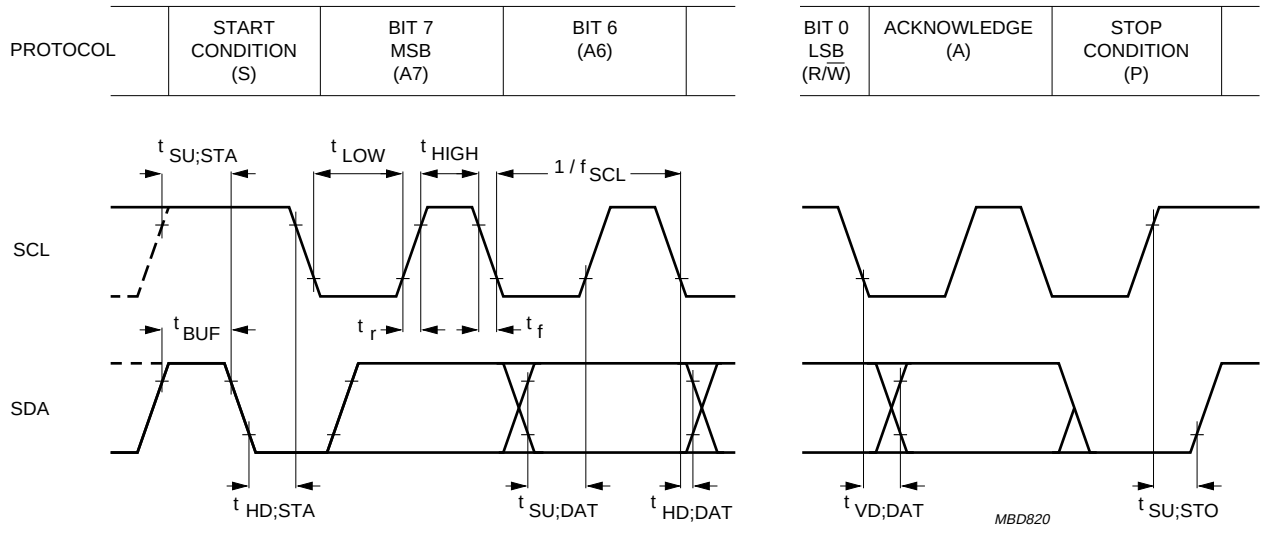


Fig.11 I²C-bus timing diagram; rise and fall times refer to V_{IL} and V_{IH}.

APPLICATION INFORMATION

Slave address

The PCA8581 has a fixed combination 1 0 1 0 as group 1, while group 2 is fully programmable (see Fig.12).

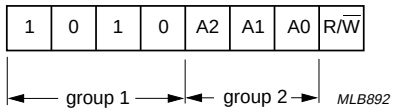
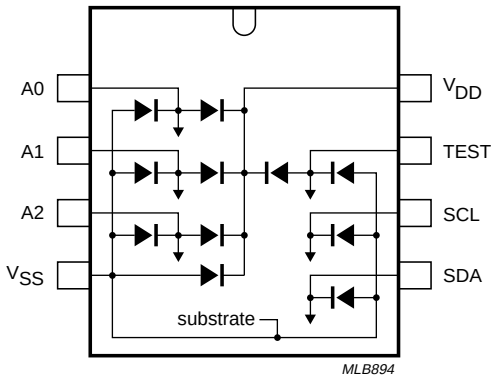


Fig.12 Slave address.

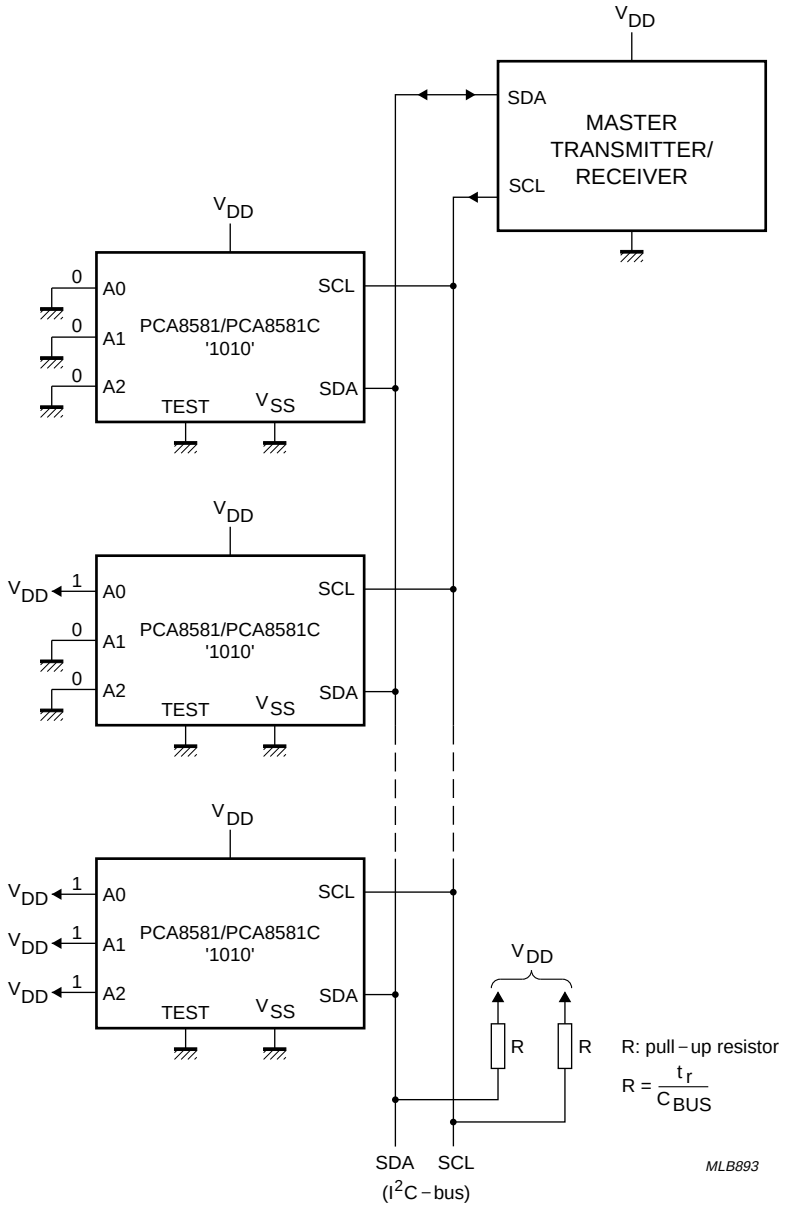
Diode protection



There is no connection between SCL and V_{DD}, and SDA and V_{DD}; this allows powering down the device without affecting I²C-bus operation.

Fig.13 Device diode protection.

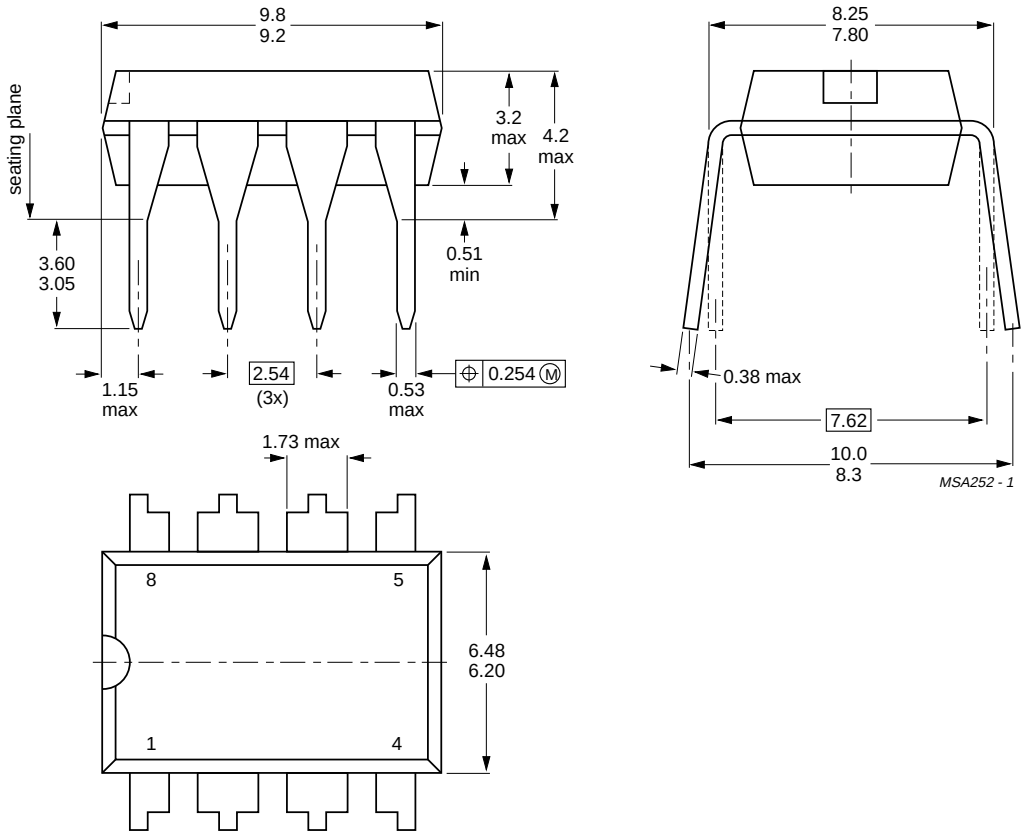
Application example



Inputs A0, A1 and A2 must be connected to V_{DD} of V_{SS} but not left open-circuit.

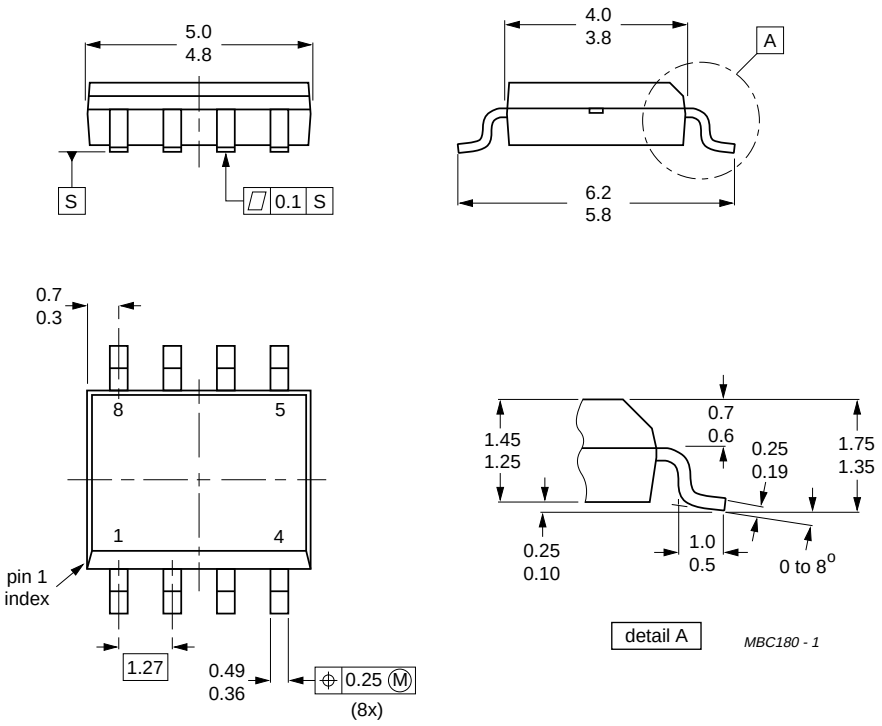
Fig.14 Application diagram.

PACKAGE OUTLINES



Dimensions in mm.

Fig.15 Plastic dual in-line package; 8 leads (300 mil); DIP8, SOT97-1.



Dimensions in mm.

Fig.16 Plastic small outline package; 8 leads (SO8, SOT96-1).

SOLDERING

Plastic dual in-line packages

BY DIP OR WAVE

The maximum permissible temperature of the solder is 260 °C; this temperature must not be in contact with the joint for more than 5 s. The total contact time of successive solder waves must not exceed 5 s.

The device may be mounted up to the seating plane, but the temperature of the plastic body must not exceed the specified storage maximum. If the printed-circuit board has been pre-heated, forced cooling may be necessary immediately after soldering to keep the temperature within the permissible limit.

REPAIRING SOLDERED JOINTS

Apply a low-voltage soldering iron below the seating plane (or not more than 2 mm above it). If its temperature is below 300 °C, it must not be in contact for more than 10 s; if between 300 and 400 °C, for not more than 5 s.

Plastic small-outline packages

BY WAVE

During placement and before soldering, the component must be fixed with a droplet of adhesive. After curing the adhesive, the component can be soldered. The adhesive can be applied by screen printing, pin transfer or syringe dispensing.

Maximum permissible solder temperature is 260 °C, and maximum duration of package immersion in solder bath is 10 s, if allowed to cool to less than 150 °C within 6 s. Typical dwell time is 4 s at 250 °C.

A modified wave soldering technique is recommended using two solder waves (dual-wave), in which a turbulent wave with high upward pressure is followed by a smooth laminar wave. Using a mildly-activated flux eliminates the need for removal of corrosive residues in most applications.

BY SOLDER PASTE REFLOW

Reflow soldering requires the solder paste (a suspension of fine solder particles, flux and binding agent) to be applied to the substrate by screen printing, stencilling or pressure-syringe dispensing before device placement.

Several techniques exist for reflowing; for example, thermal conduction by heated belt, infrared, and vapour-phase reflow. Dwell times vary between 50 and 300 s according to method. Typical reflow temperatures range from 215 to 250 °C.

Preheating is necessary to dry the paste and evaporate the binding agent. Preheating duration: 45 min at 45 °C.

REPAIRING SOLDERED JOINTS (BY HAND-HELD SOLDERING IRON OR PULSE-HEATED SOLDER TOOL)

Fix the component by first soldering two, diagonally opposite, end pins. Apply the heating tool to the flat part of the pin only. Contact time must be limited to 10 s at up to 300 °C. When using proper tools, all other pins can be soldered in one operation within 2 to 5 s at between 270 and 320 °C. (Pulse-heated soldering is not recommended for SO packages.)

For pulse-heated solder tool (resistance) soldering of VSO packages, solder is applied to the substrate by dipping or by an extra thick tin/lead plating before package placement.

DEFINITIONS

Data sheet status	
Objective specification	This data sheet contains target or goal specifications for product development.
Preliminary specification	This data sheet contains preliminary data; supplementary data may be published later.
Product specification	This data sheet contains final product specifications.
Limiting values	
Limiting values given are in accordance with the Absolute Maximum Rating System (IEC 134). 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.	
Application information	
Where application information is given, it is advisory and does not form part of the specification.	

LIFE SUPPORT APPLICATIONS

These products are not designed for use in life support appliances, devices, or systems where malfunction of these products can reasonably be expected to result in personal injury. Philips customers using or selling these products for use in such applications do so at their own risk and agree to fully indemnify Philips for any damages resulting from such improper use or sale.

PURCHASE OF PHILIPS I²C COMPONENTS

Purchase of Philips I²C components conveys a license under the Philips' I²C patent to use the components in the I²C system provided the system conforms to the I²C specification defined by Philips. This specification can be ordered using the code 9398 393 40011.