AN256

PCA9500/PCA9501 provides simple card maintenance and control using I²C-bus

Rev. 02 — 23 March 2009 Application note

Document information

Info	Content
Keywords	PCA9500, PCA9501, GPIO, EEPROM
Abstract	PCA9500 provides drop-in replacement for PCF8574 with integrated 2-kbit EEPROM. PCA9501 provides same functionality with six address pins allowing up to 64 packages to be located on the same bus.

Revision history

Rev	Date	Description
02	20090323	application note; second release Modifications: • The format of this application note has been redesigned to comply with the new identity guidelines of NXP Semiconductors. • Legal texts have been adapted to the new company name where appropriate. • Changed part number from “PTN3500” to “PCA9500” • Changed part number from “PTN3501” to “PCA9501”
01	20010613	application note; initial version

Contact information

For more information, please visit: **http://www.nxp.com**

For sales office addresses, please send an email to: **salesaddresses@nxp.com**

1. Introduction

The PCA9500 and PCA9501 are general-purpose maintenance and control devices. Both of the parts feature a fully programmable I²C-bus serial to 8-bit parallel port expander and an internal 256 × 8 EEPROM. The PCA950x devices have different I²C-bus addresses for the EEPROM and for the I/O expander.

The PCA9500 has three address pins allowing for up to 8 devices to share the common two-wire I²C serial data bus, while the PCA9501 has six address pins, thus allowing for up to 64 devices to share the bus.

The PCA9501 also features an interrupt pin ($\overline{INT}$), which could be fed to the interrupt logic of a microcontroller. By sending an interrupt signal on this line, the remote I/O can inform the microcontroller if there has been a change in the data on its port without having to communicate via the I²C-bus. This gives the chip a type of master function, yet it still remains a simple slave device.

Both parts use low supply voltage between 2.5 V and 3.6 V, support live insertion, and operate at a speed of up to 400 kbit/s.

The schematics below represent the diagrams of the basic building blocks of both PCA9500 and PCA9501.

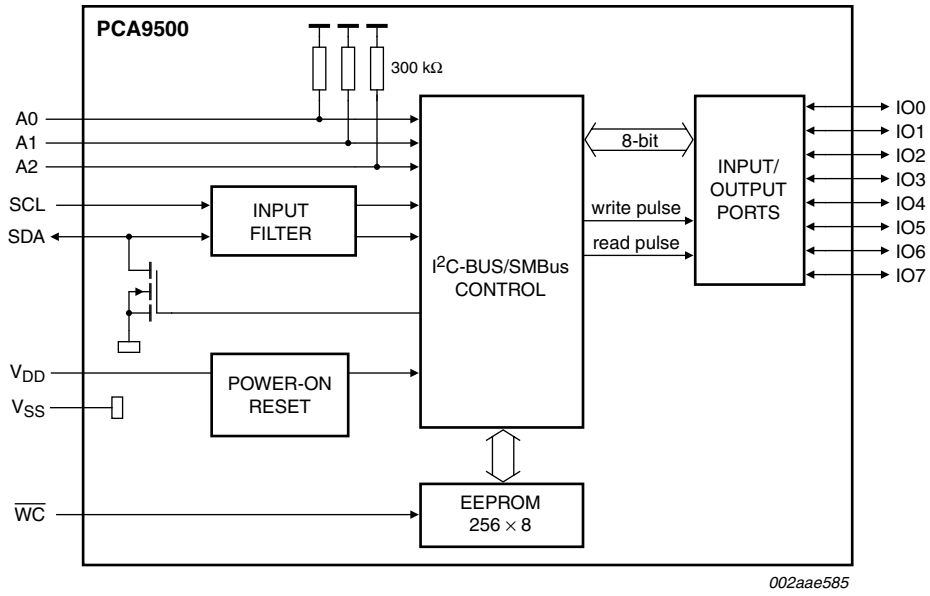


Fig 1. PCA9500 block diagram

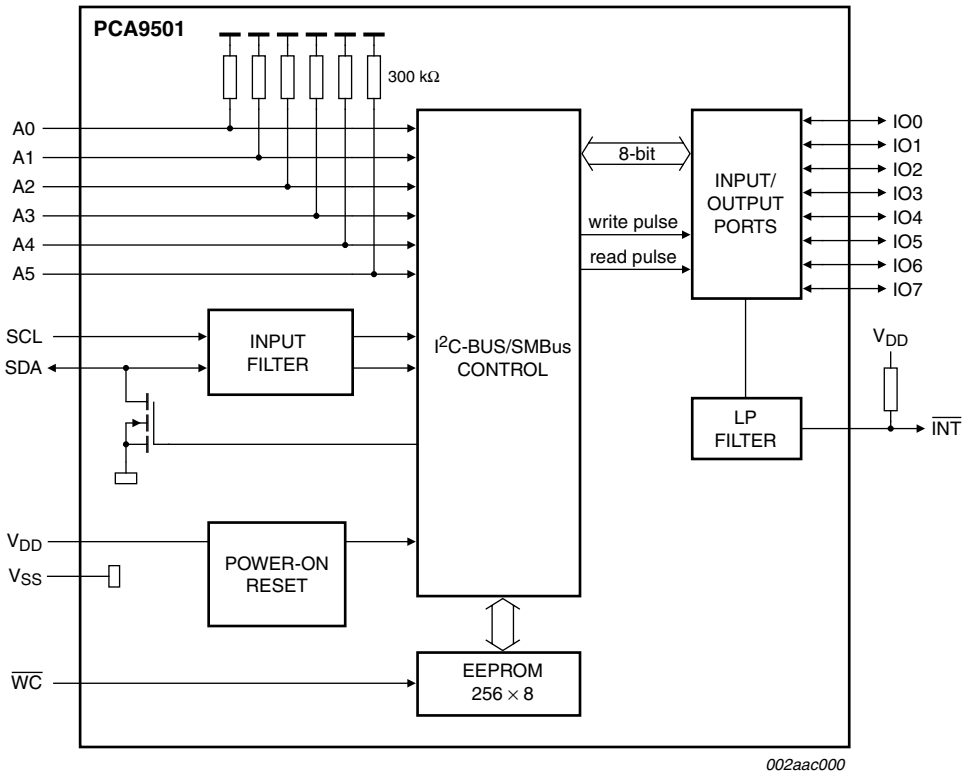


Fig 2. PCA9501 block diagram

2. Family applications and benefits

In general, the PCA950x can be used across cards in multi-rack systems, telecommunications switching equipment, cellular base stations, remote access systems, and basically in any system where the I²C-bus architecture is applicable.

The parts can be used for maintenance, control, monitoring, and configuration of other devices, as well as for communications, diagnostics, fault condition signaling, and testing. The eight general-purpose quasi-bidirectional data pins can be independently assigned as inputs or outputs to monitor board level status or activate indicator devices such as LEDs. The EEPROM can be used to store error codes or board manufacturing data for read-back by application software for diagnostic purposes.

The benefits of PCA9500 and PCA9501 come from the fact that both of them integrate general-purpose I/Os and non-volatile memory in a single small device, thus providing ease of design and enabling the effortless addition of I²C-bus capabilities to multi-card systems. In addition, the parts facilitate use in removable cards on backplane systems by supporting live insertion. PCA950x supports live insertion by implementing overvoltage capability on all I/O pins. Overvoltage conditions should not be applied to the power supply pins, as the pins are governed by their recommended maximum operating conditions and absolute maximum ratings.

The PCA950x also utilizes low-cost of ownership due to industry-wide support of I²C-bus and product availability while the small size and low power consumption can be easily accommodated on most card designs.

Figure 3 represents a typical utilization of the PCA9500 on a system level.

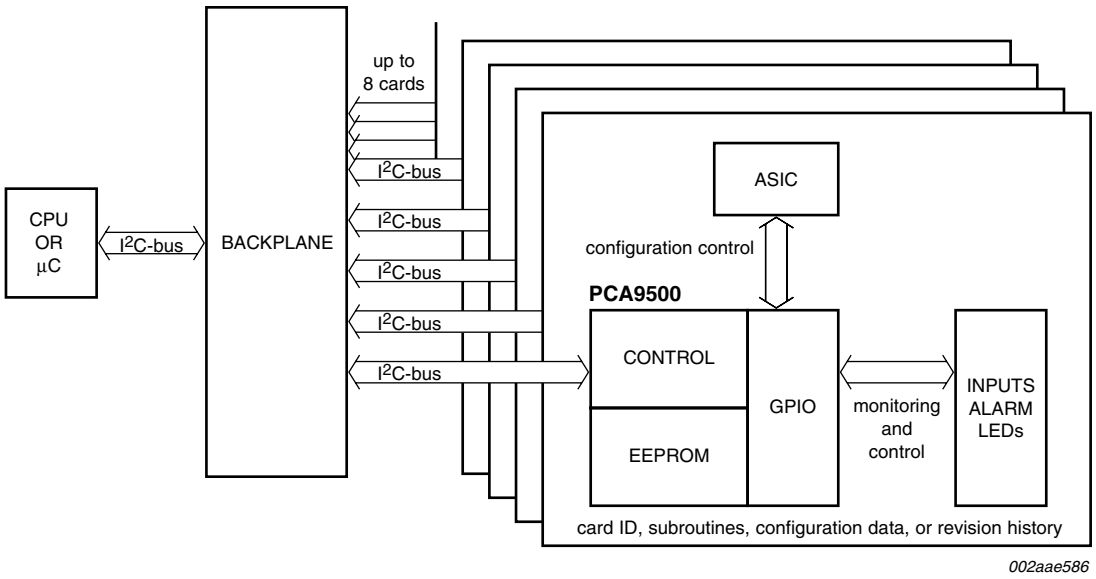
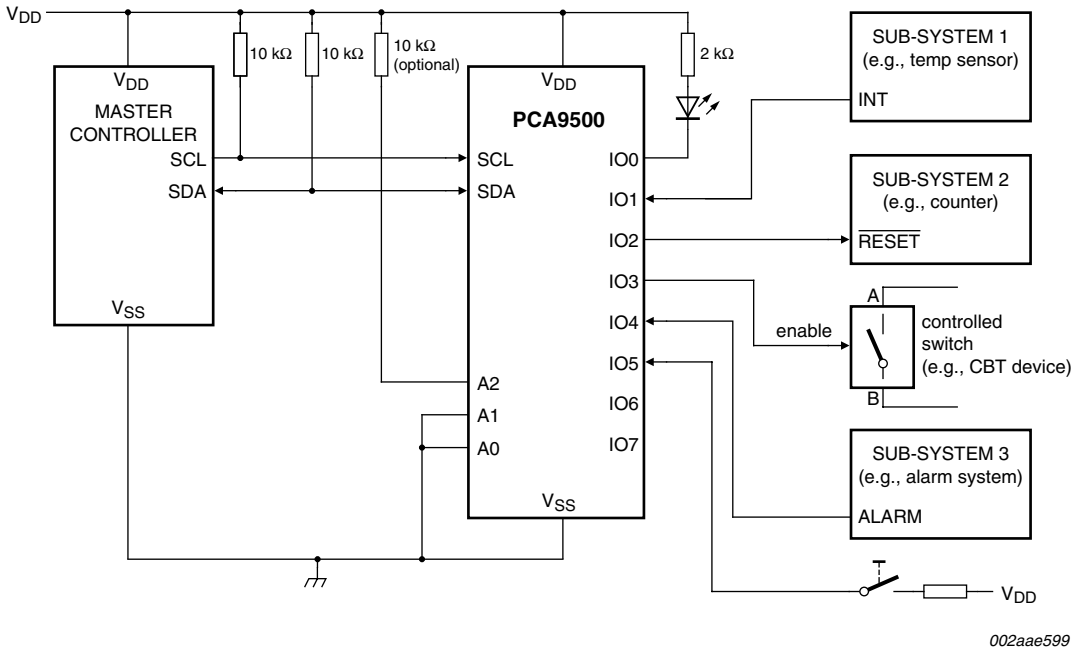


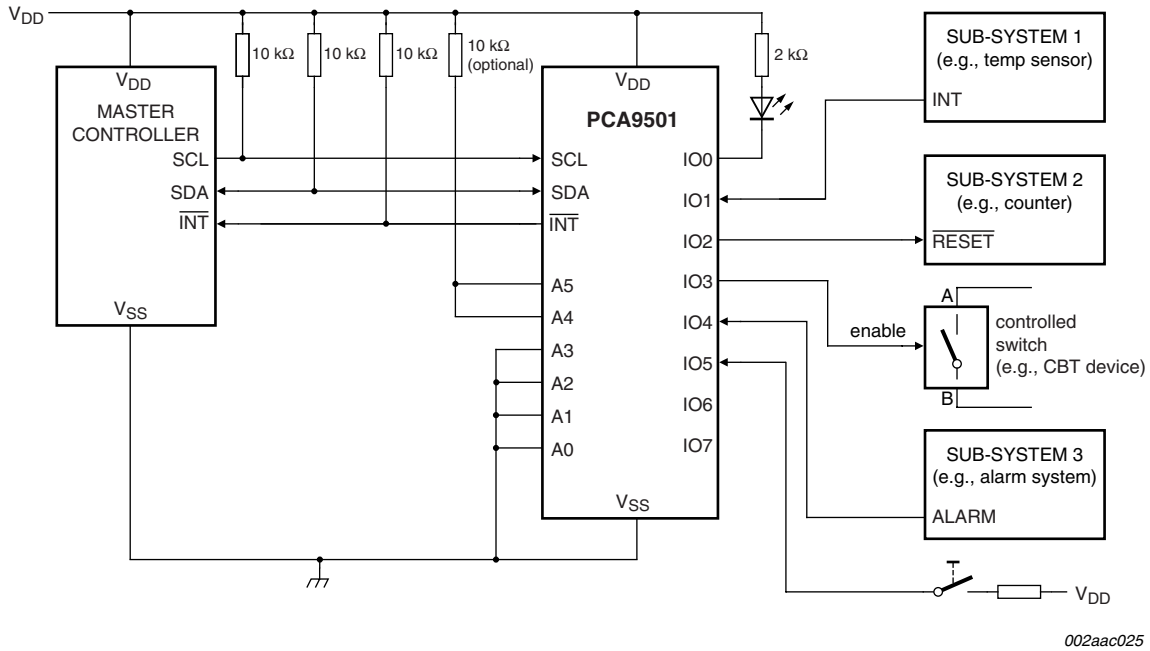
Fig 3. System level utilization of PCA9500

3. Application diagrams

The diagrams in Figure 4 represent the proper usage of the PCA9500 and PCA9501.



a. PCA9500



b. PCA9501

Fig 4. Application diagrams

The I²C-bus pins SDA and SCL on both chips and the interrupt pin ($\overline{INT}$) on PCA9501 are open-drain type in order to allow busing and hence require appropriate external pull-ups. The total load of the bus determines the value of the resistors.

The address pins for both devices have internal 130 kΩ resistors, so no additional external resistors are required. The state of the address pins (A0 to A5) is not latched upon power-up, and the address of PCA950x can be changed during uptime by changing the state of any address pin. It is important to note that the I²C-bus addresses of the EEPROM and the I/O port cannot be changed independently, since the addresses of both internal devices are each given the same address offset simultaneously with changing settings of the address pins.

At power on, the I/Os are HIGH, and they should remain HIGH before being used as inputs. The I/O expander can be used in various applications. It could be connected to other ICs in order to obtain or deliver information, or it could be connected to LEDs for indicating purposes. Equation 1 would yield the right value resistor when using LEDs:

$$R = \frac{V_{DD} - V_{LED} - V_{OL}}{I_{sink}} \quad (1)$$

For example, for a typical LED with a forward voltage of 1.6 V and a current of 10 mA, while V_{OL} is 0.3 V, the calculations will yield a resistor value of 140 kΩ.

Due to overvoltage support, PCA950x can be interfaced directly to a 5 V bus system without the use of level shifting. In such case the SCL & SDA pull-up resistors would be connected to the 5 V supply.

The number of PCA9501s that can be tied to the same I²C-bus signal is 64 or a combined bus capacitance of 400 pF, whichever is reached first. The 400 pF boundary is set because the devices have a limited pull-down current; however, the use of devices, such as the PCA9515A, which isolates system capacitance to two sub-systems of < 400 pF amplify the current sinking capabilities, would overcome the capacitance limitations.

An explicit write control signal ($\overline{WC}$) was implemented on PCA950x for the sake of compatibility with legacy types of serial EEPROM still widely available on the market. For convenience, $\overline{WC}$ may simply be tied permanently to ground, enabling the on-chip high-voltage memory write voltage generator.

4. Related products

Table 1 summarizes the basic similarities and differences between PCA950x and PCF8574.

Table 1. Feature summary

Feature		PCA9500	PCA9501	PCF8574
Packages	DIP16			•
	SO16	•		•
	TSSOP16	•		
	HVQFN16	•		
	SO20		•	
	SSOP20			•
	TSSOP20		•	
	HVQFN20		•	
Supply voltage		2.5 V to 3.6 V	2.5 V to 3.6 V	2.5 V to 6.0 V
	5 V tolerant I/Os	•	•	•
Pinning	$\overline{WC}$	•	•	
	$\overline{INT}$		•	•
	A0, A1, A2	130 kΩ pull-up	130 kΩ pull-up	no pull-up
I²C-bus address	port expander	0100	0xxx	0100
	serial EEPROM	1010	1xxx	n/a

In some cases, the SO16 version of PCA9500 can be a suitable—as well as enhanced—replacement of the legacy PCF8574 I/O expander. When not using the $\overline{INT}$ pin of the PCF8574T and after verifying that any pull-down or driving circuitry is sufficiently strong to overcome the PCA9500's internal 130 kΩ pull-ups, the PCA9500 can occupy an existing PCF8574 footprint while conveniently adding or replacing a serial EEPROM.

5. Abbreviations

Table 2. Abbreviations

Acronym	Description
ASIC	Application Specific Integrated Circuit
CPU	Central Processing Unit
EEPROM	Electrically Erasable Programmable Read-Only Memory
I²C-bus	Inter-Integrated Circuit bus
I/O	Input/Output
LED	Light-Emitting Diode
μP	microProcessor

6. References

[1] **UM10204, "I²C-bus specification and user manual" —** NXP Semiconductors; www.nxp.com/acrobat_download/usermanuals/UM10204_3.pdf

[2] **PCA9500, "8-bit I²C and SMBus I/O port with 2-kbit EEPROM" —** Product data sheet; NXP Semiconductors; www.nxp.com/pip/PCA9500

[3] **PCA9501, "8-bit I²C-bus and SMBus I/O port with interrupt, 2-kbit EEPROM and 6 address pins" —** Product data sheet; NXP Semiconductors; www.nxp.com/pip/PCA9501

[4] **PCA9515A, "I²C-bus repeater" —** Product data sheet; NXP Semiconductors; www.nxp.com/pip/PCA9515A

7. Legal information

7.1 Definitions

Draft — The document is a draft version only. The content is still under internal review and subject to formal approval, which may result in modifications or additions. NXP Semiconductors does not give any representations or warranties as to the accuracy or completeness of information included herein and shall have no liability for the consequences of use of such information.

7.2 Disclaimers

General — Information in this document is believed to be accurate and reliable. However, NXP Semiconductors does not give any representations or warranties, expressed or implied, as to the accuracy or completeness of such information and shall have no liability for the consequences of use of such information.

Right to make changes — NXP Semiconductors reserves the right to make changes to information published in this document, including without limitation specifications and product descriptions, at any time and without notice. This document supersedes and replaces all information supplied prior to the publication hereof.

Suitability for use — NXP Semiconductors products are not designed, authorized or warranted to be suitable for use in medical, military, aircraft, space or life support equipment, nor in applications where failure or malfunction of an NXP Semiconductors product can reasonably be expected to result in personal injury, death or severe property or environmental damage. NXP Semiconductors accepts no liability for inclusion and/or use of NXP Semiconductors products in such equipment or applications and therefore such inclusion and/or use is at the customer's own risk.

Applications — Applications that are described herein for any of these products are for illustrative purposes only. NXP Semiconductors makes no representation or warranty that such applications will be suitable for the specified use without further testing or modification.

Export control — This document as well as the item(s) described herein may be subject to export control regulations. Export might require a prior authorization from national authorities.

7.3 Trademarks

Notice: All referenced brands, product names, service names and trademarks are the property of their respective owners.

I²C-bus — logo is a trademark of NXP B.V.

8. Contents

For more information, please visit: http://www.nxp.com
For sales office addresses, please send an email to: salesaddresses@nxp.com

Date of release: 23 March 2009
Document identifier: AN256_2