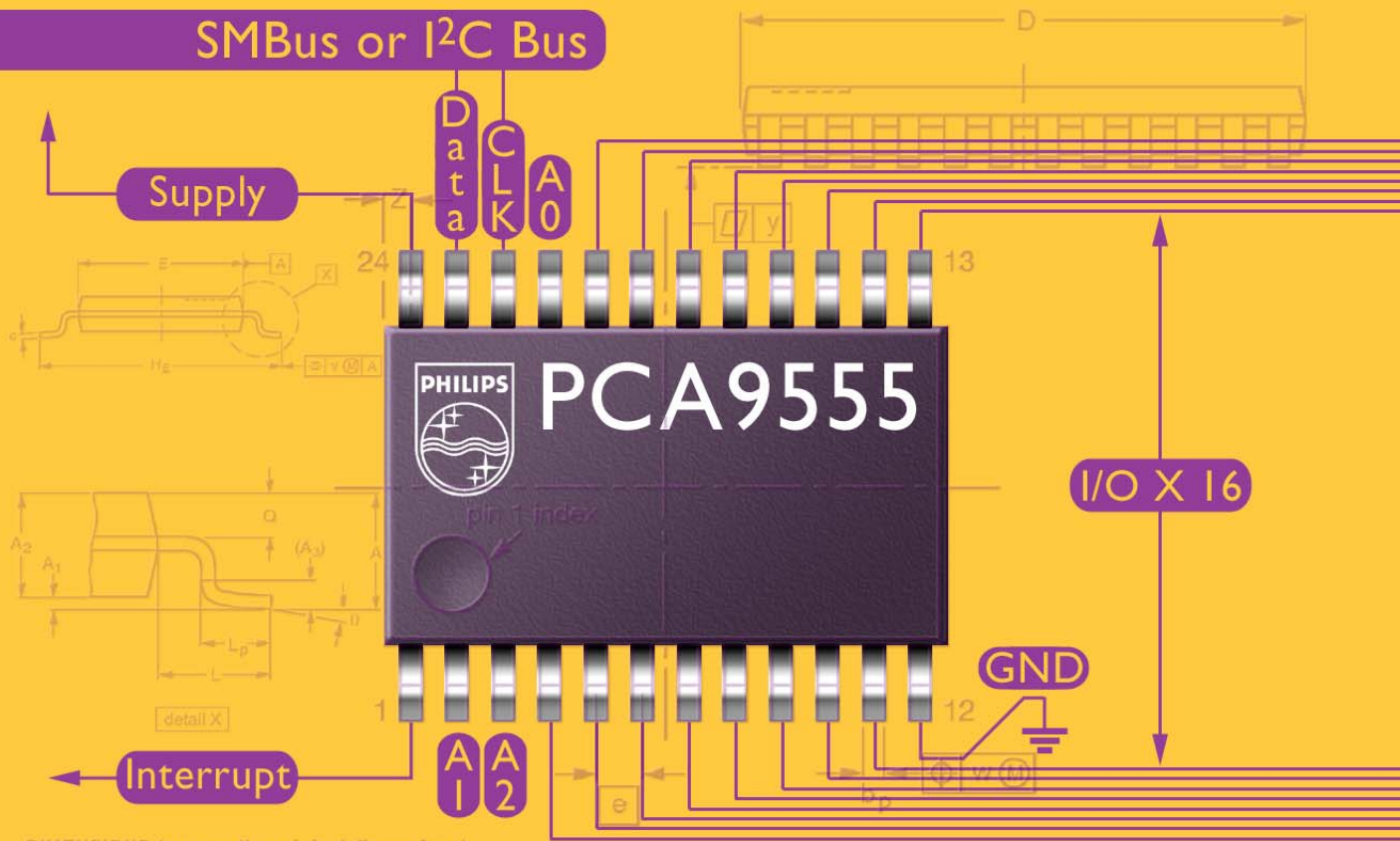


Philips Semiconductors I²C Handbook



DIMENSIONS (mm are the original dimensions)

UNIT	A _{max.}	A ₁	A ₂	A ₃	b _p	c	D ⁽¹⁾	E ⁽²⁾	e	H _E	L	L _p	Q	v	w	y	Z ⁽¹⁾	θ
mm	1.10	0.15 0.05	0.95 0.80	0.25	0.30 0.19													

General Purpose Input/Output IC

Quick Overview of general
purpose I²C Logic Devices

2H 2004

I²C Bus Technical Overview

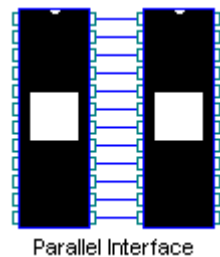
The I²C (Inter-Integrated Circuit) Bus is a two-wire, low to medium speed, communication bus (a path for electronic signals) developed by Philips Semiconductors in the early 1980s. I²C was created to reduce the manufacturing costs of electronic products. It provides a low-cost, but powerful, chip-to-chip communication link within these products. Initial applications for I²C included volume and contrast control in radios and televisions. Over the past decade, I²C has expanded its communications role to include a wide range of applications. Today, I²C can be found in a wide variety of computer, industrial, entertainment, medical, and military systems, with almost unlimited growth potential.

Industry Standard

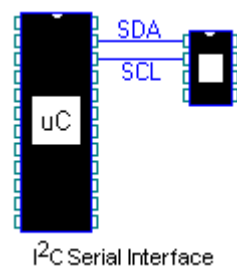
The "I²C Bus Specification," published by Philips Semiconductor, provides a communication protocol definition of the signal activity on the I²C Bus. This specification helps instruct semiconductor device manufacturers, and electronic product developers, in the correct use of the technology. The specification is freely available on the Internet (www.semiconductors.philips.com/buses/i2c/).

Low Cost

Prior to I²C, chip-to-chip communications used many wires in a parallel interface, often requiring ICs (integrated circuits) to have 24, 28, or more pins. Many of these pins were used for inter-chip addressing, selection, control, and data transfers. In a parallel interface, 8 data bits are typically transferred from a sender IC to a receiver IC in a single operation.



I²C performs chip-to-chip communications using only two wires in a serial interface, allowing ICs to communicate with fewer pins. The two wires in the I²C Bus are called Clock (SCL) and Data (SDA). These two wires carry addressing, selection, control, and data, one bit at a time. The SDA wire carries the data, while the SCL wire synchronizes the sender and receiver during the transfer. ICs that use the I²C Bus can perform the same function as their larger parallel interface counterparts, but with far fewer pins. This greatly reduces the size and cost of ICs based on the I²C Bus.

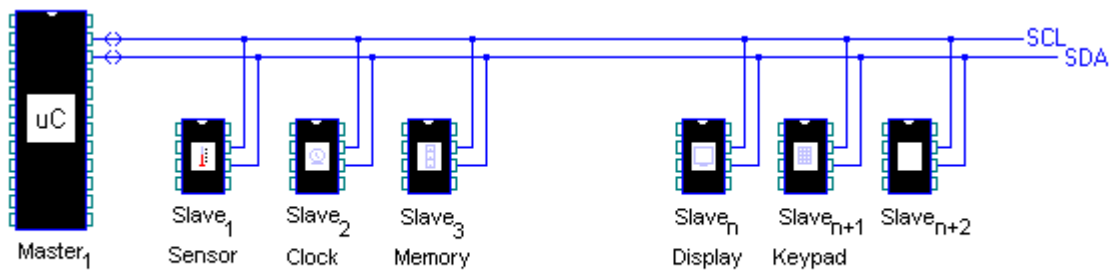


A second savings from the two-wire I²C Bus design is in printed circuit board (PCB) size and costs. With ICs based on the I²C Bus needing far fewer wires (copper traces) for inter-chip communications, circuit boards using I²C ICs are greatly reduced in size, complexity, and cost.

More Power

Although cost savings alone would be enough to make the I²C Bus a success, its developers were also charged with creating a powerful communication link. I²C meets this challenge by supporting several powerful features.

Courtesy of www.mcc-us.com



One I²C Master, Multiple Slaves

Master-Slave Hierarchy

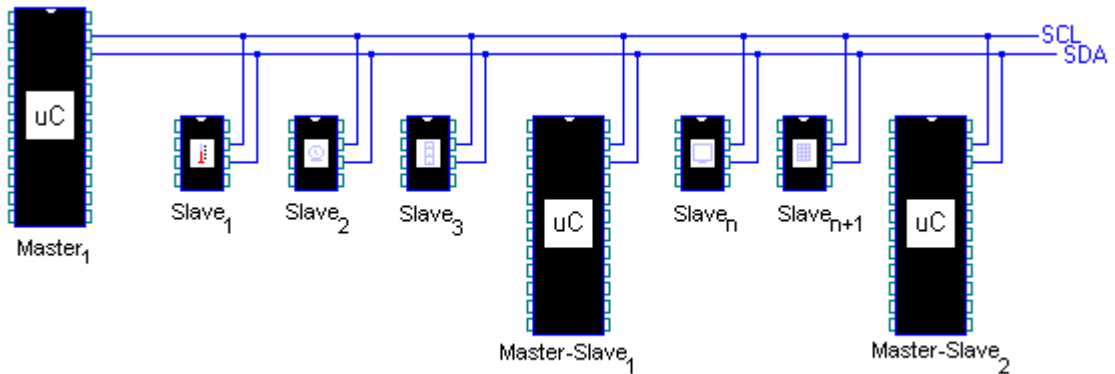
I²C devices are classified as master or slave. A device that initiates a message is called a master, while a device that responds to a message is called a slave. A device can be master-only, slave-only, or switch between master and slave, as the application requires.

Multiple Devices

I²C can connect many ICs on just two-wires. Each I²C slave device has its own unique slave address. When a master sends a message, it includes the slave address at the beginning of the message. All devices on the bus hear the message, but only the slave that recognizes its own address participates in the transfer.

Multi-Master Support

I²C also supports multiple master devices on the bus at the same time, a powerful feature that optimizes bus use by keeping bus message traffic to a minimum. To support multiple masters, I²C must resolve signal conflicts, should two or more master devices try to talk on the bus at the same time. This feat, called bus arbitration loss detection, allows a master to detect when its bus signals are conflicting with those of another master. A master that detects arbitration loss terminates its use of the bus, allowing the message generated by another master to cross the bus unharmed.



Multi-Master, Multi-Slave

Summary

The I²C Bus is a time-proven, industry standard, communication protocol used in a wide variety of electronic products. I²C is found in products we use every day, like cellular and conventional telephones, computers, and ATMs (automatic teller machines). Its low cost and powerful features make I²C ideal for low to medium speed chip-to-chip communications.

I²C is supported by a large and growing number of semiconductor and system manufacturers. These companies offer a variety of electronic devices, including memories, input and output devices, sensors of many types, real-time clocks, displays, data entry devices, and much more. I²C is an effective technology that can lower product costs and increase product performance.

Philips I²C Logic Products

I²C Functions:

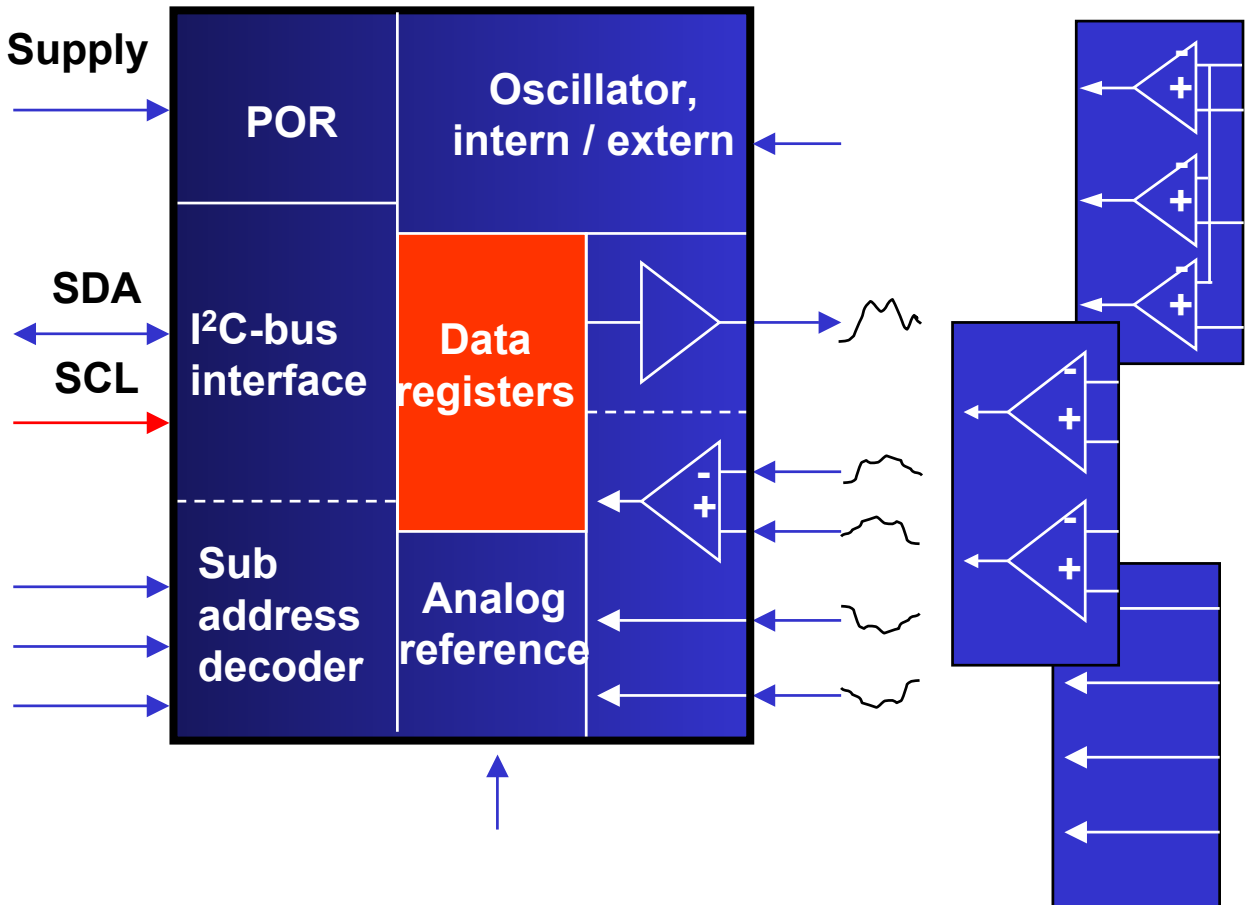
- A/D and D/A Conversion
- Bus Master – 8-bit parallel to I²C protocol
- Bus repeater, hubs and expansion
- Jumper and DIP switch replacement
- Power, dim and blink LEDs
- General Purpose I/O expansion
- Bus isolation and extension
- Bus multiplexing
- Non-volatile storage -Serial EEPROMs
- System monitoring (temperature/voltage)
- Voltage Level Translations

Advanced Family Features:

- 400 kHz I²C operation
- 2.3 to 5.5 V operating supply voltage
- -40 to +85 °C operating temperature
- I²C and SMBus compatibility
- Hardware address pins (A₀, A₁, A₂)
- DIP, SO, SSOP, QSOP, TSSOP and HVQFN packages
- High volume process manufacturing

www.semiconductors.philips.com/logic/i2c

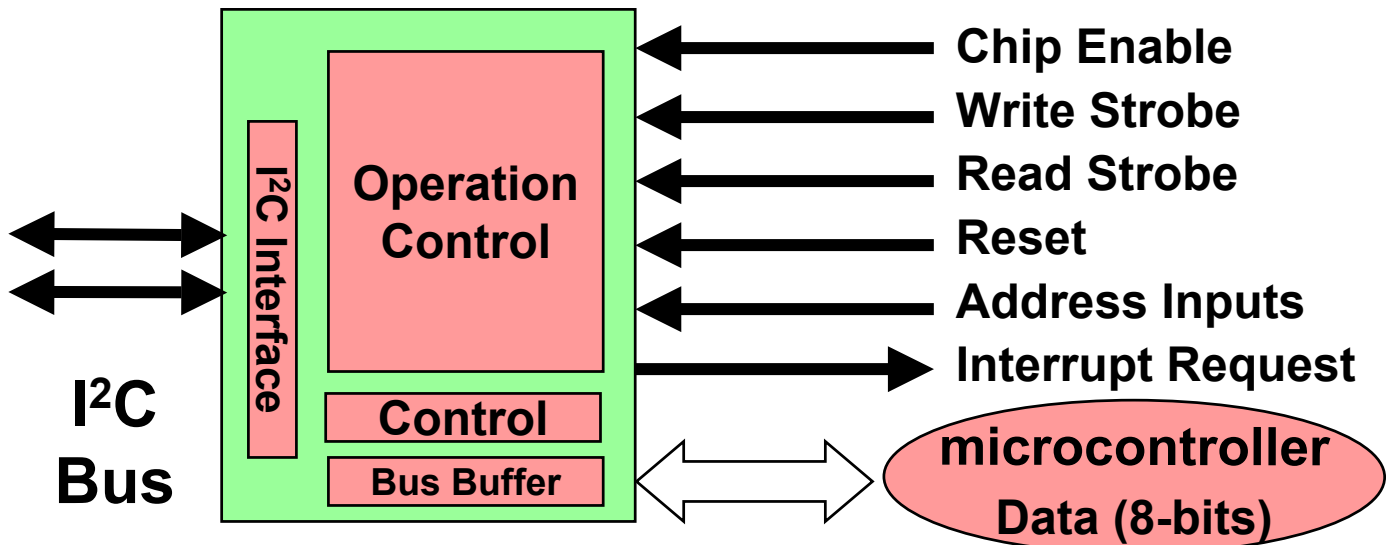
I²C Analog to Digital Converter



- Converts signals from digital to analog and analog to digital
- 4 channel Analog to Digital converter
- 1 channel Digital to Analog converter
- Internal oscillator
- Power On Reset (POR)

• **PCF8591, 100 kHz 4 channel 8 bit ADC**

Parallel Bus to I²C Bus Controller



–Serves as an interface between most standard 8-bit parallel-bus microcontrollers/microprocessors and the serial I²C bus.

–Allows the parallel bus system to communicate bi-directionally with the I²C bus.

–Provides both master and slave functions.

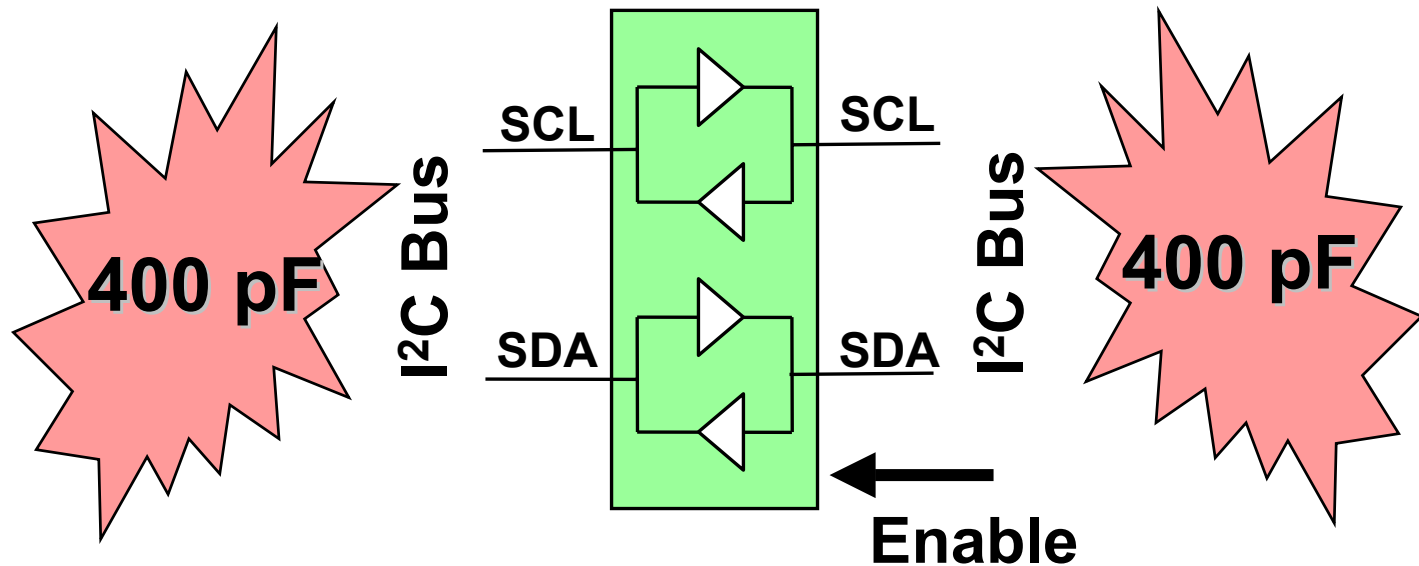
–Communication with the I²C bus is carried out on a byte-wise basis using interrupt or polled handshake.

–Controls all the I²C bus specific sequences, protocol, arbitration and timing.

–Internal oscillator (PCA9564)

- **PCA9564, 400 kHz Parallel Bus to I²C Bus Controller**
- **PCF8584, 100 kHz Parallel Bus to I²C Bus Controller**

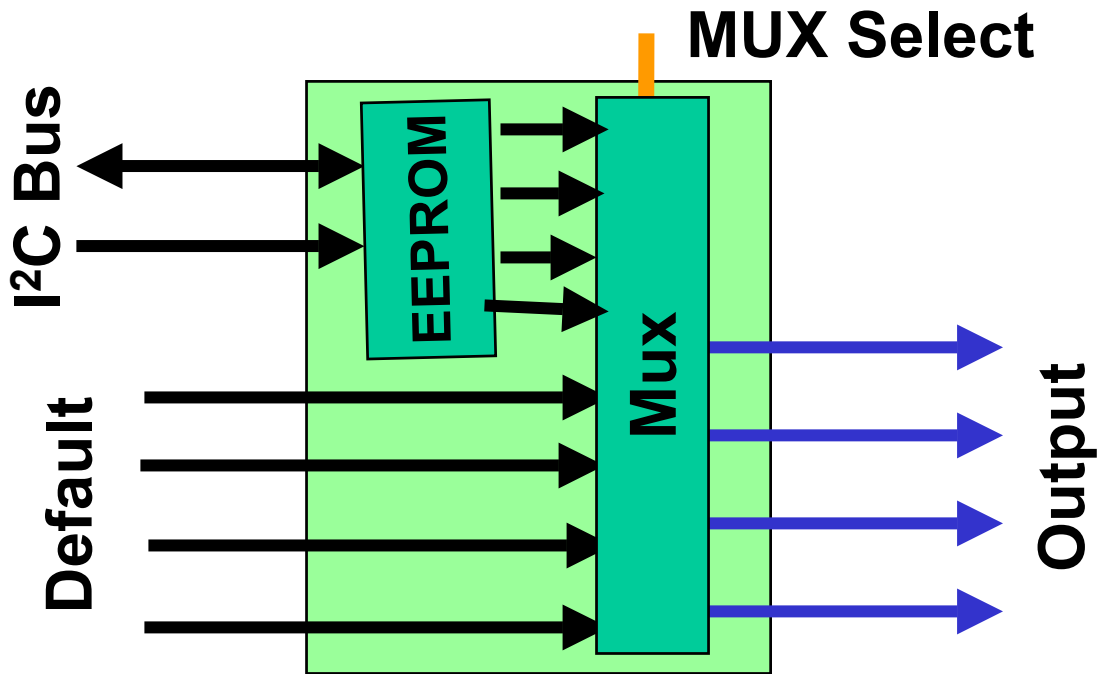
I²C Bus Repeater, Hub and Extenders



- Bi-directional I²C drivers, enable designers to isolate the I²C bus capacitance, accommodating more I²C devices or a longer bus length.
- 400 pF load allowed on each segment.
- Different voltages (3.3 V or 5.0 V) allowed on each segment.
- Devices transparent to bus arbitration and contention protocols in a multi-master environment.
- P82B96 allows twisted pair, differential transmission or Opto-Electrical isolation of the I²C Bus

- PCA9510/11/12/13/14, I²C Hot Swap Bus Buffer
- PCA9515/15A/17, I²C Bus Repeater
- PCA9516/16A, 5-Channel I²C Hub
- PCA9518, Expandable 5-Channel I²C Hub
- P82B96, Dual Bi-Directional Bus Buffer
- P82B715, I²C Bus Extender

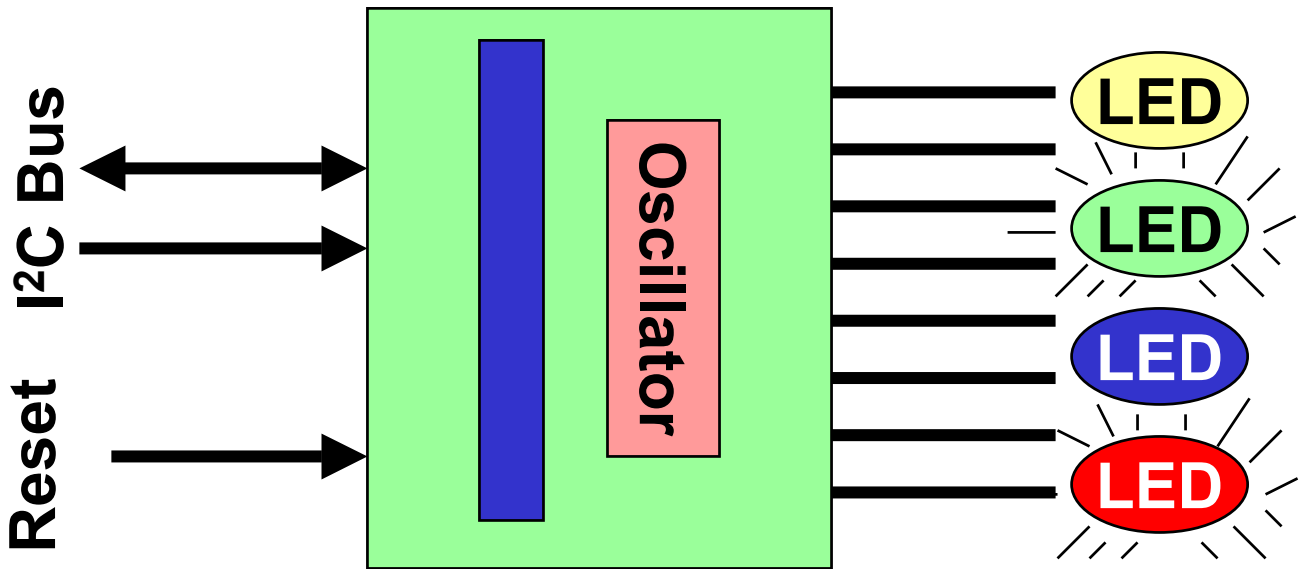
I²C EEPROM based DIP Switches



- Replacement for jumpers or dip switches.
- I²C controlled integrated EEPROM and Multiplexer eliminates need to open equipment to modify jumpers/dip switches by hand.
- Multiplex between the default values or the setting stored in the onboard I²C EEPROM register and programmed from the I²C bus.
- The non-volatile I²C EEPROM register values stay resident even when the device is powered down

- **PCA8550, 4-bit Multiplexed/1-bit Latched 5-bit EEPROM**
- **PCA9559, 5-bit Multiplexed/1-bit Latched 6-bit EEPROM**
- **PCA9560, Dual 5-bit Multiplexed/1-bit Latched EEPROM**
- **PCA9561, Quad 6-bit Multiplexed EEPROM**

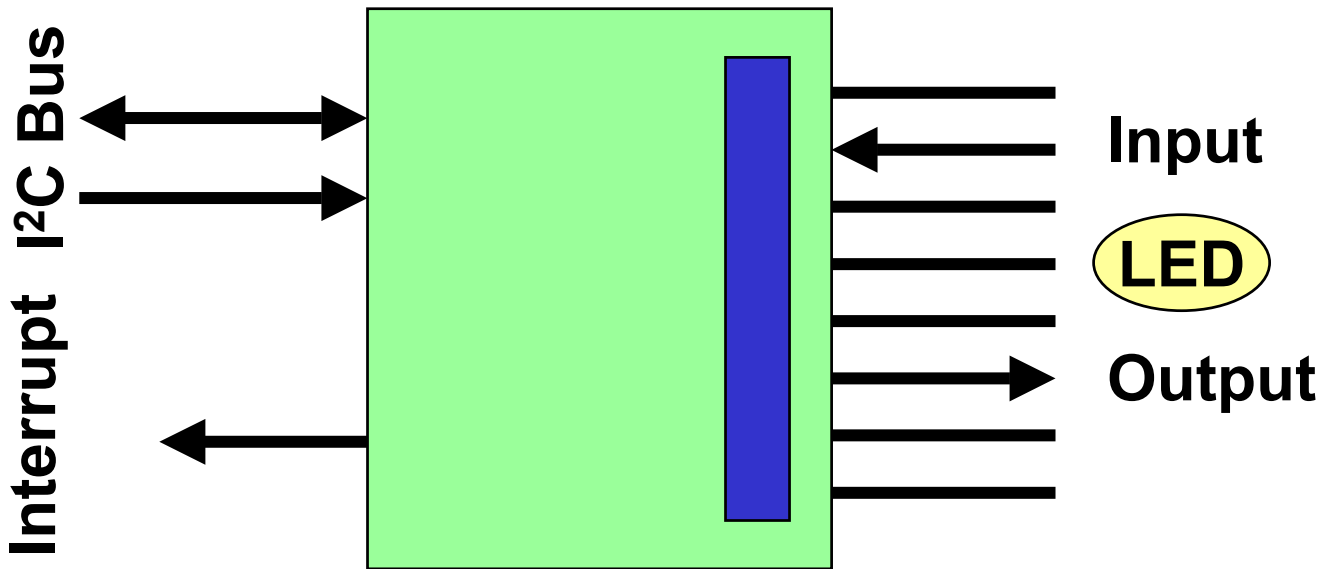
I²C LED Dimmers/Blinkers



- Used for general-purpose LED dimming and blinking.
- Internal oscillator, no external components required.
- Two user definable blink rates and duty cycles.
- Single transmission to turn LEDs on, off, or blink at one of the two programmable blink rates.
- I²C/SMBus not tied up by sending repeated transmissions to blink LEDs.
- Hardware Reset pin.
- High current open drain outputs.
- PCA953x Dimmers vary between 160 Hz and 1.6 seconds
- PCA955x Blinkers vary between 40 Hz and 6.4 seconds

- **PCA9530/50, 2-Bit I²C/SMBus LED Controller**
- **PCA9533/53, 4-bit I²C/SMBus LED Controller**
- **PCA9531/51, 8-bit I²C/SMBus LED Controller**
- **PCA9532/52, 16-bit I²C/SMBus LED Controller**

I²C General Purpose Quasi I/O



-Used for general-purpose input and output (GPIO) extension from the I²C/SMBus.

-Connect parallel I/O to the serial I²C/SMBus and provide expansion capability for the I/O controller Hub (South Bridge).

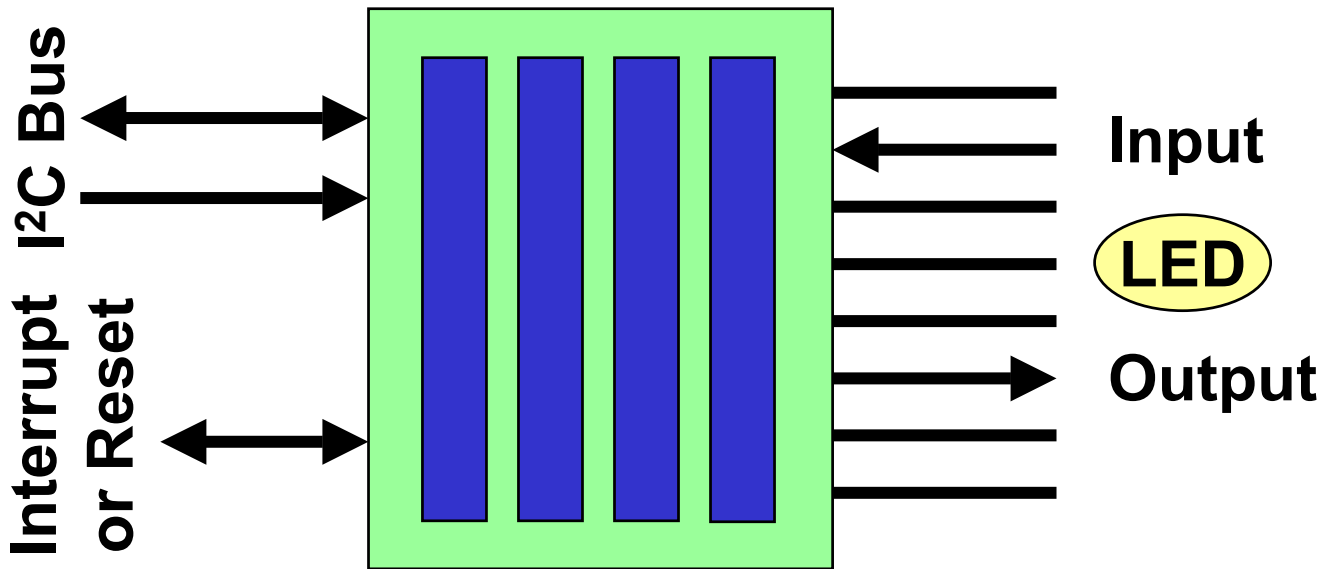
-One registers for **Quasi Output** (upper transistor on for one/half clock cycle):

-Input or Output (value)

-Devices may have Interrupt output pin.

- **PCA9500, 8-bit GPIO w/ 2kbit EEPROM**
- **PCA9501, 8-bit GPIO w/2kbit EEPROM & Interrupt**
- **PCA9558, 8-bit GPIO w/5-bit DIP Switch & 2kbit EEPROM**
- **PCF8574/74A, 8-bit I²C I/O Port with Interrupt**
- **PCF8575/75C, 16-bit I²C I/O Port with Interrupt**

I²C General Purpose True I/O



-Used for general-purpose input and output (GPIO) extension from the I²C/SMBus.

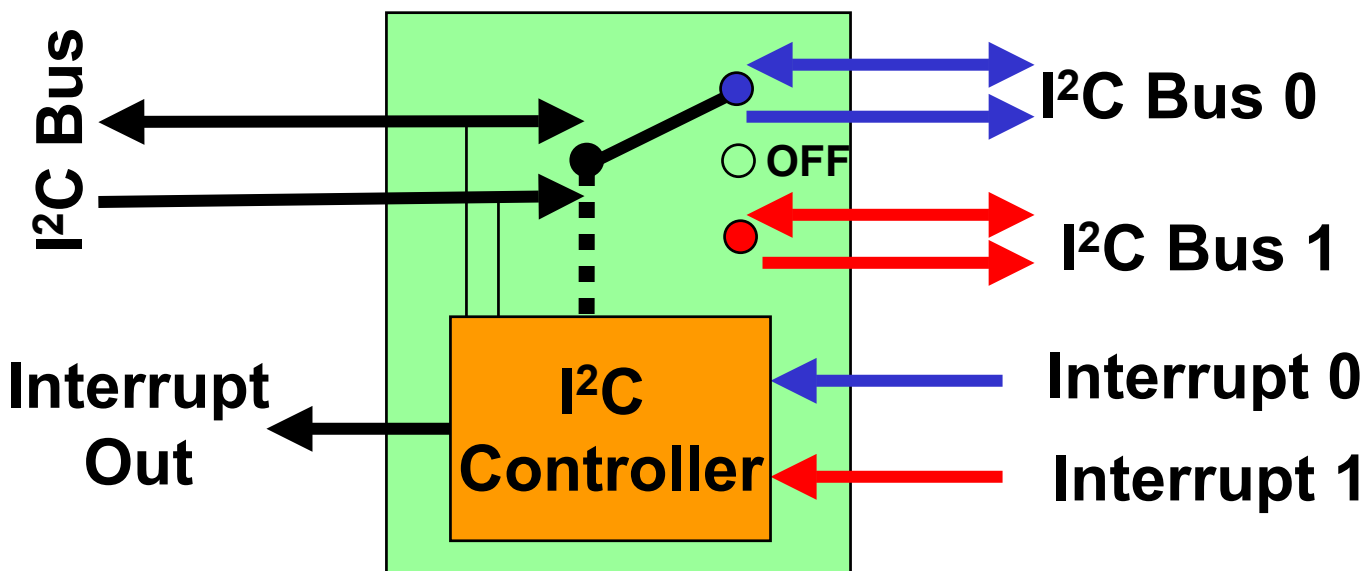
-Connect parallel I/O to the serial I²C/SMBus and provide expansion capability for the I/O controller Hub.

Four sets of registers for **true outputs** (push-pull outputs):

- Configuration (Input or Output)
- Input (Read I/O value)
- Output (Force output value)
- Polarity (active high or low)

- PCA9534/54/54A, 8-bit I²C and SMBus I/O Port with Int
- PCA9535/55, 16-bit I²C and SMBus I/O Port with Interrupt
- PCA9536, 4-bit I²C and SMBus I/O Port
- PCA9537, 4-bit I²C and SMBus I/O Port with Int & Reset
- PCA9538, 8-bit I²C and SMBus I/O Port with Int & Reset
- PCA9539, 16-bit I²C and SMBus I/O Port with Int & Reset
- PCA9557, 8-bit I²C and SMBus I/O Port with Reset

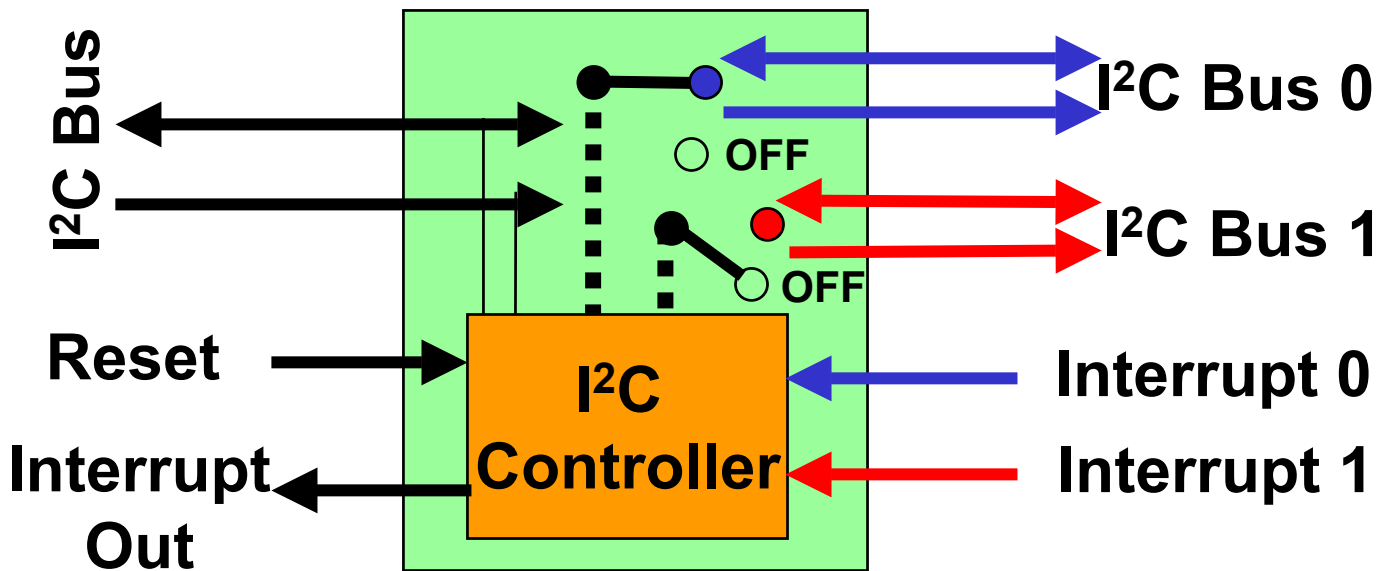
I²C Multiplexers



- The SCL/SDA upstream channel fans out to multiple SCx/SDx channels that are selected by the programmable control register.
- The Multiplexers can select none or only one SCx/SDx channels at a time.
- Applications include:
 - Address conflict resolution (e.g., SPD EEPROMs on DIMMs).
 - I²C sub-branch isolation
 - I²C bus level shifting (e.g., individual SCx/SDx channels at 5.0 V, 3.3 V, 2.5 V or 1.8 V).
- Interrupt logic provides flag to master

- **PCA9540B, 1 to 2-Channel Multiplexer**
- **PCA9541, 2 to 1 Master Selector with Int Logic & Reset**
- **PCA9542A, 1 to 2-Channel Multiplexer with Interrupt Logic**
- **PCA9544A, 1 to 4-Channel Multiplexer with Interrupt Logic**
- **PCA9547, 1 to 8-Channel Multiplexer with Reset**

I²C Switches



-The SCL/SDA upstream channel fans out to multiple SCx/SDx channels that are selected by the programmable control register.

-The Switches can select individual SCx/SDx channels one at a time, all at once or in any combination through I²C commands.

-Applications include:

- Address conflict resolution (e.g., SPD EEPROMs on DIMMs).

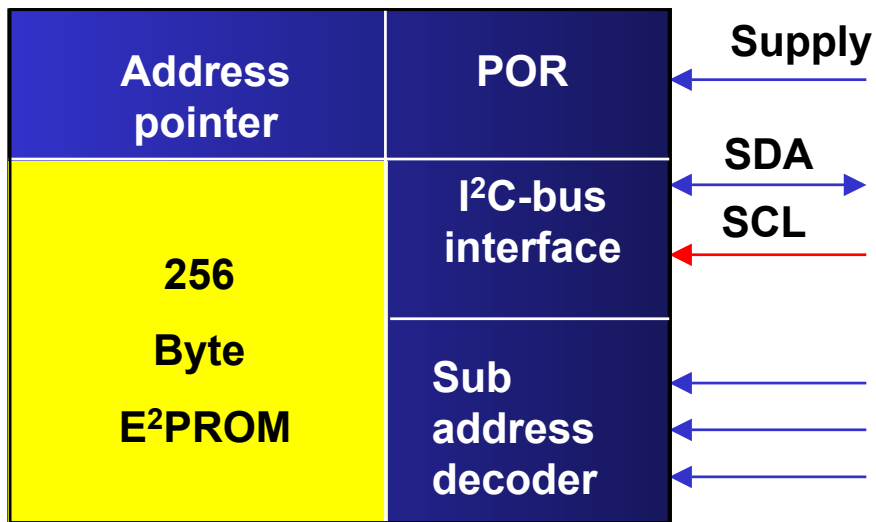
- I²C sub-branch isolation

- I²C bus level shifting (e.g., individual SCx/SDx channels at 5.0 V, 3.3 V, 2.5 V or 1.8 V).

-Hardware Reset provides a means of resetting the bus should it hang up, without rebooting the entire system.

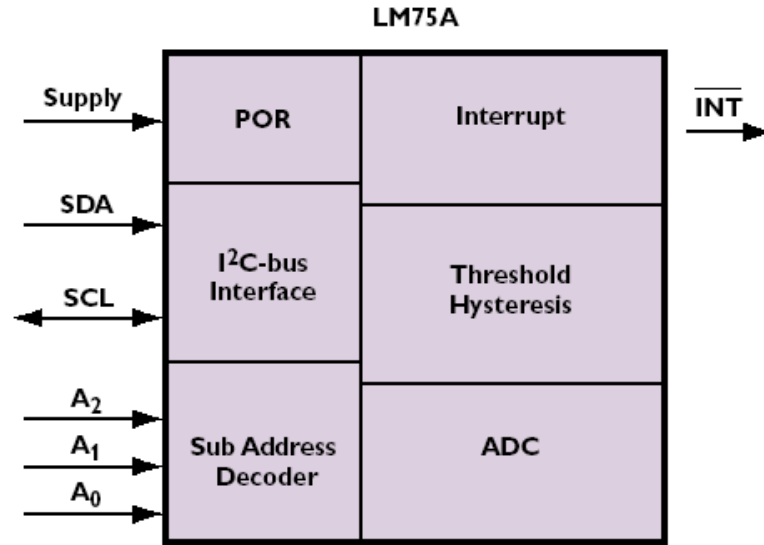
- PCA9543A, 1 to 2-Channel Switch with Int Logic and Reset
- PCA9545A, 1 to 4-Channel Switch with Int Logic and Reset
- PCA9546A, 1 to 4-Channel Switch with Reset
- PCA9548A, 1 to 8-Channel Switch with Reset

I²C Serial EEPROM



- Wide voltage range minimizes the number of EEPROMs that need to be in inventory
- I²C bus is used to read and write information to and from the memory
- Wide voltage range of 2.5 to 5.5V
- 1,000,000 read and write cycles
- 10 year data retention
- **PCA24S08, 1024 x 8-bit EEPROM with security**
- **PCF8581(C), 128 x 8-bit CMOS EEPROM**
- **PCF8582C-2, 256 x 8-bit CMOS EEPROM**
- **PCF8594C-2, 512 x 8-bit CMOS EEPROM**
- **PCF8598C-2, 1024 x 8-bit CMOS EEPROM**
- **PCF85102C-2, 256 x 8-bit CMOS EEPROM**
- **PCF85103C-2, 256 x 8-bit CMOS EEPROM**
- **PCF85116-3, 2048 x 8-bit CMOS EEPROM**

I²C Temperature and Voltage Sensors

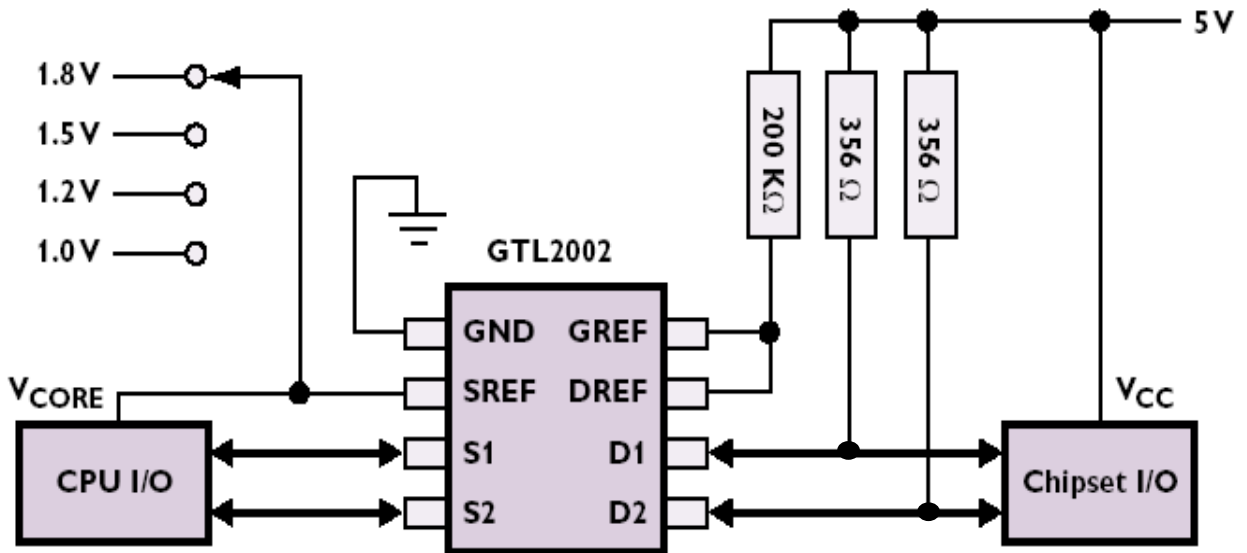


-Hardware monitors use the I²C bus to report temperature and/or voltage.

-Some of the temperature monitors include analog input or external sense pins that allow external transistors/diodes to be located in external components (e.g., processors) that sense the temperature much more accurately than if the sensor was mounted externally on the package.

- **NE1617A, I²C Temperature Monitor**
- **NE1618, High Accuracy I²C Temperature Monitor**
- **NE1619, I²C Temperature and Voltage Monitor**
- **LM75A, ± 2 °C Digital Temp Sensor and Thermal Watchdog™**
- **SA56004-X, ±1 °C Accurate, Remote/Local Digital Temperature Sensor with Over Temperature Alarms**
- **SE95, ± 1 °C Digital Temp Sensor and Thermal Watchdog™**

I²C Voltage Level Translator



- Voltage translation between any voltage from 1.0 V to 5.0 V
- Open drain on both sides with no drive
- Bi-directional with no direction pin
- Reference voltage clamps the input voltage with low propagation delay
- Used for bi-directional translation of I²C buses at 3.3V and/or 5 V to the processor I²C port at 1.2 V or 1.5 V or any voltage in-between
- BiCMOS process provides excellent ESD performance

- **GTL2000, 20-bit Bi-directional Level Translator**
- **GTL2002, 2-bit Bi-directional Level Translator**
- **GTL2010, 10-bit Bi-directional Level Translator**