

I²C *Bus*



What is I²C ?

- Developed by Philips Semiconductors in early 1980 for providing a simple way to talk between IC's by using a minimum number of pins
- It's a Inter-Integrated Circuit Bus.
- It's a simple bi-directional 2-wire bus for efficient inter-IC control. No specific wiring or connectors but just PCB tracks. (It's a two wire **serial** interface)



I²C Continued...

- Since a serial Interface it reduces cost of manufacturing of electronic product.
- Has become a recognized standard throughout our industry and is used now by ALL major IC manufacturers.



I²C Features

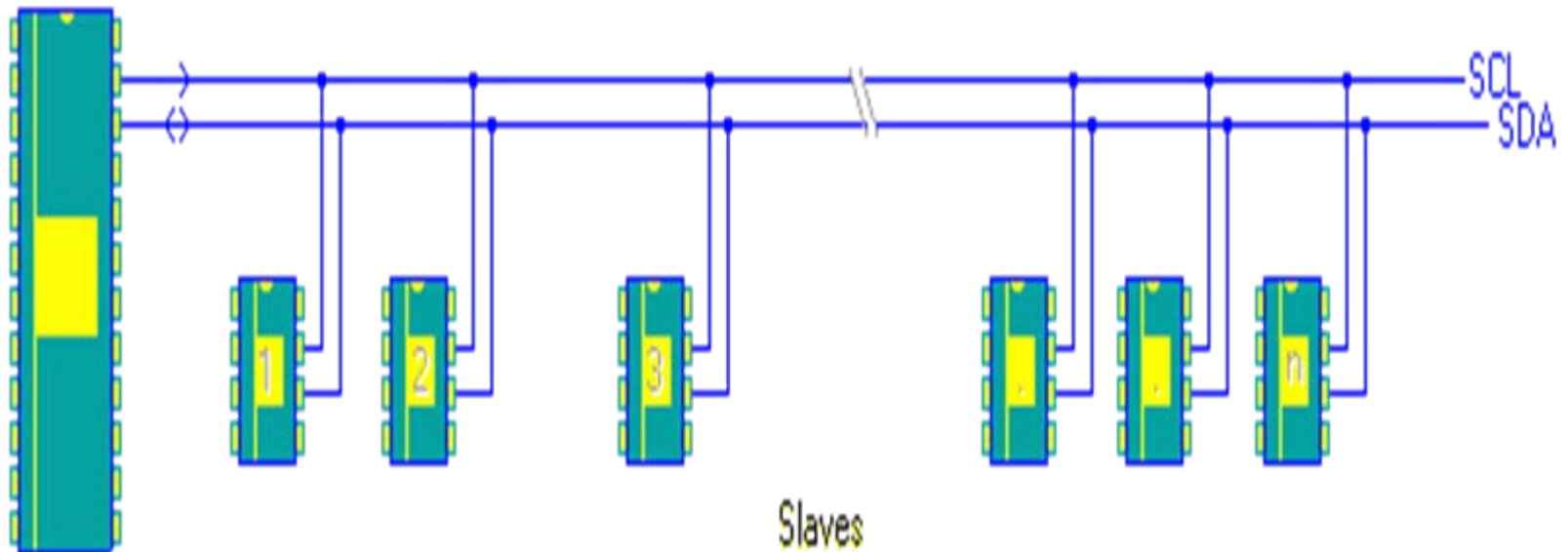
- Only two bus lines are required: a **serial data line (SDA)** and a **serial clock line (SCL)**.
- Each device connected to the bus is software addressable by a unique address and simple master/slave relationships exist at all times; masters can operate as master-transmitters or as master-receivers.
- It's a true **multi-master** bus including collision detection and arbitration to prevent data corruption if two or more masters simultaneously initiate data transfer.



I²C Features Contd...

- **Serial, 8-bit oriented, bi-directional data** transfers can be made at up to **100 kbit/s** in the Standard-mode, up to **400 kbit/s** in the Fast-mode, or up to **3.4 Mbit/s** in the High-speed mode.
- On-chip filtering (50 ns) rejects spikes on the bus data line to preserve data integrity.
- The number of ICs that can be connected to the same bus segment is limited only by the maximum bus capacitive loading of 400 pF.

Basic I²C arrangement





I²C Communication Procedure

One IC that wants to talk to another must:

(Protocol)

- 1) Wait until it sees no activity on the I²C bus.
SDA and SCL are both high. The bus is 'free'.
- 2) Put a message on the bus that says 'its mine'
- I have **STARTED** to use the bus. All other ICs then **LISTEN** to the bus data to see whether they might be the one who will be called up (addressed).



Communication Contd..

- 3) Provide on the CLOCK (SCL) wire a clock signal. It will be used by all the ICs as the reference time at which each bit of DATA on the data (SDA) wire will be correct (valid) and can be used. The data on the data wire (SDA) must be valid at the time the clock wire (SCL) switches from 'low' to 'high' voltage.
- 4) Put out in serial form the **unique binary 'address'** (name) of the IC that it wants to communicate with.
- 5) Put a message (one bit) on the bus telling whether it wants to SEND or RECEIVE data from the other chip. (The **read/write wire** is gone!)

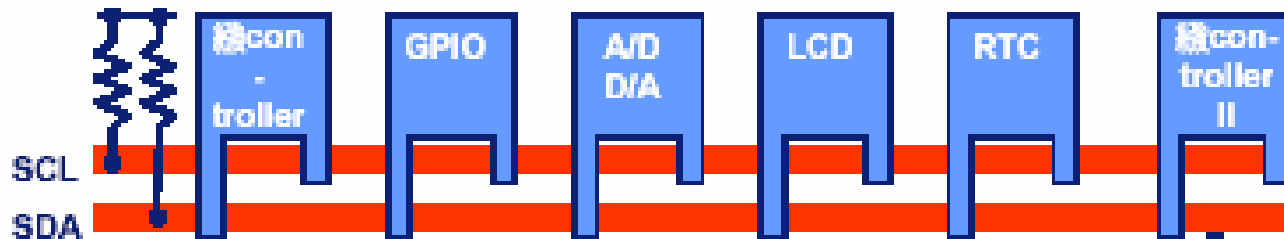


Communication Contd..

- 6) Ask the other IC to ACKNOWLEDGE (using one bit) that it recognized its address and is ready to communicate.
- 7) After the other IC acknowledges all is OK, data can be transferred.
- 8) The first IC sends or receives as many 8-bit words of data as it wants. After every 8-bit data word the sending IC expects the receiving IC to acknowledge the transfer is going OK.
- 9) When all the data is finished the first chip must free up the bus and it does that by a special message called 'STOP'. It is just one bit of information transferred by a special 'wiggling' of the SDA/SCL wires of the bus.

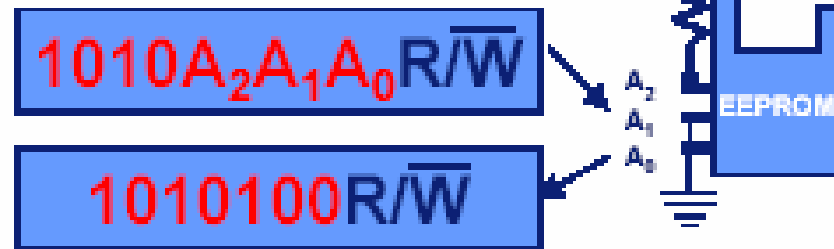
I²C Bus Basics - Address and Data

The master always sends the SCL (clock) signal.



New devices or functions can be easily 'clipped on' to an existing bus!

Each device is addressed individually by software with a unique address that can be modified by hardware pins.



The open drain/collector outputs provide for a 'wired-AND' connection that allows devices to be added or removed without impact and always require a pull-up resistor.

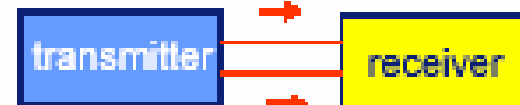
Write data



< n data bytes >

Master

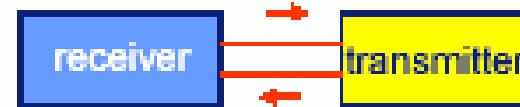
Slave



Read data

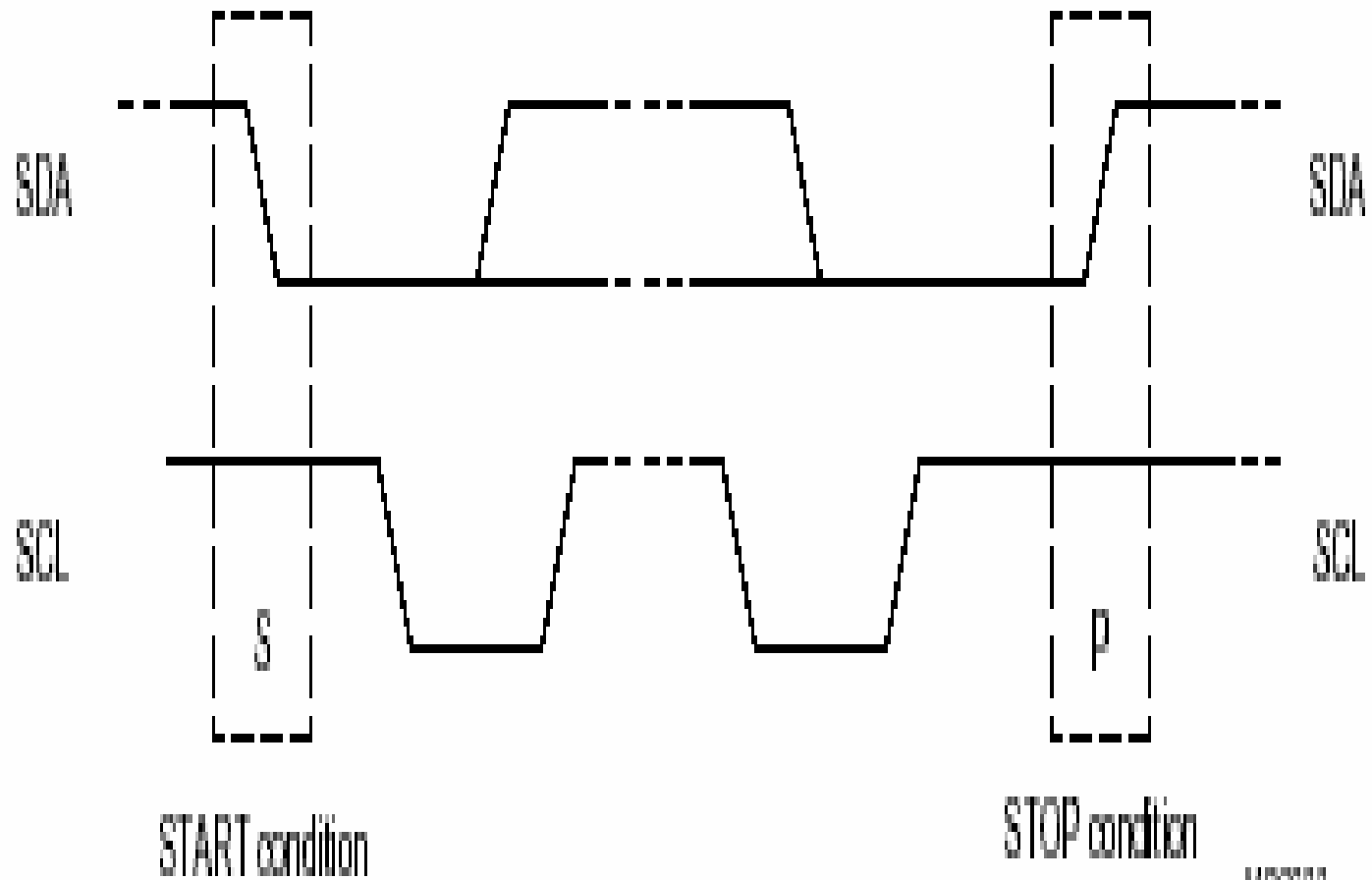


< n data bytes > last data byte



S = Start condition
A = Acknowledge
P = Stop condition

R/W = read / write not
A = Not Acknowledge



Start and Stop Conditions

I²C Address, 7-bit and 10-bit formats

- The 1st byte after START determines the Slave to be addressed
- Some exceptions to the rule:
 - "General Call" address: all devices are addressed : 0000 000 + R/W = 0
 - 10-bit slave addressing : 1111 0XX + R/W = X

• 7-bit addressing



• 10-bit addressing





I²C Benefits

- Well known bus, over 20 years of existence, has become world standard.
- Standard adopted by industries like telecom, networking, consumer, automotive etc.
- Used in many applications like cellphones, PDA's, DVD, set top boxes etc.
- Designed to stay in market for several years.
- Used by giants like HP, Compaq, IBM, Cisco, Intel, Nokia etc.



Benefits contd...

- **Functional blocks on the block diagram correspond with the actual ICs; designs proceed rapidly from block diagram to final schematic.**
- **No need to design bus interfaces because the I2C bus interface is already integrated on-chip.**
- **Integrated addressing and data-transfer protocol allow systems to be completely software-defined.**
- **The same IC types can often be used in many different applications.**



Benefits contd...

- **Design-time reduces as designers quickly become familiar with the frequently used functional blocks represented by I2C bus compatible ICs.**
- **ICs can be added to or removed from a system without affecting any other circuits on the bus.**
- **Fault diagnosis and debugging are simple; malfunctions can be immediately traced.**
- **Assembling a library of reusable software modules can reduce software development time.**



I2C manufactures benefits

- The simple 2-wire serial I2C bus minimizes interconnections so ICs have fewer pins and there are not so many PCB tracks; result - smaller and less expensive PCBs
- The completely integrated I2C bus protocol eliminates the need for address decoders and other 'glue logic'
- The multi-master capability of the I2C bus allows rapid testing/alignment of end-user equipment via external connections to an assembly-line



manufactures benefits Contd..

- Increases system design flexibility by allowing simple construction of equipment variants and easy upgrading to keep design up-to-date
- I2C bus is a de facto world standard that is implemented in over 1000 different ICs (Philips has > 400) and licensed to more than 70 companies



Home-work ?

- I²C advantages.
- I²C signals(Protocol) summary.
- Electrical Specifications and timings.
- Download I²C specification file ver 2.1,Jan 2000.
- Download I²C manual(AN 10216-01.pdf)

Thank - You