INTEGRATED CIRCUITS

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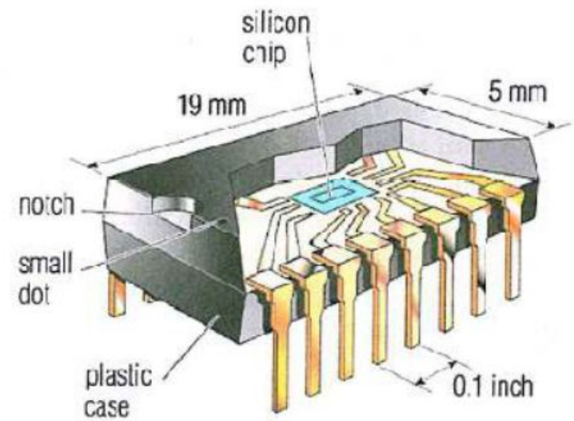
INTRODUCTION

- Integrated Circuits are arrangements of several electronic components in a common housing.
- The major advantage is the very high density of the components; the total arrangement therefore will be very compact.
- As well they are quite resistant to mechanical stress.
- The small housing and therefore the small surface is a disadvantage because some additional cooling might be required.
- A heat sink or fan must be attached then.
- Another disadvantage is that IC's cannot be repaired; a defective IC must always be replaced.

Usually the following components are integrated in IC’s:

1. Semiconductors (Transistors, Diodes)
2. Resistors
3. Capacitors

- Inductances usually cannot be integrated due to their large space requirements. IC’s can be found in each and every modern appliance, in analogues as well as in digital ones. Functional blocks can be found in a single IC, requiring only a very small amount of space, i.e. Processors (Computer), Amplifier



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Number Systems

Four number system

- **Decimal (10)**
- **Binary (2)**
- **Octal (8)**
- **Hexadecimal (16)**

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Binary numbers?

- Computers work only on two states
  - On
  - Off
- Basic memory elements hold only two states
  - Zero / One
- Thus a number system with two elements {0,1}
- A binary digit – bit !

Decimal numbers

$1439 = 1 \times 10^{3} + 4 \times 10^{2} + 3 \times 10^{1} + 9 \times 10^{0}$

Thousands ↑ Hundreds ↑ Tens ↑ Ones ↑

- Radix = 10

Binary→Decimal

$1101 = 1 \times 2^3 + 1 \times 2^2 + 0 \times 2^1 + 1 \times 2^0$

$= 1 \times 8 + 1 \times 4 + 0 \times 2 + 1 \times 1$

$= 8 + 4 + 0 + 1$

$(1101)_2 = (13)_{10}$

1, 2, 4, 8, 16, 32, 64, 128, 256, 512, ...

Decimal → Binary

2	13	1	↑ LSB
2	6	0	
2	3	1	
2	1	1	MSB
	0		

$$(13)_{10} = (1101)_2$$

Octal → Decimal

$137 = 1 \times 8^2 + 3 \times 8^1 + 7 \times 8^0$

$= 1 \times 64 + 3 \times 8 + 7 \times 1$

$= 64 + 24 + 7$

$(137)_8 = (95)_{10}$

- Digits used in Octal number system – 0 to 7

Decimal → Octal

8	95	7	LSP ↑
8	11	3	
8	1	1	
	0		MSP

$$(95)_{10} = (137)_{8}$$

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Hex→Decimal

$BAD = 11 \times 16^2 + 10 \times 16^1 + 13 \times 16^0$

$= 11 \times 256 + 10 \times 16 + 13 \times 1$

$= 2816 + 160 + 13$

$(BAD)_{16} = (2989)_{10}$

A = 10, B = 11, C = 12, D = 13, E = 14, F = 15

Decimal→Hex

16	2989	13	LSP
16	186	10	
16	11	11	
	0		MSP

$$(2989)_{10} = (BAD)_{16}$$

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Why octal or hex?

- Ease of use and conversion
- Three bits make one octal digit

  111 010 110 101

  7 2 6 5 => 7265 in octal

- Four bits make one hexadecimal digit

  1110 1011 0101

  E B 5 => EB5 in hex

  4 bits = nibble

1’s complement

- MSB as in sign magnitude
- Complement all the other bits
- Given a positive number complement all bits to get negative equivalent
- E.g. for a 3 bit set
  - “-2”

Sign	Bit	Bit
1	0	1
0	1	0

2’s complement

- 1’s complement plus one
- E.g. for a 3 bit set
  - “-2”

Sign	Bit	Bit
1	1	0
0	1	0

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Unsigned: Addition

Like normal decimal addition

B

A

+	0	1
0	0	1
1	1	10

The carry out of the MSB is neglected

$$\begin{array}{r} 0101\ (5) \\ +\ 1001\ (9) \\ \hline 1110\ (14) \end{array}$$

Unsigned: Subtraction

Like normal decimal subtraction

B

A

-	0	1
0	0	11
1	1	0

```
  1001 (9)
- 0101 (5)
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  0100 (4)
```

A borrow (shown in red) from the MSB implies a negative

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Digital IC's

- Most of the integrated circuits in use today are digital ICs. These devices are widely used in digital computers and portable electronic calculators to perform various arithmetic and decision making functions. Digital ICs are produced using both bipolar (transistors) and MOS (FET) construction techniques. These circuits can be very simple or extremely complex and are therefore available at the SSI, MSI and LSI levels, (Small Scale Integration, Medium Scale Integration and Large Scale integration).
- All digital circuits are capable of recognizing only two voltage levels (sometimes called logic levels) at each of its inputs. Instead of referring to the specific voltages involved (which can vary with different types of digital circuits), it is common practice to refer to on level as a *high* logic level or a logic 1 and the other voltage level as a *low* logic level or a logic 0.
- A digital circuit can therefore be thought of as a device which responds to various high and low (1 or 0) logic levels and the actual voltages involved can be ignored. Table 3 shows the output levels (1 or 0) produced by a NAND gate when all possible combinations (as this is a 2-input NAND gate only 4 combinations are possible) of input levels have been applied.

Logic Gate:

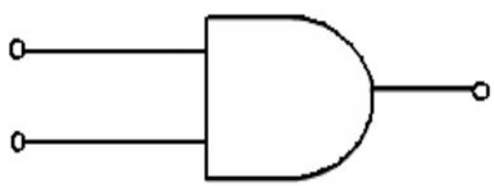
- Actually the term logic is applied to digital circuits used to implement logic functions. Several kinds of digital logic circuits are the basic elements that form the building blocks for such complex digital system as the computer.
- The lines connected to each symbols are the inputs and outputs.
- The inputs are on the left of each symbol and the output is on the right.

- A circuit that performs a specific logic operation (AND, OR) is called a logic gate.

➢ AND Gate:

- An AND gate can have two or more inputs and performs what is know as multiplication.
- The output of AND gate is high when all inputs are high otherwise all outputs are low.

Logical Symbol



Truth Table

Inputs		Output
A	B	X
0	0	0
0	1	0
1	0	0
1	1	1

- It's logical expression is, X=A.B