Logic Design

Administration

Instructor:

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Schedule

- Outlines (Use index to check the location of the textbook)
- Lectures: 1:40-3:00PM, Th, Room 302

Textbook

- M. M. Mano, “Digital Design”, Prentice Hall, 2010.
- A.F.Kana, "Digital Logic Design", 2012
- Digital Design and Computer Architecture, David Money Harris and Sarah L. Harris, published by Morgan Kaufmann, 2007.

Week One
Introduction to numbering systems

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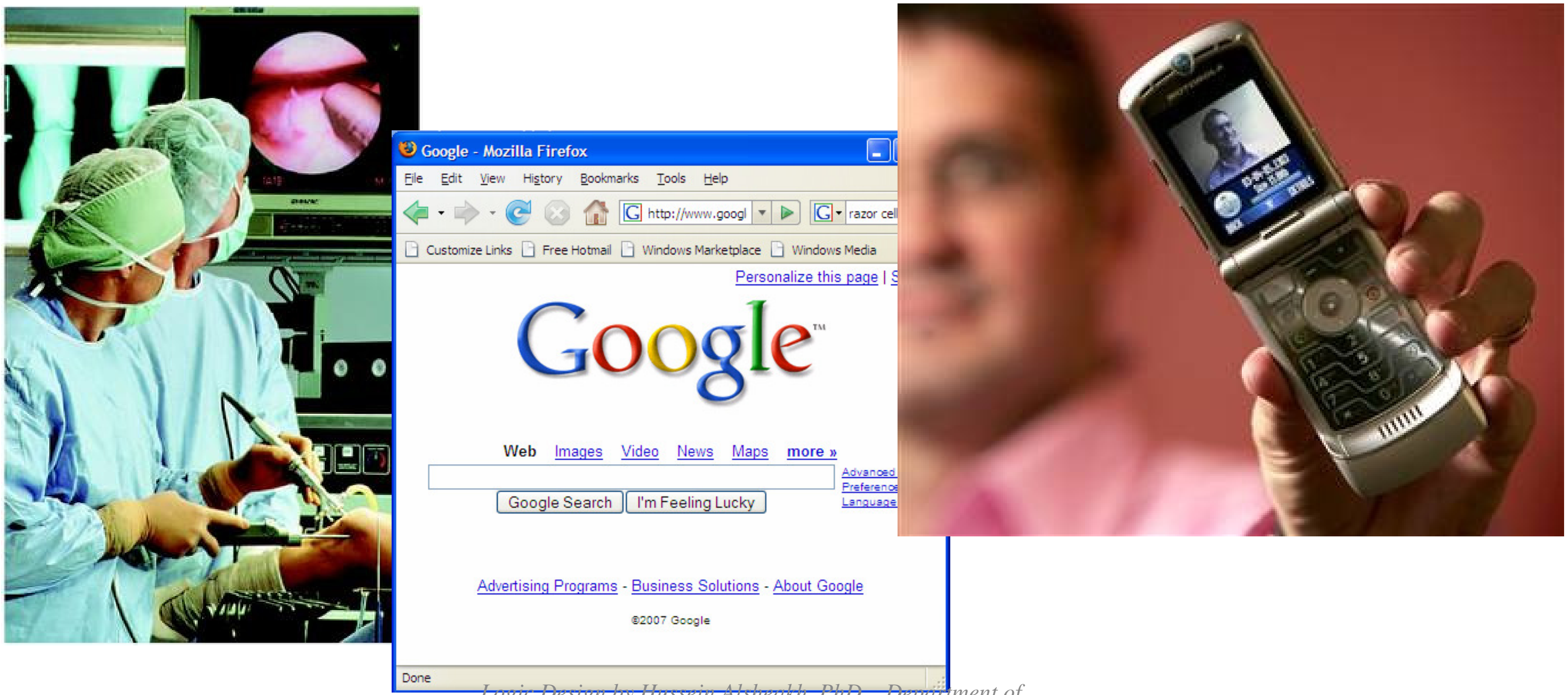
Motivation

- Microprocessors have revolutionized our world
  - Cell phones, internet, rapid advances in medicine, etc.
- The semiconductor industry has grown from $21 billion in 1985 to $213 billion in 2004.

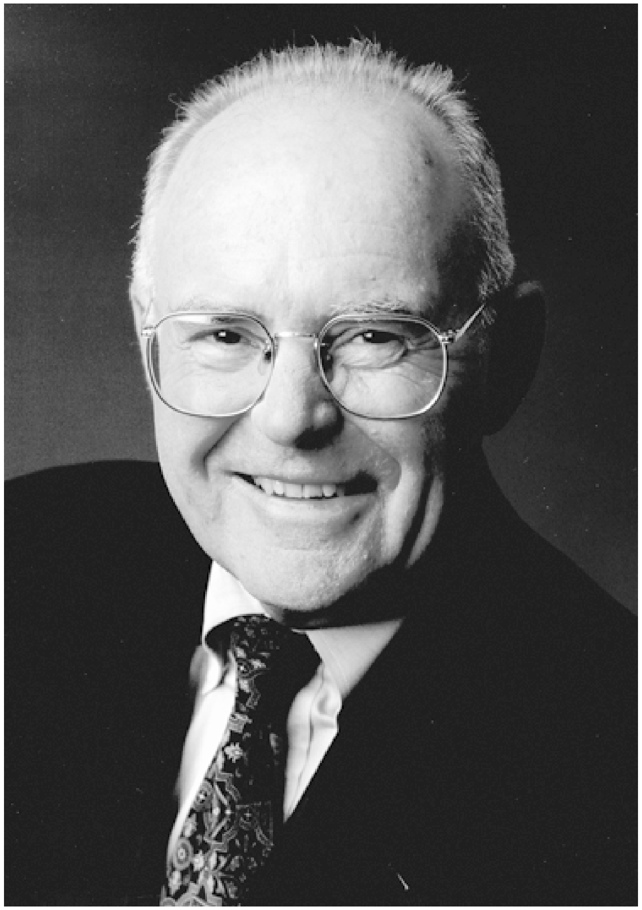


Robert Noyce, 1927 - 1990

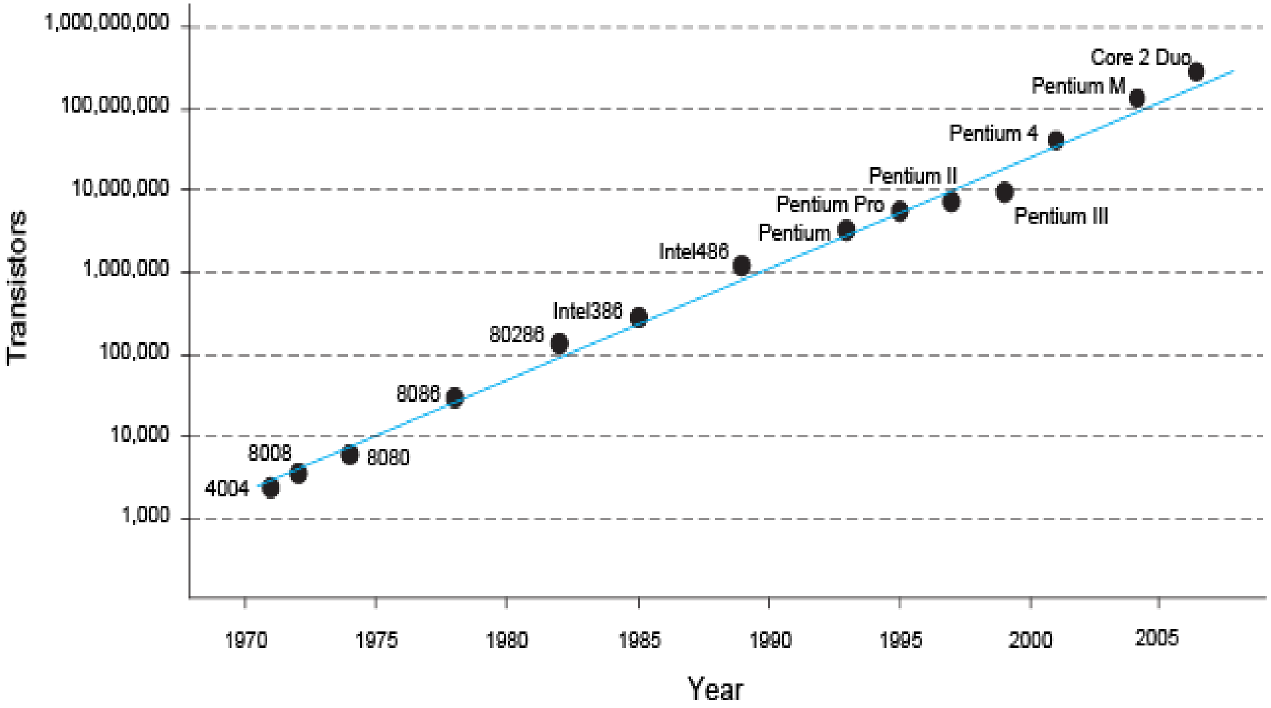
- *Nicknamed “Mayor of Silicon Valley”*
- *Cofounded Fairchild Semiconductor in 1957*
- *Cofounded Intel in 1968*
- *Co-invented the integrated circuit*

Gordon Moore, 1929 -

- *Cofounded Intel in 1968 with Robert Noyce.*
- ***Moore's Law:*** *the number of transistors on a computer chip doubles every year (observed in 1965)*
- *Since 1975, transistor counts have doubled every two years.*



Moore’s Law



“If the automobile had followed the same development cycle as the computer, a Rolls-Royce would today cost $100, get one million miles to the gallon, and explode once a year . . .”

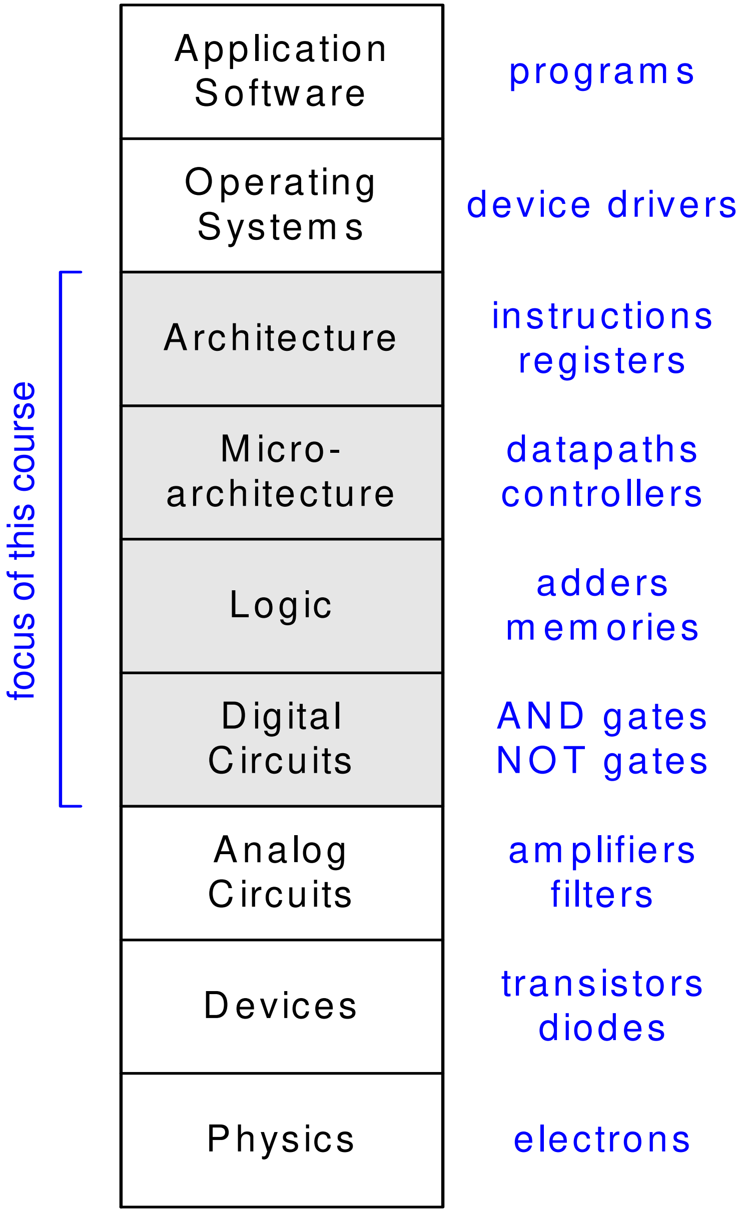
– Robert Cringley

Objectives

- The purpose of this course is to learn what’s under the hood of an electronic component by:
  - Understand the basic and relative numbering systems (e.g., decimal, binary, octal, hexadecimal, and other systems).
  - Designing logical circuits built from using the logical gates using Boolean algebra
  - Understand simplified logical circuits built from using the logical gates using Boolean algebra and K-Map will open the gate to simplify logical circuits.
  - Understand the design of combinational circuits such as decoder, encoder, multiplexer, counters, etc.
  - Develop problem-solving skills and understanding of circuit theory through the application of techniques.
  - Understand the sequential logic circuits such as flip-flops.

Scope

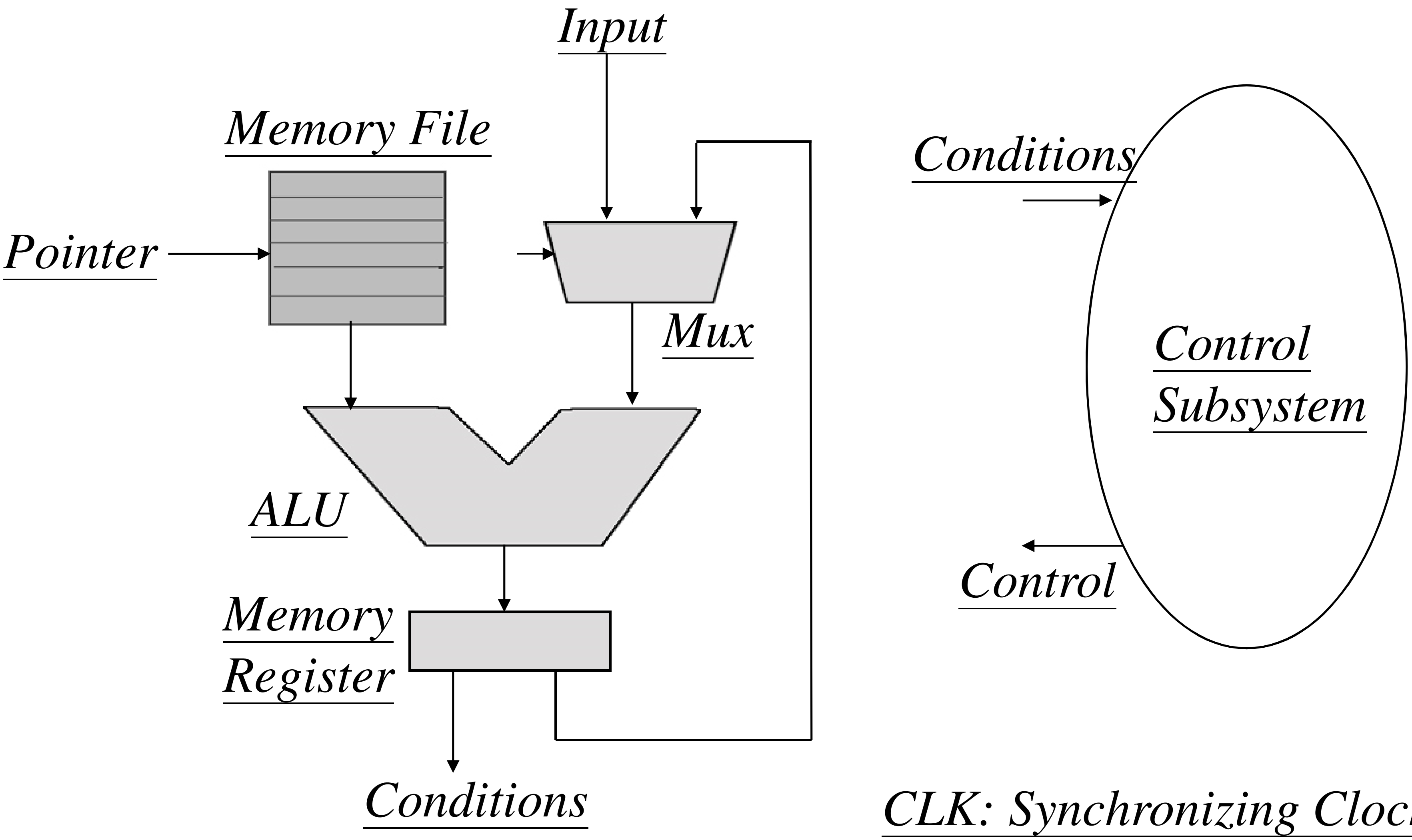
- ***<u>Hiding details when they aren't important</u>***



focus of this course

Application Software	programs
Operating Systems	device drivers
Architecture	instructions registers
Micro-architecture	datapaths controllers
Logic	adders memories
Digital Circuits	AND gates NOT gates
Analog Circuits	amplifiers filters
Devices	transistors diodes
Physics	electrons

Overall Picture



Input

Memory File

Pointer

Mux

ALU

Memory

Register

Conditions

Conditions

Control

Subsystem

Control

CLK: Synchronizing Clock

Scope

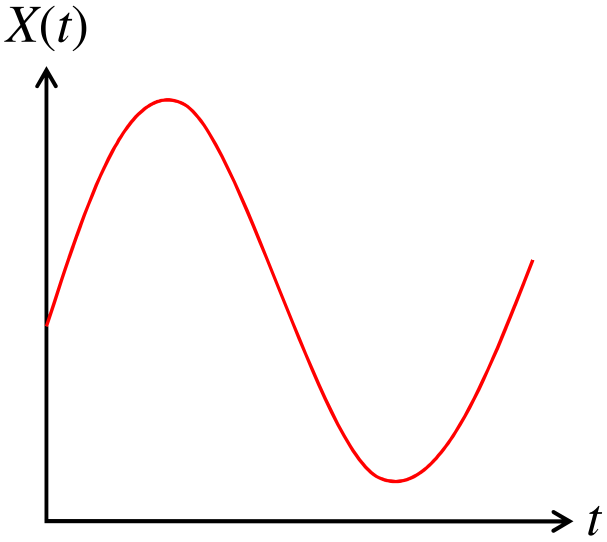
Subjects	**Building Blocks**	**Theory**
Combinational Logic	AND, OR, NOT,XOR	Boolean Algebra
Sequential Network	AND, OR, NOT, FF	Finite State Machine
Standard Modules	Operators, Interconnects, Memory	Arithmetics, Universal Logic
System Design	Data Paths, Control Paths	Methodologies

Digital Systems and Binary Numbers

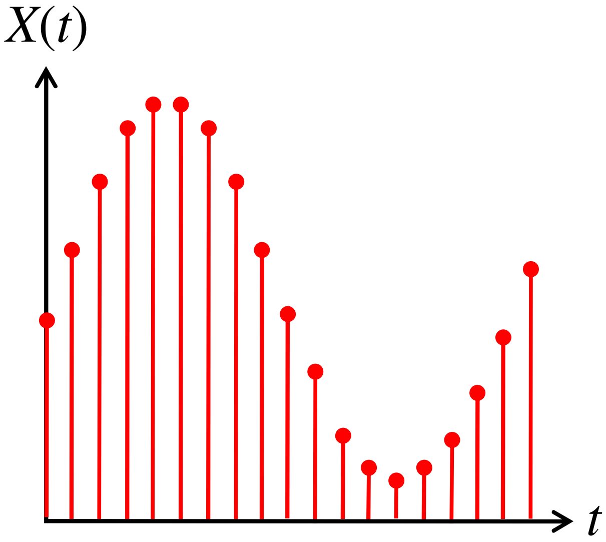
- Digital age and information age
- Digital computers
  - General purposes
  - Many scientific, industrial and commercial applications
- Digital systems
  - Telephone switching exchanges
  - Digital camera
  - Electronic calculators, PDA's
  - Digital TV
- Discrete information-processing systems
  - Manipulate discrete elements of information
  - For example, {1, 2, 3, …} and {A, B, C, …}…

Analog and Digital Signal

- Analog system
  - The physical quantities or signals may vary continuously over a specified range.
- Digital system
  - The physical quantities or signals can assume only discrete values.
  - Greater accuracy



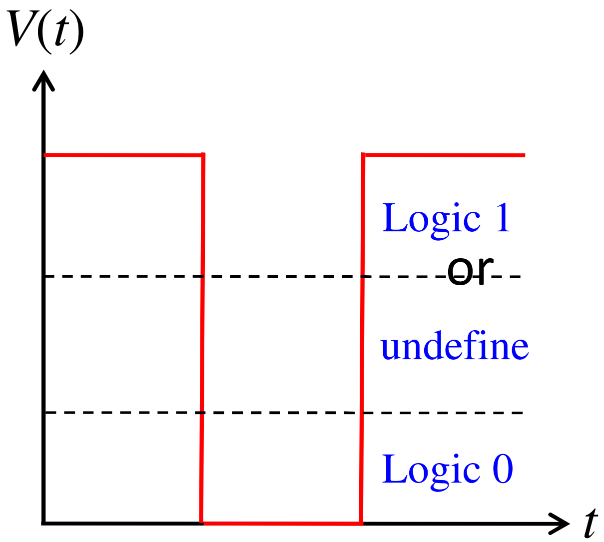
Analog signal



Digital signal

Binary Digital Signal

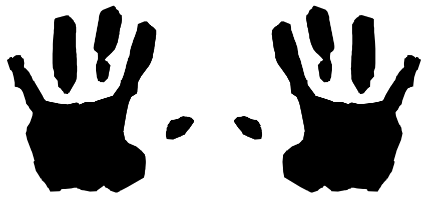
- An information variable represented by physical quantity.
- For digital systems, the variable takes on discrete values.
  - Two level, or binary values are the most prevalent values.
- Binary values are represented abstractly by:
  - Digits 0 and 1
  - Words (symbols) False (F) and True (T)
  - Words (symbols) Low (L) and High (H)
  - And words On and Off
- Binary values are represented by values ranges of values of physical quantities.

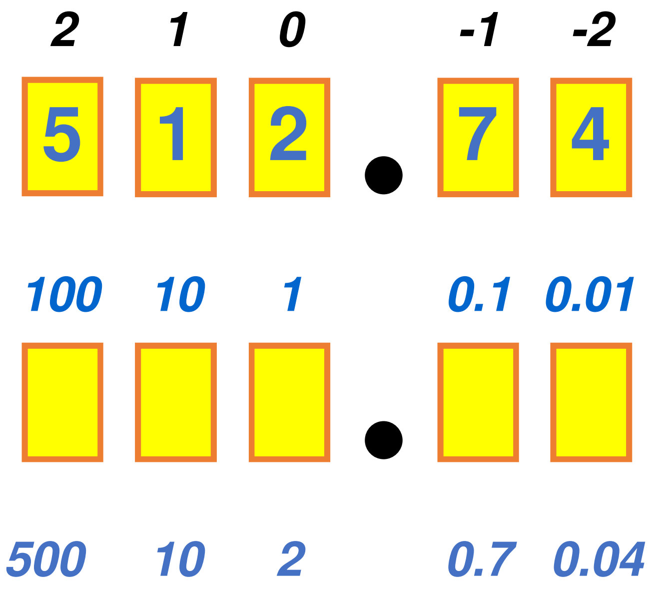


Binary digital signal

Decimal Number System

- Base (also called radix) = 10
  - 10 digits { 0, 1, 2, 3, 4, 5, 6, 7, 8, 9 }
- Digit Position
  - Integer & fraction
- Digit Weight
  - Weight = $(Base)^{Position}$
- Magnitude
  - Sum of "*Digit* x *Weight*"
- Formal Notation





2 1 0 -1 -2

5 1 2 . 7 4

100 10 1 0.1 0.01

.

500 10 2 0.7 0.04

$$d_2 * B^2 + d_1 * B^1 + d_0 * B^0 + d_{-1} * B^{-1} + d_{-2} * B^{-2}$$

$$(512.74)_{10}$$

Octal Number System

- Base = 8
  - 8 digits { 0, 1, 2, 3, 4, 5, 6, 7 }
- Weights
  - Weight = (*Base*) ^{Position}
- Magnitude
  - Sum of "*Digit* x *Weight*"
- Formal Notation

64	*8*	*1*		*1/8*	*1/64*
5	1	2	●	7	4
2	*1*	*0*		*-1*	*-2*

$$5*8^{2}+1*8^{1}+2*8^{0}+7*8^{-1}+4*8^{-2}$$

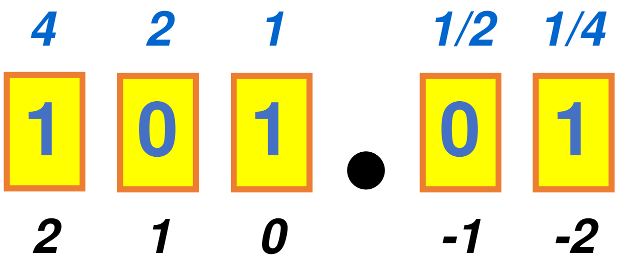
$$=(330.9375)_{8}$$

$$(512.74)_{10}$$

Binary Number System

- Base = 2
  - 2 digits { 0, 1 }, called *b*inary dig*its* or “*bits*”
- Weights
  - Weight = (*Base*) ^{Position}
- Magnitude
  - Sum of “*Bit* x *Weight*”
- Formal Notation
- Groups of bits   4 bits = *Nibble*

  8 bits = *Byte*



$1*2^{2}+0*2^{1}+1*2^{0}+0*2^{-1}+1*2^{-2}$

$=(5.25)_{10}$

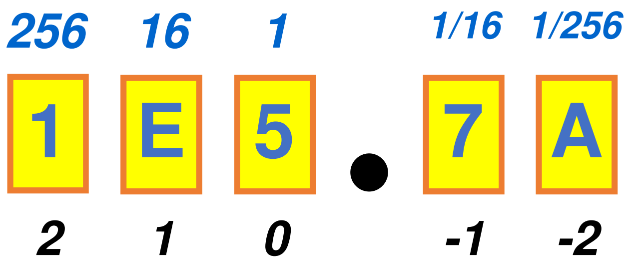
$(101.01)_{2}$

1 0 1 1

1 1 0 0 0 1 0 1

Hexadecimal Number System

- Base = 16
  - 16 digits { 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F }
- Weights
  - Weight = $(Base)^{Position}$
- Magnitude
  - Sum of "*Digit* x *Weight*"
- Formal Notation



$$1 * 16^{2} + 14 * 16^{1} + 5 * 16^{0} + 7 * 16^{-1} + 10 * 16^{-2}$$

$$=(485.4765625)_{10}$$

$$(1E5.7A)_{16}$$

The Power of 2

n	2^n
0	$2^0=1$
1	$2^1=2$
2	$2^2=4$
3	$2^3=8$
4	$2^4=16$
5	$2^5=32$
6	$2^6=64$
7	$2^7=128$

n	2^n	
8	$2^8=256$	
9	$2^9=512$	
10	$2^{10}=1024$	**Kilo**
11	$2^{11}=2048$	
12	$2^{12}=4096$	
20	$2^{20}=1M$	**Mega**
30	$2^{30}=1G$	**Giga**
40	$2^{40}=1T$	**Tera**

Decimal, Binary, Octal and Hexadecimal

Decimal	Binary	Octal	Hex
00	0000	00	0
01	0001	01	1
02	0010	02	2
03	0011	03	3
04	0100	04	4
05	0101	05	5
06	0110	06	6
07	0111	07	7
08	1000	10	8
09	1001	11	9
10	1010	12	A
11	1011	13	B
12	1100	14	C
13	1101	15	D
14	1110	16	E
15	1111	17	F