Basic Electrical and Electronics Engineering

LECTURE 5.1

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BEEE102L

Basic Electrical and Electronics Engineering

1. **DC Circuits**
2. **AC Circuits**
3. **Magnetic Circuits**
4. **Electrical Machines**
5. **Digital Systems**
6. **Semiconductor Devices and Applications**

Books

Text Book

[1] John Bird, 'Electrical circuit theory and technology', Newnes publications, 4th Edition, 2010.

Reference Book

[2] Allan R. Hambley, 'Electrical Engineering - Principles & Applications' Pearson Education, First Impression, 6/e, 2013.

[3] Simon Haykin, 'Communication Systems' , John Wiley & Sons, 5th Edition, 2009.

[4] Charles K Alexander , Mathew N O Sadiku, 'Fundamentals of Electric Circuits', Tata Mc Graw Hill , 2012.

[5] Batarseh, 'Power Electronics Circuits', Wiley, 2003.

[6] W. H. Hayt, J. E. Kemmerly and S. M. Durbin, 'Engineering Circuit Analysis', 6/e, Tata McGraw Hill, New Delhi, 2011.

[7] Fitzger ald, Higgabogan, Grabel, 'Basic Electrical Engineering', 5th ed, McGraw Hill, 2009.

[8] S.L.Uppal, 'Electrical Wiring Estimating and Costing' , Khannapublishers, NewDelhi, 2008.

5. Digital Systems

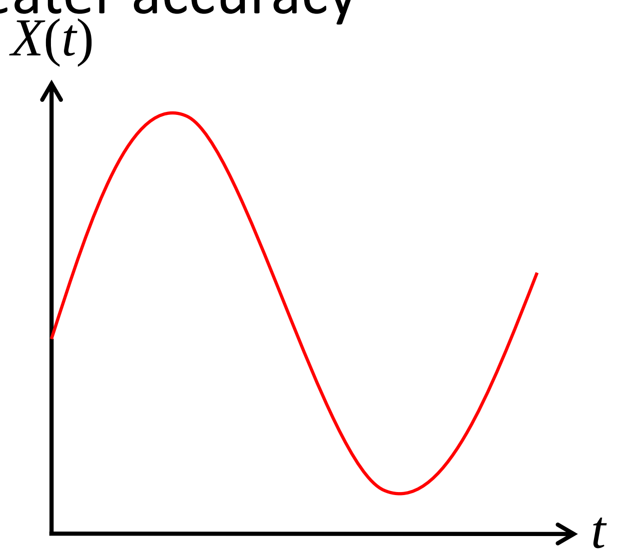
Digital Systems and Binary Numbers

Digital Systems and Binary Numbers

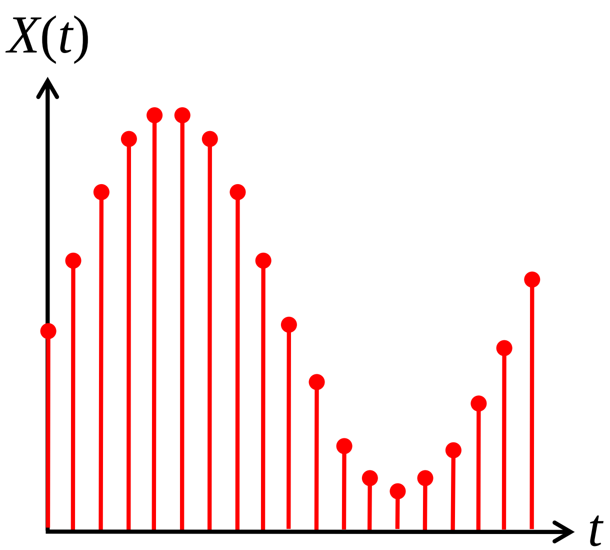
- Digital age and information age
- Digital computers
  - General purposes
  - Many scientific, industrial and commercial applications
- Digital systems
  - Telephone switching exchanges
  - Digital camera
  - Electronic calculators, PDA's
  - Digital TV
- Discrete information-processing systems
  - 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

Digital Signals

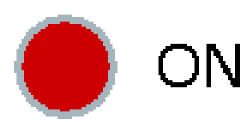
- Digital Signals have two basic states:

  1 (logic "high", or H, or "on")

  0 (logic "low", or L, or "off")

- Digital values are in a *binary* format. Binary means 2 states.

- A good example of binary is a light (only <u>on</u> or <u>off</u>)



Binary as a Voltage

Voltages are used to represent logic values:

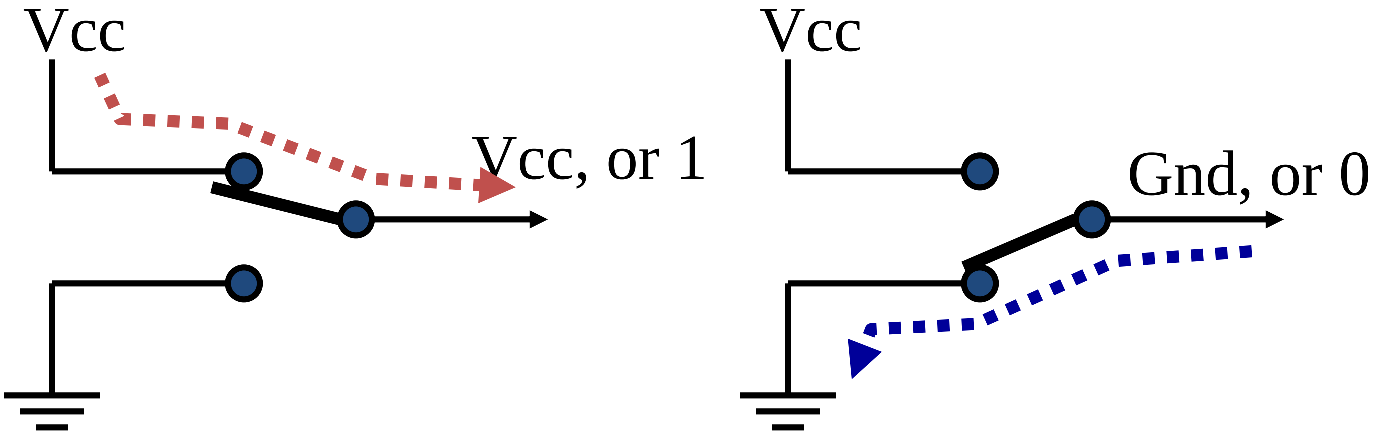
A voltage present (called Vcc or Vdd) = 1

Zero Volts or ground (called gnd or Vss) = 0

A simple switch can provide a logic high or a logic low.

A Simple Switch

- Here is a simple switch used to provide a logic value:



There are other ways to connect a switch.

Common Number Systems

System	Base	Symbols	Used by humans?	Used in computers?
Decimal	10	0, 1, … 9	Yes	No
Binary	2	0, 1	No	Yes
Octal	8	0, 1, … 7	No	No
Hexa-decimal	16	0, 1, … 9, A, B, … F	No	No

Quantities/Counting (1 of 3)

Decimal	Binary	Octal	Hexa-decimal
0	0	0	0
1	1	1	1
2	10	2	2
3	11	3	3
4	100	4	4
5	101	5	5
6	110	6	6
7	111	7	7

Quantities/Counting (2 of 3)

Decimal	Binary	Octal	Hexa-decimal
8	1000	10	8
9	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

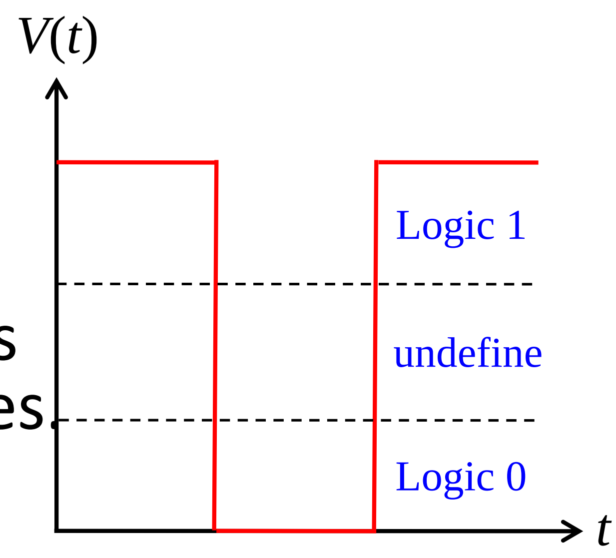
Quantities/Counting (3 of 3)

Decimal	Binary	Octal	Hexa-decimal
16	10000	20	10
17	10001	21	11
18	10010	22	12
19	10011	23	13
20	10100	24	14
21	10101	25	15
22	10110	26	16
23	10111	27	17

Etc.

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 or 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 = $(\mathit{Base})^{\mathit{Position}}$
- 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*

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

$$= (330.9375)_{10}$$

$$(512.74)_8$$

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	2	1		1/2	1/4
1	0	1	.	0	1
2	1	0		-1	-2

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

$$=(5.25)_{10}$$

$$(101.01)_{2}$$

4 bits = *Nibble* $\boxed{1\ 0\ 1\ 1}$

8 bits = *Byte* $\boxed{1\ 1\ 0\ 0\ 0\ 1\ 0\ 1}$

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

256	*16*	*1*		*1/16*	*1/256*
$\boxed{1}$	$\boxed{E}$	$\boxed{5}$	.	$\boxed{7}$	$\boxed{A}$
2	*1*	*0*		*-1*	*-2*

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

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

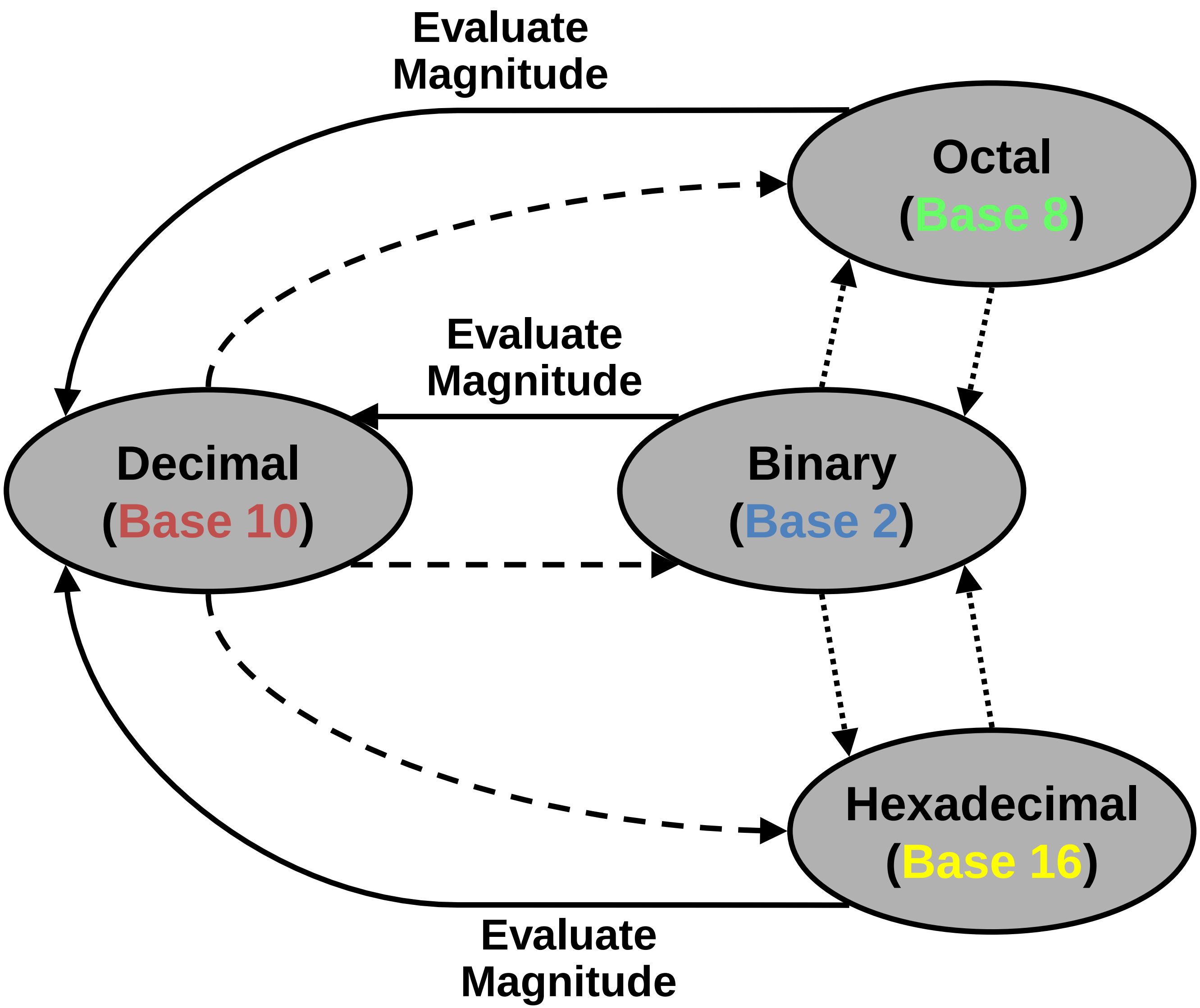
$$(1E5.7A)_{16}$$

The Power of 2

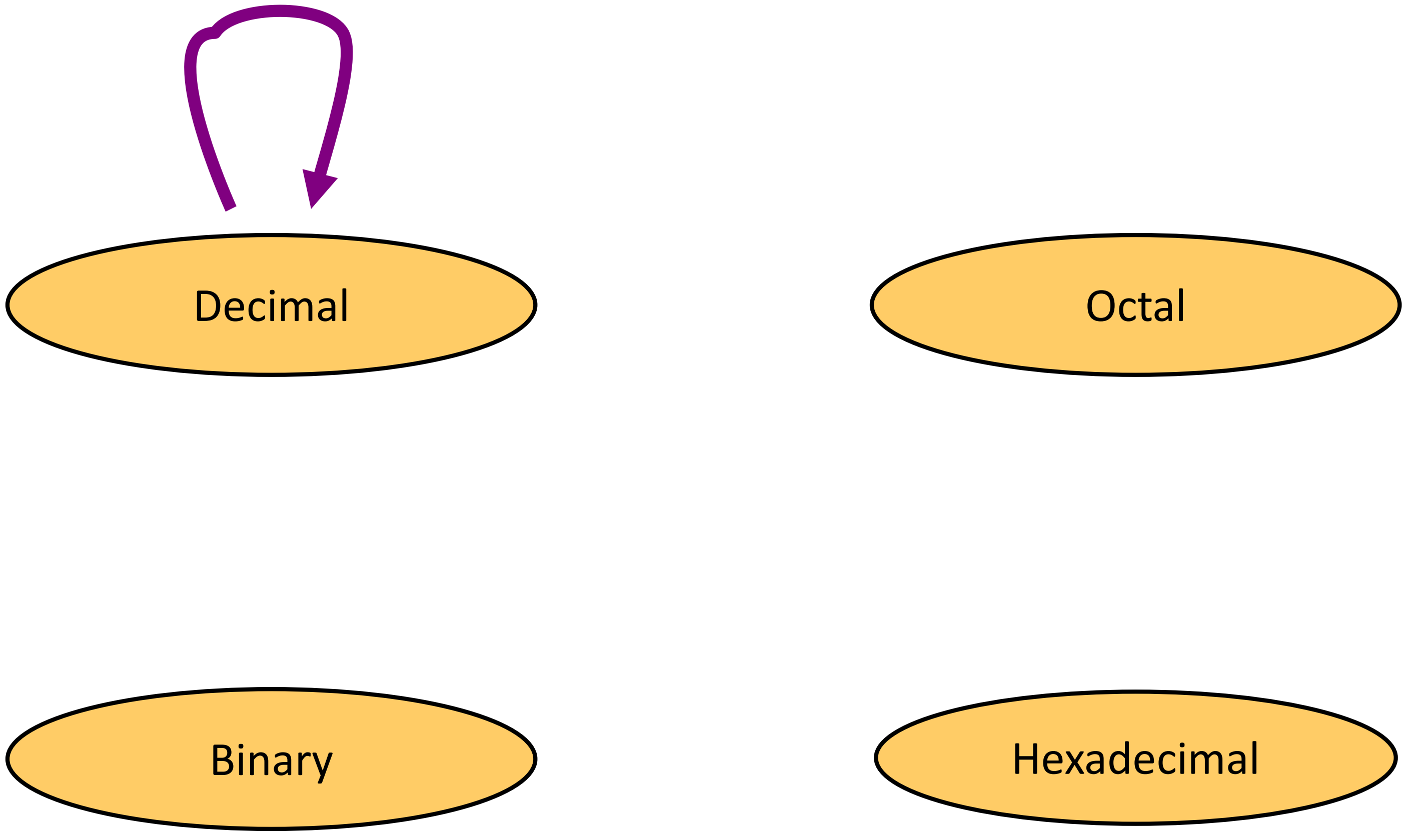
n	2^n
0	$2^0=1$
1	$2^1=2$
2	$2^2=4$
3	$2^3=8$
4	$2^4=16$
5	$2^5=32$
6	$2^6=64$
7	$2^7=128$

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

Number Base Conversions



Decimal to Decimal (just for fun)



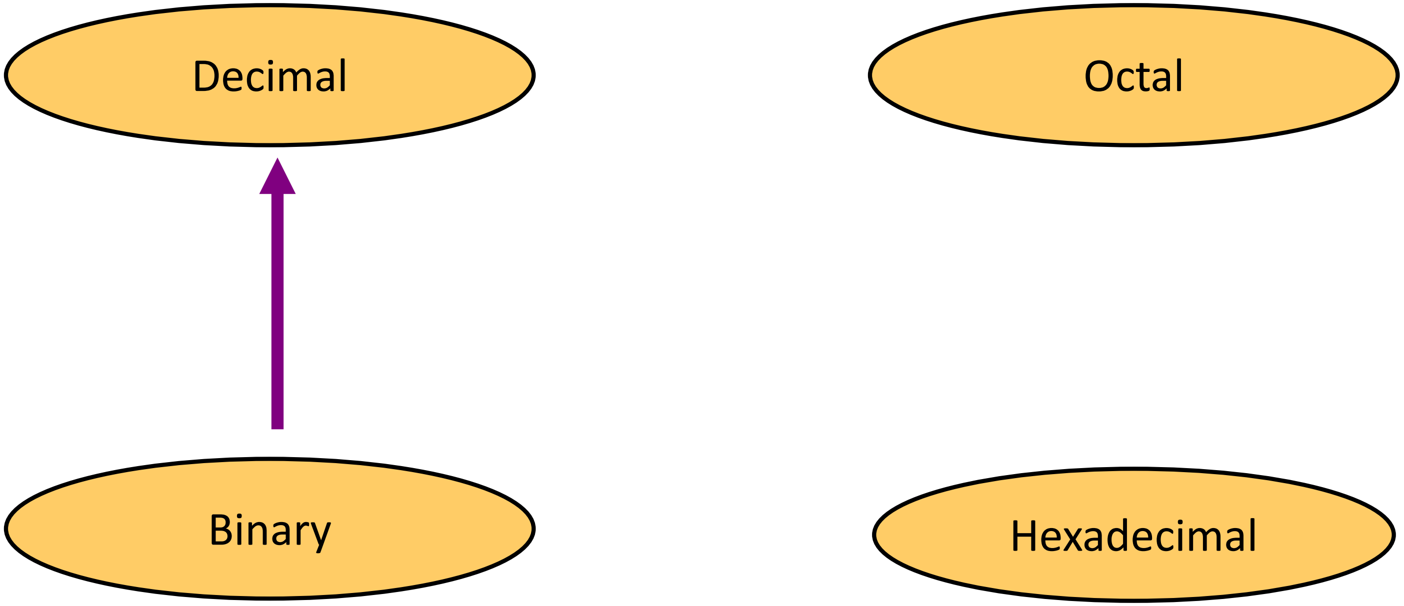
Next slide…

Weight

$$
\begin{array}{llcr}
125_{10} \Rightarrow & 5 \times 10^{0} & = & 5 \\
 & 2 \times 10^{1} & = & 20 \\
 & 1 \times 10^{2} & = & \underline{100} \\
 & & & 125
\end{array}
$$

Base

Binary to Decimal



Binary to Decimal

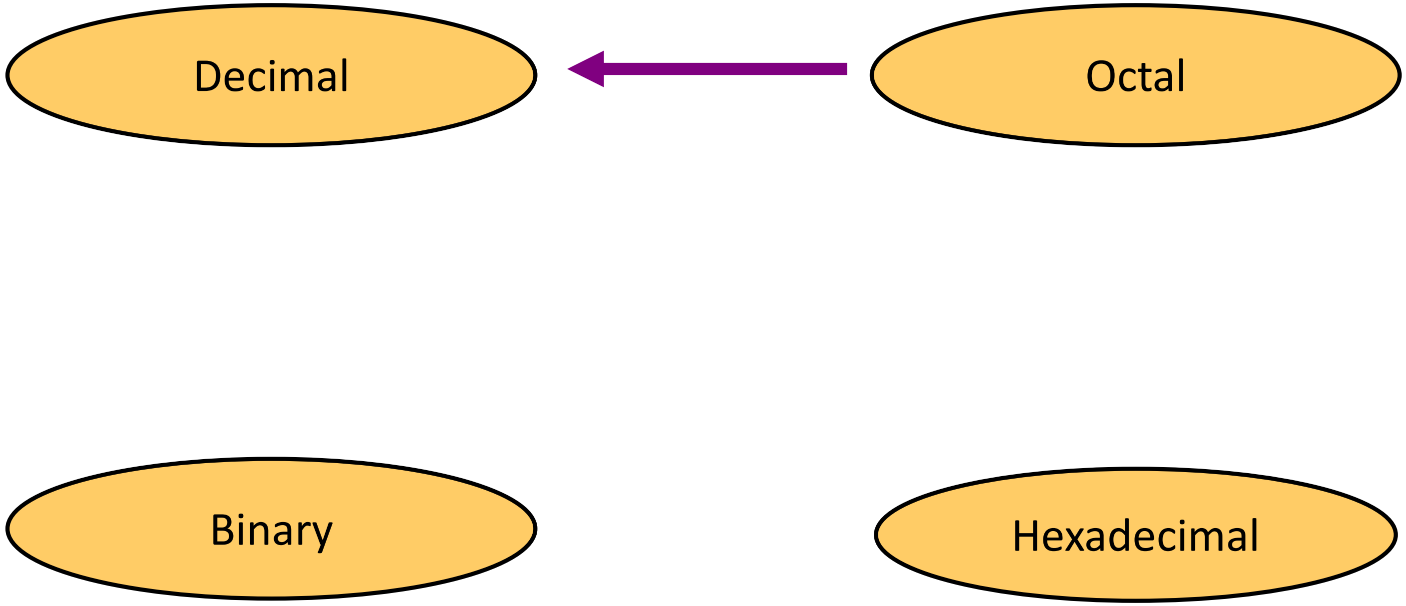
- Technique
  - Multiply each bit by 2^n, where n is the “weight” of the bit
  - The weight is the position of the bit, starting from 0 on the right
  - Add the results

Example

Bit “0”

$$
\begin{array}{llllll}
101011_2 \;=> & 1 & \times & 2^0 & = & 1 \\
 & 1 & \times & 2^1 & = & 2 \\
 & 0 & \times & 2^2 & = & 0 \\
 & 1 & \times & 2^3 & = & 8 \\
 & 0 & \times & 2^4 & = & 0 \\
 & 1 & \times & 2^5 & = & \underline{32} \\
 & & & & & 43_{10}
\end{array}
$$

Octal to Decimal



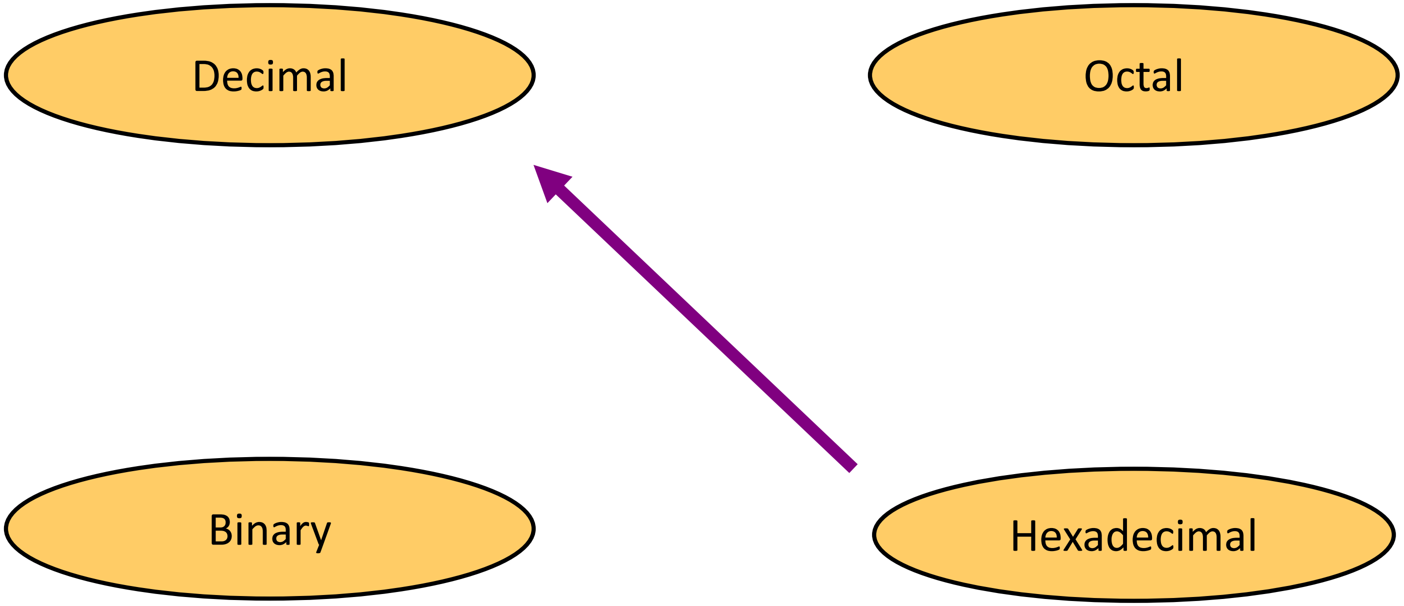
Octal to Decimal

- Technique
  - Multiply each bit by 8^n, where *n* is the "weight" of the bit
  - The weight is the position of the bit, starting from 0 on the right
  - Add the results

Example

$$724_8 \Rightarrow \begin{array}{rcl} 4 \times 8^0 & = & 4 \\ 2 \times 8^1 & = & 16 \\ 7 \times 8^2 & = & 448 \\ \hline & & 468_{10} \end{array}$$

Hexadecimal to Decimal



Hexadecimal to Decimal

- Technique
  - Multiply each bit by 16^n, where n is the “weight” of the bit
  - The weight is the position of the bit, starting from 0 on the right
  - Add the results

Example

$$
\begin{array}{llrcrcr}
ABC_{16} \Rightarrow & C \times 16^0 = & 12 & \times & 1 & = & 12 \\
 & B \times 16^1 = & 11 & \times & 16 & = & 176 \\
 & A \times 16^2 = & 10 & \times & 256 & = & \underline{2560} \\
 & & & & & & 2748_{10}
\end{array}
$$

Decimal to Binary

- Technique
  - Divide by two, keep track of the remainder
  - First remainder is bit 0 (LSB, least-significant bit)
  - Second remainder is bit 1
  - Etc.

Decimal (*Integer*) to Binary Conversion

- Divide the number by the 'Base' (=2)
- Take the remainder (either 0 or 1) as a coefficient
- Take the quotient and repeat the division

Example: $(13)_{10}$

	Quotient	Remainder	Coefficient
13 / 2 =	6	1	$a_0 = 1$
6 / 2 =	3	0	$a_1 = 0$
3 / 2 =	1	1	$a_2 = 1$
1 / 2 =	0	1	$a_3 = 1$

Answer: $(13)_{10} = (a_3\, a_2\, a_1\, a_0)_2 = (1101)_2$

MSB LSB

Decimal (*Fraction*) to Binary Conversion

- Multiply the number by the 'Base' (=2)
- Take the integer (either 0 or 1) as a coefficient
- Take the resultant fraction and repeat the division

Example: $(0.625)_{10}$

	Integer		Fraction	Coefficient
$0.625 * 2 =$	1	.	25	$a_{-1} = 1$
$0.25 * 2 =$	0	.	5	$a_{-2} = 0$
$0.5 * 2 =$	1	.	0	$a_{-3} = 1$

Answer: $(0.625)_{10} = (0.a_{-1}\ a_{-2}\ a_{-3})_2 = (0.101)_2$

MSB LSB

Decimal to Octal Conversion

Example: $(175)_{10}$

	Quotient	Remainder	Coefficient
$175 / 8 =$	21	7	$a_0 = 7$
$21 / 8 =$	2	5	$a_1 = 5$
$2 / 8 =$	0	2	$a_2 = 2$

Answer: $(175)_{10} = (a_2\, a_1\, a_0)_8 = (257)_8$

Example: $(0.3125)_{10}$

	Integer		Fraction	Coefficient
$0.3125 * 8 =$	2	.	5	$a_{-1} = 2$
$0.5 * 8 =$	4	.	0	$a_{-2} = 4$

Answer: $(0.3125)_{10} = (0.a_{-1}\, a_{-2}\, a_{-3})_8 = (0.24)_8$

Binary − Octal Conversion

- $8 = 2^3$
- Each group of 3 bits represents an octal digit

Example:

Assume Zeros

$$(\underbrace{1\ 0}\ \underbrace{1\ 1\ 0}\ .\ \underbrace{0\ 1})_2$$

$$(2 \quad 6 \quad . \quad 2)_8$$

Octal	Binary
0	0 0 0
1	0 0 1
2	0 1 0
3	0 1 1
4	1 0 0
5	1 0 1
6	1 1 0
7	1 1 1

Works both ways (*Binary* to *Octal* & *Octal* to *Binary*)

Binary – Hexadecimal Conversion

- $16 = 2^4$
- Each group of 4 bits represents a hexadecimal digit

Example:

Assume Zeros

$(10110.01)_2$

$(16.4)_{16}$

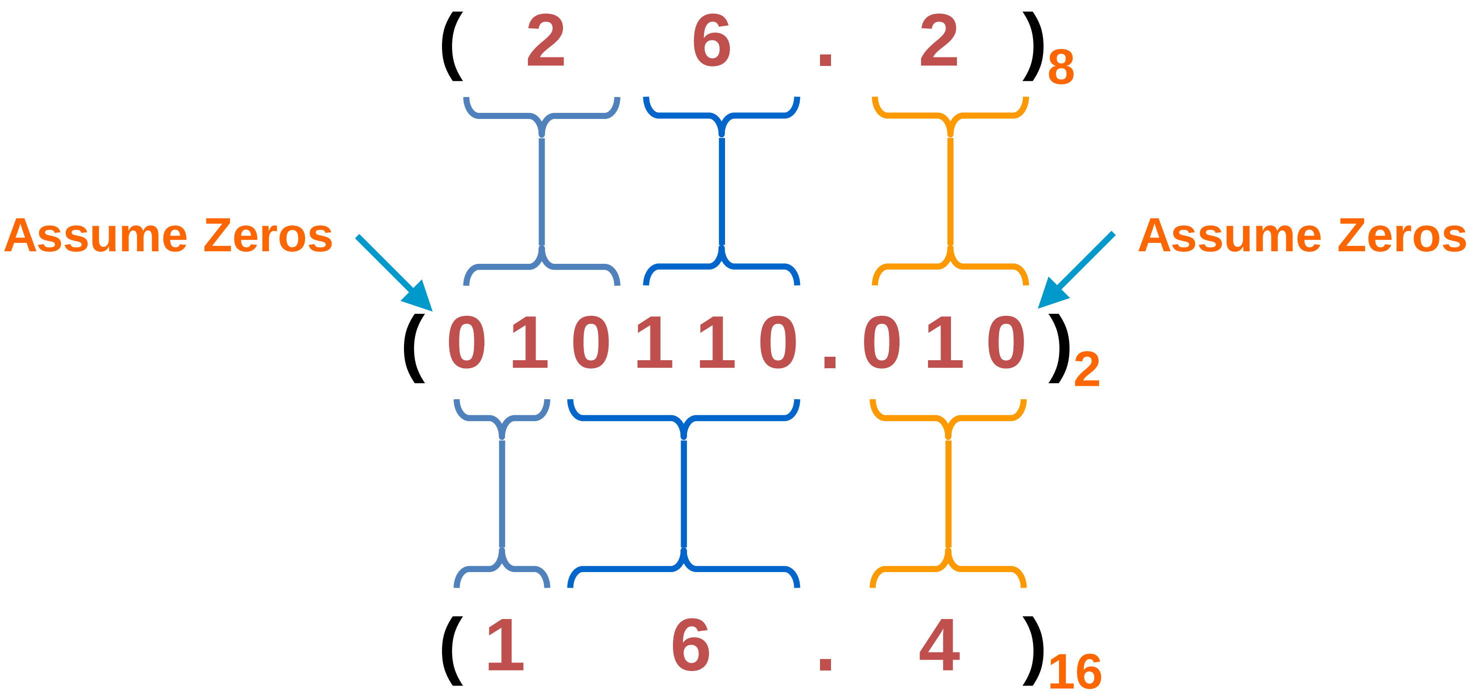
Hex	Binary
0	0 0 0 0
1	0 0 0 1
2	0 0 1 0
3	0 0 1 1
4	0 1 0 0
5	0 1 0 1
6	0 1 1 0
7	0 1 1 1
8	1 0 0 0
9	1 0 0 1
A	1 0 1 0
B	1 0 1 1
C	1 1 0 0
D	1 1 0 1
E	1 1 1 0
F	1 1 1 1

Works both ways (*Binary* to *Hex* & *Hex* to *Binary*)

Octal – Hexadecimal Conversion

- Convert to Binary as an intermediate step

Example:



Works both ways (*Octal* to *Hex* & *Hex* to *Octal*)

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