Chapter 2
Number Systems
SKEE1223 Digital Electronics

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Overview

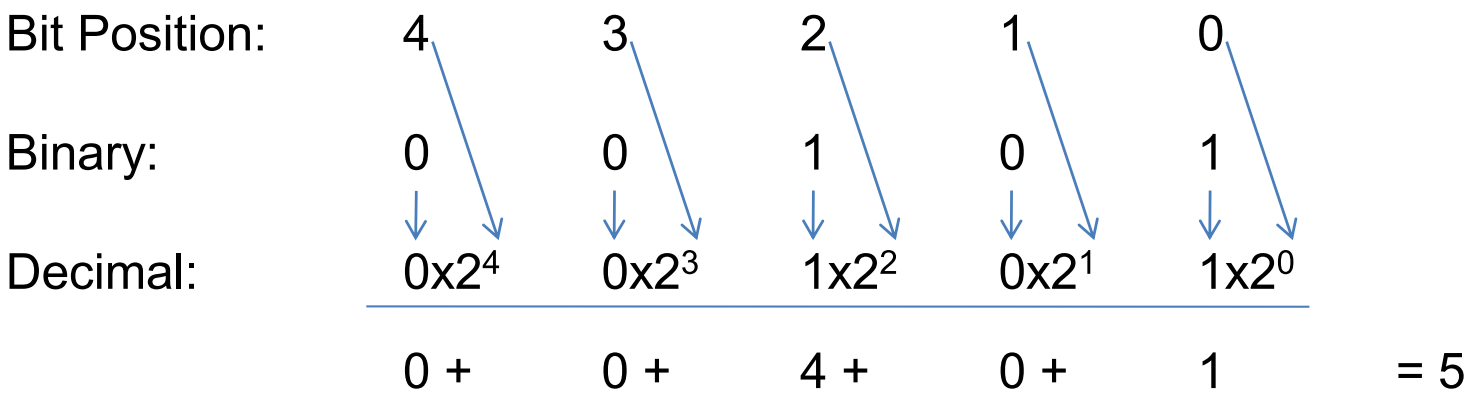
Counting in Binary

- Binary mean two
- In binary number system, a digit has only two values: 0 and 1

Decimal	Binary
0	0
1	1
2	10
3	11
4	100
5	101
6	110
7	111
8	1000
9	1001
10	1010

Binary → Decimal

- Example: find the decimal value of 00101



Therefore, $00101_2 = 5_{10}$

More Number Conversions

650_{10} to binary using repeated division method:

Value	Quotient	Remainder
$650 \div 2$	325	0
$325 \div 2$	162	1
$162 \div 2$	81	0
$81 \div 2$	40	1
$40 \div 2$	20	0
$20 \div 2$	10	0
$10 \div 2$	5	0
$5 \div 2$	2	1
$2 \div 2$	1	0
$1 \div 2$	0	1

- Therefore, $650_{10} = 1010001010_2$

Binary $\longleftrightarrow$ Decimal

- Convert these binary numbers to decimal:
  - $1010_2 => 2^3+2^1=10$
  - $10111_2 => 2^4+2^2+2^1+2^0=23$
- Convert these decimal numbers to binary:
  - $19 = 2^4 + 2^1 + 2^0 = 10011_2$
  - $58 = 2^5 + 2^4 + 2^3 + 2^1 = 111010_2$

Common Bit Groups

Name	Number of bits
Nibble (or nybble)	4
Byte	8
Word	16 or 32*

* depends on system

- Word size is determined by manufacturer.
  - For computers (Intel processors), a word is 16 bits.
  - For handphones (ARM processors), a word is 32 bits.
  - There are processors that use word size $\neq 2^n$

Maximum Values

Number of bits n	Largest value 2^{n-1}
1	1
2	3
3	7
4	15
5	31
6	63
7	127
8	255
10	1023
12	4095
16	65535
24	16777216
32	4294967295

Multiples of Bit/Bytes

Prefix	Symbol	Power-of-2	Power-of-10
kilo-	K	2^{10}	10^{3}
mega-	M	2^{20}	10^{6}
giga-	G	2^{30}	10^{9}
tera-	T	2^{40}	10^{12}
peta-	P	2^{50}	10^{15}
exa-	E	2^{60}	10^{18}
zeta-	Z	2^{70}	10^{21}
yotta-	Y	2^{80}	10^{24}

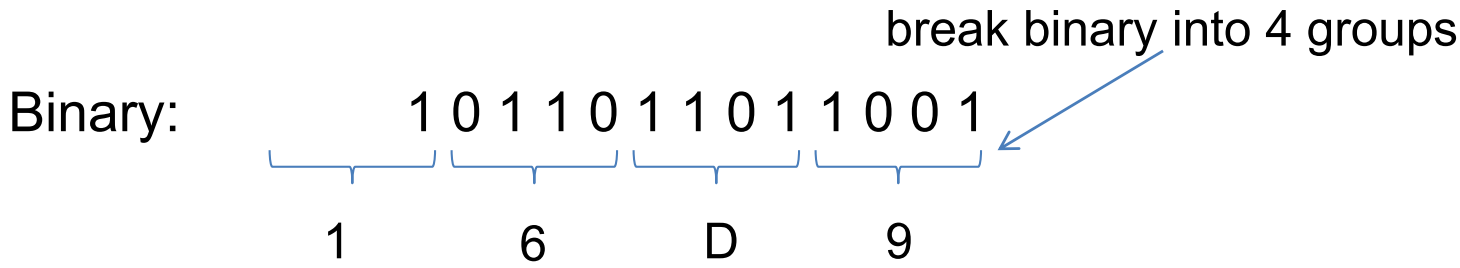
Counting in Hexadecimal

- Hexadecimal (hex) means sixteen
- In hex system, a digit can take the value 0 through 9, A through F.
- Hex is used to write binary numbers in compact form.

Binary	Decimal	Hexadecimal	Binary	Decimal	Hexadecimal
0000	0	0	1000	8	8
0001	1	1	1001	9	9
0010	2	2	1010	10	A
0011	3	3	1011	11	B
0100	4	4	1100	12	C
0101	5	5	1101	13	D
0110	6	6	1110	14	E
0111	7	7	1111	15	F

Hexadecimal → Decimal

- Hexadecimal number conversion: Convert 1011011011001_2 to hexadecimal



Hexadecimal: $1\ 6\ D\ 9_{16}$

Hexadecimal $\longleftrightarrow$ Decimal

- Convert the following to binary:
  - $CF8E_{16}$ => 1100 1111 1000 1110_2
  - 974_{16} => 1001 0111 01002
- Convert the following to hexadecimal
  - 1111 0000 1010_2 => $F0A_{16}$
  - 10 0001 1101 1001_2 => $21D9_{16}$

More Number Conversions

- Convert $A7B_{16}$ to binary and decimal – easy
- Convert 650_{10} to hexadecimal – 2 ways
  - Convert to binary first, then to hex
  - Convert directly to hex

More Number Conversions

- 650_{10} to hexadecimal using repeated division method:
- 650/16 = 40.625 , 0.625 x 16 = 10=A (Least significant bit (MSB))
- 40/16 = 2.5 , 0.5 x 16 = 8 = 8
- 2/16 = 0.125 , 0.125 x 16 = 2 = 2 (Most significant bit (MSB))
- Therefore, $650_{10} = 28A_{16}$

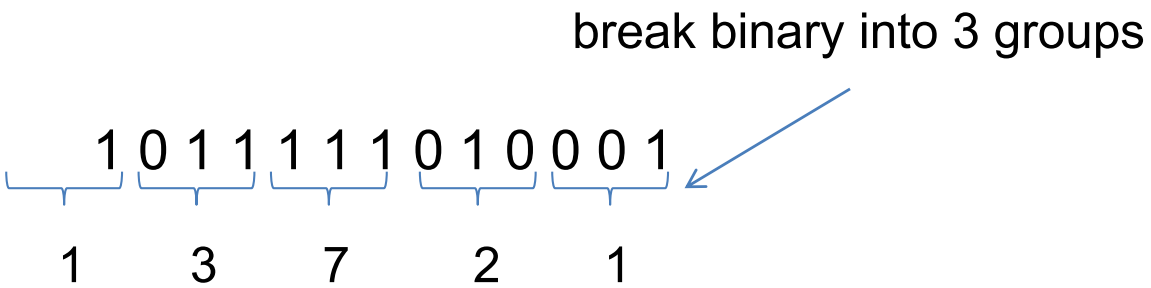
Counting in Octal

- Octal means eight
- In octal number system, a digit can take the value 0 through 7.

Octal	Decimal	Binary
0	0	000
1	1	001
2	2	010
3	3	011
4	4	100
5	5	101
6	6	110
7	7	111

Octal → Decimal

- Octal numbers conversion: Convert 1011111010001_2 to octal



Octal: $1\ 3\ 7\ 2\ 1_8$

Octal Numbers

- Convert the following to binary
  - $25_8 = 10\ 101_2$
  - $140_8 = 001\ 100\ 000_2$
- Convert the following to octal
  - $110\ 101_2 = 65_8$
  - $1\ 101\ 111\ 001_2 = 1571_8$

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