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EIE2050 Digital Logic and System Tutorial 1

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Research Bldg B 514

Office Hour: Tue 10:30-11:30

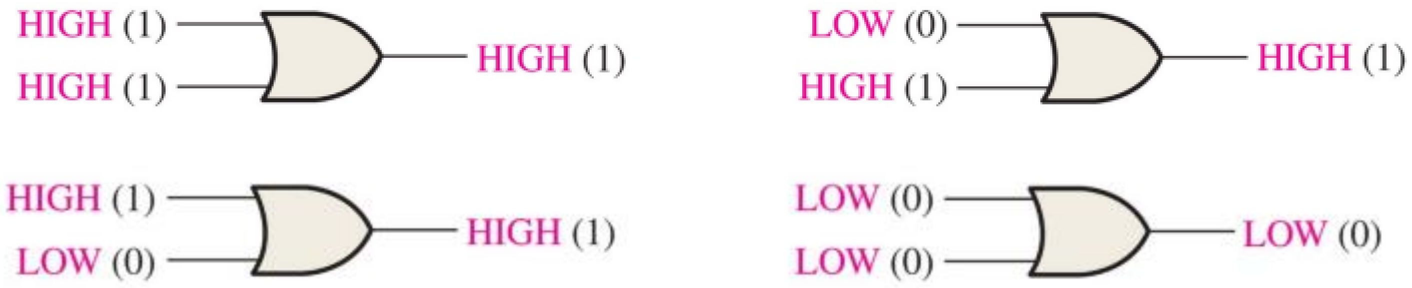
Basic Logic Functions

NOT, AND, and OR

NOT

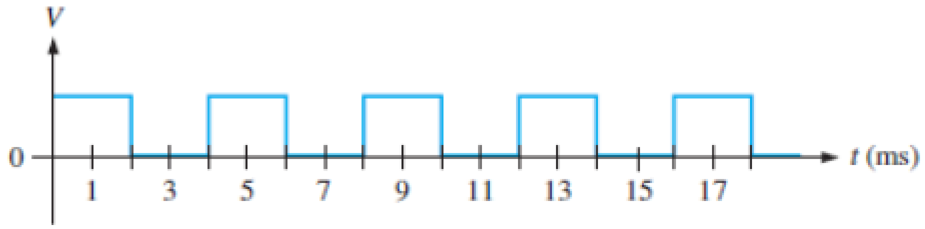
AND

OR



Waveform Characteristics

1. What is the frequency of the waveform?
2. Is the pulse waveform periodic or nonperiodic?
3. Determine the duty cycle of the waveform



1. f = 0.25 kHz = 250 Hz
2. The waveform is periodic because it repeats at a fixed interval.
3. t_W = 2 ms; T = 4 ms; duty circle = 50%

Binary Conversion

TABLE 2–2

Binary weights.

Positive Powers of Two (Whole Numbers)								
2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
256	128	64	32	16	8	4	2	1

Negative Powers of Two (Fractional Number)					
2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}	2^{-6}
1/2 0.5	1/4 0.25	1/8 0.125	1/16 0.625	1/32 0.03125	1/64 0.015625

Ex1: Convert the binary whole number 1101101 to decimal.
Ex2: Convert the binary fractional number 0.1011 to decimal.

Binary Conversion

Ex1: Determine the weight of each bit that is a 1, and then find the sum of the weights to get the decimal number.

Weight:	2^6	2^5	2^4	2^3	2^2	2^1	2^0
Binary number:	1	1	0	1	1	0	1

$$1101101 = 2^6 + 2^5 + 2^3 + 2^2 + 2^0$$
$$= 64 + 32 + 8 + 4 + 1 = \mathbf{109}$$

Ex2:

Weight:	2^{-1}	2^{-2}	2^{-3}	2^{-4}
Binary number:	0 . 1	0	1	1

$$0.1011 = 2^{-1} + 2^{-3} + 2^{-4}$$
$$= 0.5 + 0.125 + 0.0625 = \mathbf{0.6875}$$

Binary Conversion

Convert a decimal number to binary

1. Repeated Division-by-2 Method

- Divide the integer number by two
- Integer number

2	233	1	…remainder
2	116	0	
2	58	0	
2	29	1	
2	14	0	
2	7	1	
2	3	1	
2	1	1	…MSB
	0		

- Stop when the whole-number quotient is 0
- $(233)_{10} = (11101001)_2$

2. Repeated Multiplication-by-2 Method

Repeatedly multiply the fractional results by two decimal fraction

$$
\begin{array}{lrr}
\text{Decimal fraction} & & 0.8125 \\
 & \times & 2 \\
\text{MSB...} & & 1.6250 \\
 & \times & 2 \\
 & & 1.2500 \\
 & \times & 2 \\
 & & 0.5000 \\
 & \times & 2 \\
 & & 1.0000
\end{array}
$$

Continue to the desired number of decimal places or stop when the fractional part is all zeros.

$(0.8125)_{10} = (0.1101)_2$

$(233.8125)_{10} = (11101001.1101)_2$

Binary Conversion

Octal/ Binary Conversion

Octal/binary conversion.

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

Octal to Binary:

(a) $\underbrace{\overset{1}{\downarrow}\;001}\underbrace{\overset{3}{\downarrow}\;011} = \mathbf{001011}$

(b) $\underbrace{\overset{2}{\downarrow}\;010}\underbrace{\overset{5}{\downarrow}\;101} = \mathbf{010101}$

Binary to Octal

(a) $\underbrace{110}_{6}\underbrace{101}_{5} = \mathbf{65_8}$

(b) $\underbrace{101}_{5}\underbrace{111}_{7}\underbrace{001}_{1} = \mathbf{571_8}$

Binary Conversion

Hexadecimal/ Binary Conversion

TABLE 2–3

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

Binary to Hexadecimal

$$\underbrace{1100}_{\downarrow\ C}\underbrace{1010}_{\downarrow\ A}\underbrace{0101}_{\downarrow\ 5}\underbrace{0111}_{\downarrow\ 7} = CA57_{16}$$

Binary Operation

Binary Addtion

Examples:

$$\begin{array}{r} 11 \\ +\ 11 \\ \hline \mathbf{110} \end{array} \qquad \begin{array}{r} 110 \\ +\ 100 \\ \hline \mathbf{1010} \end{array}$$

Binary Subtraction

Examples:

$$\begin{array}{r} 11 \\ -10 \\ \hline \mathbf{01} \end{array} \qquad \begin{array}{r} 101 \\ -011 \\ \hline \mathbf{010} \end{array}$$

Binary Operation

Binary Multiplication

Examples:

$$\begin{array}{r} 11 \\ \times\ 11 \\ \hline 11 \\ +11 \\ \hline \mathbf{1001} \end{array} \qquad\qquad \begin{array}{r} 111 \\ \times\ 101 \\ \hline 111 \\ 000 \\ +111 \\ \hline \mathbf{100011} \end{array}$$

Binary Division

Examples:

$$\textbf{(a)}\quad \begin{array}{r} \mathbf{10} \\ 11\overline{)110} \\ 11 \\ \hline 000 \end{array} \qquad \begin{array}{r} 2 \\ 3\overline{)6} \\ 6 \\ \hline 0 \end{array} \qquad\qquad \textbf{(b)}\quad \begin{array}{r} \mathbf{11} \\ 10\overline{)110} \\ 10 \\ \hline 10 \\ 10 \\ \hline 00 \end{array} \qquad \begin{array}{r} 3 \\ 2\overline{)6} \\ 6 \\ \hline 0 \end{array}$$

Binary Operation

Complements of Binary Numbers

1’s Complements:

The 1’s **complement** of a binary number is found by changing all 1s to 0s and all 0s to 1s, as illustrated below:

$$
\begin{array}{ll}
1\,0\,1\,1\,0\,0\,1\,0 & \text{Binary number} \\
\downarrow\downarrow\downarrow\downarrow\downarrow\downarrow\downarrow\downarrow & \\
0\,1\,0\,0\,1\,1\,0\,1 & \text{1's complement}
\end{array}
$$

2’s Complements:

The 2’s complement of a binary number is found by adding 1 to the LSB of the 1’s complement.

$$\text{2's complement} = (\text{1's complement}) + 1$$

Examples:

$$
\begin{array}{rl}
10110010 & \text{Binary number} \\
01001101 & \text{1's complement} \\
+ \qquad\quad 1 & \text{Add 1} \\
\hline
\mathbf{01001110} & \text{2's complement}
\end{array}
$$

Binary Operation

Signed Numbers

The Sign Bit:

The left-most bit in a signed binary number is the **sign bit**, which tells you whether the number is positive or negative.

A 0 sign bit indicates a positive number, and a 1 sign bit indicates a negative number.

For example, the decimal number +25 is expressed as an 8-bit signed binary number using the sign-magnitude form as

$$\underset{\text{Sign bit}}{0}\,\underbrace{0011001}_{\text{Magnitude bits}}$$

The decimal number −25 is expressed as

10011001

Binary Operation

Arithmetic Operations with Signed Numbers

Addition: Add the two numbers and discard any final carry bit.

$$
\begin{array}{rr}
 & 00001111 \\
+ & 11111010 \\
\hline
\text{Discard carry} \longrightarrow 1 & 00001001
\end{array}
$$

Subtraction: To subtract two signed numbers, take the 2' s complement of the subtrahend and add. Discard any final carry bit.

$10001000 - 11100010$

$$
\begin{array}{rrl}
 & 10001000 & \text{Minuend } (-120) \\
+ & 00011110 & \text{2's complement of subtrahend } (+30) \\
\hline
 & \mathbf{10100110} & \text{Difference } (-90)
\end{array}
$$

Multiplication& Division:

Same sign→ Positive

Different signs→ Negative

Error Codes

Cyclic Redundancy Check

Determine the transmitted CRC for the following byte of data (D: 11010011) and generator code (G: 1010).

Append 0000 to the data, D' =110100110000

$$\frac{D'}{G} = \frac{110100110000}{1010}$$

```
110100110000
1010
 1110
 1010
  1000
  1010
   1011
   1010
      1000
      1010
       100
```

Modulo-2 operation

One-bit error at the receiving end

```
100100110100
1010
  1100
  1010
   1101
   1010
    1111
    1010
     1010
     1010
```

0100

Remainder(Checksum): 0100

The transmitted CRC is 110100110100