Digital Logic Circuits

Lesson # 6

Boolean Algebra and Basic Logic Gates

Section 6.1

Digital Logic Circuits

- Devices which can be used to design digital circuits.
  - Transistor-transistor Logic (TTL)
  - Complementary Metal-Oxide Semiconductor Logic (CMOS)
    - Taking NMOS (*n*-channel) and PMOS (*p*-channel) and using them in a complementary fashion
  - Emitter Coupled Logic (ECL)
  - Integrated Circuits
    - Application-specific integrated circuits (ASICs)

Review of Binary Logic

- Logic variables
  - Logic 1
    - High, True, On
  - Logic 2
    - Low, False, Off
- Binary digits – a **BI**nary digi**T** or bit
- Binary words – several bits stringed together to make up an number or code:
  - Byte is a 8 bit word
  - Nibble is a 4 bit word

Boolean Algebra

- Truth Tables – a way of representing a logic function
- Venn Diagrams – another useful way of representing a logic function
- Fundament Logic Functions

AND

A	*B*	*C=AB*
0	*0*	*0*
0	*1*	*0*
1	*0*	*0*
1	*1*	*1*

OR

A	*B*	*C=A+B*
0	*0*	*0*
0	*1*	*1*
1	*0*	*1*
1	*1*	*1*

NOT

A	$\overline{A}$
0	*1*
1	*0*

Some Theory

- AND, NOT

$$AA = A$$

$$A1 = A$$

$$A0 = 0$$

$$AB = BA$$

$$A(BC) = (AB)C = ABC$$

$$A\overline{A} = 0$$

$$\overline{\overline{A}} = A$$

More Theory

- OR, AND, NOT

$$(A+B)+C = A+(B+C) = A+B+C$$

$$A(B+C) = AB + AC$$

$$A + 0 = A$$

$$A + 1 = 1$$

$$A + \overline{A} = 1$$

$$A + A = A$$

- De Morgan's laws

$$AB = \overline{\overline{A}+\overline{B}} \Rightarrow \overline{AB} = \overline{A}+\overline{B}$$

$$A+B = \overline{\overline{A}\,\overline{B}} \Rightarrow \overline{A+B} = \overline{A}\,\overline{B}$$

Some More Logic Functions

NAND

A	B	$C=\overline{AB}$
0	0	1
0	1	1
1	0	1
1	1	0

NOR

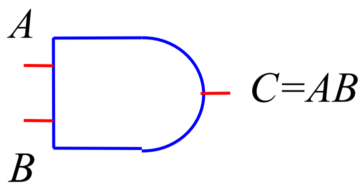
A	B	$C=\overline{A+B}$
0	0	1
0	1	0
1	0	0
1	1	0

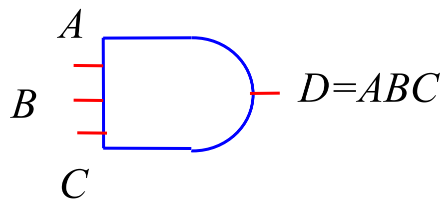
XOR

A	B	$C=A\oplus B$
0	0	0
0	1	1
1	0	1
1	1	0

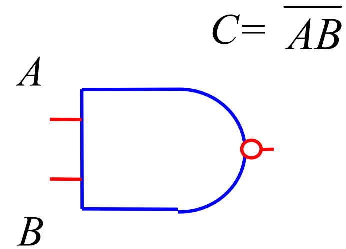
Basic Logic Gate Circuits

AND

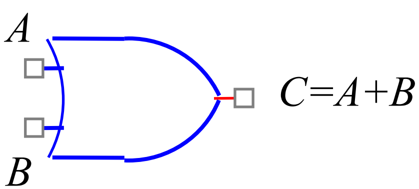


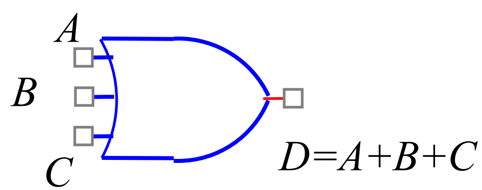


NAND

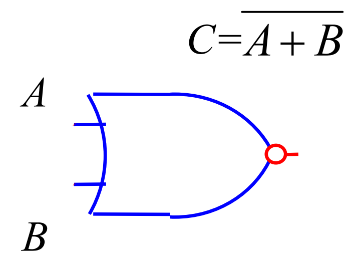


OR

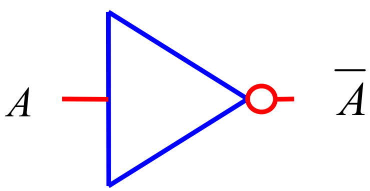




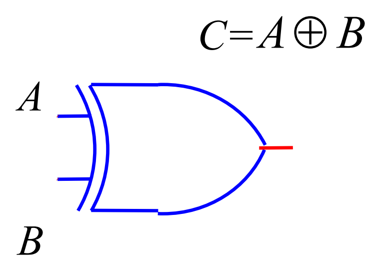
NOR



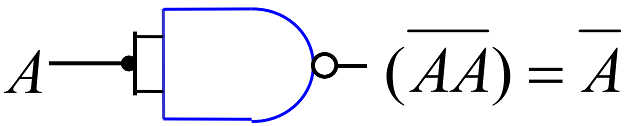
NOT
(Inverter)



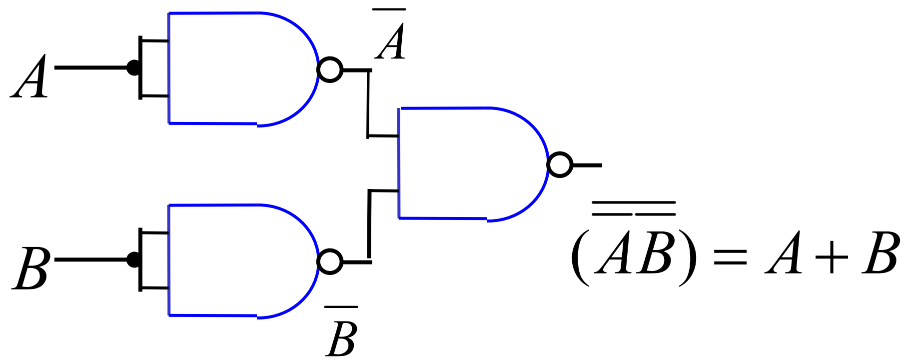
XOR



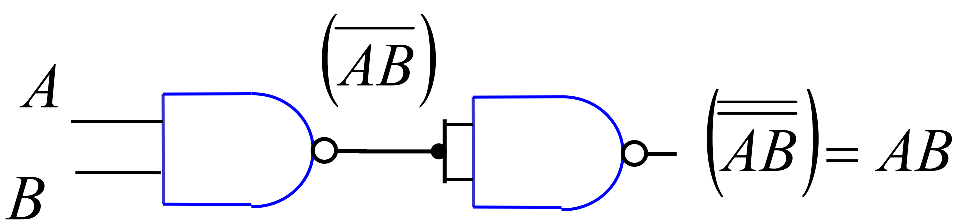
Logic Circuits Only Using NAND Gates



NOT (Inverter)

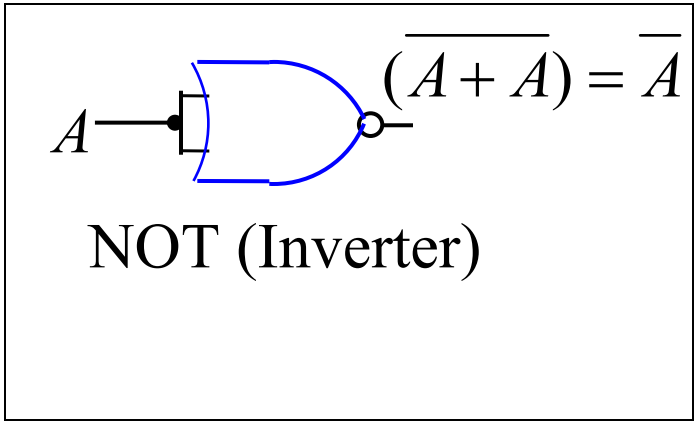


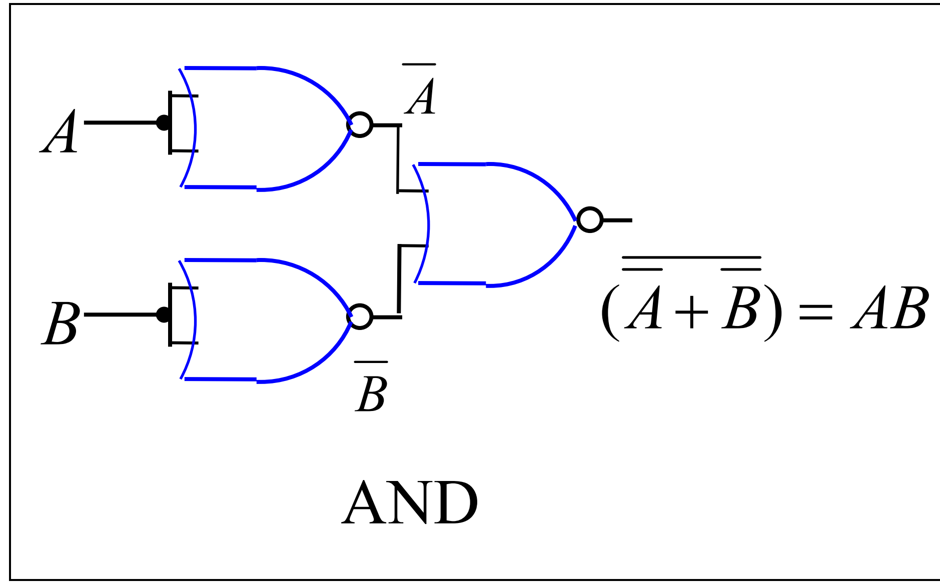
OR

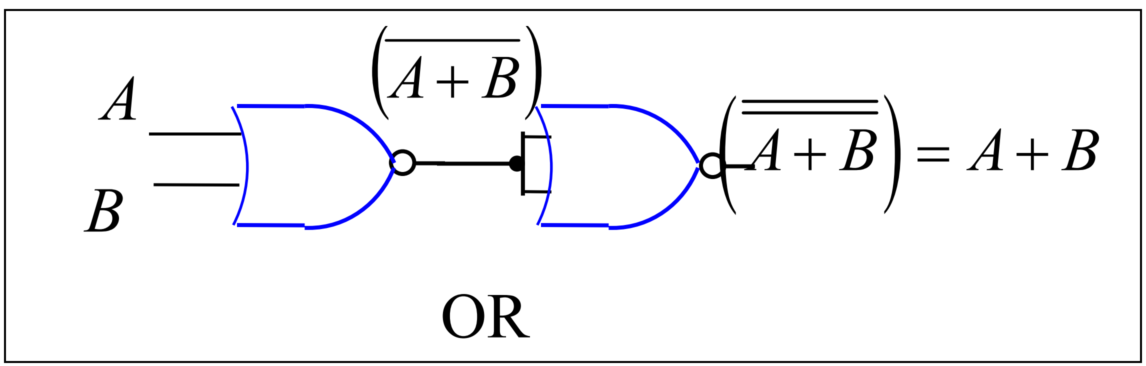


AND

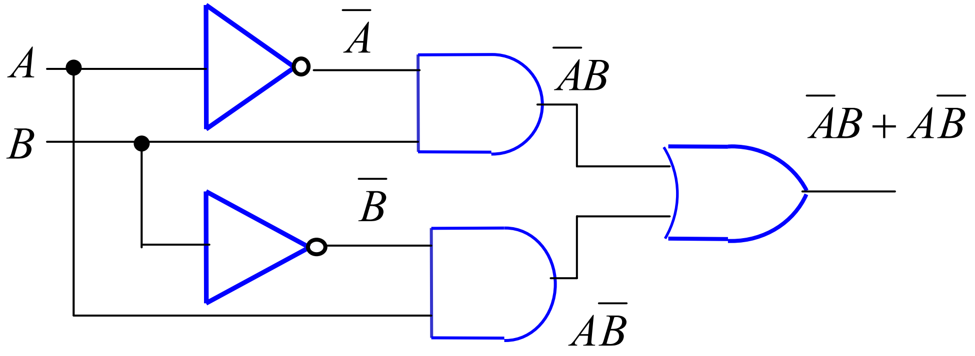
Logic Circuits Only Using NOR Gates



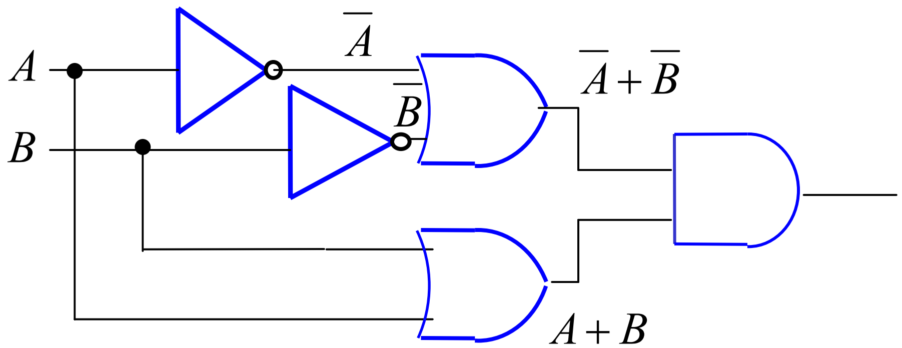




Examples



A	B	$C = \overline{A}B + A\overline{B}$
0	0	0
0	1	1
1	0	1
1	1	0



$$
\begin{aligned}
(A+B)(\overline{A}+\overline{B}) &= A\overline{A} + \overline{A}B + A\overline{B} + B\overline{B} \\
&= 0 + \overline{A}B + A\overline{B} + 0 \\
&= \overline{A}B + A\overline{B}
\end{aligned}
$$

Homework

- Boolean Algebra
  - Problems: 6.3, 6.5-11