Chapter – 2

Digital Logic

Logic Gate

- A digital circuit having one or more signals but only one output signal is called a *gate*.
- Connecting the different types of gates in different ways makes it possible to produce circuits that perform arithmetic and other functions associated with the ALU.
- Since they stimulates the metal processes, gates are often called *logic circuits*.

Types of Gates:

There are three types of gates:

i. Basic Gates: NOT, AND and OR Gates
ii. Universal Gates: NAND and NOR Gates
iii. Exclusive Gates: X-OR and X-NOR Gates

Theory on Gates:

i. Definition
   a. What is does?
   b. Number of inputs and outputs
   c. Binary variable assignment to inputs and outputs
ii. Generic logic symbol and Boolean Expression
iii. Particularized (for example: 2 inputs, or 3 inputs or 4 inputs etc.) definition, logic symbol, Boolean expression and truth table.
iv. Equivalent circuit diagram of logic gate
v. Timing Diagram
vi. Pin Diagram of IC

Digital Logic Symbols

- The ***Institute of Electrical and Electronics Engineers (IEEE)*** along with the ***American National Standards Institute (ANSI)*** have developed a new symbolic language and set of symbols to be used with digital logic circuits.
- IEEE Standard Graphics Symbols for Logic Functions, ***ANSI/IEEE Std91-1984***, provides two different types of symbol:
  - 1st type: distinctive-shape symbols (used throughout the chapter)

- 2nd type: rectangular-shape symbols, uses a rectangular box with a special symbol for each type of gate.

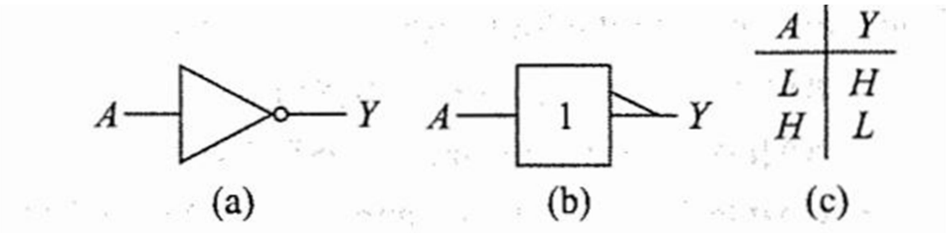


Figure: (a) Standard Symbol of NOT Gate, (b) IEEE Symbol, (c) Truth Table

Hex Inverter: 7404 IC

- The 7404 is an hex inverter. That is, it is an IC (Integrated Circuit) that contains six inverters.
- It is integrated in DIP package, whose pin diagram is shown below.

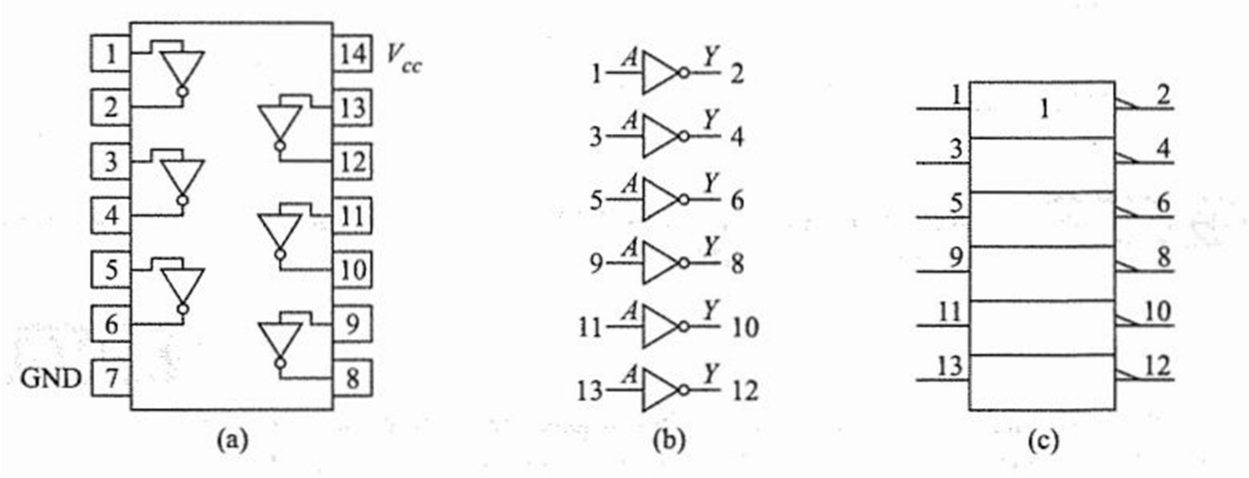


Figure: Hex Inverter, 7404 , (a) Pin Configuration, (b) Logic Symbol, (c) Logic Symbol (IEEE)

Three input AND Gate: 7411 IC

- A 7411 is an IC that contains 3-input ANG gates.
- Its DIP package and pin configuration is shown below in (a)

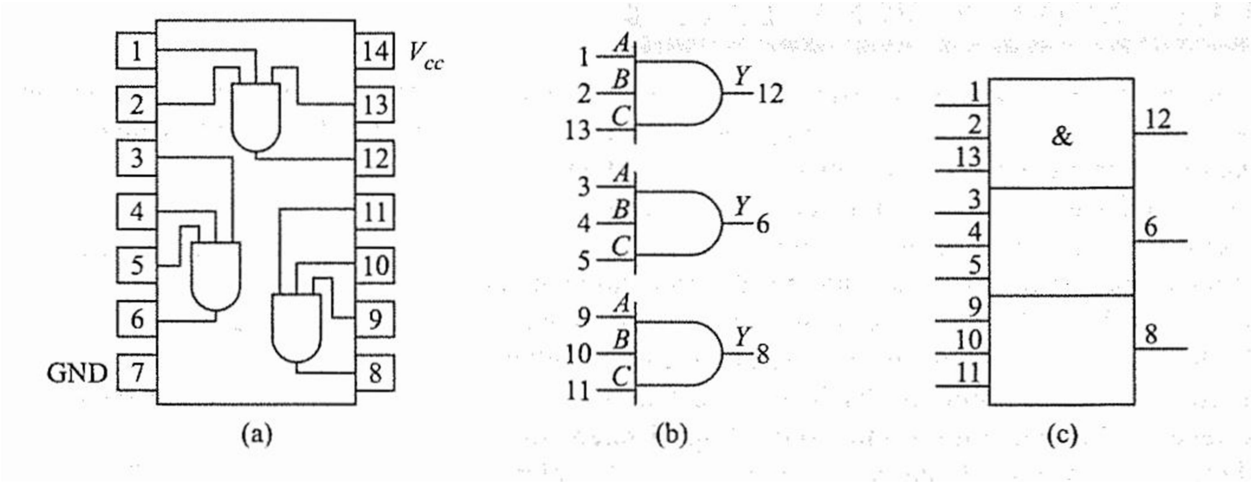


Figure: Triple Three-Input AND gate, 7411: (a) Pin configuration, (b) Logic symbol, (c) Logic Symbol (IEEE)

Quad 2-Input OR Gate: 7432 IC

- The pin configuration and symbols for the 7432 quad 2-input OR gate is shown below.

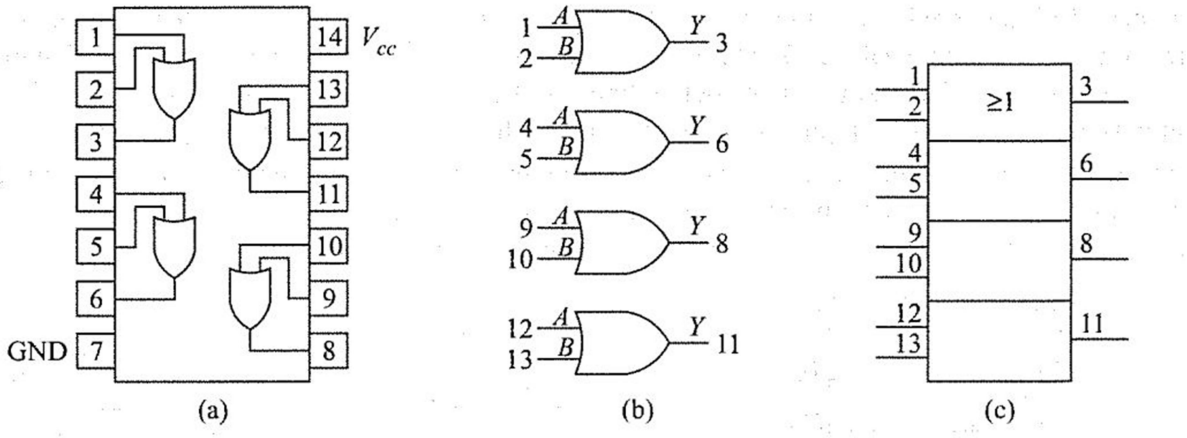


Figure: Quad 2-Input OR Gate: 7432: (a) Pin configuration, (b) Logic Symbol, (c) Logic Symbol (IEEE)

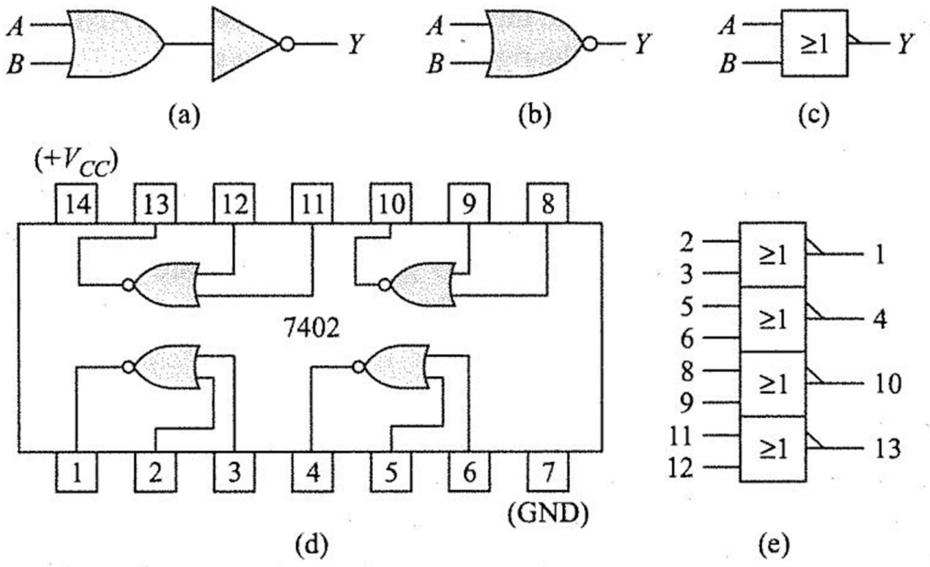
Some Standard Digital Circuits

TTL	ECL	CMOS	Function
7400	—	74HC00	Quad 2-input NAND gate
7402	MC10102	74HC02	Quad 2-input NOR gate
7404		74HC04	Hex inverter
7408	MC10104	74HC08	Quad 2-input AND gate
7432	MC10103	74HC32	Quad 2-input OR gate

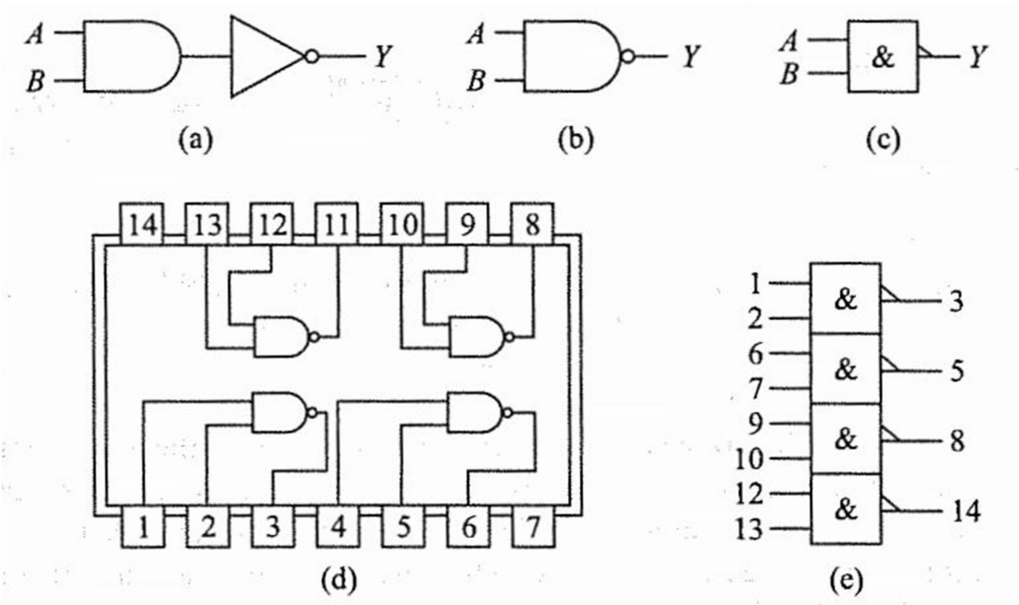
Need of Universal Logic Gates

- NAND and NOR are universal gates
- Fabrication of Integrated Circuit (IC) that performs the logic operation becomes easier with gate of only one king is used; so these gates are called universal gates.
- Basic gates can't be used for this reason, because conversion among themselves itself are not possible. As for example, one cannot gate OR operation by using any number or combination of AND gates.

NOR Gate Symbol



NAND Gate Symbol



De-Morgan Theorem

i. First Theorem
ii. Second Theorem

Theory on De-Morgan Theorem

i. Generalized Statement
ii. Supposition of Binary Variables
iii. Mathematically Equivalent Boolean Expressions
iv. Equivalent Logic symbols/circuits
v. Particularized Example (for example: for 2 inputs) which should consists of all above points
vi. Verification by truth table

Universality of NOR Gate

Constructing all other gates from NOR gates only.

Universality of NAND Gate

Construction all other gates form NAND gates only.

Bubbled AND Gate

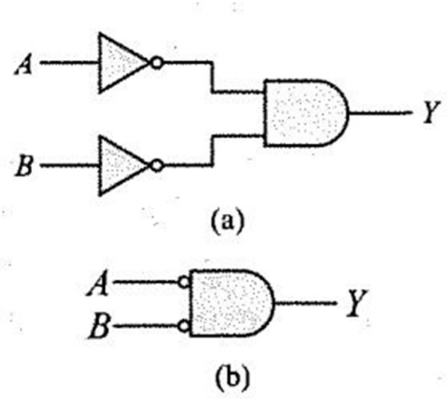


Figure: (a) AND gate with inverted inputs, (b) Equivalent Symbol

Bubbled OR Gate

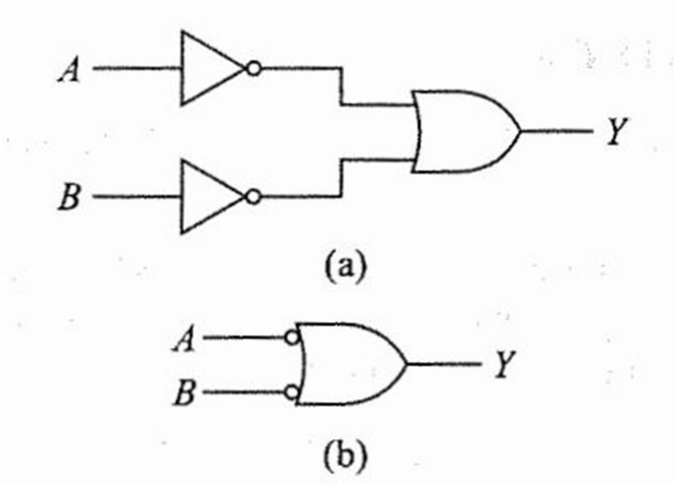
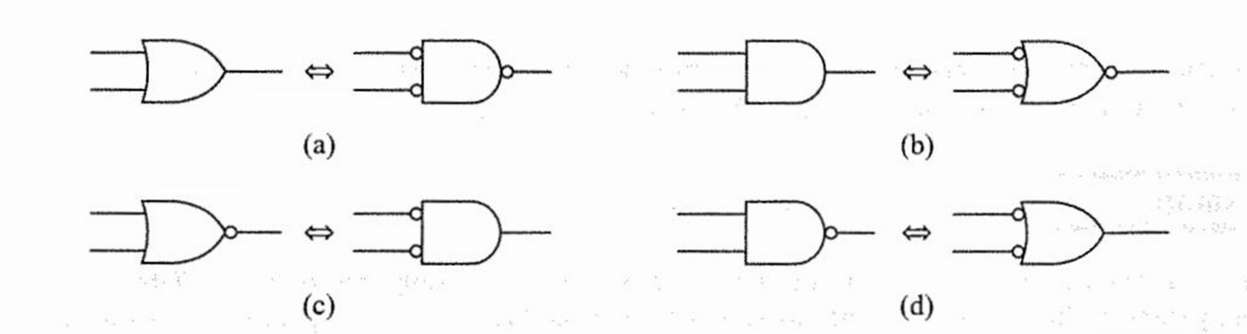


Figure: (a) OR gate with inverted inputs, (b) Equivalent symbol

Some logic equivalence circuit



Standard TTL Gates

Type	*Quad 2-Input*	*Triple 3-Input*	*Dual 4-Input*	*Single 8-Input*
NAND	7400	7410	7420	7430
NOR	7402	7427	7425	
AND	7408	7411	7421	
OR	7432			

Some of the common logic gates configurations and their standard identifier digits are as follows:

- Quad 2-input NAND – **00**
- Quad 2-input NOR – **02**
- Hex Inverter – **04**
- Quad 2-input AND – **08**
- Triple 3-input NAND – **10**
- Triple 3-input AND – **11**
- Dual 4-input NAND – **20**
- Dual 2-input AND – **21**
- Triple 3-input NOR – **27**
- Single 8-input NAND – **30**
- Quad 2-input OR – **32**
- Quad XOR – **86**
- Quad XNOR – **266**

AND-OR-INVERT GATES

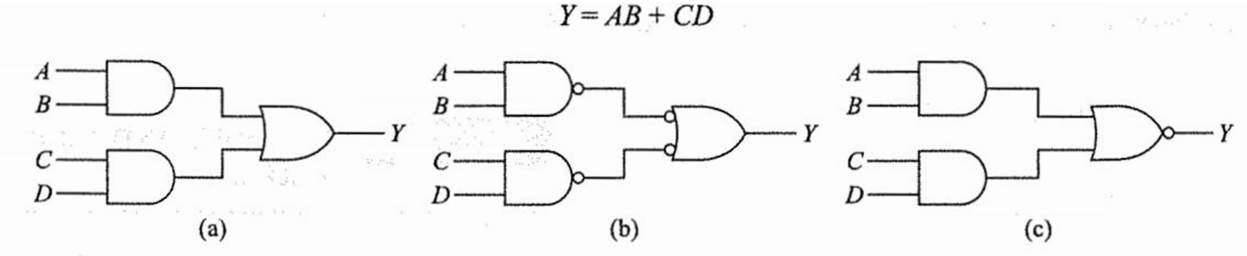


Figure: (a) AND-OR circuit, (b) NAND-NAND circuit, (c) AND-OR-INVERT circuit

Positive and Negative Logic

- In positive logic, binary 0 is used for low voltage and binary 1 is used for high voltage.
- In contrast, in negative logic, binary 0 is used for high voltage and binary 1 is used for low voltage.

- An OR gate in a positive logic system becomes an AND gate in a negative logic.

A	B	Y
LOW	LOW	LOW
LOW	HIGH	HIGH
HIGH	HIGH	HIGH
HIGH	HIGH	HIGH

Equivalence between the positive and negative logic:

Positive OR ←→ Negative AND

Positive AND ←→ Negative OR

Positive NOR ←→ Negative NAND

Positive NAND ←→ Negative NOR