Logic Gates

Transistor: Building Block of Computers

Microprocessors contain millions of transistors

- Intel Pentium 4 (2000): **48 million**
- IBM PowerPC 750FX (2002): **38 million**
- IBM/Apple PowerPC G5 (2003): **58 million**

Logically, each transistor acts as a switch

Combined to implement logic functions

- **AND, OR, NOT**

Combined to build higher-level structures

- **Adder, multiplexer, decoder, register, …**

Computers and Electricity

Gate

A device that performs a basic operation on electrical signals

Circuits

Gates combined to perform more complicated tasks

How do we describe the behavior of gates and circuits?

Boolean expressions

Uses Boolean algebra, a mathematical notation for expressing two-valued logic

Logic diagrams

A graphical representation of a circuit; each gate has its own symbol

Truth tables

A table showing all possible input value and the associated output values

Constructing Gates

Transistor

A device that acts either as a wire that conducts electricity or as a resistor that blocks the flow of electricity, depending on the voltage level of an input signal

A transistor has no moving parts, yet acts like a switch

It is made of a semiconductor material, which is neither a particularly good conductor of electricity nor a particularly good insulator

Constructing Gates

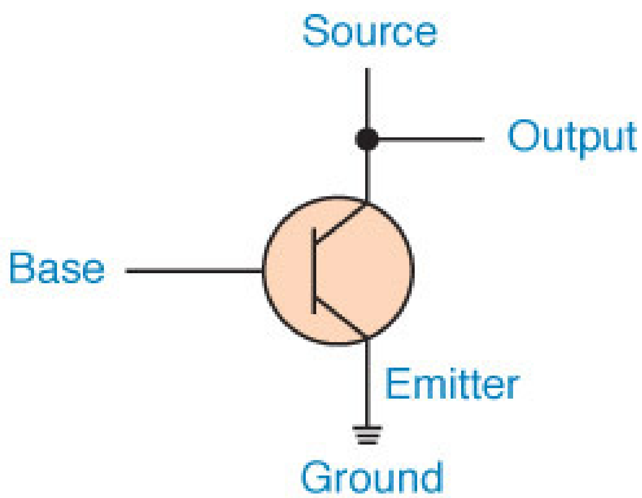
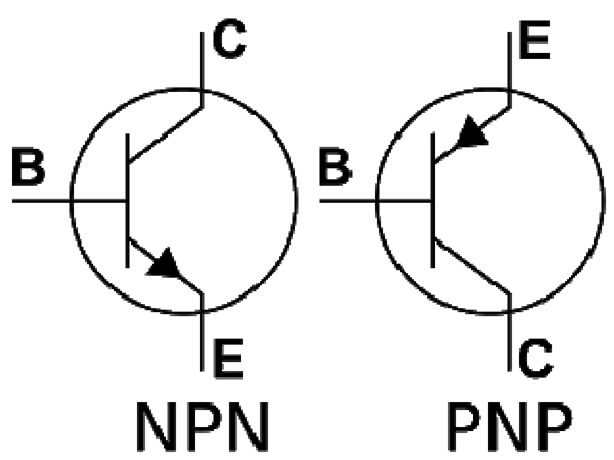


Figure The connections of a transistor

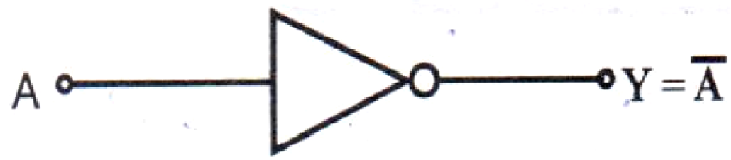


A transistor has three terminals

- A source
- A base
- An emitter, typically connected to a ground wire

If the electrical signal is grounded, it is allowed to flow through an alternative route to the ground (literally) where it can do no harm

NOT Gate



(a)

Truty Table
(NOT Gate)

A	Y
0	1
1	0

(b)

Fig. (a) Symbol of NOT Gate (b) Truth Table

Working (Transistor Analogy)

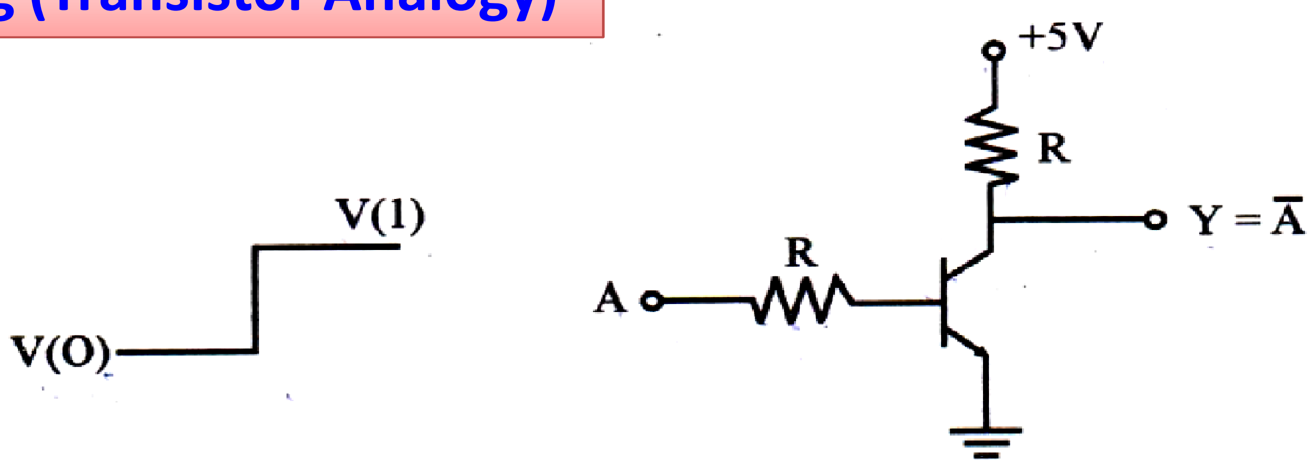
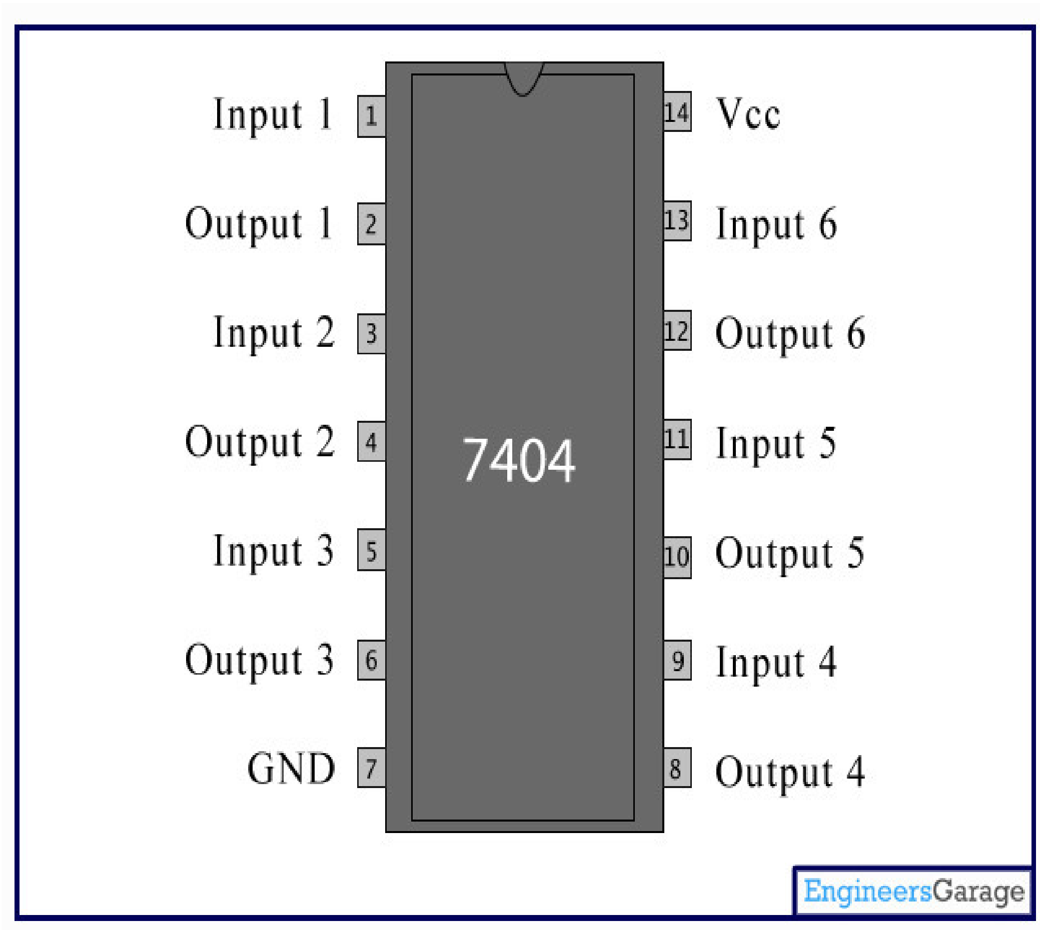


Fig. Transistor NOT Gate



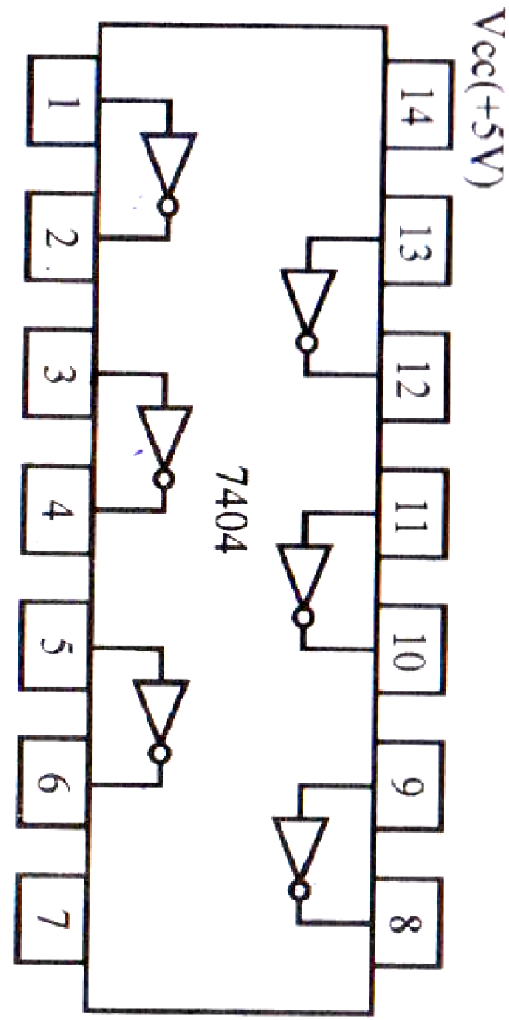
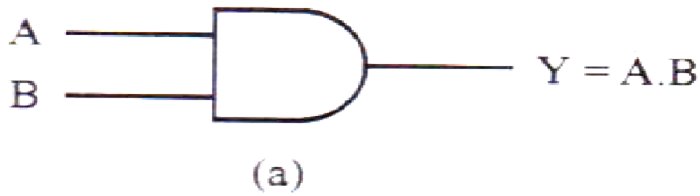


Fig. : Pinout diagram of 74LS04 IC

AND Gate



Truth Table
(AND Gate)

A	B	Y
0	0	0
0	1	0
1	0	0
1	1	1

(b)

Fig. (a) Symbol of AND Gate (b) Truth Table

Working (Diode Analogy):

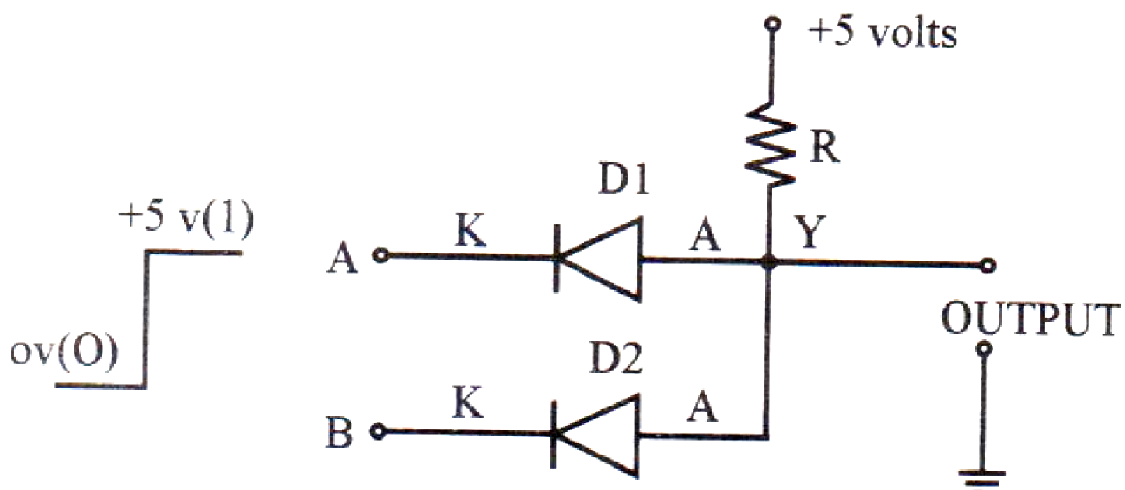


Fig. Circuit of AND gate

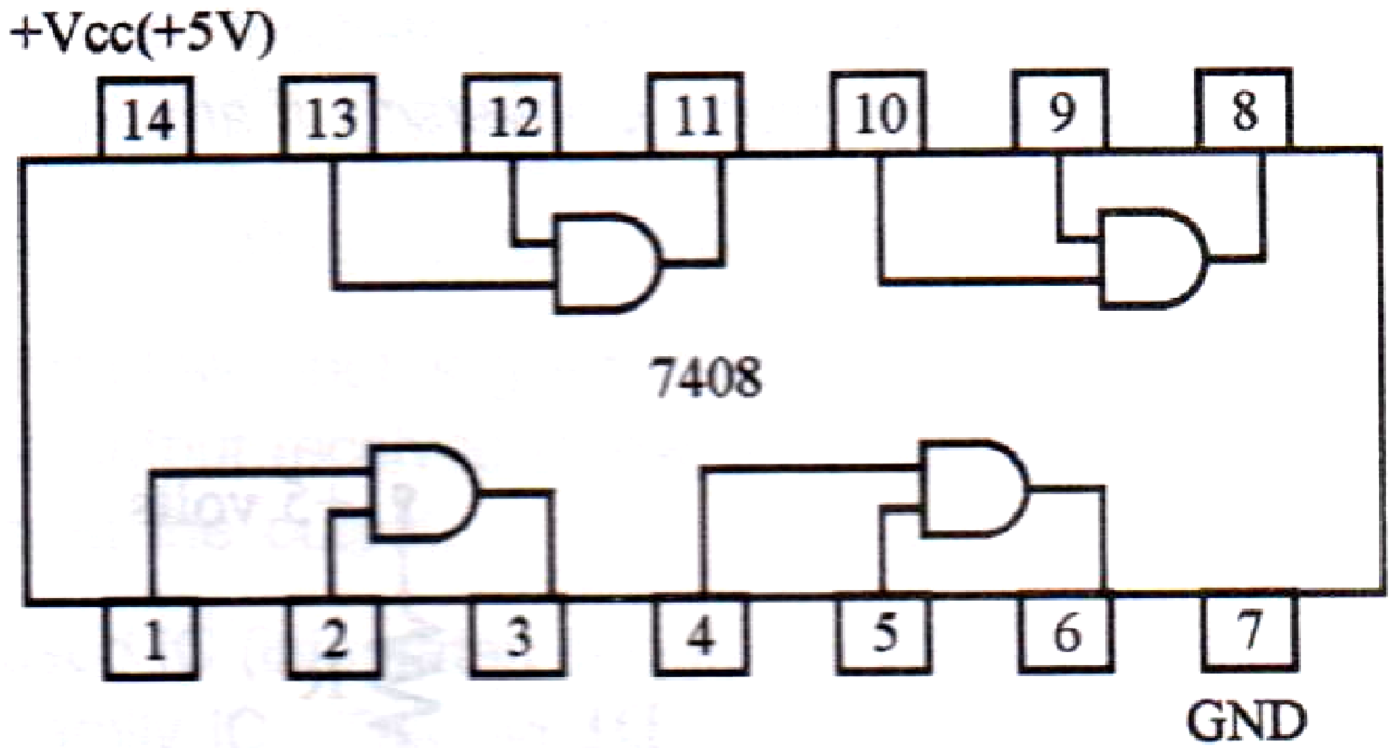
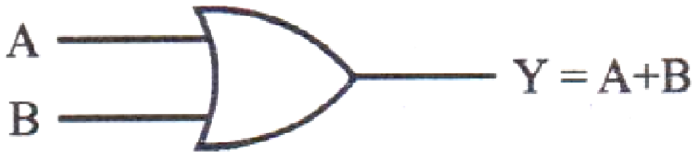


Fig. Pinout diagram of 74LS08 IC

OR Gate



(a)

Truth Table
(OR Gate)

A	B	Y
0	0	0
0	1	1
1	0	1
1	1	1

(b)

Fig. : (a) Symbol of OR Gate (b) Truth Table

Working (Diode Analogy):

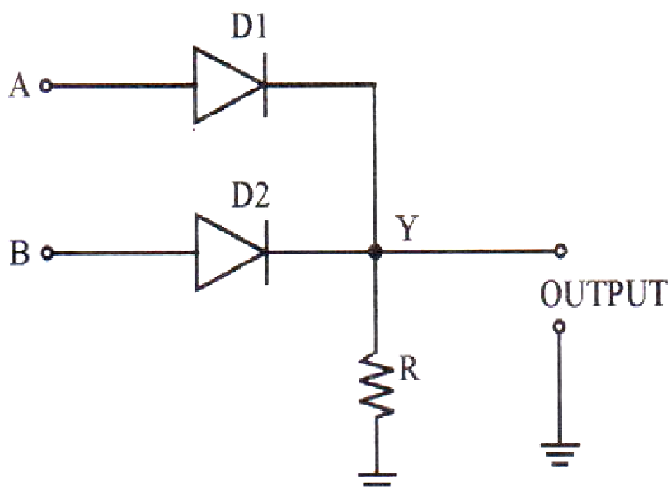


Fig. Circuit of OR Gate

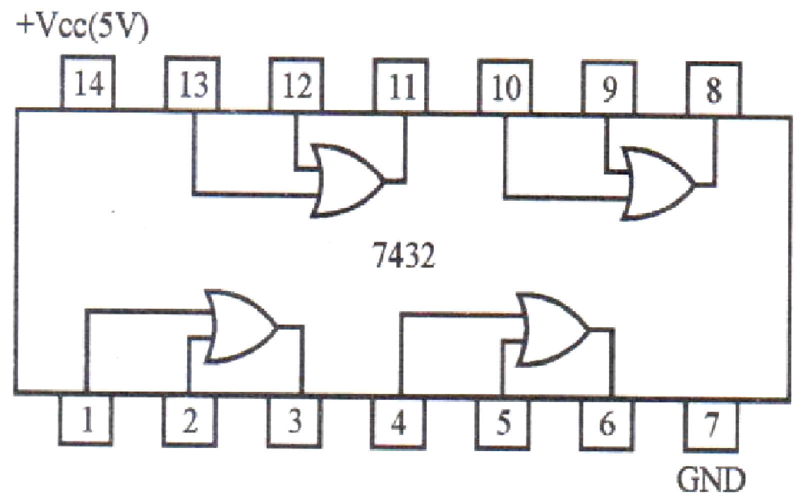
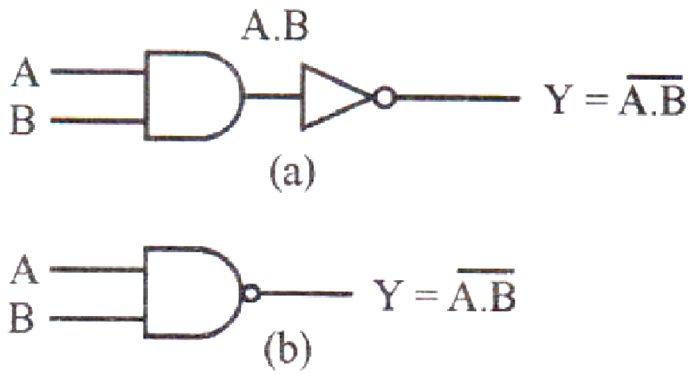


Fig. Pin out diagram of 74LS32 IC

NAND Gate



Truth Table
(NAND Gate)

A	B	Y
0	0	1
0	1	1
1	0	1
1	1	0

(c)

Fig. (a) NAND realization using AND and NOT gate (b) Symbol (c) Truth Table of NAND gate

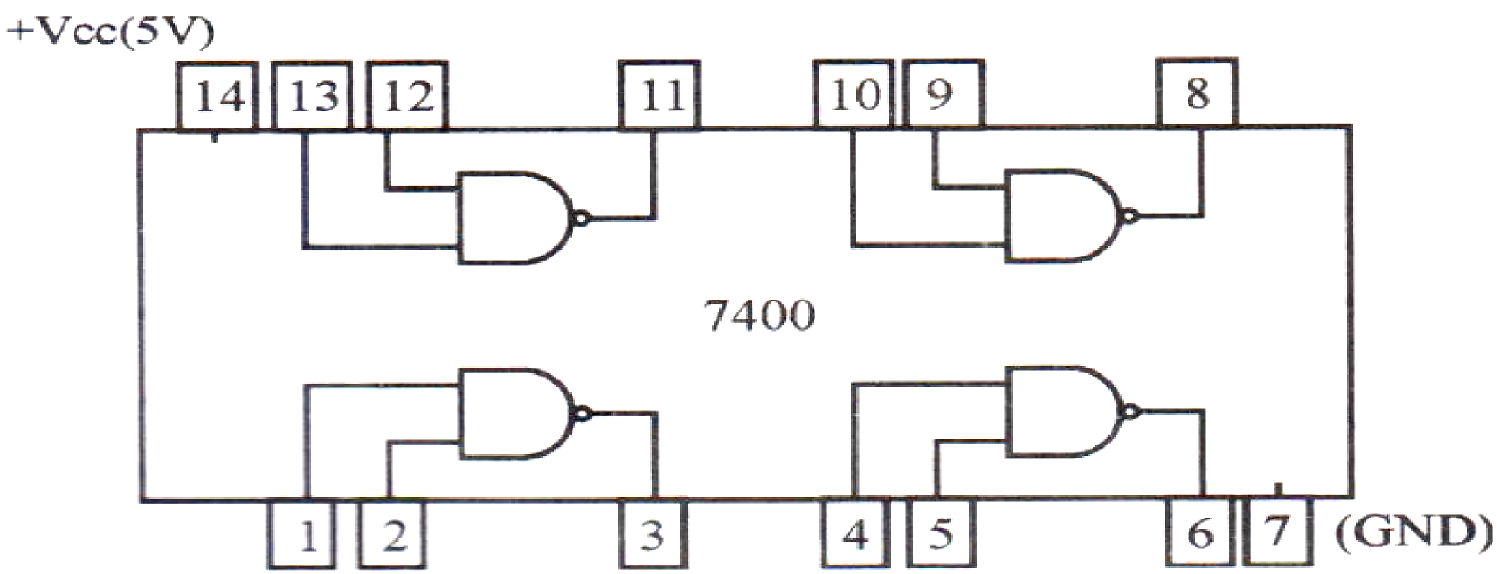


Fig. *Pin out diagram of 74LS00 IC*

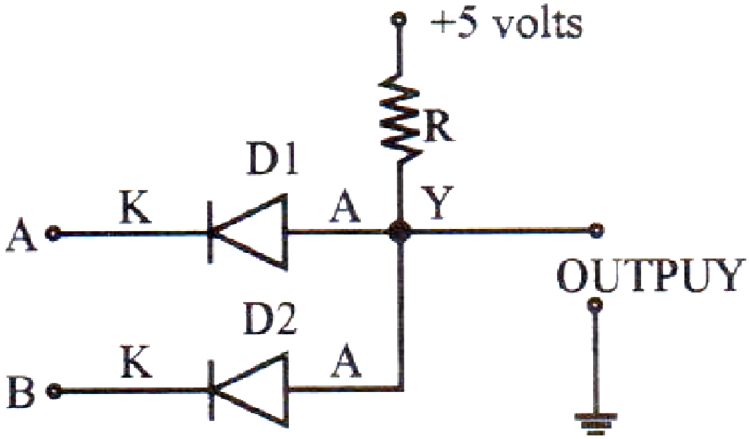


Fig AND Gate

+

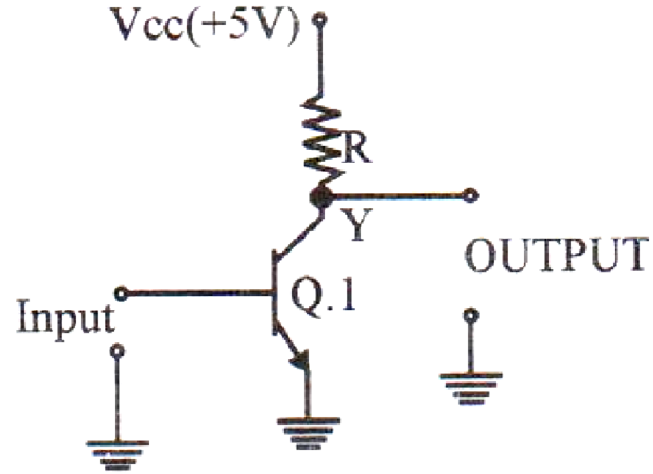


Fig. NOT Gate

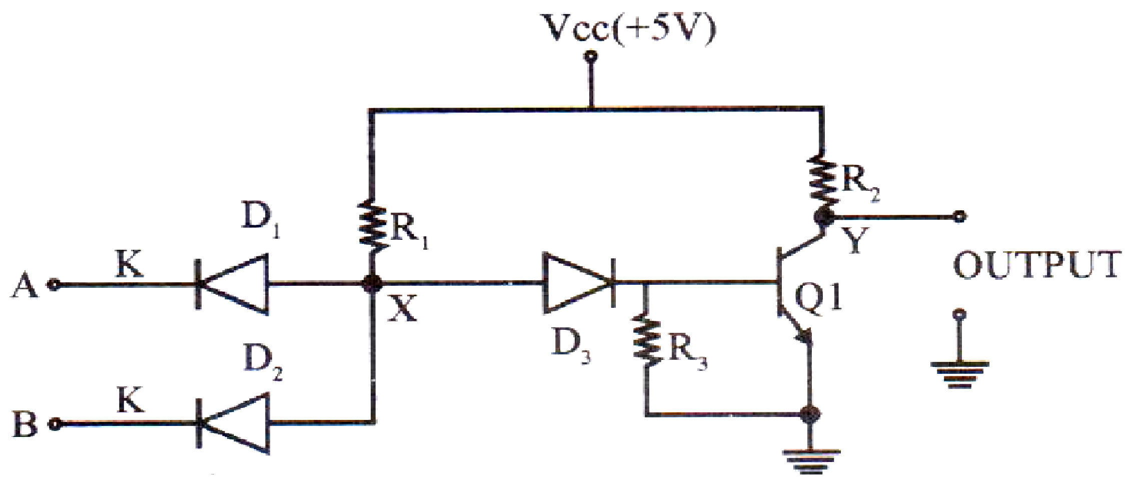
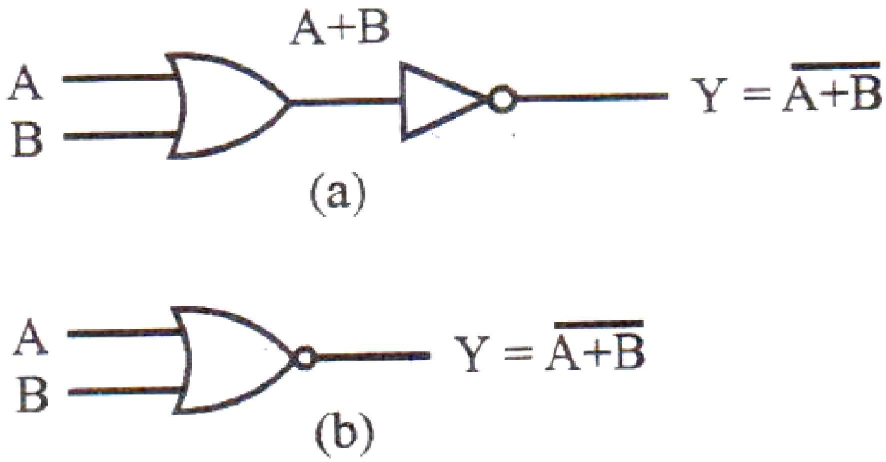


Fig NAND Gate

NOR Gate



Truth Table
(NOR Gate)

A	B	Y
0	0	1
0	1	0
1	0	0
1	1	0

(c)

Fig. (a) NOR from OR and NOT (b) Symbol (c) Truth Table

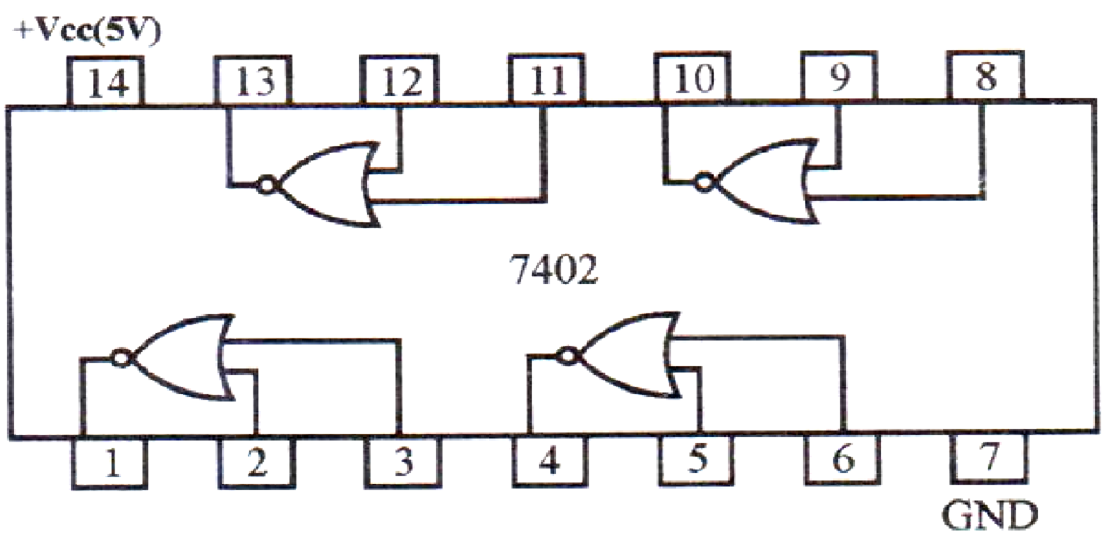


Fig. Pin out diagram of 74LS02 IC

In Fig. the OR and NOT gates are combined to form the NOR gate.

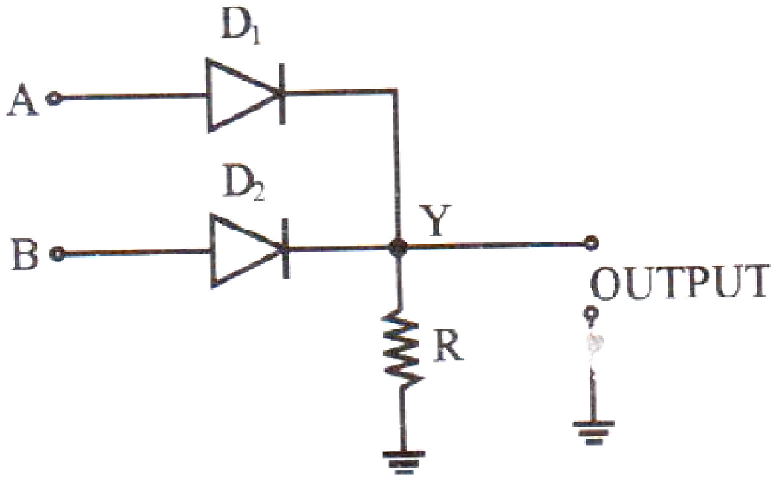


Fig OR Gate

+

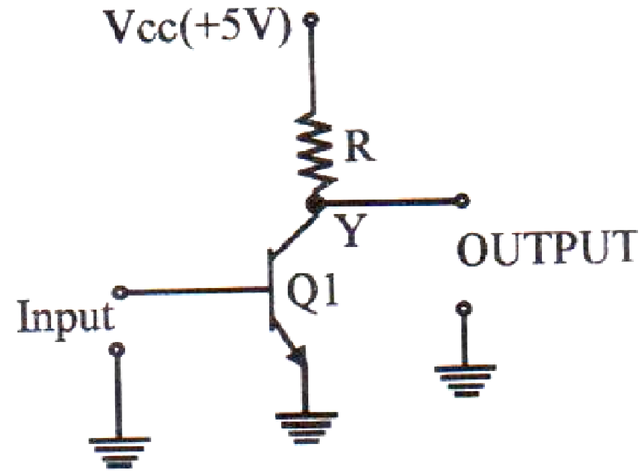


Fig. NOT Gate

⇩

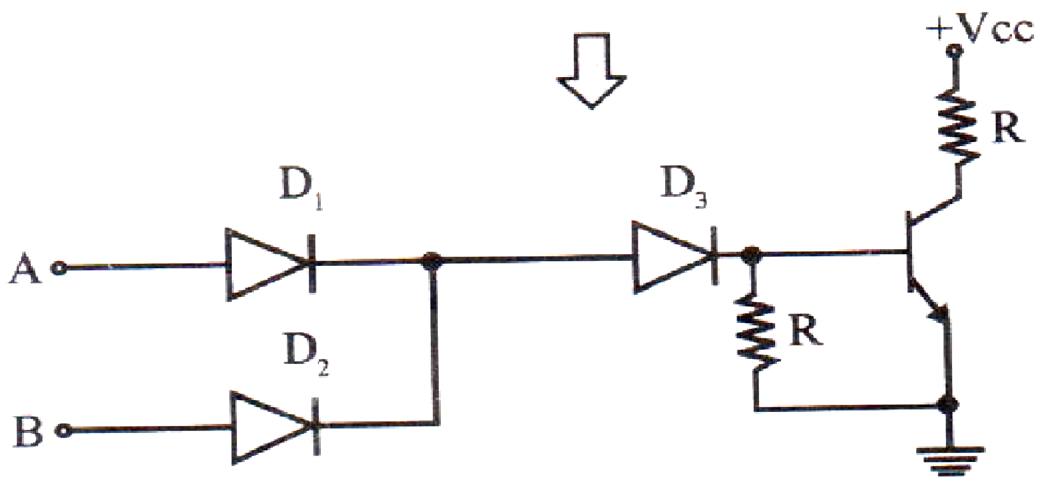
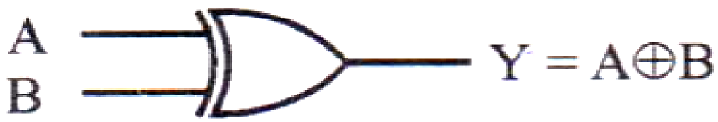


Fig NOR Gate

Ex OR Gate

$$Y = \bar{A}.B + A.\bar{B}$$

$$Y = A \oplus B$$



(a)

Truth Table
(EXOR Gate)

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

(b)

Fig. (a) Symbol (b) Truth Table of Ex OR gate

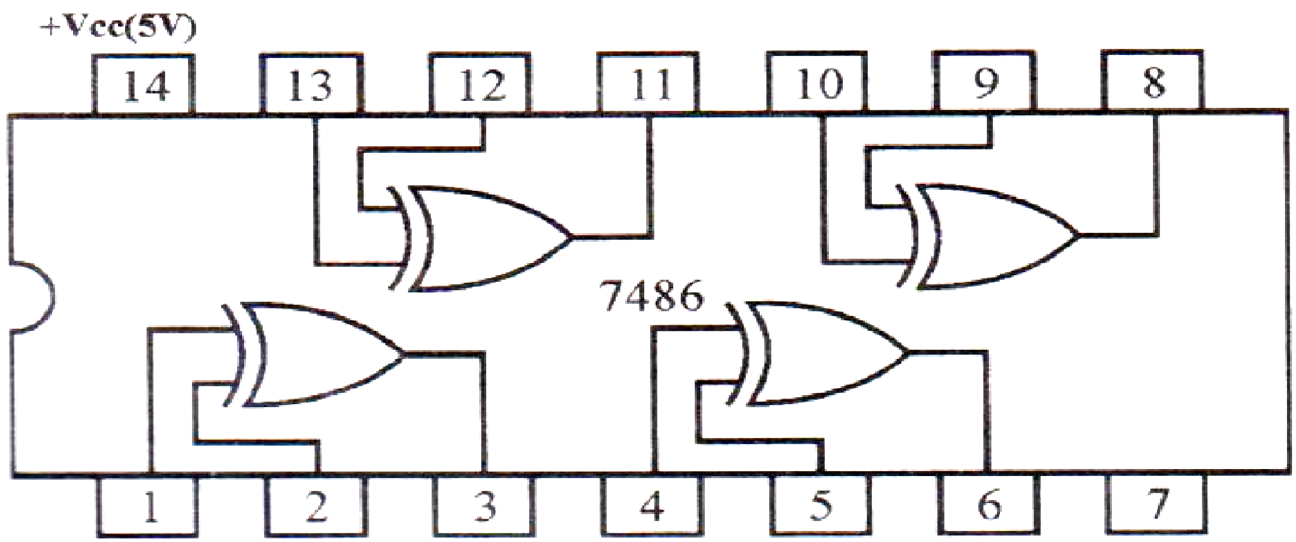


Fig Pin out diagram of 74LS86 IC

Ex NOR Gate

$$Y = \overline{A \oplus B} = A.B$$

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

(a)

Truth Table

(EX NOR Gate)

A	B	$Y = \overline{A \oplus B}$
0	0	1
0	1	0
1	0	0
1	1	1

(b)

Fig. (a) Symbol (b) Truth table of NOR gate

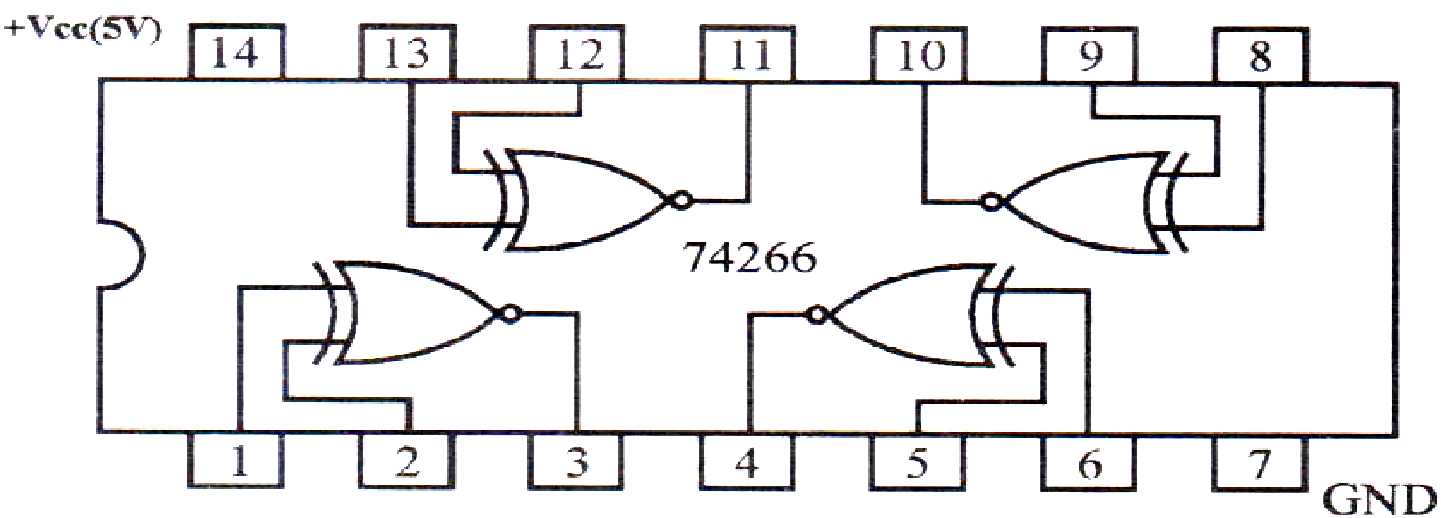


Fig. Pin out diagram of 74LS266 IC