UNIT 16

BASIC ELECTRONICS

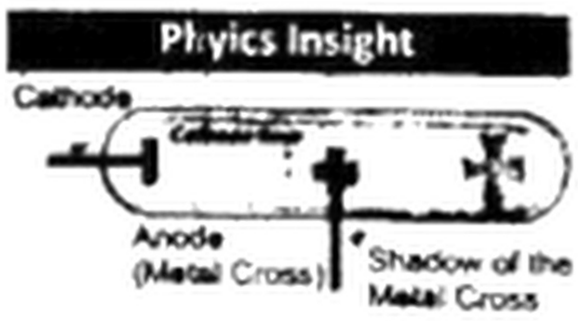
After studying this unit, the students will be able to:

a. Explain the process of thermionic emission emitted from a filament.
b. Describe the simple construction and use of an electron gun as a source of electron beam.
c. Describe the effect of electric field on an electron beam.
d. Describe the effect of magnetic field on an electron beam.
e. Describe the basic principle of CRO and make a list of its uses.
f. Differentiate between analogue and digital electronics. .
g. State the basic operations of digital electronics.
h. Identify and draw the symbols for the logic. Gates (NOT, OR, AND, NOR and NAND)
i. State the action of the logic gates in truth table form
j. Describe the simple uses of logic gates.

Q.1 What is electron gun? Describe the process of thermionic emission?

Answer: Electron gun

The part of a discharge tube, from which the negative charges (electrons) are produced from a hot cathode and are accelerated towards the screen is called electron gun.



Thermionic emission

"The process of' emission of electrons from the hot metal surfaces is called thermionic emission." Metals contain a large number of free electrons. At room temperature electrons cannot escape metal surface due to attractive forces of

atomic nucleus. If the metal is heated to a high cross is formed at the end temperature, some of the free electrons may gain sufficient energy to escape the metal surface. Thermionic emission can also be produced by electrically heating a fine tungsten filament.

When an opaque object like a metal cross is placed in the path the of cathode rays in a cathode-ray the tube, 3 shadow of the metal cross is formed at the end opposite to the cathode This is an evidence that rays of some kind are Passing straight through the tube.

Q.2 Describe, 'using one simple diagram in each case, what happened when a narrow been of electrons is passed through (a) a uniform magnetic field (b) a uniform electric field. What do these results indicate about the charge on an electron?

Answer

Electrons gun is used to investigate the properties of electron beam as shown in the figure 16.1

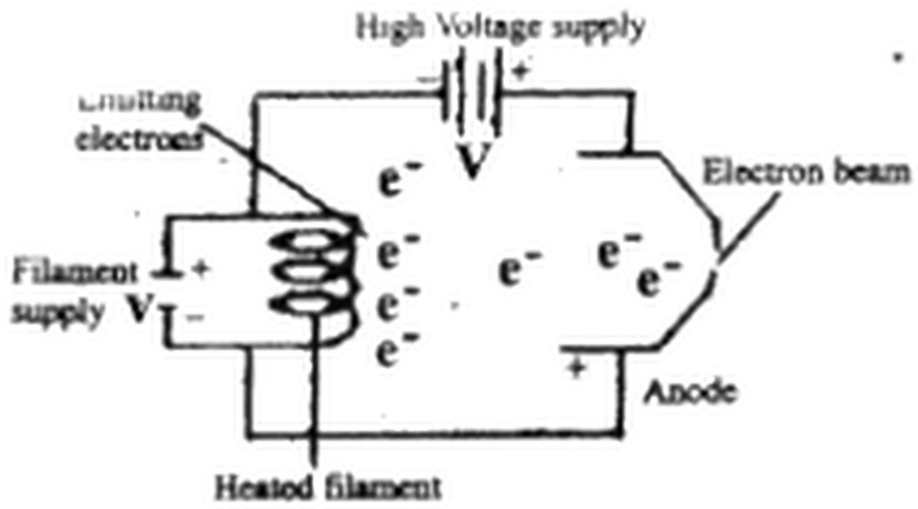


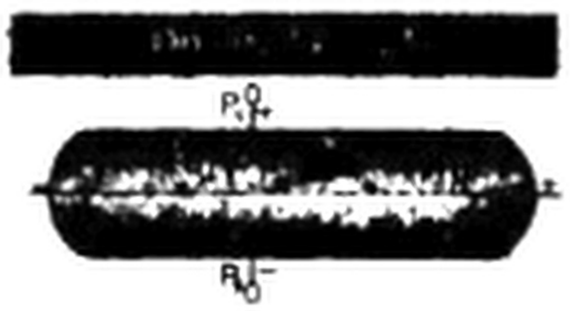
Fig. 16.1: Electron gun

The electrons are produced by thermionic emission from a tungsten filament heated by 6v supply. A high positive potential (several thousands) is applied to a cylindrical anode (+ve).

The electrons are accelerated to a high speed and pass through the hole of the anode in the form of a fine beam of electrons. The whole set up is fitted in an evacuated glass tube.

Deflection of electrons by electric field

An electric field can be set up by applying a potential difference across two parallel metal plates placed horizontally separated with some distance. When an electron beam passes between the plates, it can be seen that the electrons are deflected towards the positive plate as shown in the fig. 16.2. The reason for this is that electrons are attracted by the positive charges 'and repealed' by the negative charges due to force, F = qE, where q is the electron charge and 'E' is the electric field due to plates.



Deflection of cathode rays by an electric field

Fig 16.2

The degree of deflection of electrons from their original direction is proportional to the strength of the electric field applied.

Deflection of cathode rays by a magnetic field

Fig. 16.3

Deflection of electrons by magnetic field

Now a magnetic field is applied at right angle to the beam of electrons by using a horse—shoe magnet as shown in the fig. 16.3.

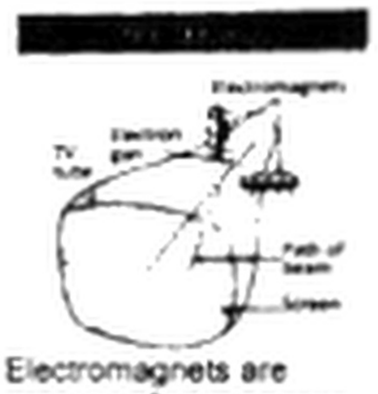
It is noticed that the spot of the electrons beam on screen is getting deflected from its original direction. Now change the direction of the horse shoe magnet. It is observed that, the spot on the fluorescent screen is getting deflected m the opposite direction.

Q3 What is a cathode ray oscilloscope? Explain the working of different parts of oscilloscope?

Answer.

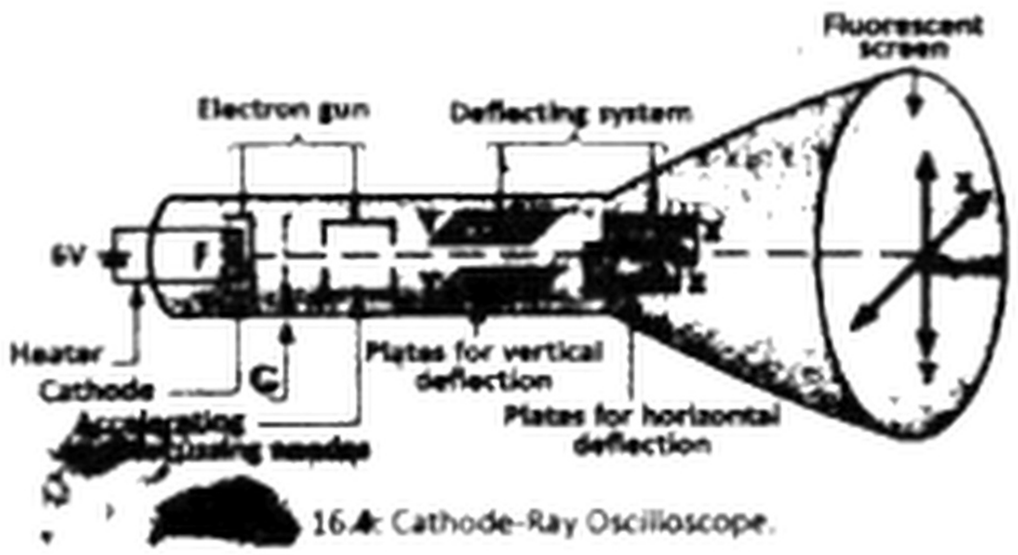
Cathode ray oscilloscope

The cathode ray oscilloscope is an instrument which is used to display the magnitude of changing electric currents or potentials as shown in the figure16.4. The information is displayed on the screen of cathode-ray tube. This screen appears as a circular or rectangular window usually with a centimeter graph superimposed on it. For example, the picture tube in over TV set and the display terminal of most computers are cathode ray tube. The cathode-ray oscilloscope consists of the following components.



Electromagnets are used it deflect electrons to desired positions on the screen of television tube.

- The electron gun.
- The deflecting plates
- The fluorescent screen.



16.4: Cathode-Ray Oscilloscope.

1. The electron gun

The cathode-ray oscilloscope consists of an "electron gun" for producing a beam of fast moving electrons called cathode rays.

Point to ponder!
When a magnet is brought near to the screen of a television tube picture on the screen is distorted. Do you know why?

The electron gun consists of the electron source which is an electrically heated cathode that effects electrons. Electron gun also has an electrode called grid 'G' for controlling the flow of electrons In the beam.

The grid is connected to a negative potential the more negative this potential, the more electrons will be repelled from the grid and hence fewer electrons will reach the anode and the screen. The number of electrons reaching the screen determines the brightness on the screen light. Hence the Negative potential of the gird can be used as brightness control. The anode is connected to positive potential and hence is used to accelerate the electrons. The electrons are focused in to a fine beam on the bass through the anode.

Do you know?
The beam of electrons was called a cathode ray because the electron had not yet been discovered. The old terminology scurvies in electronic engineering. Where a cathode-ray tube is any tube constructed along Thomson's lines whether in a computer monitor, a television, or an oscilloscope.

2) The deflating plates

After leaving the electron gun, the electron beam passes between a pair of horizontal plates. A potential difference applied between these plates' deflects the beam in a vertical plane. This pair of plates provides the y—axis or vertical movements of the spot on the screen. A pair of vertical plates provides the x-axis or horizontal movement of the spot on the screen.

3) The florescent screen

The screen of a cathode ray tube consists of a thin layer of phosphor, which is a material that gives light as a result of bombardment by fast moving electrons.

USES of C.R.O

The CRO is used in many fields of 'Science, displaying the Wave-forms, measuring voltages, range finding (as in order), echo-sounding (to find the depth of sea beds). The CRO is also used to display heart beats.

Do you know?

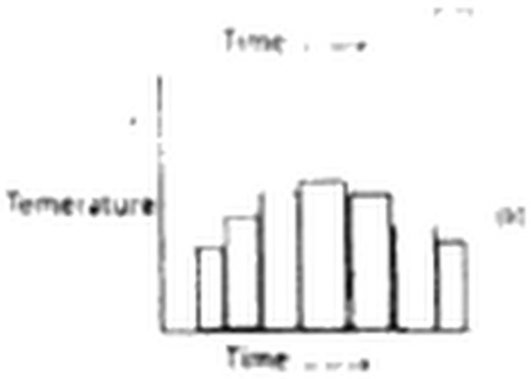
The glow in the tube is due to circular motion of electron in the magnet : field. The glow comes from the light emitted from the excitation of the gas atoms in the tube

Q.4 What do you understand by digital and analogue quantities?

Answer

1) Analogue quantities

The quantities whose values vary continuously or remain constant are known as analogue quantities. For example, the temperature of air varies in a 'continuous fashion during 24 hours of a day.



If we plot a graph between "me and temperature recorded at different times, we get a graph like shown in the figure 16.5 (a)

This graph shows that temperature varies continuously with time. Therefore, we say that temperature is an analogue quantity.

Similarly, time, pressure, distance etc. are analogue mg quantities.

2) Digital quantities

The quantities whose values vary in non-continuous manner are called digital quantities. Digital version of analogue signal is shown in the figure 16.5 (b).

Digital quantities are expressed in the form of digits or numbers.

Q.5 Differentiate between-analogue electronics and digital electronics?

Answer:

1) Analogue electronics

"The branch of electronics consisting of circuits 'which process analogue quantities is called analogue electronics."

For instance, the public address system is an analogue system in which the microphone converts sound into continuously varying electric 'potential. This potential is-an analogue signal which is fed into an amplifier. An amplifier is an analogue circuit which amplifies the signal without changing its shape to such as extent that is can operate a loud speaker. In this way, loud sound is produced out of the speaker. Radios, televisions and telephones are a few common devices that transfer analogue signals.

2) Digital electronics

"The branch of electronics which deals with digital quantities is called digital electronics. The computer operates by counting the digits. The word digit has been adopted from this mode of computer's operation. For this purpose, digital electronic uses only two digits (0) zero and 1(one) and the whole data becomes easy.

Q.6 Discuss analogue and digital signals graphically? What are analogue and digital converters?

Answer:

Analogue and digital signals

Fig. 16.6 shows an analogue and digital signal. A continuously varying signal is called an analogue Signal.

For example; an alternating voltage varying between the maximum value of +5v and minimum value of —5V is an analogue signal as shown in fig. 16.6 (a).

A signal that can have only two discrete values is called a digital signal as shown in the fig. 16.6 (b).

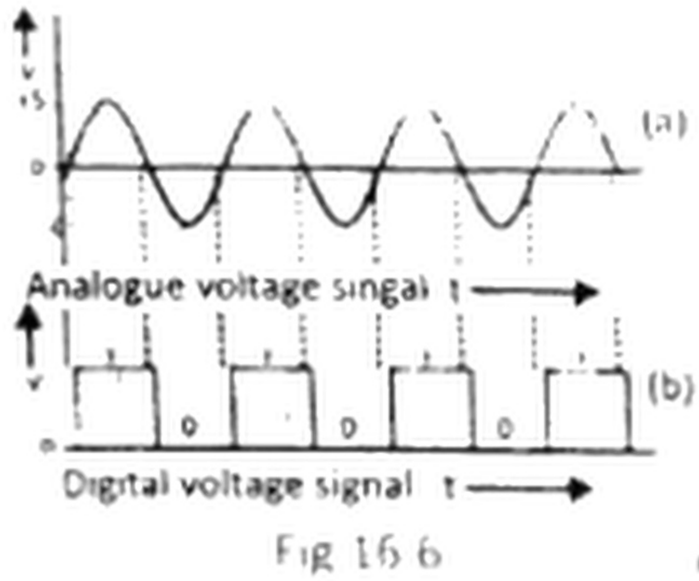


Fig 16.6

The signal has only two values i.e. +5v and 0V. The high voltage is +5v and the low voltage is 0V. It can be seen that' digital signal provides the data by -a maximum and a minimum voltage level. The changes occurring in the digital signal are not continuous.

For quite a long period the use of digital electronics was limited to computers only, but now-a-days its application is very wide spread. Modern telephone system, radars system, naval and other system of military importance, devices to control the operation of industrial machines. Medical equipment and many household appliances are using digital technology.

For your information

Digital technology has entered every part of our lives. Digital TV gives excellent view and allows you to be interactive. Digital cameras are fast replacing traditional film equipment. You can download an image into a PC and crop, enhance, airbrush and edit the picture.

Smart ID cards are being developed. A single card can be a passport, national insurance card and driving license all in one. The card could also hold biometric data like an eye retina scan and voice scan for unique identification and security. All of this data would be held digitally in the tiny chip.

Analogue and digital converters

In our daily life, the quantities that we perceive by our senses are usually analogue quantities which cannot be processed by digital circuits. To overcome this problem, a speed circuit has been designed which converts the analogue signal into a digital one in the form of digits. This circuit is known as analogue to digital converter (ADC).

Fig. 16.7

When we get an analogue signal in the form of digits, we can process it with digital circuit, the output which is also in digital form. This digital output is converted into analogue by a circuit known as digital to analogue converter (DAC).

Q.7 Write a note on the basic operations of digital electronics-logic gates?

Answer

A switch has only two possible states. It could be either open or closed. Similarly, a given statement. Would be either true or it would be false. Such things which can have only two possible states are known as binary variables. The states of binary variables are ' usually represented by the digits 0 and 1. Suppose we form a circuit by connecting a lamp to a battery using a switch's'. We call state of switch as input and state of current or lamp as output. When the switch is open, no current passes through the circuit and lamp is off. In other words, when input is zero, output is also zero. When the switch is closed current passes through the circuit and lamp is on. Thus the output current is also a binary variable. In case the current is passing, we can say the value of the output is I and it is zero when no current is passing.

Introduction to Boolean algebra

The algebra used to describe logic operations by symbols is called Boolean Algebra. Like ordinary algebra, English alphabets (A, B, C etc.) are used to represent the Boolean variables. However, Boolean variable can have only two values; 0 and 1. Digital circuits perform the binary arithmetic operations with binary digits 1 and 0. These operations are called logic function or logical operations.

These states are also called logic states or logic variables. 'If the values of input variables of a circuit are known, the value of 7 output can be determined by using Boolean algebra also called as algebra of logics.

Instead of variables that represent numerical quantities as in Conventional algebra, Boolean algebra handles variables that represent two types of logic propositions; 'true' and 'false'.

Boolean algebra's simple interpretation of logic operators AND, OR and NOT has allowed the systematic development of complex digital system.

Since a logic gate is a switching circuit (i.e. digital circuit); It's outputs have only one of the two possible states. Either a high voltage '1'or a low voltage '0'— it is either ON or OFF.

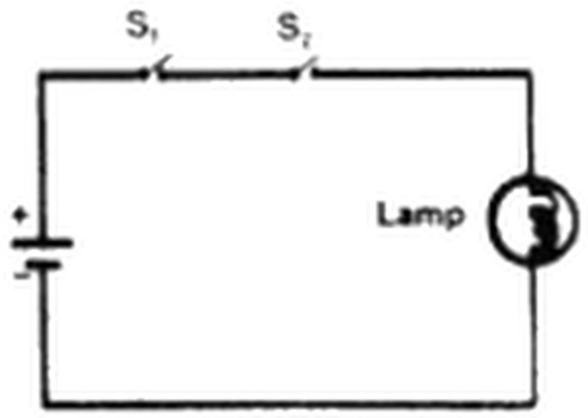


Fig. 16.8

Table 16.2

S_1	S_2	Lamp
Open	Open	OFF
Open	Closed	OFF
Closed	Open	OFF
Closed	Closed	ON

A	B	X = A.B
0	0	0
0	1	0
1	0	0

Q.8 What is AND gate? Give its symbol and truth table?

Answer

AND Gate

The fig. 16.8 shows the logic AND operations, in which a lamp is connected to a battery using two switches 51 and 52 connected in series considered as two inputs. There are four possible states of these two switches which are given below:

1. When S. and S; are both open, the lamp 'is off.
2. When SI is open and S: closed, the lamp is off.
3. When S. is closed and S; open, the lamp is off.
4. When both S. and S: are closed, the lamp is ON.

The four possible combination of switches S_1 and S_2 are shown in the table I6.2. It is clear that when either of the switches (S_1 or S_2) or both are open, the lamp is OFF. When both switches are closed the lamp is ON.

Symbol

Symbol for AND operation is dot (.). Its Boolean expression is x= AB and is read as "X equals A and B."

Truth table

1) Set of inputs and outputs in binary form is called truth table. In binary language:

A when either of the inputs or both the input are low (0). The output is low (0).

When both the inputs are high" (1), the output is high (1). The. Truth table AND operation is shown in table 16.3, where x represents the output. Therefore, AND operation may be represented by switches connected in series. With each switch representing an input.

2) When two switches are closed i.e., the inputs of the AND operation are at logic '1', the output of the AND operation will be at logic '1'. But when two switches are open W. the inputs of AND operation will be at logic '0'. For any other state of two switches (i.e. the input of AND operation) the output will be zero.

AND Gate:

The circuit which implements the AND operation is known as AND gate. Its symbol is shown in fig. 16.9.

Fig. 16.9

AND gate has two or more than two inputs and only one output. The value of output of

AND gate is always in accordance with the truth table of AND operation. it means output of AND gate will be '1' only when both of its inputs are at logic '1' and for all other situations output of AND gate will be '0'.

Q.9 What is an OR gate? Give its symbol and truth table?

Answer

OR operation

In order to understand the logic OR operation. fig. 16.10 is shown. A-Lamp is connected to a battery using two switches S' and S is connected in parallel considered as two inputs.

There are four possible states of these two switches which are given below:

1. When S' and S; are open, the lamp is OFF.
2. When S is open and S' close, the lamp is ON.
3. When S' is closed and S; open, the lamp is ON.
4. When both S' and S; are closed, the lamp is ON.

As evident from the circuit in fig. 16.10", the lamp will be on if and only if at least one of the switches is closed. In the language of Boolean algebra. We say the lamp will glow if at least one of the values of S_1 and S_2 is at logic '1'.

Table 16.4 describes all possible states of the switches for 'OR' Operation.

Symbol

OR operation is represented by the symbol of plus (+).Boolean expression for 'OR' operation is: x = A '+ and is read as "x equal A or B."

S_1	S_2	Lamp
Open	Open	OFF
Open	Closed	ON
Closed	Open	ON
Closed	Closed	ON

Table 16.5

Truth table

Truth table of OR operation is shown in table 16.5 An OR operation may be represented by switches connected in

Parallel, since only one of these parallel switches need to turn on in order to flow current in the circuit.

A	B	X = A+B
0	0	0
0	1	1
1	0	1
1	1	1

OR gate

The electronic circuit which implements the OR operation is known as OR gate. Symbolically, OR gate is shown in the fig. 16.11.

OR gate

Fig.16.11

It has two or more than two inputs and has only one output. The values of output of 'OR' gate are always in accordance with the truth table of 'OR' operation.

It means, the value of output of 'OR' gate will be '1' when one of its inputs is at '1'. The output will be '0', when both inputs are at '0'.

Q.10 What is a NOT gate? Give its symbol and truth table?

Answer

NOT operation

The circuit of NOT operation is shown in the fig. 16.12. A lamp is connected to a battery with a switch S.

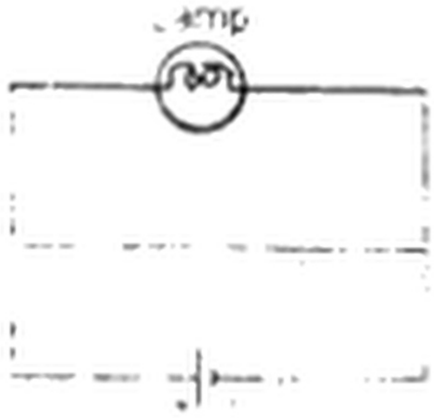


Fig 16.12

When the switch is open, current will pass through the lamp and it will glow.

When switch is closed, no current will pass through the lamp due to large resistance of its filament and it will not glow. States of the switch and the lamp are shown in table 16.6.

NOT operation is represented by a line or bar over the symbol i.e. and is read as 'x equals A NOT." it means NOT operation changes the state of a Boolean variable.

For example, if the value ofa Boolean variable is 1, then after NOT operation its value would change to '0'. Similarly, if its value before NOT operation is '0', then after NOT operation it would change to '1'. Thus NOT operation invents the state

Table 16.6

S	Lamp
Open	ON
Closed	OFF

Table 16.7

A	
0	
1	0

of Boolean variable. Truth table of NOT operation is shown in table 16.7.

NOT gate

The electronic circuit which implements NOT operation is known as NOT gate. Symbol of NOT gate is shown in fig. 16.13.

It has only one input and one output terminal. NOT gate work in such a way that if its input is '0', its output would be '. '1'. Similarly if its input is 1, then output would be zero.

NOT gate performs the basic logical function called inversion or complementation NOT gate is also called invertor. The purpose of this gate is to convert one logic level into the opposite logic level.

Fig. 16.13

When a HIGH level is applied to an inverter, a LOW level appears on its output and vice versa.

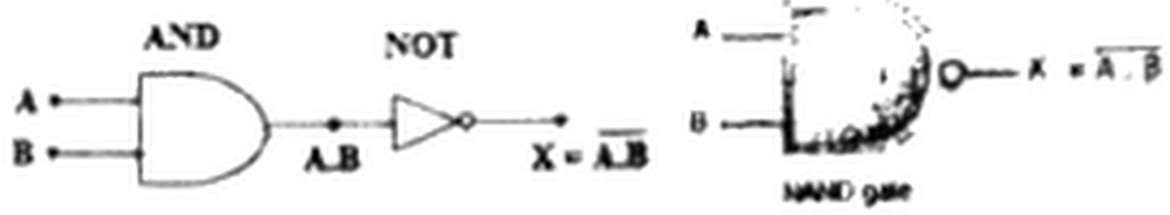
Q.11 What are NAND and NOR gates? Give their symbols and truth tables?

Answer

NAND gate

NAND operation is simply an AND operation followed by a NOT operation.

For example, NAND gate is obtained by coupling a NOT gate with the output terminal of the AND gate (fig16.4 a). The NOT



(a) Fig.16.14 (b)

gate Inverts the output of the AND gate. The output of the NAND equals AB and is written as x = A.B. It is read as X equals A AND NOT. Symbol of NAND gate is shown in fig. I6.14 (b).

As shown in the figure. The NOT gate has been replaced with a small Circle. In the

Symbol of NAND gate shows NOT operation. Truth table of NAND gate 15 shown

Table 16.8

A	B	$X = \overline{A.B}$
0	0	1
0	1	1
1	0	1
1	1	0

For your information

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

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

$X = \overline{\overline{A.B}} = A.B$

Here double line indicates double NOT operation

Table 16.9

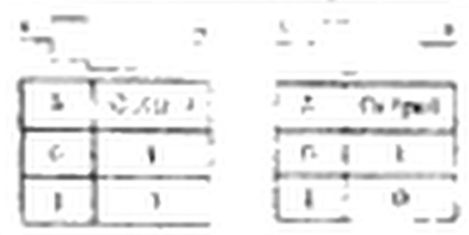
A	B	$X = \overline{A + B}$
0	0	1
0	1	0
1	0	0
1	1	0

in table 16.8.

NOR gate

The NOR operation is simply an OR operation followed by a NOT operation. The NOR gate is obtained by coupling the output of the OR gate with the NOT gate as shown in the figure 16. 15 (a).

For your information



Formation of NOT gate from NAND and NOR gates with the resultant truth tables.

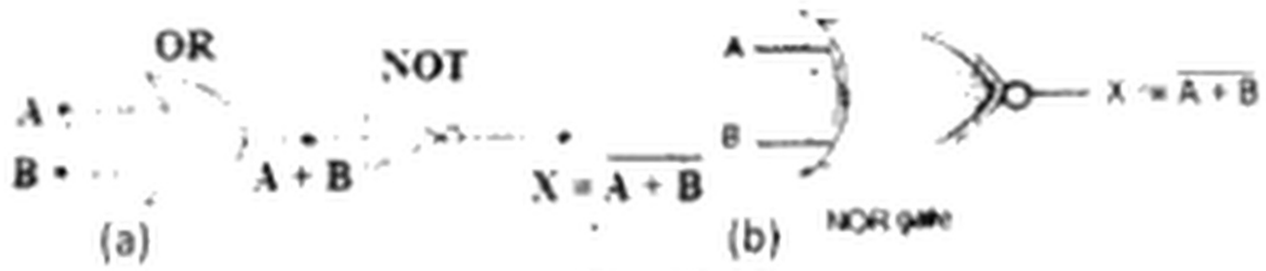


Fig. 16.15

Thus for the same combination of inputs, the output of a NOR gate will be opposite to that of an OR gate. Its Boolean expression is X = A + B. It is read as X equals A or B NOT. Symbol of NOR gate is shown in the figure 16.15 (b). Table 16.9 is the truth table of NOR gate.

Q.12 Write the use of logic gates with the help of an example?

Answer

Use of logic gales in electronic circuits to do useful tasks. These circuits usually use light depending resistors (LDRs) to keep inputs LOW. An LDR can act as a switch that is closed when illuminated by light and open in the dark.

House safety alarm

For your information
Most of today's technologies fall under classification of digital electronics.
Digital electronics devices store and process ***bits*** electronically.
A bit represents data using 1's and 0's.
Eight bits is ***byte*** - the standard grouping in digital electronics.
Digitization is the process of transforming information into 1's and 0's

We can use single NAND gate to make burglar alarm. This can be done by using NAND gate, an LDR, a push-button switch 3 and alarm as shown in fall under the

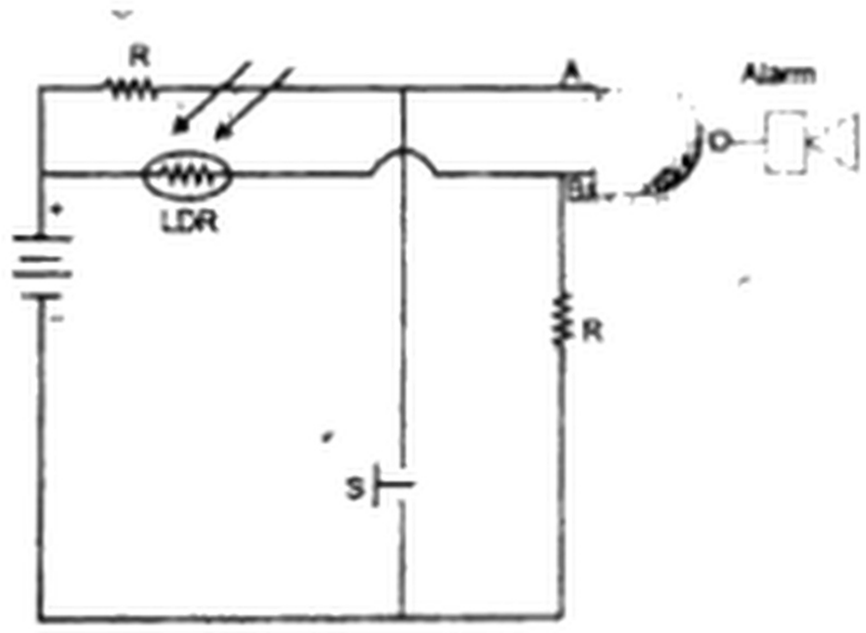


Fig. 16.16: Burglar alarm schematic circuit

figure 16,16, digital electronics.

Connect LDR between NAND gate input B and the positive terminal of the battery.

The LDR will cause a HIGH level input (1) at B when in light because of its low resistance.

The LDR will cause a low level input (0) at B when light is interrupted and causes high resistance in LDR. A low level signal is also caused at A when burglar steps on switch

S: So this burglar alarm sounds when either burglar interrupts light falling on LDR or steps on switch 'S'