PHYSICS

ELECTRONICS

Activity

In your groups, can you site some of the activities in the world that electronics has aided?

Possible answers

- Storing money
- Monitoring heart beat
- Carrying sound of people's voices into other peoples through phone calls
- Bringing air planes onto land etc.

NOTE: The world of electronics is easier to understand if it is divided into two distinct categories i.e.

i) The digital world
ii) The analogue world.

DIGITAL ELECTRONICS

SCENARIO

Mr. Okello is a technician. He opened a computer that had a fault to mechanize it.

TASK

a) What as some of component devices he saw in the computer.
b) State the function of each component.
c) How are the electric components combined in the electrical circuit?

Soln

Resistors

- Used in current limiting devices like LED to provide light and protect components from damage
- Used in potentiometers for volume control and speed control in motors.
- Used in heating elements like electric heaters and ovens to turn current into heat.
- Applied in most electronics to damp out unwanted signals called noise.
- Applied in power supply units and filter circuit networks.

Diodes

- Applied in communication systems as clippers o cut off unwanted signals.
- Applied in limiters to limit certain kinds of frequencies of signals to some tolerable values.
- Used in clampers and voltage multipliers for increasing voltage of the circuit.
- Used in rectifiers to connect a.c to d.c
- Used in logic gates to perform digital logical operations like NAND, AND, OR, NOR etc.
- Used in solar cells to provide solar electricity.

Transistors

- Used in electronic circuits as electronic switches having only two states ON or OFF.
- Used in power amplification circuits e.g., the audio amplifier for public address systems.

Capacitors

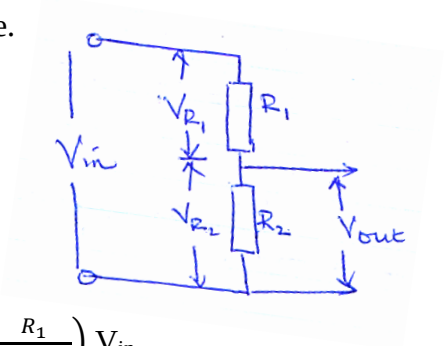
- Applied for charge storage and release when required in electronic circuits
- Used for smoothening, filtering and by passing of A.C
- Used for power factor correction during electricity transmission.

These pieces of electronic components do perform different functions or jobs. They are linked together by cables or printed mental connections to form an electronic equipment (circuit) that performs a particular function.

POTENTIAL DIVIDERS

A potential divider is a simple circuit that uses resistors to supply a variable potential difference.

A potential divider in its simplest form consists of two resistors in series connected across source of voltage.



Where,

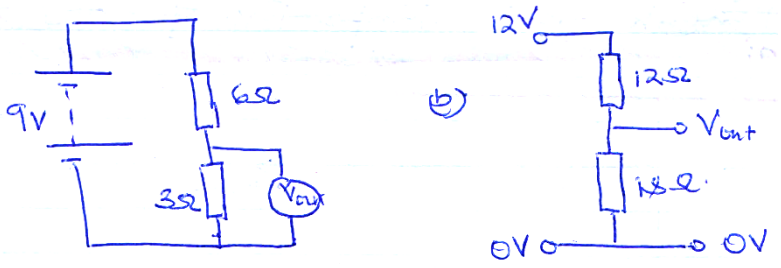
V_{in} – Input voltage

V_{out} – Output Voltage

NOTE: $V_{out} = \left(\frac{R_1}{R_1 + R_2}\right) V_{in}$

Trials

1. Calculate the output voltage in each of the following.



2. Find the missing values

Applications of potential dividers.

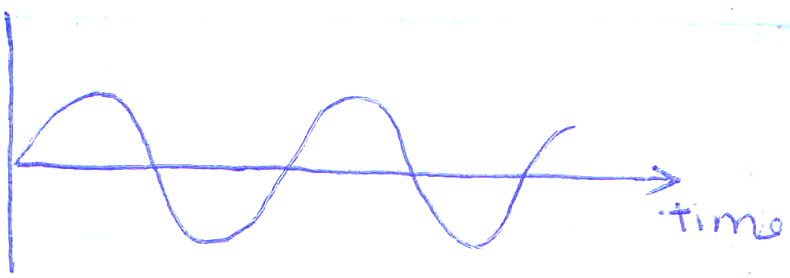
- Used to control audio volume.
- Used to control the temperature in a freezer.
- Used to monitor changes of light intensity in a room.
-

A. Digital signal and analog signal

1. Analogue signal

- The term analogue refers to any wave form. If the wave form is able to convey information, then it is an analogue signal.
- Therefore, an analogue signal is a continuous signal where by one-time varying quantity varies with another time-based variable e.g., frequency of sound from human voice, voltage of electricity through a wire, temperature of a day etc.

  i.e.



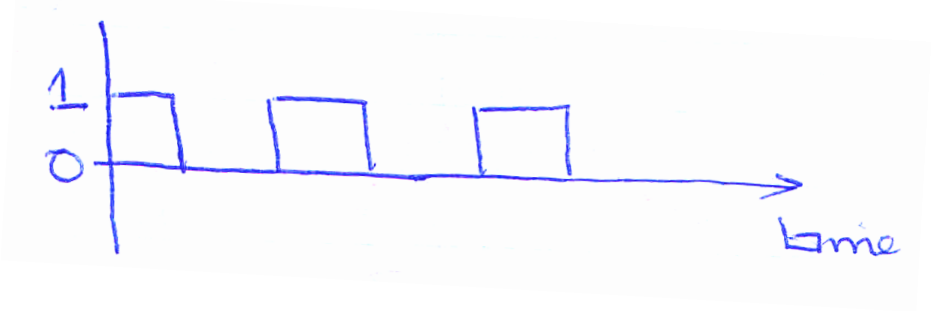
Examples of analog signals include

- Temperature sensors
- FM radio signals
- Photocells
- Light sensors etc.

2. Digital signal

A digital signal is a signal that is used to represent data as a sequence of separate values at any point in a time.

In the digital world, there are only wo states that are important ON or OFF e.g. when you switch the light on in your classroom, you know that there are only two possible positions, the light switch can be ON or OFF



Examples of digital signals include

- Computers
- CDs
- DVDs etc.

Advantages of digital signals

- Digital circuits can convey information with less noise, distortion and interference
- Digital signals are easy to design than analogue circuits
- Digital signals are cheaper than analogue circuits
- Digital circuits can be reproduced easily in mass quantities comparatively at low costs.

ELEMENTARY LOGIC GATES AND MEMORY CIRCUITS

Digital circuits are designed to process digital signal and the building blocks for this digital circuit are called a logic gate

Activity

a) Why do you think schools must have a gate?
b) What challenges are related to lack of a gate in school?
c) Why do you think school gates are mostly constructed in front of the administration block?
d) Relating the experience of your school to an electric circuit, do you think a circuit at some point may need a gate? Explain your answer.

In an electric circuit, a switch acts like a gate for the school.

It can allow current to flow in the circuit or not.

In electronics we assign the number **"1"** to indicate that current is flowing and the number **"0"** to indicate the current is not flowing. If a switch uses **"1"** to indicate flow of current and **"0"** to indicate no flow of current in a circuit, then such a switch is called a logic gate.

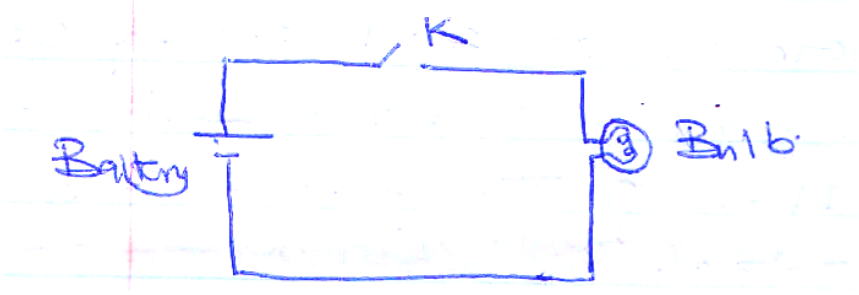
This system of using **"1"** for a true value and **"0"** for a false value is called binary system and the resulting algebra is known as Boolean algebra.

Activity.

What you need?

- A cell
- A battery
- Connecting wires
- A bulb

What to do?



a) Arrange the circuit as shown above
b) Close switch K; What happens?
c) Open switch K; What happens?
d) Use **"1"** or **"0"** to describe your observations.
e) Make conclusion about use of the binary digits **"0"** and **"1"** in an electric circuit using the table below.

State of switch	State of bulb

The above table is called a truth table;
Truth table helps to show how a logic gate functions.

NOTE: In digital circuits, the "**ON"** or **"1"** state can be represented as a high voltage and the "**OFF"** or **"0"** can be represented as low voltage. In this way, digital signals or numbers in binary can be recorded in a circuit without confusion.

TYPES OF BASIC LOGIC GATES

There are several basic logic gates used in performing operations in digital systems.
The common ones are;

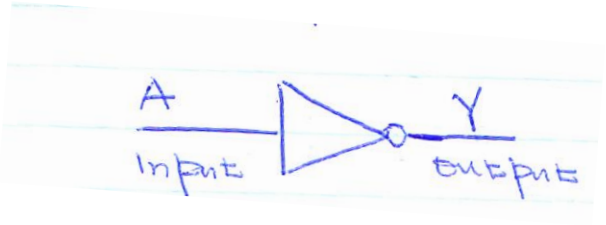
1. NOT gate (Inverter)
2. AND gate
3. NAND / NOT AND gate
4. OR Gate
5. NOR / NOT OR gate

NOT Gate / INVERTER

This is the simplest of all logic gates and has only one input and one output.

It changes a **"1"** input and becomes **"0"** output and a **"0"** input and becomes a **"1"** output

i.e.



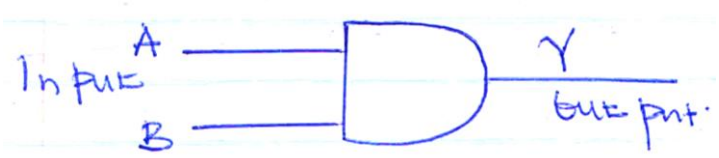
The Boolean expression is $Y=\overline{A}$, read as Y equals NOT A

The truth table of NOT gate is as follows;

INPUT	OUTPUT
A	**$Y=\overline{A}$**
0	1
1	0

AND Gate

- The AND gate can have a number of inputs but only one output.
- For simplicity, we can deal with a two input AND gate.
- An AND gate gives a **"1"** (high output) if all the inputs A and B are both "1" (high input) otherwise the output is "0" (low).

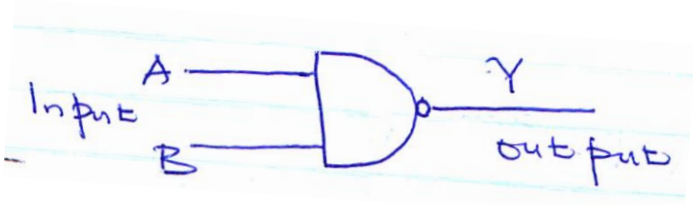


- The Boolean expression of AND gate is Y = A.B
- The truth table of a two input AND gate is as shown below;

INPUT		OUTPUT
A	**B**	**Y = A. B**
0	0	0
0	1	0
1	0	0
1	1	1

NAND (NOT AND GATE)

- The symbol for a NAND gate is the same as for the AND gate but with a small circle at the output.
- This small circle is always taken to indicate a NOT OR INVERTER operation,

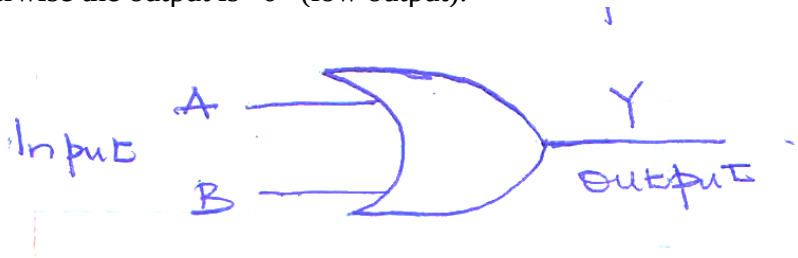


- The Boolean expression of a NAND gate is $Y = \overline{A.B}$.
- The truth table of a two input NAND gate is as shown;

INPUT		OUTPUT
A	**B**	**$Y = \overline{A.B}$**
0	0	1
0	1	1
1	0	1
1	1	0

OR GATE

- An OR gate can have any number of inputs but for simplicity we consider a two input OR gate
- AN OR gate gives an output "1" (high Output) if either input A or B or both are high otherwise the output is "0" (low output).



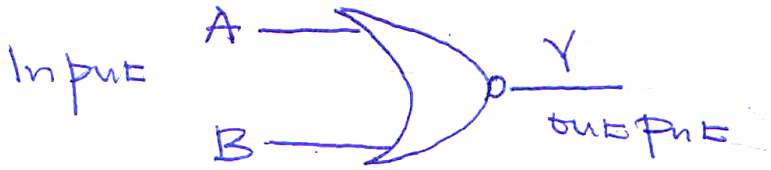
- The Boolean expression of an OR gate is Y = A+B.

Its truth table is as below;

INPUT		OUTPUT
A	**B**	**Y = A + B**
0	0	0
1	0	1
0	1	1
1	1	1

The NOT OR gate (NOT gate)

- A NOR gate is equivalent to an OR gate followed by a NOT gate (INVERTER) that is all the output of the OR gate are inverted.

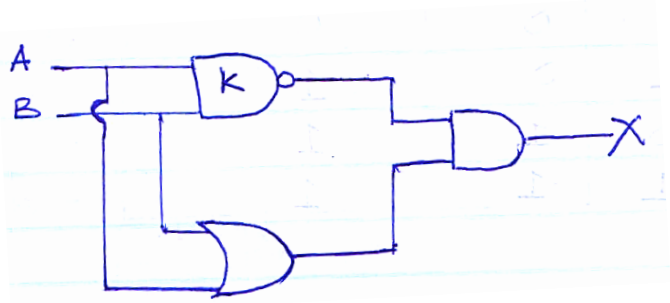


- The Boolean expression of a two input NOR gate is $Y = \overline{A + B}$
- The truth table truth table for a two input NOR gate is as follows

INPUT		OUTPUT
A	**B**	**$Y = \overline{A+B}$**
0	**0**	**1**
0	**1**	**0**
1	**0**	**0**
1	**1**	**0**

Trials

1. The combination of logic gates in the figure below is suggested for use in a certain logic system



i) Name the logic gate K.

ii) Construct the truth table to determine output X.

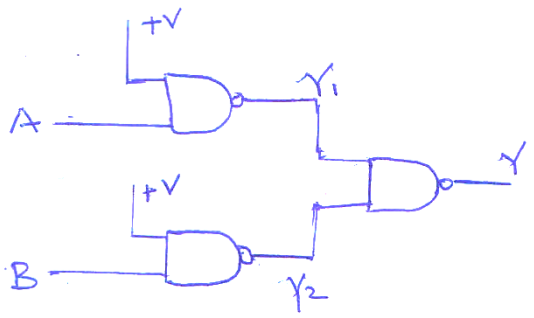
Soln

i) NAND gate

ii)

A	B	$Y_1 = \overline{AB}$	$Y_2 = A+B$	X
0	0	1	0	0
0	1	1	1	1
1	0	1	1	1
1	1	0	1	0

2. Construct the truth table to determine the output in combination of the logic gates below



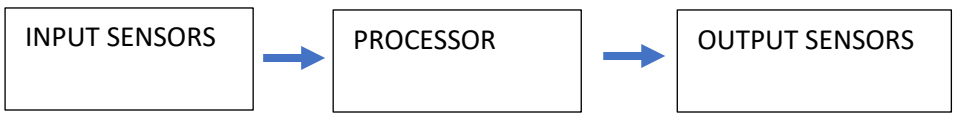
Soln

A	**B**	**$Y_1 = \overline{A}$**	**$Y_2 = \overline{B}$**	**$Y = \overline{AB}$**
0	0	1	1	0
0	1	1	0	1
1	0	0	1	1
1	1	0	0	1

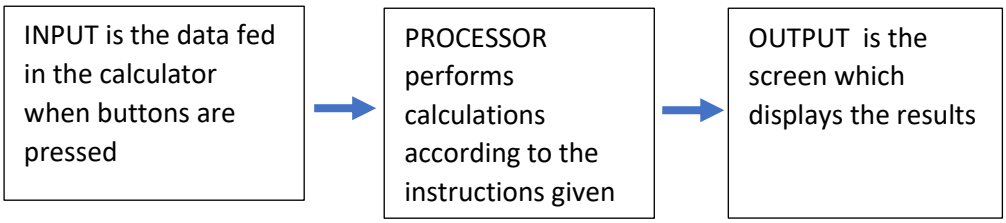
USE OF LOGIC GATES IN CONTROL CIRCUITS

Many electronic systems are designed in three or four parts. These include;

a) The input sensor
b) The processor (electronic system)
c) The memory (absent in some systems)
d) The output (Transducer)

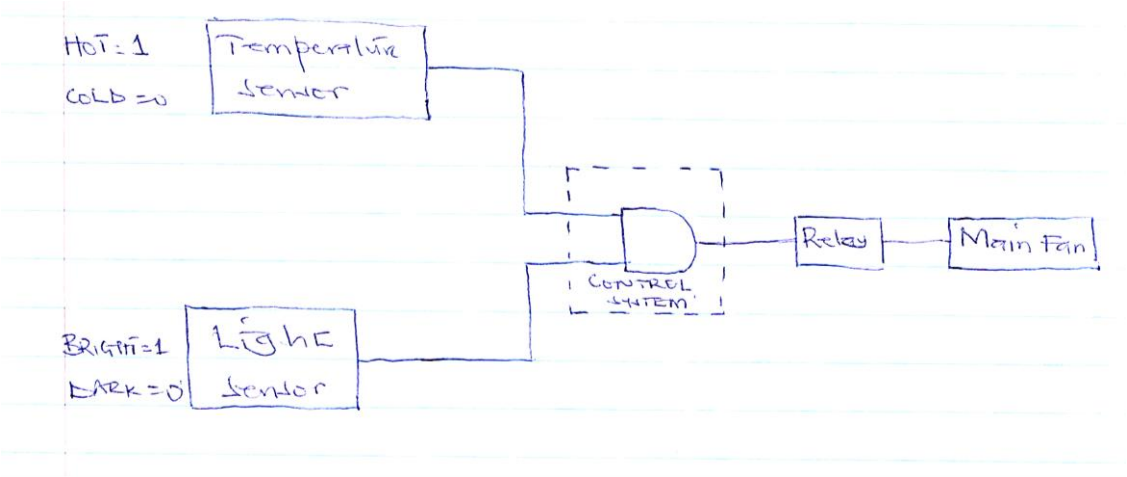


Example is a calculator. If it is considered as an electronic system, we can identify the parts of the calculator as;



Trials

1. The circuit diagram below shows an automatic switch for a fan for cooling in the house



   a) Under what condition does the system turn on the fan?

   b) What is the disadvantage of the switch?

2. Draw the logic circuit for an alarm that will ring if either smoke is detected or a high temperature is detected construct its truth table.
3. Draw a logic circuit which will automatically switch on security lights when it is dark and construct its truth table.
4. A school gate is designed to open automatically when it detects a learner has washed his hands either with sanitizer or soap. Draw a logic circuit you can use to operate the gate. Construct the truth table for the circuit.

STABLE AND BISTABLE SWITCHES

Assignment

1. In your graphs, research and make presentations on how bistable switches can be constructed from two NOR gates.
2. State the applications of stable and bistable switches.