MCSE503P – Computer Architecture and Organization Lab (L53+L54)

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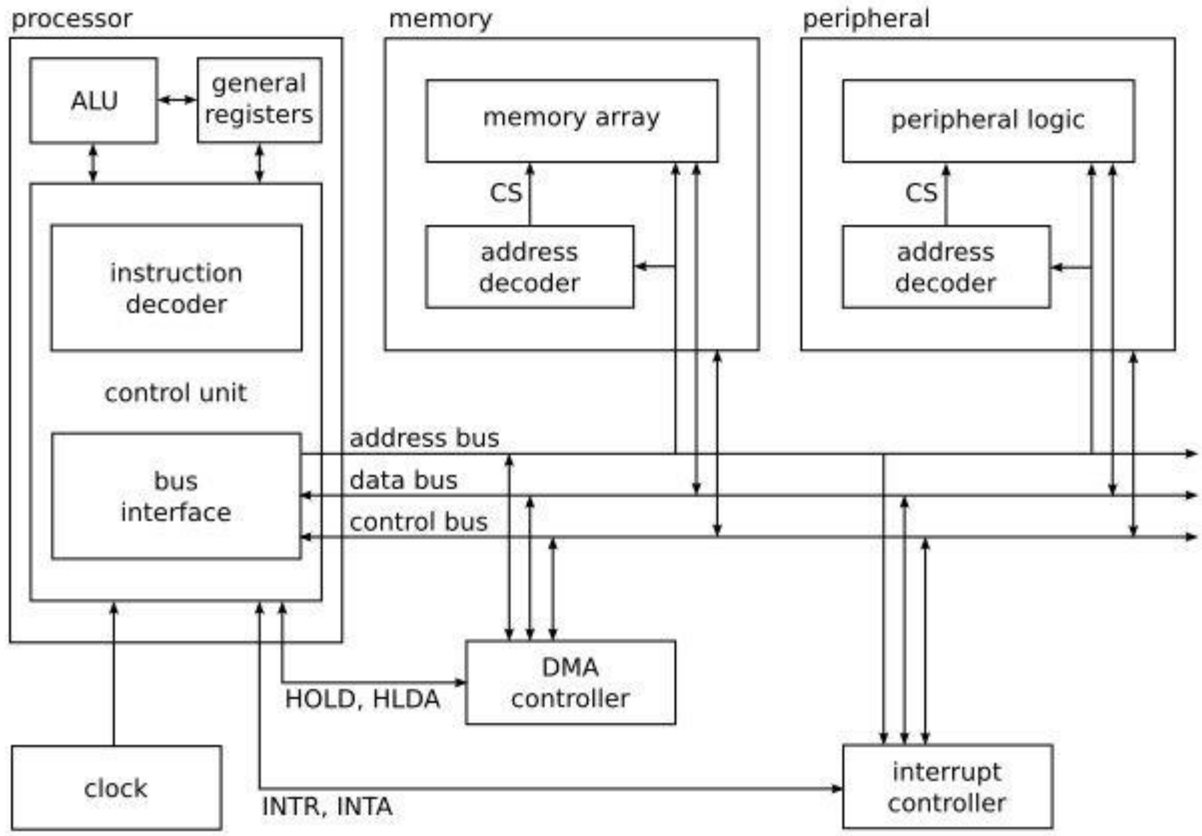
Lab Exercise No: 01

(1) (a) Study about computer system organization and architecture:
Discuss about functional components, types, generations and working aspects with respect to CISC and RISC architecture.

Computer architecture :- Designing computers, data storage devices, and networking hardware is the focus of CA. These devices store and run programmes, convey data, and facilitate interactions between computers, via networks, and with humans. To create extremely performant computing systems, computer architects use parallelism and a variety of memory organising techniques. Given that their primary areas of expertise are hardware design, computer scientists and engineers must work closely together to develop computer architecture. An in-depth understanding of a computer system's core operations, structure, and implementation is provided through the Computer Organization and Architecture Tutorial. Organization, on the other hand, specifies how the system is set up to allow proper use of all the tools that have been catalogued.

Computer Architecture can be divided into mainly three categories, which are as follows –

- Every time a processor receives an instruction, its job is to read it and respond appropriately. This is known as instruction set architecture, or ISA. It acts on memory address mode in addition to allocating memory to instructions (Direct Addressing mode or Indirect Addressing mode).
- Micro Architecture – This explains how a certain processor will process and apply ISA instructions.
- System design – This covers all of the system's hardware, including virtualization and multiprocessing.



The term "computer organisation" refers to the level of abstraction that lies between the operating system level and the level of digital logic. At this level, the main elements are functional units or subsystems that are built from the lower level building blocks that were discussed in the previous module and correspond to particular pieces of hardware.

• The phrase "computer architecture," which is closely related, stresses the engineering choices and trade-offs necessary to create a "good" design. The answer to queries like, "How many registers should there be?" is provided by the computer architect.

What kind of machine instructions are appropriate?

o How ought the cache to be set up?

o What virtual memory hardware support is necessary?

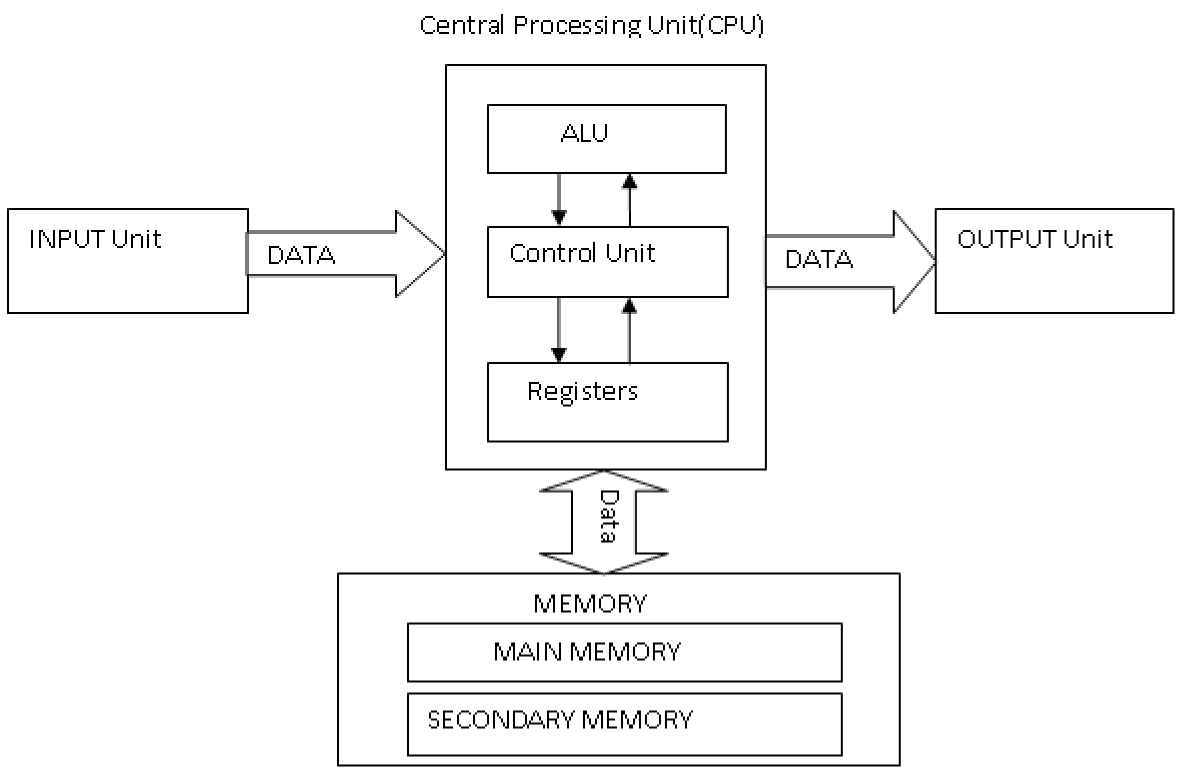
Functional components:-

A computer device is composed of a number of components that aid in its efficient processing and operation. The computer is made up of five fundamental parts that make data processing simple and practical.

Components of a computer system are, by definition, the essential pieces that enable an electronic device to perform more quickly and smoothly. There are five fundamental elements, including:

1. Input Unit
2. Output Unit
3. Central processing unit

3.1. control unit
3.2. Registers
3.3. Arithmetical and Logical Unit
4. Memory unit



1. Input unit

A computer device is composed of a number of components that aid in its efficient processing and operation. The computer is made up of five fundamental parts that make data processing simple and practical.Components of a computer system are, by definition, the essential pieces that enable an electronic device to perform more quickly and smoothly. There are five fundamental elements, including:

2. Output Unit

When we tell a computer to do anything, it responds by going back and giving us the outcome. Output is the name of this outcome. The computer is connected to a variety of output devices. A monitor is among the most elementary. Everything that we type on the keyboard or click with the mouse is seen on the monitor. Thus, after all processing is completed inside a device's mechanism, the output unit provides us with the final outcome.

3. Memory Unit

Utilizing an input device, we can enter data into a computer, which is instantaneously saved in the memory of the central processing unit (CPU). Due to some pre-existing code, the Memory Unit sends the information on to the other CPU components.Similar to this, before the output is given to the user after the computer has processed our command, it is saved in the memory unit.

4. Central Processing Unit (CPU)

The Central Processing Unit is the core of any computer devices. It comprises three major components of the computer which have been discussed above:

- Memory Unit
- Control Unit
- Arithmetic and Logical Unit

Control Unit

This is the central component that controls how the computer system operates as a whole. One of the most important parts of the computer system, it. The data entered through the input unit is collected by the control unit, which then sends it for processing, receives the result, and displays it to the user. It can be referred to as the hub of all processing operations occurring within a computer device.In essence, the Control Unit handles all of the instructions received, data interpretation, signalling for data execution, and data retrieval.

Arithmetic & Logical Unit

The CPU's Arithmetic and Logical Unit performs all mathematical calculations and arithmetic operations, as the name implies. It can also carry out tasks like data comparison and decision-making. The ALU consists of circuits that can be used to do computations based on addition, subtraction, multiplication, division, and other numerical operations.

Types of Computers There are five types of computers: ¬

Supercomputers: Supercomputers are built to process enormous amounts of data, such as billions of instructions or pieces of data in a single second. It mostly has uses in engineering and science, including forecasting the weather, doing simulations, and studying nuclear energy.

Mainframe computer: Mainframe computers are made to serve hundreds or thousands of concurrent users. Due to all of these features, the mainframe computer is perfect for large businesses processing a lot of data, such as those in the banking and telecom industries.Minicomputer-

Minicomputer is a medium size multiprocessing computer. In this type of computer, there are two or more processors, and it supports 4 to 200 users at one time. Minicomputers are used in places like institutes or departments for different work like billing, accounting, inventory management etc.

Workstation- Workstation is designed for technical or scientific applications. It consists of a fast microprocessor, with a large amount of RAM and high-speed graphic adapter. It is a single-user computer. It generally used to perform a specific task with great accuracy.

PC (Personal Computer)-

It is also known as a microcomputer. It is basically a generalpurpose computer and designed for individual use. It consists of a microprocessor as a central processing unit (CPU), memory, input unit, and output unit.

Generations of Modern Computers

Computer generation means a step of advancement in technology. It also reflects the growth of computer industry. The advancement in technology existed not only in hardware but also in software.

- First Generation Computers(1945-1956)
- Second Generation Computers(1956-1963)
- Third Generation Computers(1964-1971)
- Fourth Generation Computers(1971-Present)
- Fifth Generation Computers(Present and Beyond)

The government worked to build computers during World War II in order to take advantage of their potential strategic relevance. By 1944, an IBM engineer from Harvard had created an entirely electronic calculator. It was an electrical relay computer known as "Mark I." John Presper Eckert and John W. Mauchly created the first entirely electronic computer, the "Electronic Numerical Integrator and Calculator" (ENIAC), in 1945. This all-purpose computer was 1,000 times quicker than MARK I. The "Electronic Discrete Variable Automatic Computer" (EDVAC), created by John Von Neumann in 1945, has a memory that can store both data and a stored programme. Both the "conditional control transfer" and the stored memory technology (stored programme notion) permitted the computer to be halted and then resumed at any time. In 1950,

i. First Generation Computers(1945-1956):

1. Vacuum tubes for internal operations. (Heat and reliability problems)
2. Magnetic drums were used for memory.
3. Punched cards were used for input and output.
4. Low level languages for programming were used.
5. Processing speed was very slow.
6. It was very expensive.
7. The system was not very powerful.
8. The system was huge and non portable.
9. It did not have much memory.

ii. Second Generation Computers(1956-1963)

The important features of second generation systems are:

1. The period 1956 to 1963 is roughly considered as the period of Second Generation of Computers.

2. The second generation computers were developed by using transistor technology. They are used for internal operations.
3. Magnetic tapes and disks were used for secondary memory.
4. High level languages were used for developing programs. Such as COBOL (Common Business Oriented Language) and FORTRAN (FORmula TRANslation)
5. The systems were faster, more powerful, more reliable, cheaper, and smaller in overall size and had more memory.

iii. Third Generation Computers (1964-1971)

- The important features of third generation systems are:
- Integrated circuits on silicon chips were used for internal operations.
- Minicomputers were introduced.
- Saw the emergence of the software industry.
- The computers were able to reduce computational time.
- Maintenance cost was low as hardware failures were rare.
- Systems were totally general purpose and could be used for a number of commercial applications.
- The systems were faster, more powerful, more reliable, cheaper, smaller in overall size and had more memory.

iv. Fourth Generation Computers(1971-Present)

- The important features of fourth generation systems are:
- More circuits on chips LSI, VLSI
- Introduction to microprocessors.
- Microcomputers and personal computers which were affordable was available to the common man.
- Use of chips for memory.
- The cost of assembling reduced to a great extent.
- Easily portable because of their small size.
- Hardware failures are negligible.
- The systems were faster, more powerful, more reliable, cheaper, smaller in over all size and had more memory.

v. Fifth Generation Computers(Present-Beyond)

The important features of fifth generation systems are:

- Development of storage technology. Advancement in networking technology, Systems are more reliable, faster and cheap.

- Development of supercomputers.
- Concepts of parallel processing in computers.
- Computers are more intelligent.
- Development of robots to assist human beings.Ex: PARAM- 10,000, CRAY Machines.

RISC and CISC

Reduced Instruction Set Computer or RISC Architecture

The fundamental goal of RISC is to make hardware simpler by employing an instruction set that consists of only a few basic steps used for evaluating, loading, and storing operations.

A load command loads data but a store command stores data. RAMPAM AKARSHA 22MAI0018

It reduces the cycles per instruction and does so at the cost of the total number of instructions per program.

Characteristics of RISC:

1. It has simpler instructions and thus simple instruction decoding.
2. More general-purpose registers.
3. The instruction takes one clock cycle in order to get executed.
4. The instruction comes under the size of a single word.
5. Pipeline can be easily achieved.
6. Few data types.
7. Simpler addressing modes.

Complex Instruction Set Computer or CISC Architecture

The fundamental goal of CISC is that a single instruction will handle all evaluating, loading, and storing operations, similar to how a multiplication command will handle evaluating, loading, and storing data, which is why it’s complicated. This kind of approach tries to minimize the total number of instructions per program, and it does so at the cost of increasing the total number of cycles per instruction.

Characteristics of CISC:

1. Instructions are complex, and thus it has complex instruction decoding.
2. The instructions may take more than one clock cycle in order to get executed.
3. The instruction is larger than one-word size.
4. Lesser general-purpose registers since the operations get performed only in the memory.
5. More data types.
6. Complex addressing modes.

B. Study and implement the following using Logisim simulator: (logic diagram / truth table / Boolean expression)

i. Basic and universal gates

ii. De Morgan's theorem, associative law and distributive law

iii. Adder and subtractor circuit

iv. Boolean expression implementation as follows,

a. F1 = AB + CD

b. F2 = A'BC + C'B +ABC

c. F3 = AB' + BC'

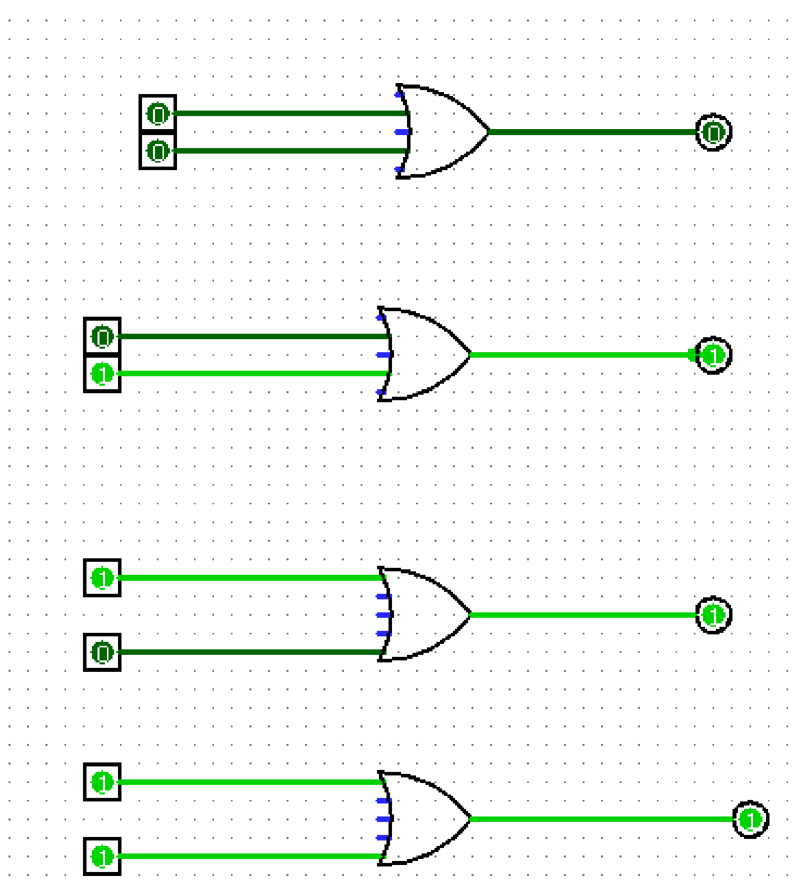
i. Basic and universal gates

a) OR GATE

1. Boolean expression

A+B =C

2. Logic diagram



3. Truth table

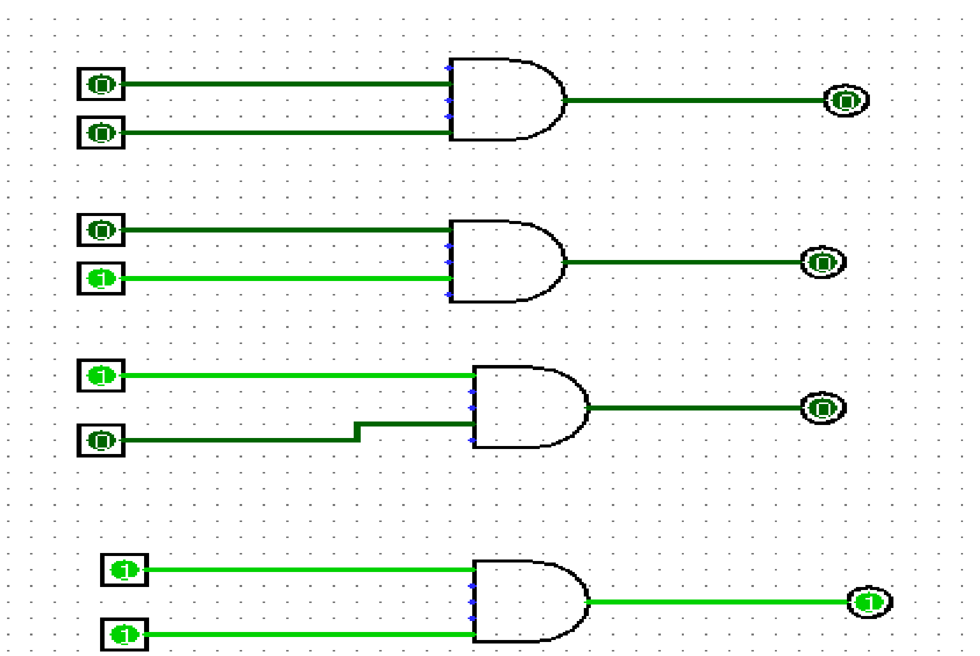
A	B	C
0	0	0
0	1	1
1	0	1
1	1	1

b) AND GATE

1.Boolean expression

A .B = C

2. Logic diagram



3. Truth table

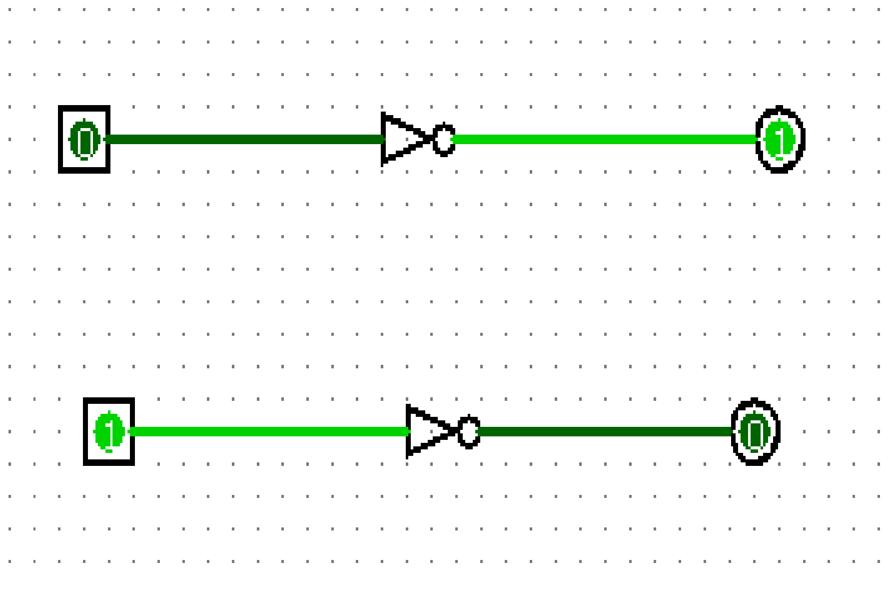
c) NOT

1. Boolean expression

A=A'

2. Logic diagram

A	B	C
0	0	0
0	1	0
1	0	0
1	1	1



3. Truth table

A	A’
1	0
0	1

2.Universal gates

A. NAND Gate
B. NOR Gate

NAND Gate :-

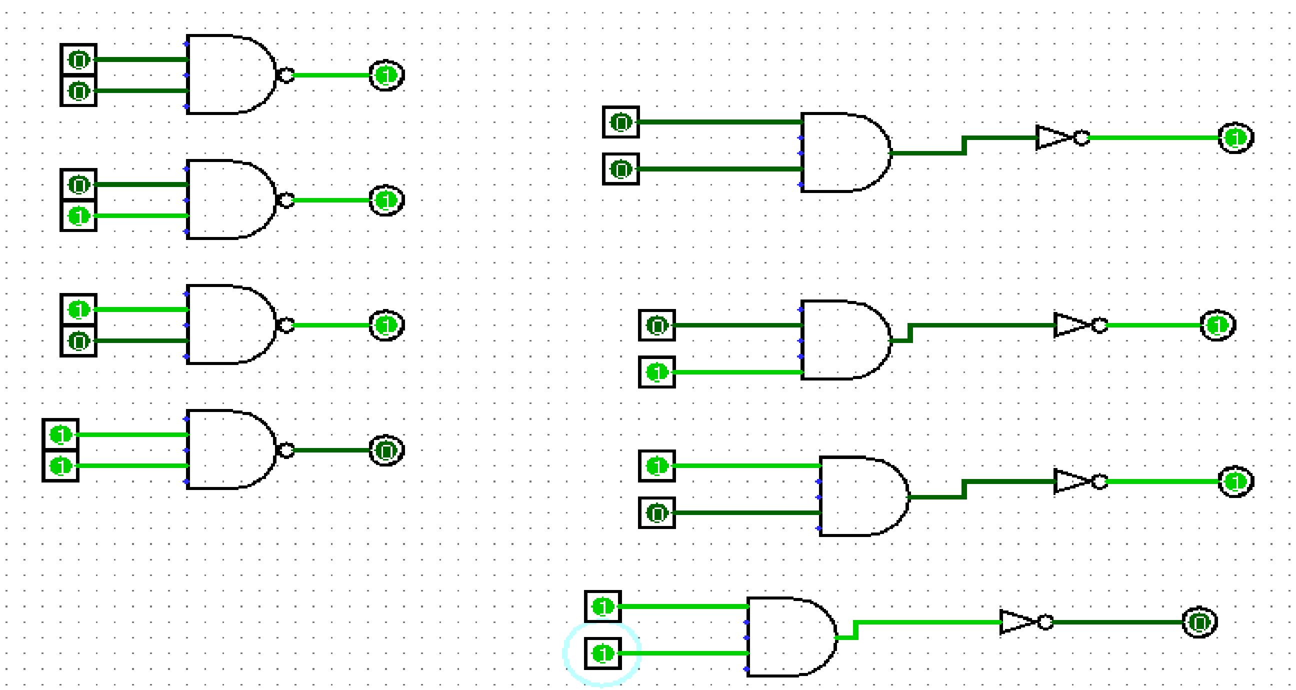
1. Boolean expression

Y=(A.B)’ = A’ +B’

2. Truth table

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

3. Logic diagram

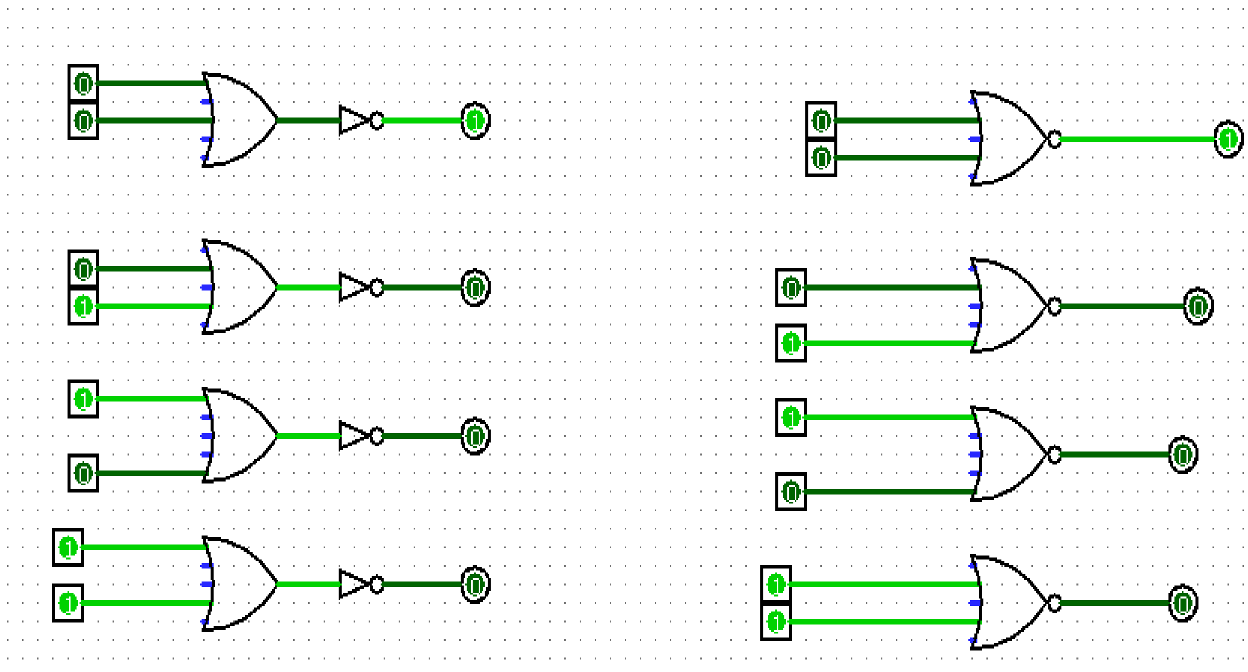


NOR Gate :-

1. Boolean expression

Y =(A +B)’ = A’.B’

2. Logic diagram



3. Truth table

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

ii. De Morgan's theorem, associative law and distributive law

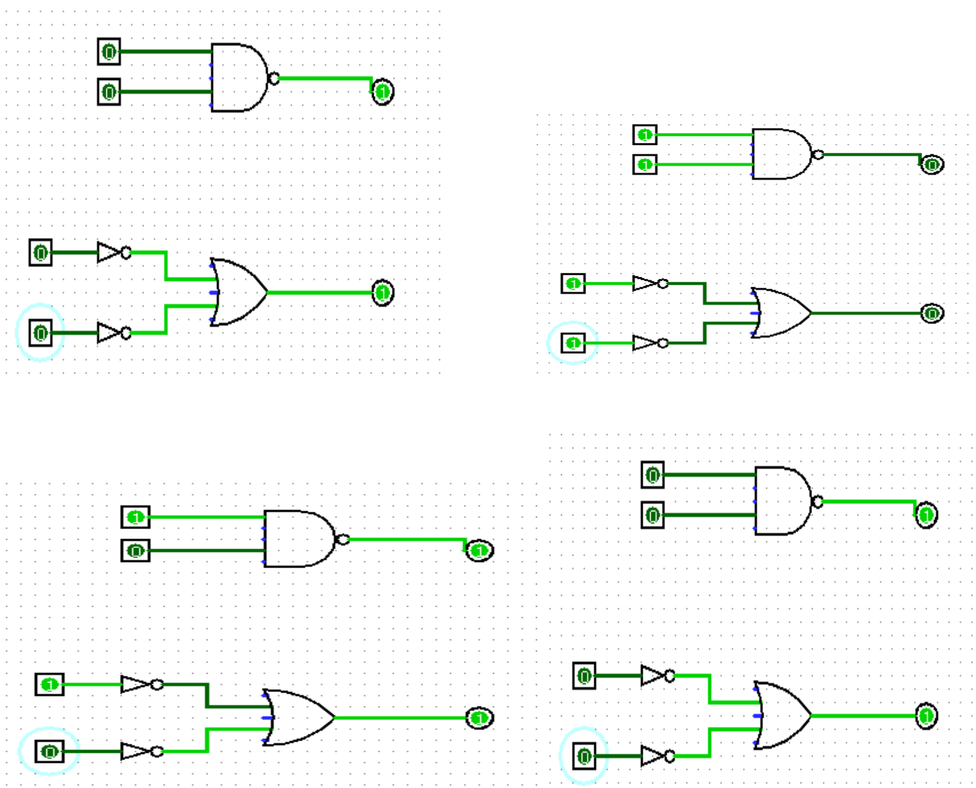
i) **De Morgan's theorem**
  (1) De Morgan's Theorem1
  (2) De Morgan's Theorem 2

De Morgan's Theorem1

Y=(A.B)’ =A’ +B’

Truth table

A	B	(A+B)’	A’	B’	A’+B’
0	0	1	1	1	1
0	1	1	1	0	1
1	0	1	0	1	1
1	1	0	0	0	0



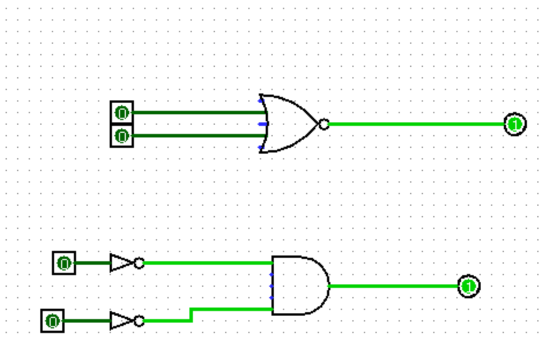
De Morgan’s Theorem 2

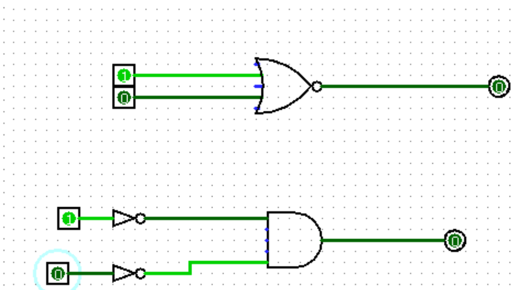
Y=(A+B)’ =A’.B’

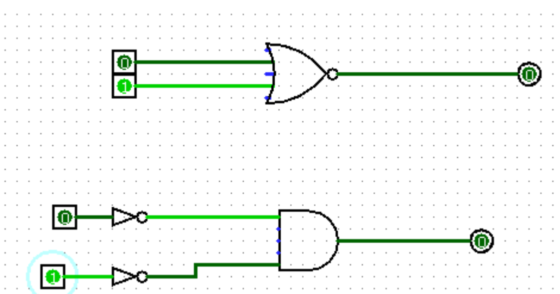
Truth table

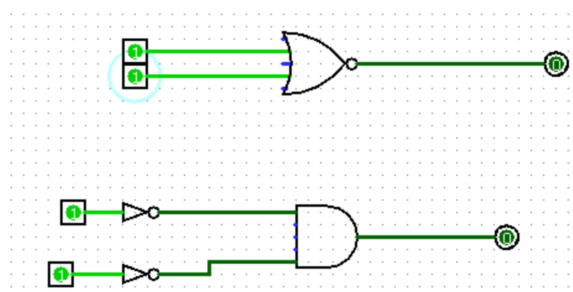
A	B	(A+B)’	A’	B’	A’.B’
0	0	1	1	1	1
0	1	0	1	0	0

1	**0**	**0**	**0**	**1**	**0**
1	**1**	**0**	**0**	**0**	**0**

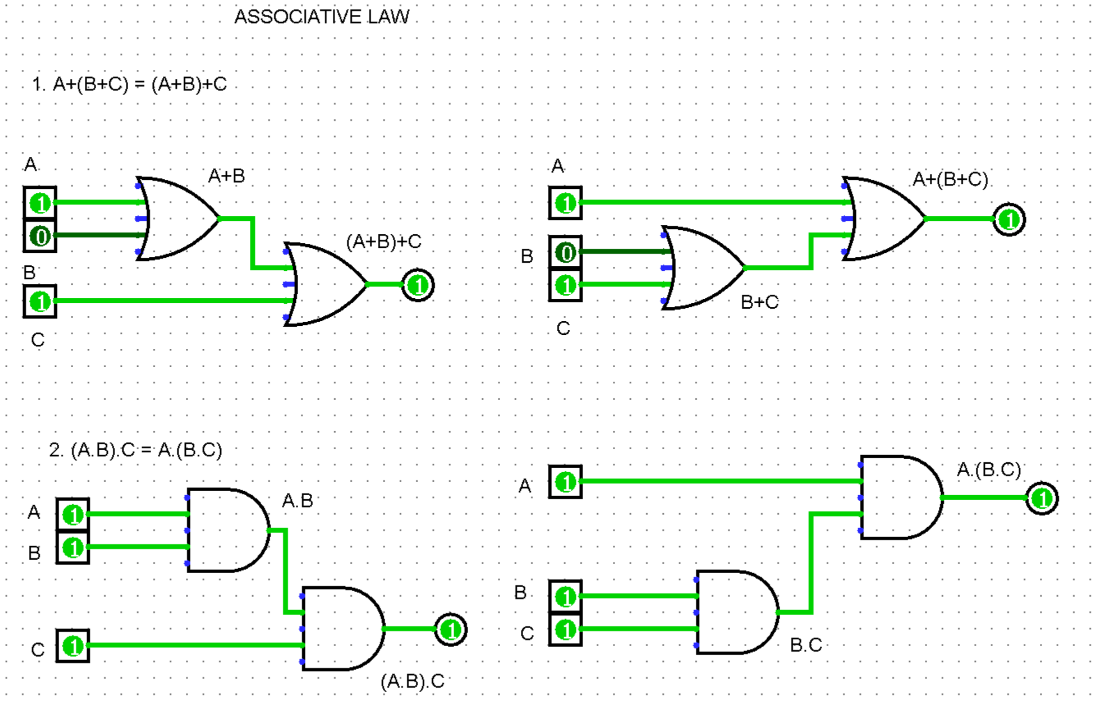




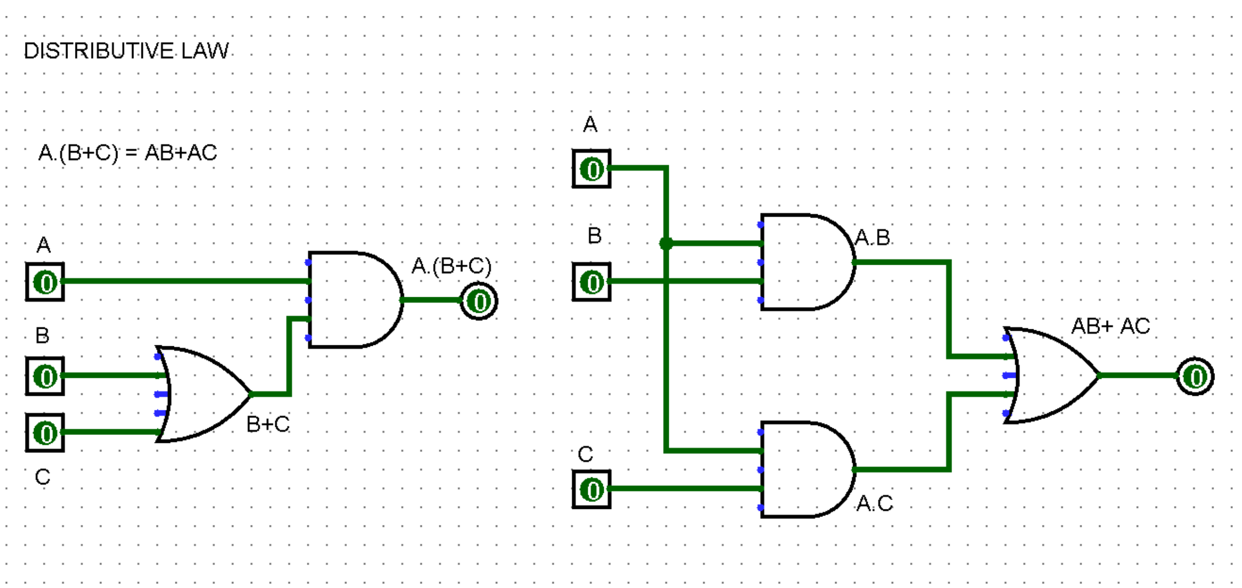




Associative Law

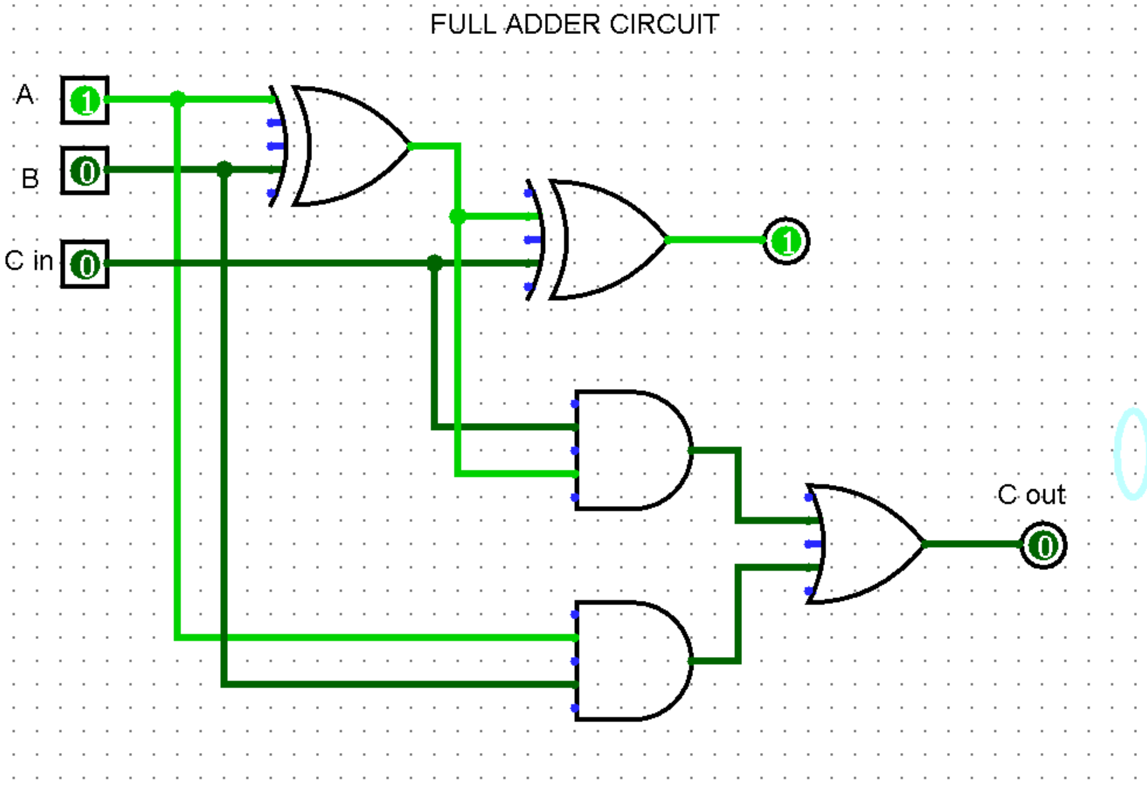


Distributive Law



iii. Adder and Subractor Circuit

Adder Circuit


FULL ADDER CIRCUIT
A
1
B
0
C in
0
1
C out
0

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Truth Table

INPUTS			OUTPUTS	
A	B	C in	Sum	C out
0	0	0	0	0
0	0	1	0	1
0	1	0	0	1
0	1	1	1	0
1	0	0	0	1
1	0	1	1	0
1	1	0	1	0
1	1	1	1	1

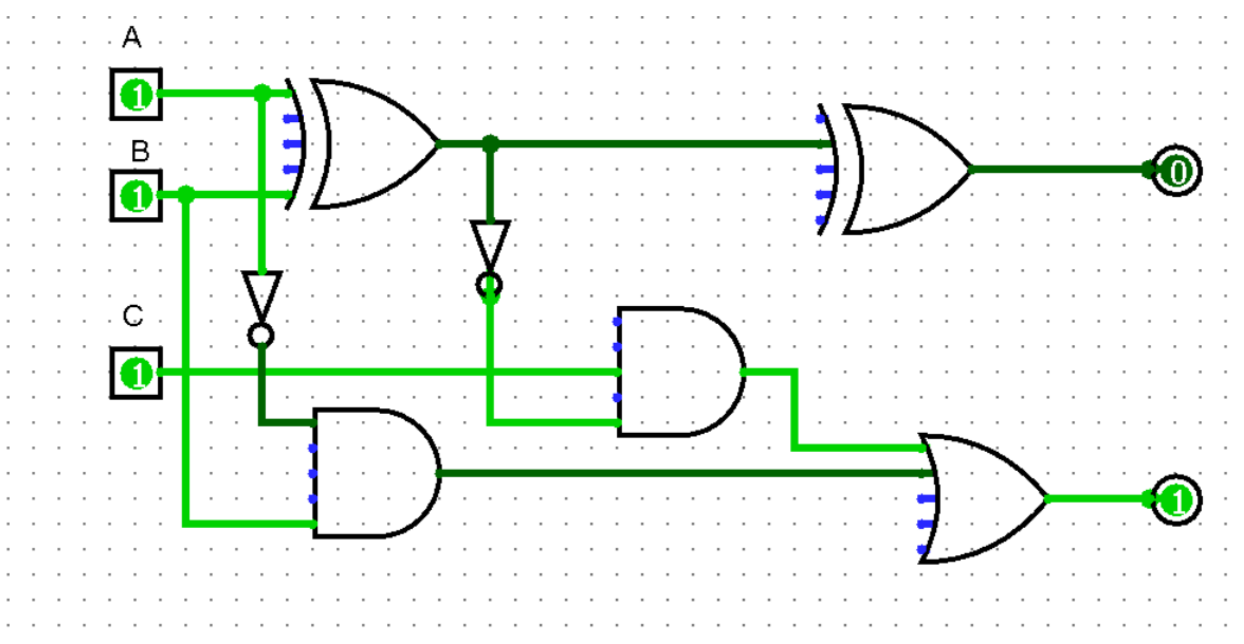
Then the Boolean expression for a full adder is as follows. For the SUM (S) bit:

SUM = (A XOR B) XOR Cin = $(A \oplus B) \oplus Cin$

For the CARRY-OUT (Cout) bit:

CARRY-OUT = A AND B OR Cin(A XOR B) = $A.B + Cin(A \oplus B)$

Subtractor



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Logical expression for difference –

D = A’B’Bin + A’BBin’ + AB’Bin’ + ABBin
= Bin XOR (A XOR B)
= (A XOR B) XOR Bin

Logical expression for borrow –

Bout = A’B’Bin + A’BBin’ + A’BBin + ABBin
= A’Bin + A’B + BBin

Truth Table

INPUTS			OUTPUTS	
A	B	BORROWin	Subractor	BORROWout
0	0	0	0	0
0	0	1	1	1
0	1	0	1	1
0	1	1	0	1
1	0	0	1	0
1	0	1	0	0
1	1	0	0	0
1	1	1	1	1

Boolean expression implementation as follows,
F1 = AB + CD
F2 = A’BC + C’B +ABC
F3 = AB’ + BC’ + CA’

F1 = AB + CD

A	B	C	D	AB	CD	F1
0	0	0	0	0	0	0
0	0	0	1	0	0	0
0	0	1	0	0	0	0
0	0	1	1	0	0	0
0	1	0	0	0	0	0
0	1	0	1	0	0	0
0	1	1	0	0	0	0
0	1	1	1	0	1	1
1	0	0	0	0	0	0
1	0	0	1	0	0	0
1	0	1	0	0	0	0
1	0	1	1	0	0	1
1	1	0	0	1	0	1

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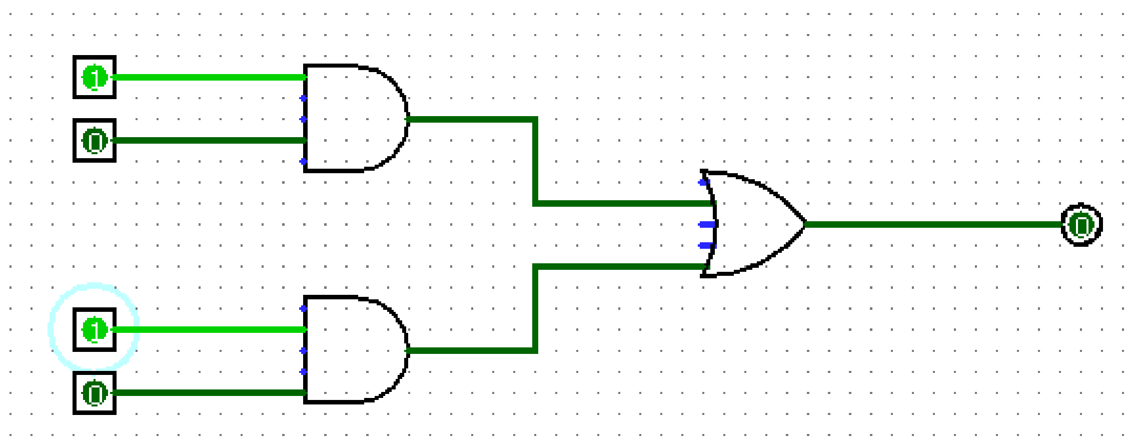
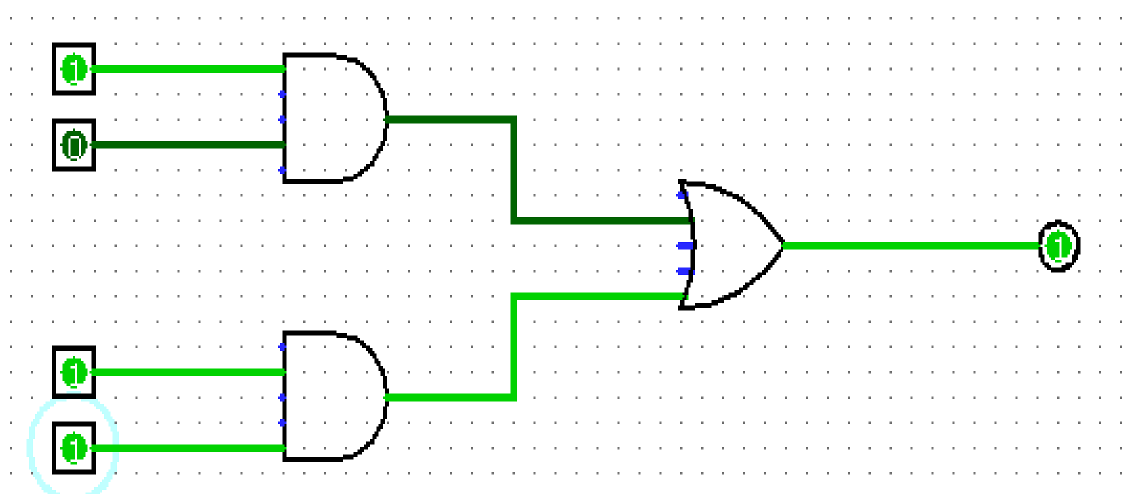
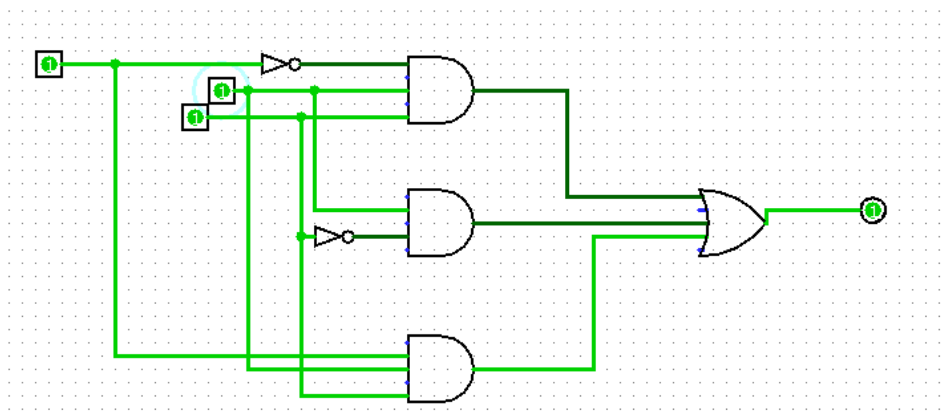
1	1	0	1	1	0	1
1	1	1	0	1	0	1
1	1	1	1	1	1	1





F2 = A'BC + C'B +ABC



F3 = AB' + BC' + CA'