EXPERIMENT - 5

Switching Theory and Logic Design (STLD)

Aim

To realize the circuit for Half Subtractor and Full Subtractor using logic gates.

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AIM:

To realize the circuit for Half Subtractor and Full Subtractor using logic gates.

Hardware and Software Apparatus Required

Hardware:

- Power supply, Bread Board, Connecting Wires, respective IC, LED, Wire Cutter.
- Circuit is designed on bread board using Integrated Chips (ICs), Voltage supply and LEDS.
- The set-up of apparatus and working of the circuit were demonstrated via recorded videos.

Software Simulation:

The schematic models of the desired circuits will be stimulated on MULTISIM (Free Software), easily accessible at www.multisim.com.

Components used – Source (Clock Voltage), Passive elements (resistor), Digital components (AND, OR, NAND, NOR, XOR, XNOR, Inverter), Probe for Analysis and annotation (Digital), Schematic connectors (Ground)

Theory:

subtractor is an electronic logic circuit for calculating the difference between two binary numbers, the minuend and the number to be subtracted, the subtrahend (see table). A full subtractor performs this calculation with three inputs: minuend bit, subtrahend bit, and borrow bit.

Half Subtractor

Half subtractor is the most essential combinational logic circuit which is used in digital electronics. Basically, this is an electronic device or in other terms, we can say it as a logic circuit. Half subtractor is used to perform two binary digits subtraction. In the previous article, we have already discussed the concepts of half adder and a full adder circuit which uses the binary numbers for the calculation. Similarly, the subtractor circuit uses binary numbers (0,1) for the subtraction. The circuit of the half subtractor can be built with two logic gates namely NAND and EX-OR gates. This circuit gives two elements such as the difference as well as the borrow.

As in binary subtraction, the major digit is 1, we can generate borrow while the subtrahend 1 is superior to minuend 0 and due to this, borrow will need. The following example gives the binary subtraction of two binary bits.

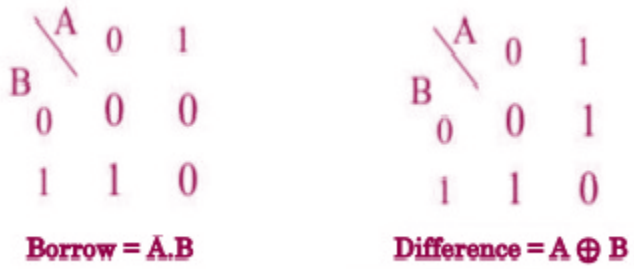
First Digit	Second Digit	Difference	Borrow
0	0	0	0
1	0	1	0
0	1	1	1
1	1	0	0

In the above subtraction, the two digits can be represented with A and B. These two digits can be subtracted and gives the resultant bits as difference and borrow.

When we observe the first two and fourth rows, the difference between these rows, then the difference and borrow are similar because the subtrahend is lesser than the minuend. Similarly, when we observe the third row, the minuend value is subtracted from the subtrahend. So the difference and borrow bits are 1 because the subtrahend digit is superior to the minuend digit.

Half subtractor is an essential tool for any kind of digital circuit to know the possible combinations of inputs and outputs. For instance, if the subtractor has two inputs then the resultant outputs will be four. The o/p of the half subtractor is mentioned in the below table that will signify the difference bit as well as borrow bit. The half subtractor truth table explanation can be done by using the logic gates like EX-OR logic gate and AND gate operation followed by NOT gate.

Solving the truth table using **K-Map** is shown below.



half subtractor k map

The Boolean expression of the half subtractor using truth table and K-map can be derived as

Difference **(D) = (**x'y **+** xy**')**

= **x ⊕ y**

Borrow (B) = x'y

Half-Subtractor Block Diagram

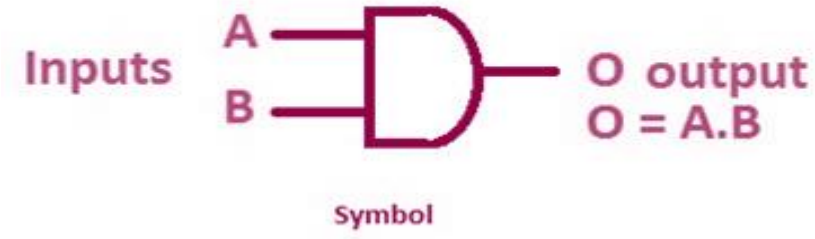
The block diagram of the half subtractor is shown above. It requires two inputs as well as gives two outputs. Here inputs are represented with A&B, and outputs are Difference and Borrow.

The above circuit can be designed with EX-OR & NAND gates. Here, the NAND gate can be build by using AND and NOT gates. So we require three logic gates for making half a subtractor circuit namely the EX-OR gate, NOT gate, and NAND gate.

A combination of AND and NOT gate produce a different combined gate named NAND Gate. The Ex-OR gate output will be the Difference bit and the NAND Gate output will be the Borrow bit for the same inputs A&B.

AND-Gate

The AND-gate is one type of digital logic gate with multiple inputs and a single output and based on the inputs combinations it will perform the logical conjunction. When all the inputs of this gate are high, then the output will be high otherwise the output will be low. The logic diagram of AND gate with truth table is shown below.



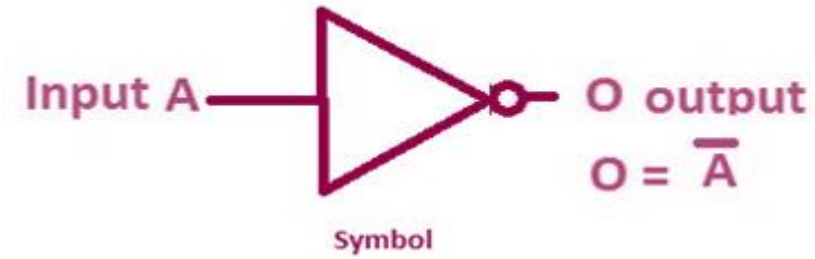
Symbol

Inputs		Output
A	B	O
0	0	0
0	1	0
1	0	0
1	1	1

Truth table

NOT Gate

The NOT-gate is one type of digital logic gate with a single input and based on the input the output will be reversed. For instance, when the input of the NOT gate is high then the output will be low. The logic diagram of NOT-gate with truth table is shown below. By using this type of logic gate, we can execute NAND and NOR gates.



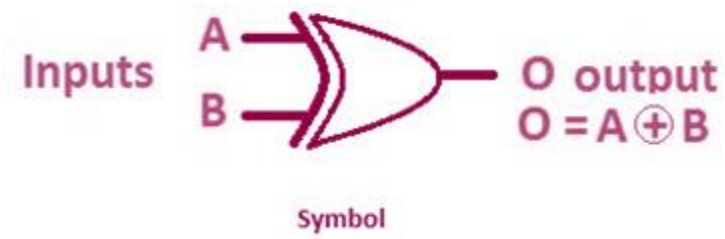
Symbol

Inputs	Output
A	O
0	1
1	0

Truth table

Ex-OR Gate

The Exclusive-OR or EX-OR gate is one type of digital logic gate with 2-inputs & single output. The working of this logic gate depends on OR gate. If any one of the inputs of this gate is high, then the output of the EX-OR gate will be high. The symbol and truth table of the EX-OR are shown below.



Symbol

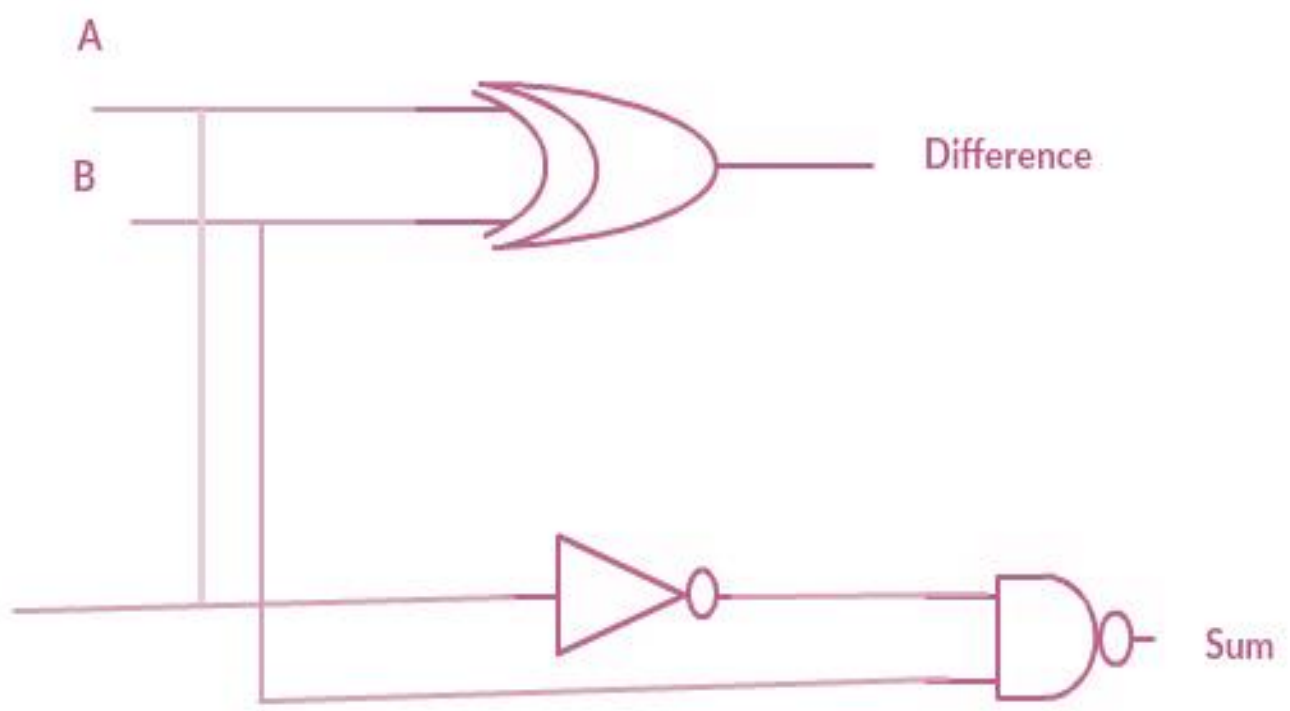
Inputs		Output
A	B	O
0	0	0
0	1	1
1	0	1
1	1	0

Truth table

EXOR Gate and its Truth Table

Half Subtractor Circuit using Nand Gate

The designing of half subtractor can be done by using logic gates like NAND gate & Ex-OR gate. In order to design this half subtractor circuit, we have to know the two concepts namely difference and borrow.



Half Subtractor Circuit using Nand Gate

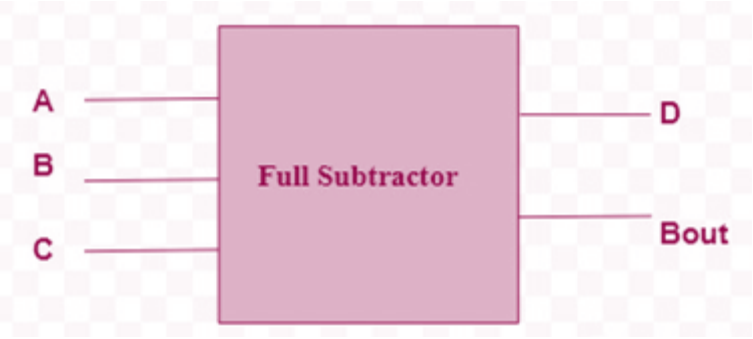
If we monitor cautiously, it is fairly clear that the variety of operation executed by this circuit which is accurately related to the EX-OR gate operation. Therefore, we can simply use the EX-OR gate for making difference. In the same way, the borrow produced by half adder circuit can be simply attained by using the blend of logic gates like AND- gate and NOT-gate.

Truth Table

First Bit	Second Bit	Difference (EX-OR Out)	Borrow (NAND Out)
0	0	0	0
1	0	1	0
0	1	1	1
1	1	0	0

Full Subtractor

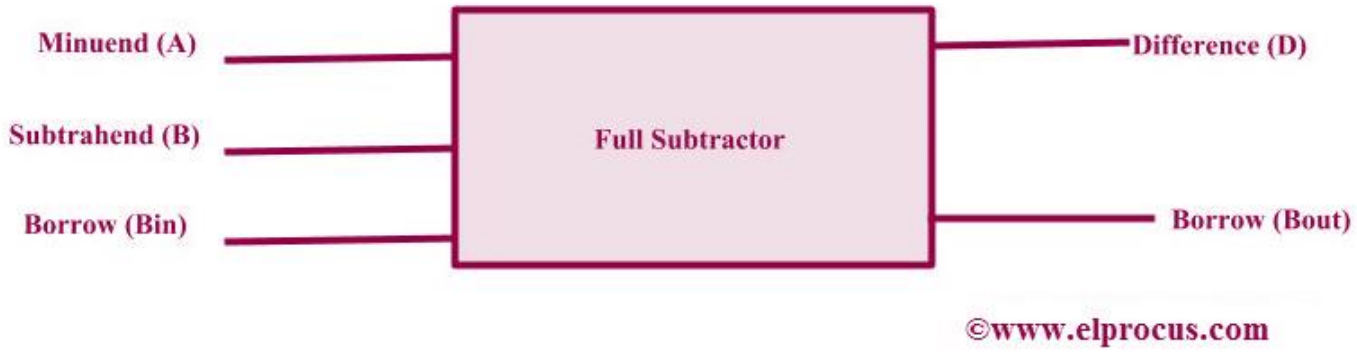
Full subtractor is an electronic device or logic circuit which performs subtraction of two binary digits. It is a combinational logic circuit used in digital electronics. Many combinational circuits are available in integrated circuit technology namely adders, encoders, decoders and multiplexers. In this article, we are going to discuss full subtractor construction using half subtractor and also the terms like truth table.



A full subtractor is formed by two half subtractors, which involves three inputs such as minuend, subtrahend and borrow, borrow bit among the inputs is obtained from subtraction of two binary digits and is subtracted from next higher order pair of bits, outputs as difference and borrow.

Full Subtractor Block Diagram

The foremost disadvantage of the half subtractor is, we cannot make a Borrow bit in this subtractor. Whereas in full subtractor design, actually we can make a Borrow bit in the circuit & can subtract with remaining two i/ps. Here A is minuend, B is subtrahend & Bin is borrow in. The outputs are Difference (Diff) & Bout (Borrow out). The complete subtractor circuit can obtain by using two half subtractors with an extra OR gate.



Full Subtractor Circuit Diagram with Logic Gates

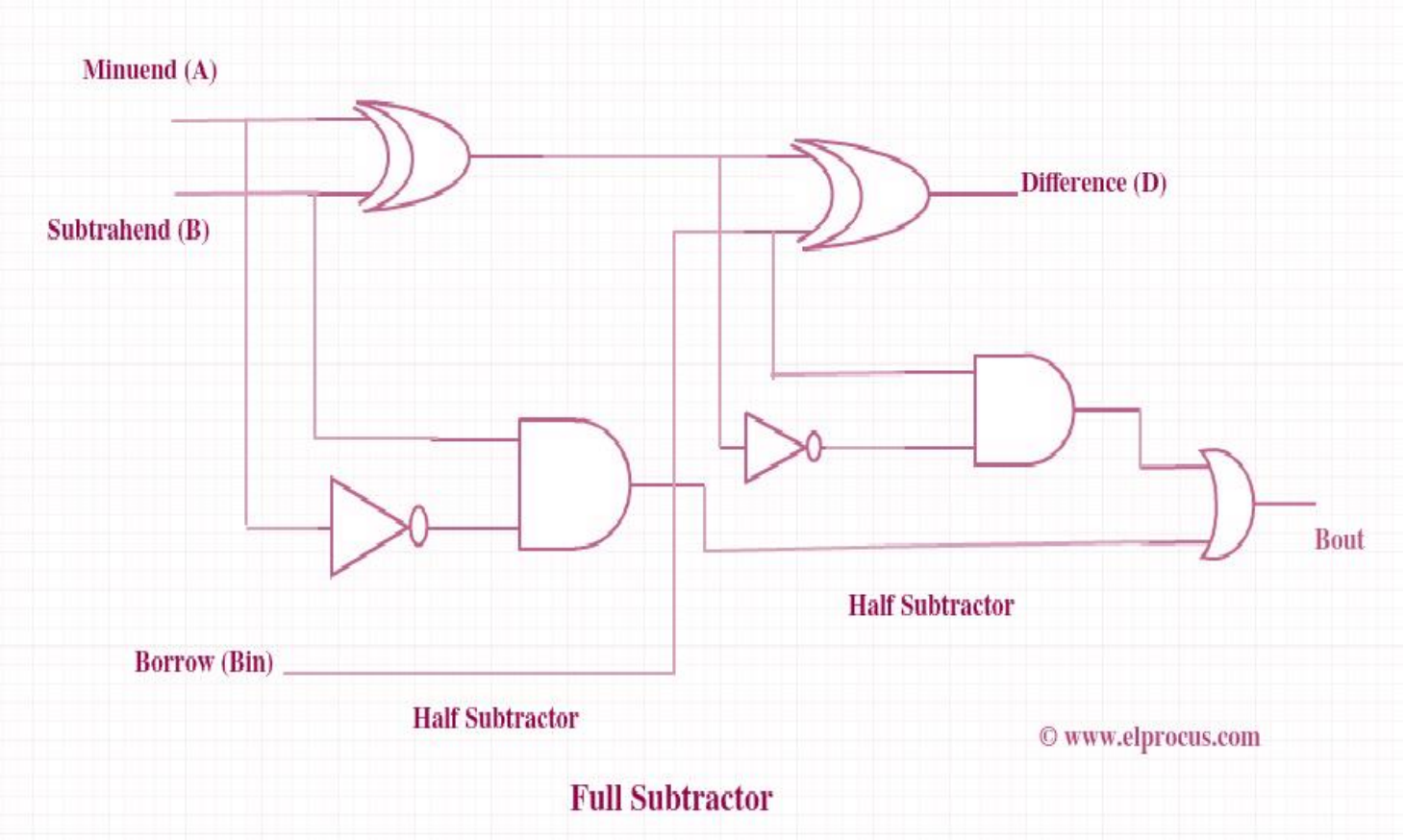
The circuit diagram of full subtractor using basic gates is shown in the following block diagram. This circuit can be done with two half-Subtractor circuits.

In the initial half-Subtractor circuit, the binary inputs are A and B. As we have discussed in the previous half-Subtractor article, it will generate two outputs namely difference (Diff) & Borrow.

The difference o/p of the left subtractor is given to the Left half-Subtractor circuit's. Diff output is further provided to the input of the right half Subtractor circuit. We offered the Borrow in bit across the other i/p of next half subtractor circuit. Once more it will give Diff out as well as Borrow out the bit. The final output of this subtractor is Diff output.

On the other hand, the Borrow out of both the half Subtractor circuits is connected to OR logic gate. Later than giving out OR logic for two output bits of the subtractor, we acquire the final Borrow out of the subtractor. The last Borrow out to signify the MSB (a most significant bit).

If we observe the internal circuit of the full Subtractor, we can see two Half Subtractors with NAND gate and XOR gate with an extra OR gate.



Full Subtractor using Logic Gates

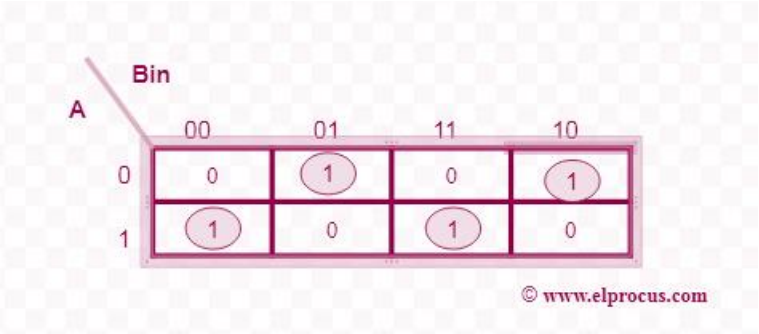
Full Subtractor Truth Table

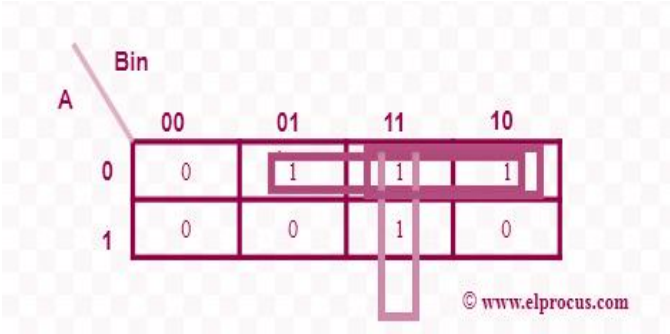
This subtractor circuit executes a subtraction between two bits, which has 3- inputs (A, B and Bin) and two outputs (D and Bout). Here the inputs indicate minuend, subtrahend, & previous borrow, whereas the two outputs are denoted as borrow o/p and difference. The following image shows the truth table of full-subtractor.

Inputs			Outputs	
Minuend (A)	**Subtrahend (B)**	**Borrow (Bin)**	**Difference (D)**	**Borrow (Bout)**
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

Full Subtractor K-Map

The simplification of the K-map for the above difference and borrow is shown below.





The full subtractor equations for the difference as well as Bin are mentioned below.

The full subtractor expression for Difference is,

D = A'B'Bin + AB'Bin'+ A'BBin' + ABBin

The full-subtractor expression for Borrow is,

Bout = A'Bin + A'B + BBin

Applications of Full Subtractor

Some of the applications of full-subtractor include the following

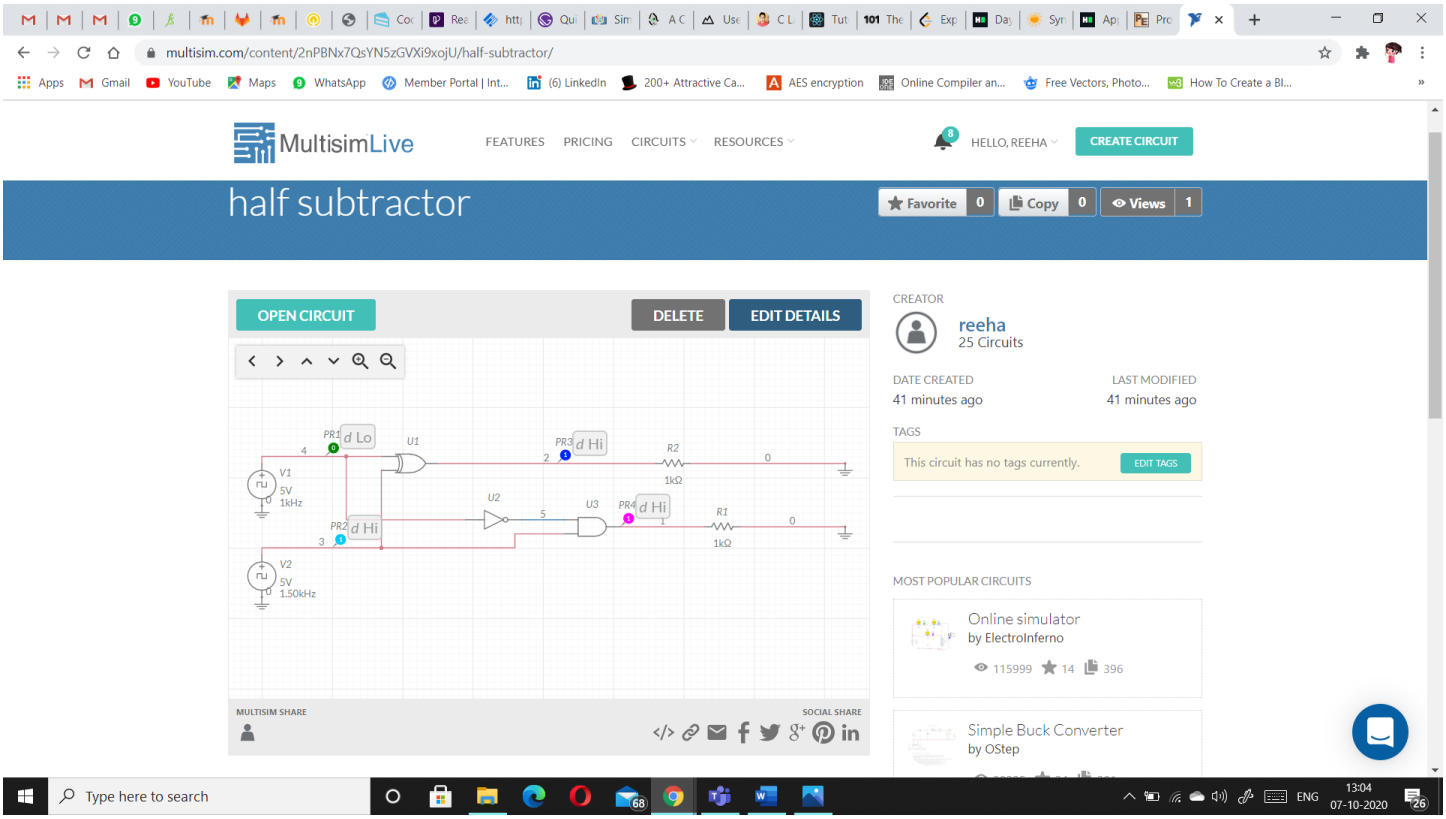
- These are generally employed for ALU (Arithmetic logic unit) in computers to subtract as CPU & GPU for the applications of graphics to decrease the circuit difficulty.
- Subtractors are mostly used for performing arithmetical functions like subtraction, in electronic calculators as well as digital devices.
- These are also applicable for different microcontrollers for arithmetic subtraction, timers, and program counter (PC)
- Subtractors are used in processors to compute tables, address, etc.
- It is also useful for DSP and networking based systems.

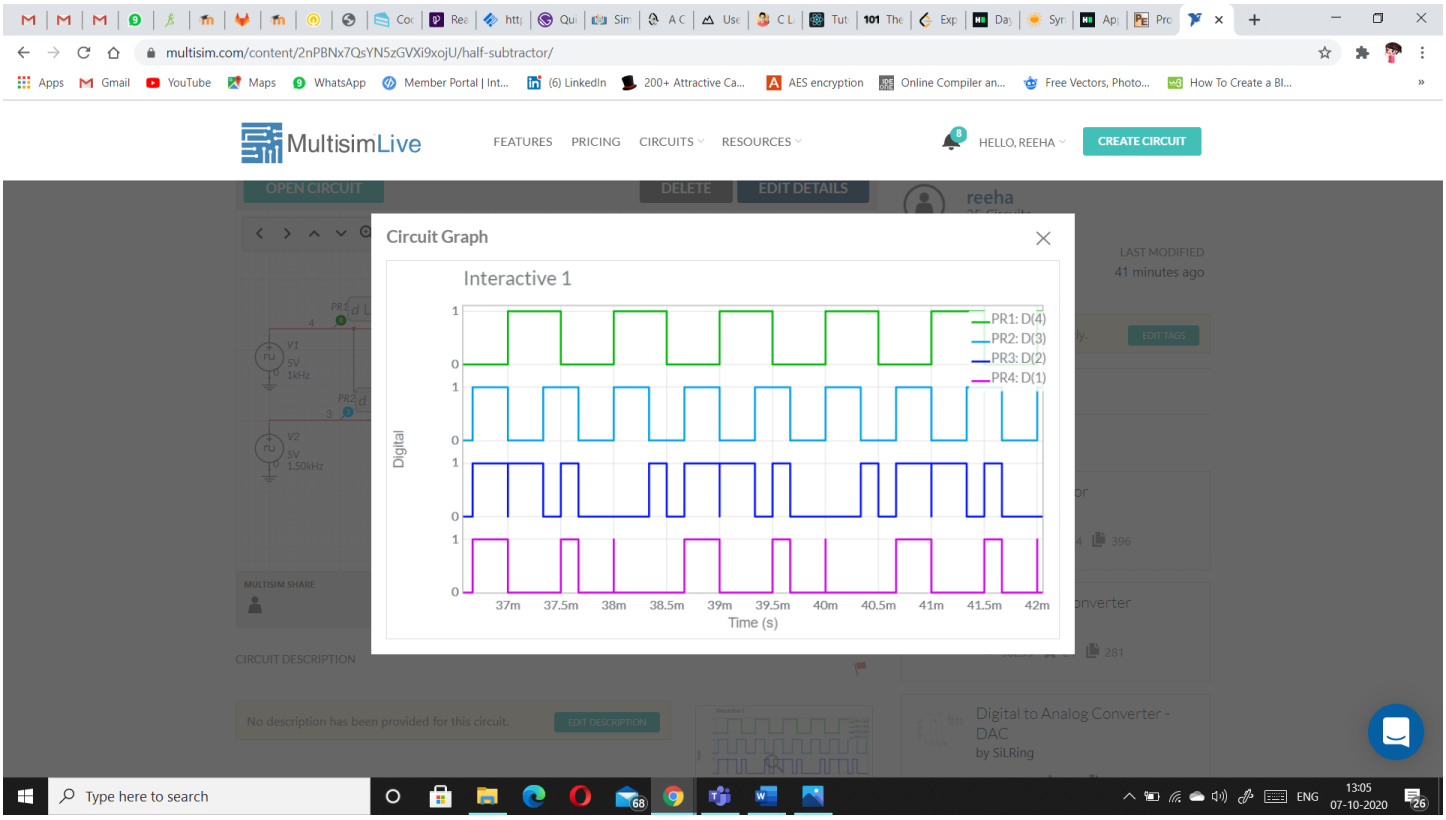
Procedure followed on MULTISIM:

1. LOG IN ON www.multisim.com
2. CREATE THE CIRCUIT
3. SAVE THE CIRCUIT
4. SAVE THE SCREENSHOTS FOR
   i. INPUT & OUTPUT WAVEFORMS (ALONG WITH YOUR ID ON TOP LEFT)
   ii. CIRCUIT (ALONG WITH YOUR ID ON TOP LEFT)

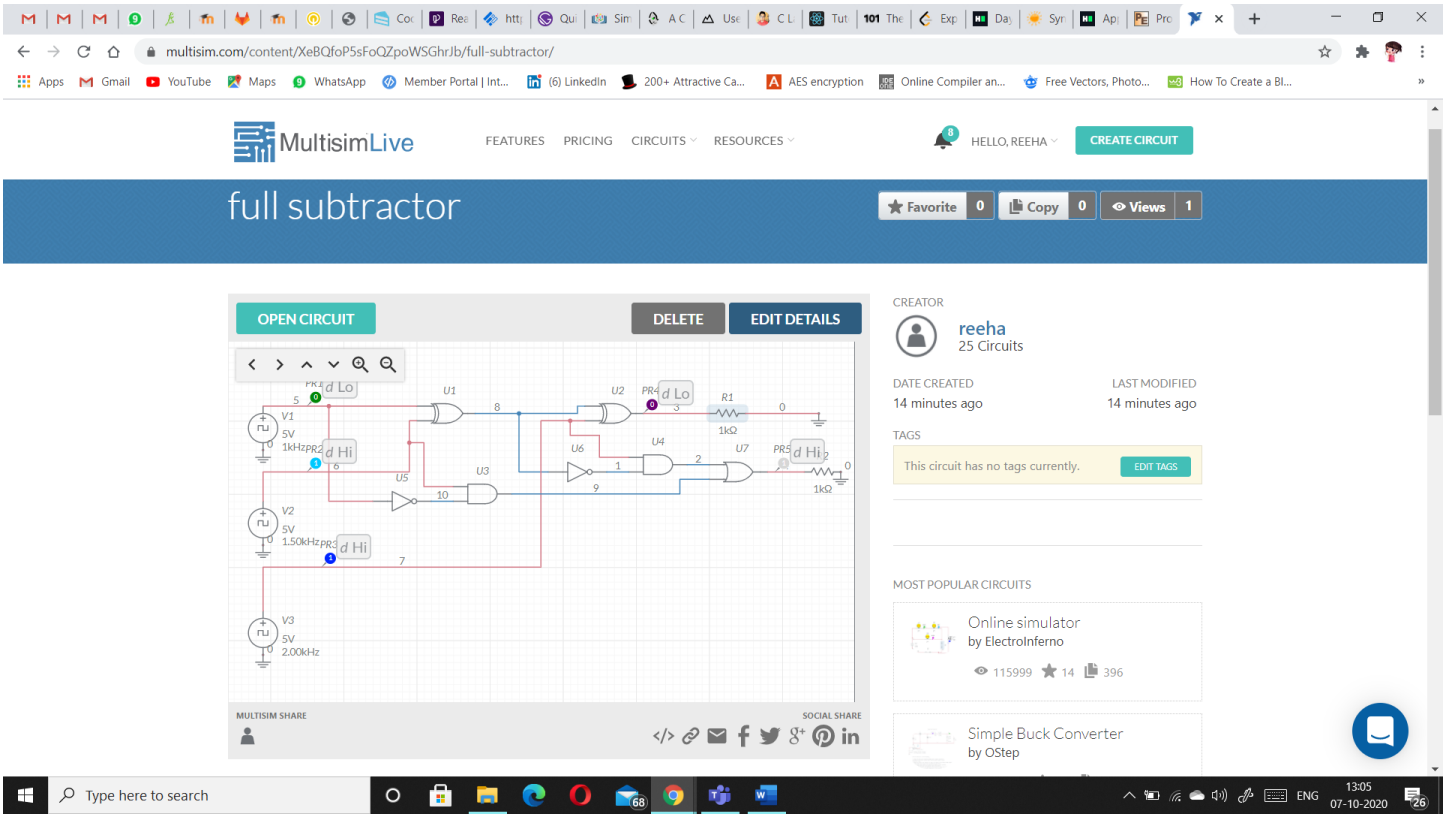
Circuits and Output waveform

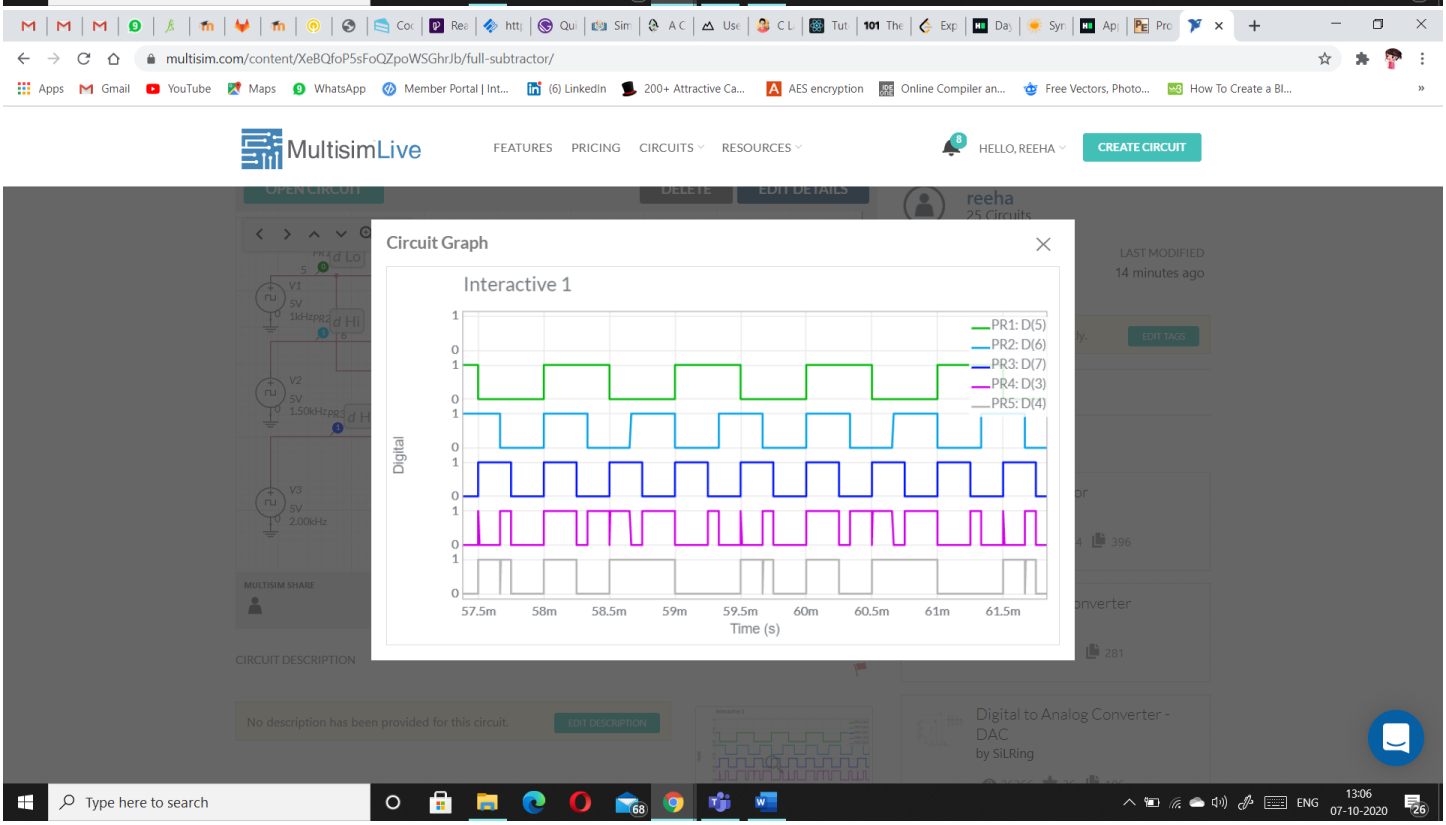
Half Subtractor





Full Subtractor





Precautions (MULTISIM):

1. Frequency of clock voltage source should be different for both inputs.
2. Place the probes carefully only at the input and output sources.
3. Use digital analyzer probe.
4. Set the type to transient.
5. Ground both the voltage sources(clock) and the resistor.