Simulation Tutorial Documentation

ABOUT VLAB

- The Virtual Laboratory, represents a pivotal shift in education, as it offers a dynamic and immersive platform for students to explore.
- Traditional physical laboratories, often come with limitations such as accessibility, resource constraints.
- This Virtual Laboratories aims to address these drawbacks by providing a safe, accessible, and flexible environment for hands-on learning, where students can conduct experiments, make mistakes, and learn in an engaging, risk-free setting.
- This underscores the urgent demand for innovative educational tools such as the Virtual Laboratory.

ABOUT VLAB

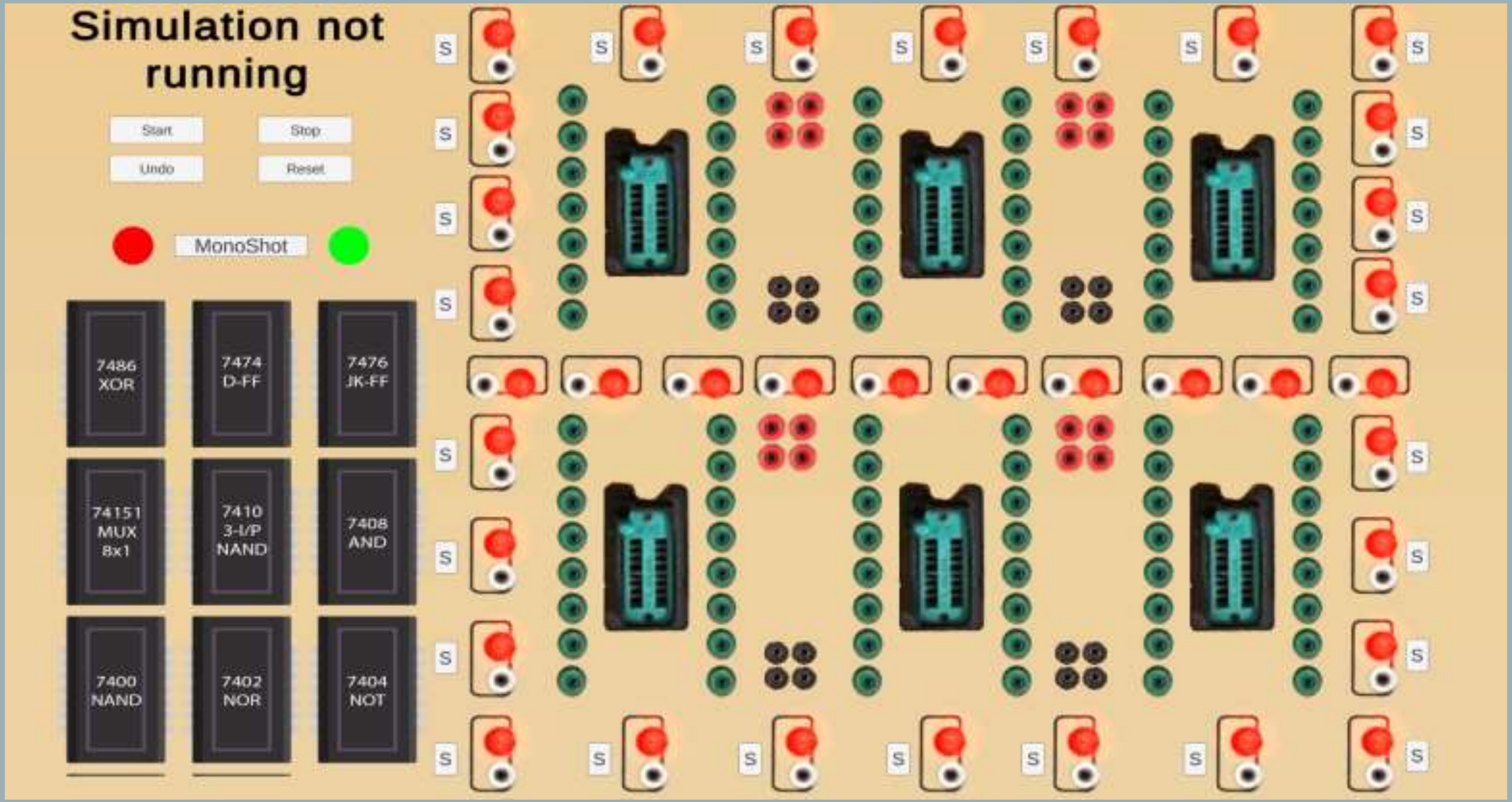
- Our Trainer Kit is built with the help of Unity.
- We have tried to replicate IC Trainer Kit RS 1001 which is used in DSLD Lab.
- Trainer Kit is integrated with the website using WebGL Build File.

Lets Get Started!!

GET STARTED

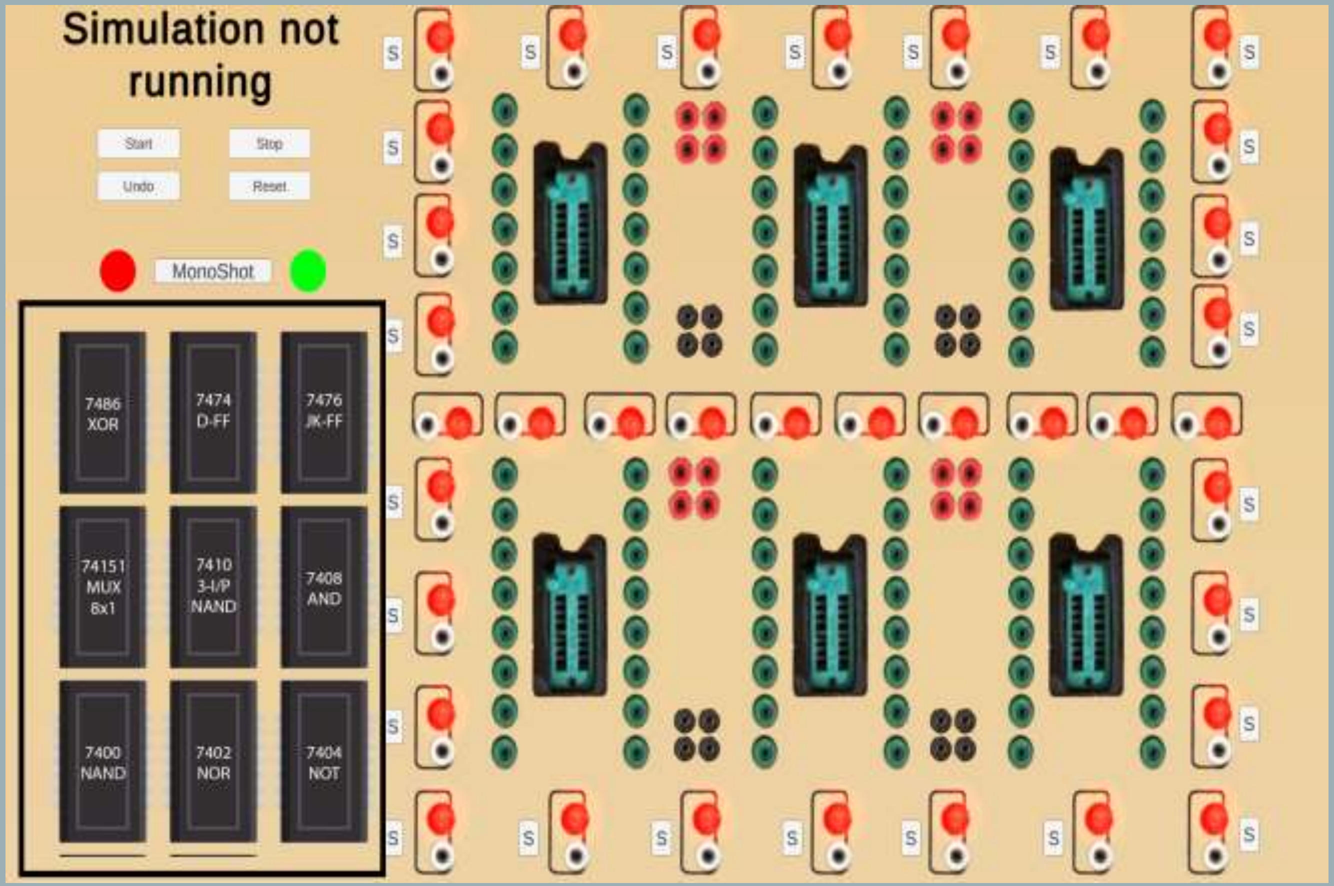
- Click on Trainer Kit.
- Click on Full Screen Mode, to Get Started!!!

INITIAL UI



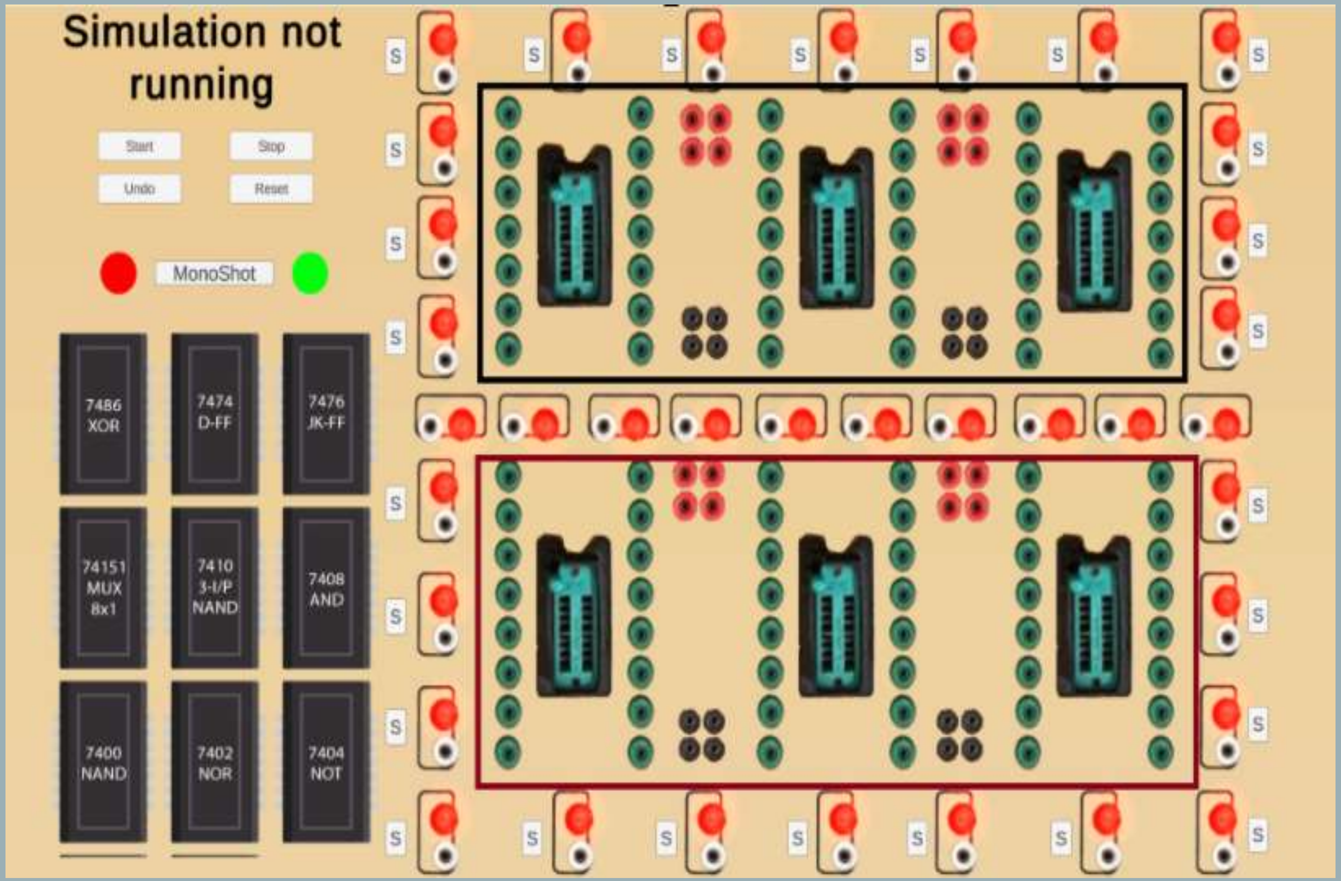
Video Reference - https://youtu.be/GfxgjZf6VW4

ICs



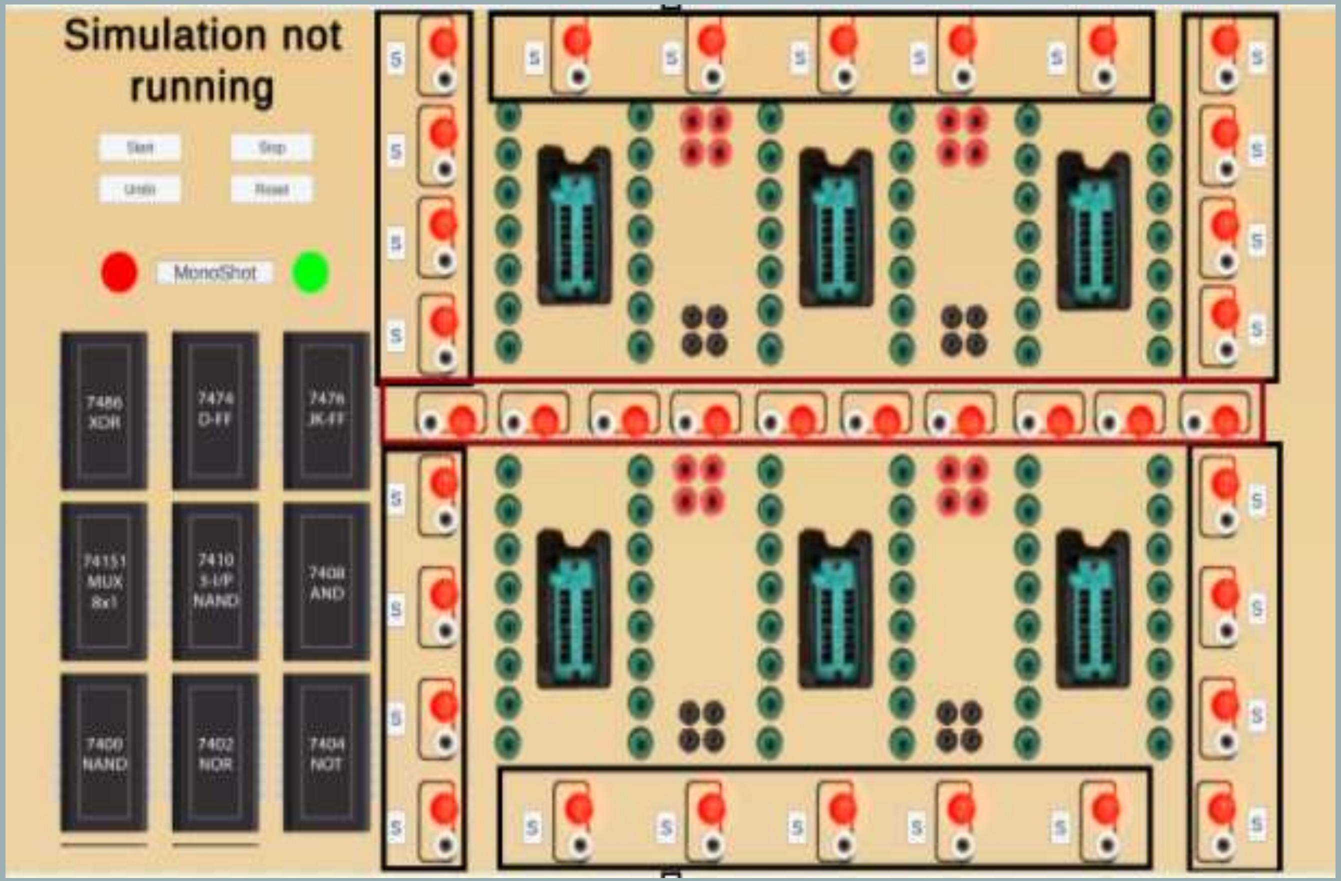
- Left hand side of the Trainer Kit contains the set of ICs.
- Set of ICs we have – AND, OR, NOT, NAND, NOR, XOR, Mod10 Counter and Many more.
- Unleash limitless experimentation with these versatile ICs!

SOCKET



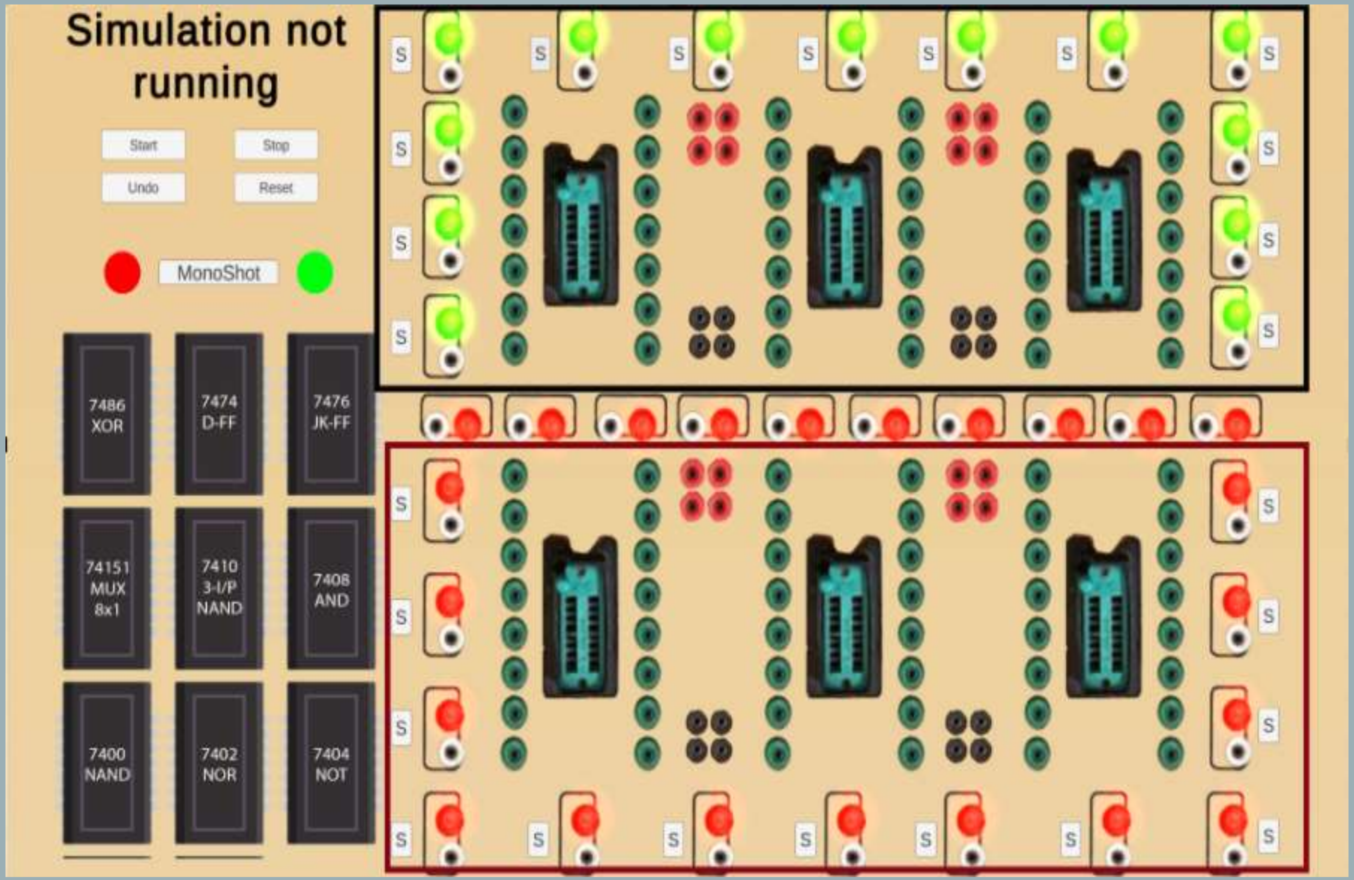
- We have 2 sets of Socket – three 14 pin sockets and three 16 pin socket.
- The Black Box shows 14 Pin Socket.
- The Red Box shows 16 Pin Socket.

INPUT AND OUTPUT PINS



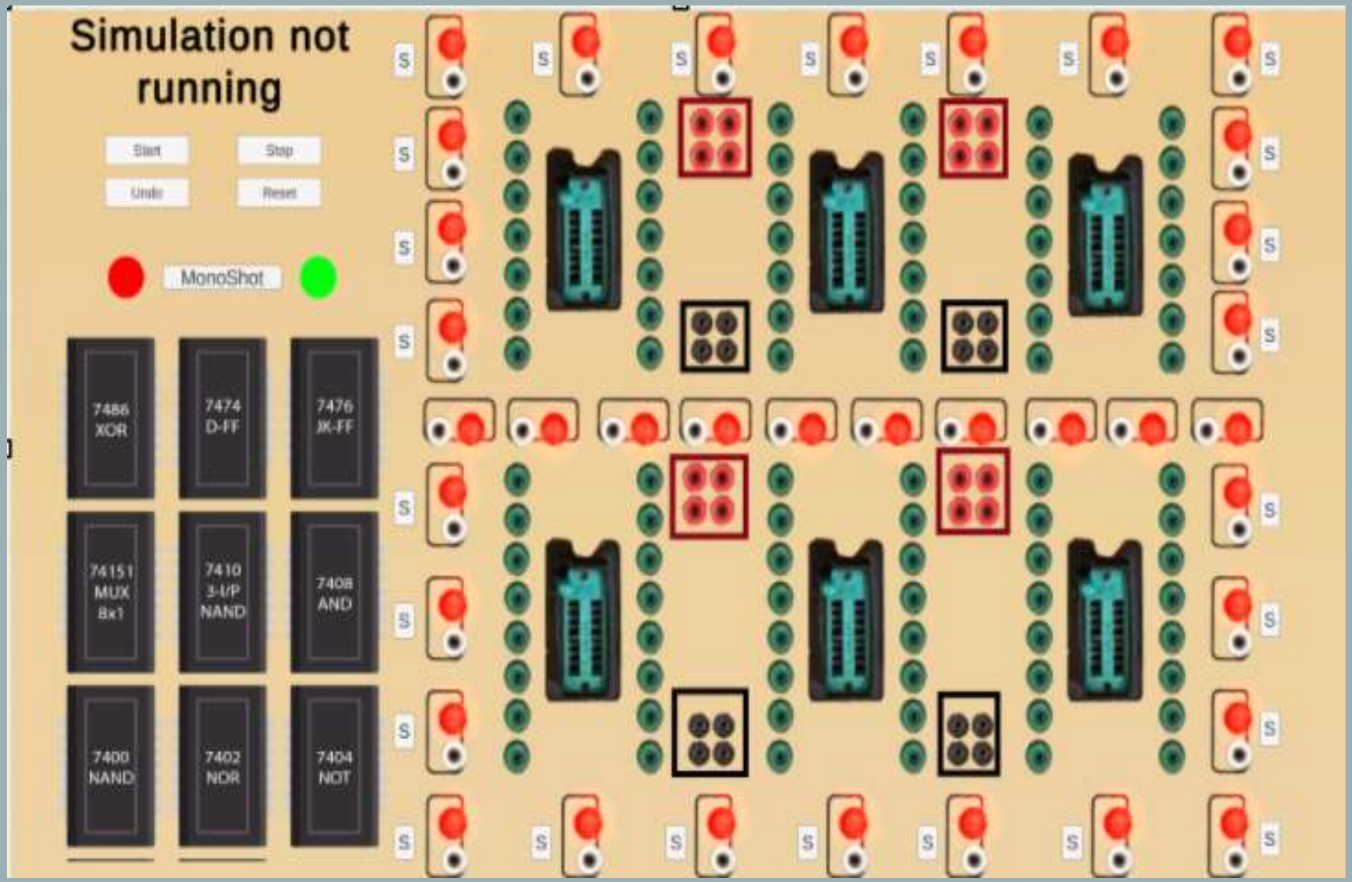
- We have a total of 28 Input Pins and 10 Output Pins.
- Black Box represents set of Input Pins.
- Red Box represents Output Pins.

INPUT AND OUTPUT PINS



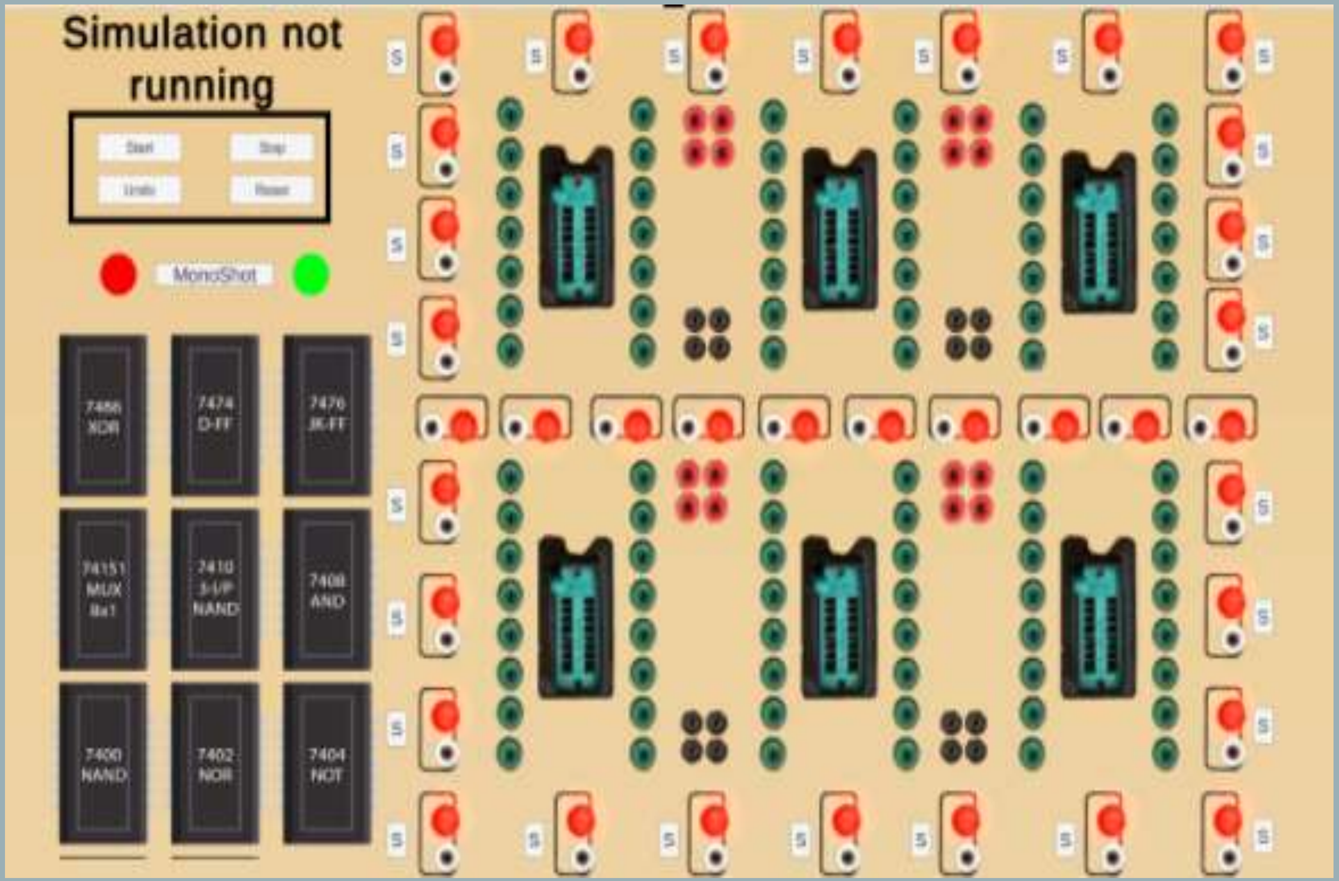
- Click on Switch (S) to toggle between positive and negative input.
- Positive is represented with a Green Light – Black Box.
- Negative is represented with a Red Light – Red Box.

Vcc AND GND



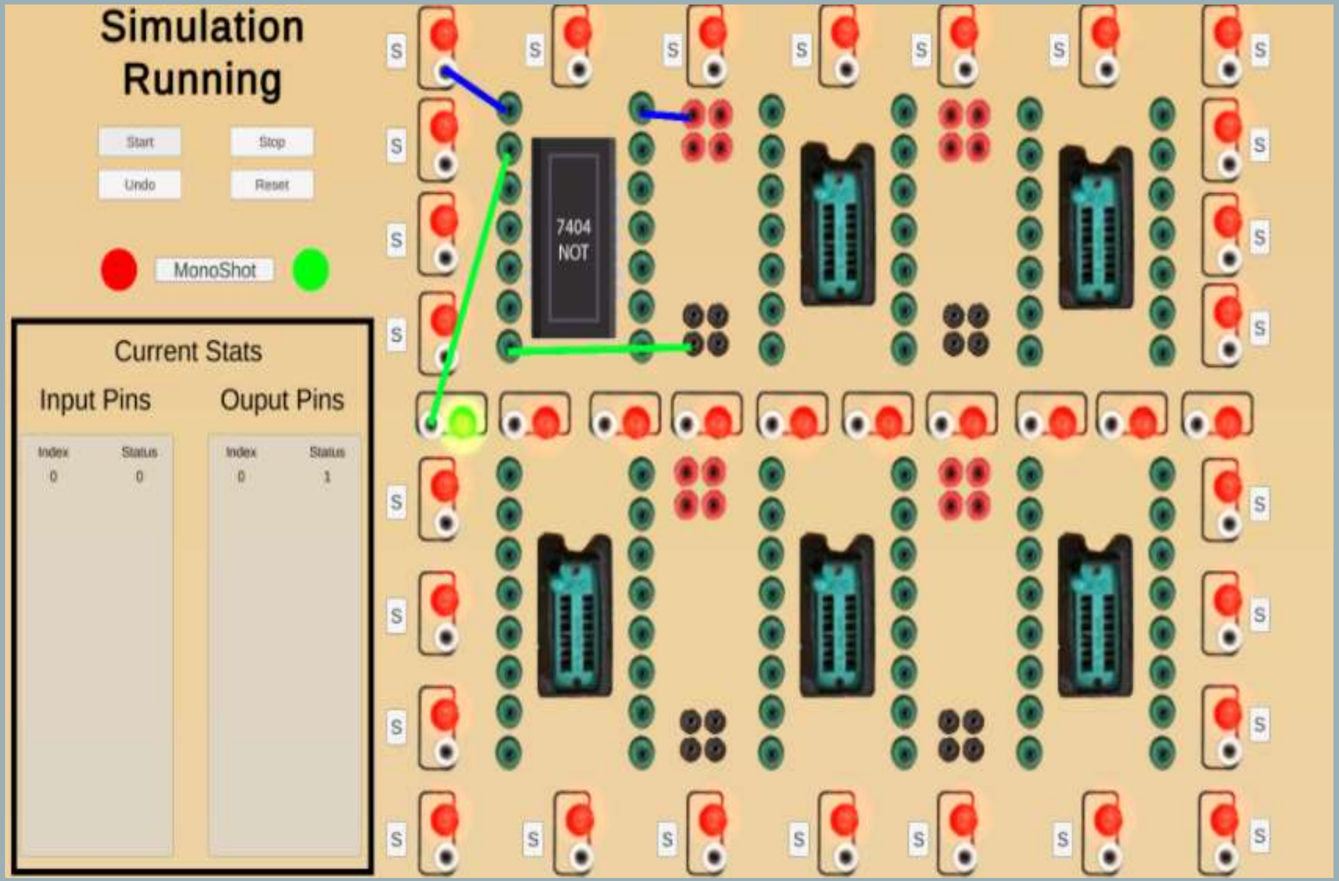
- We have a total of 16 Ground Pins and 16 Vcc Pins.
- Red Box represents Vcc Ports.
- Black Box represents Ground Ports.

Simulation Buttons



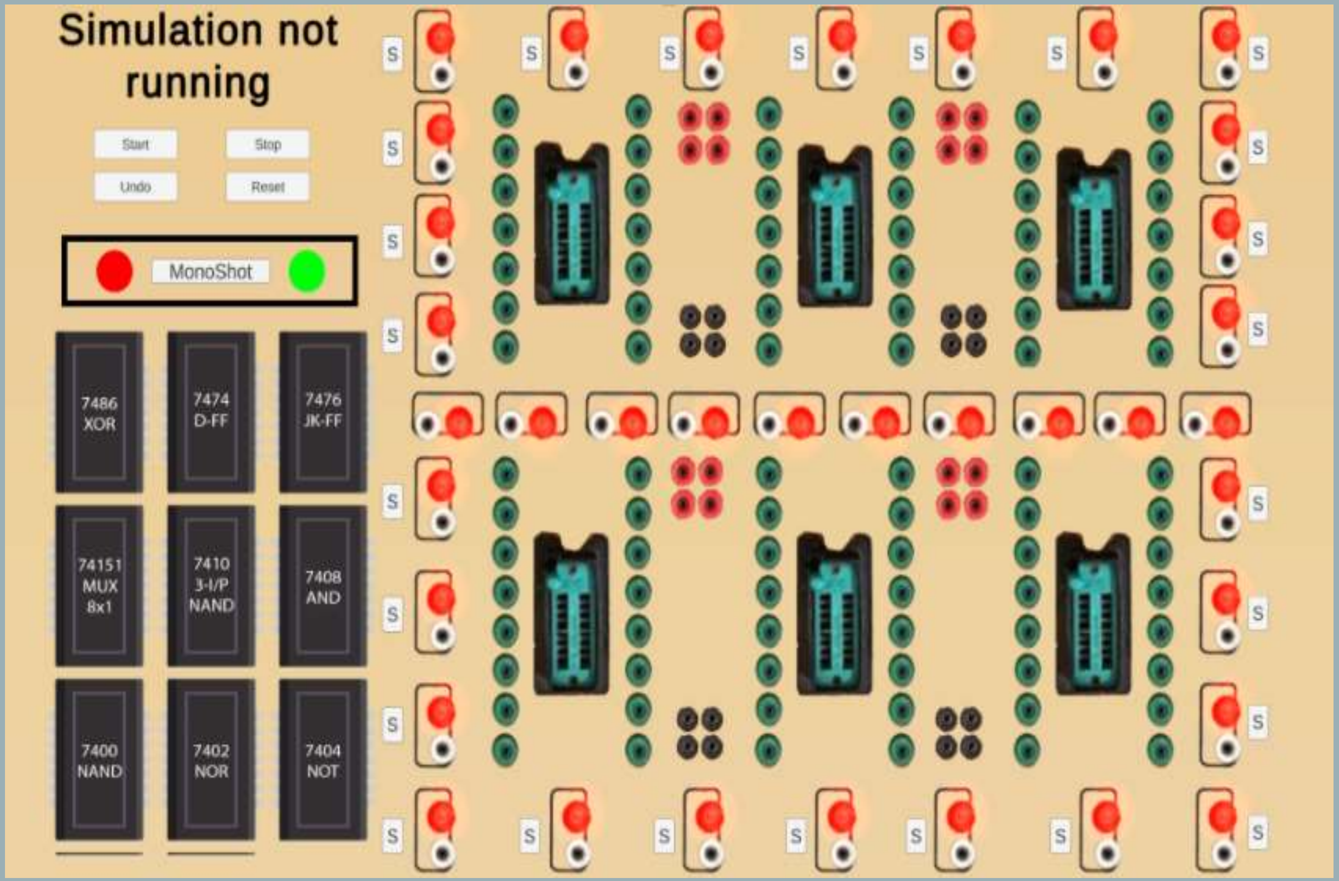
- Start – To Start the Simulation.
- Stop – To Stop the Simulation.
- Reset – To Reset the entire connection made.
- Undo – To undo the conditions to go back.

Simulation Status



- Drag and Drop IC to start the simulation.
- When you start the simulation, the Black Box represents the Simulation Status.
- Input Pins and Output Pins give corresponding Status of the current connection.

Clock - Monoshot



- Monoshot represents clock pulse.
- Click on Monoshot, for each clock pulse.
- Green represents positive clock pulse.
- Red represents negative clock pulse.

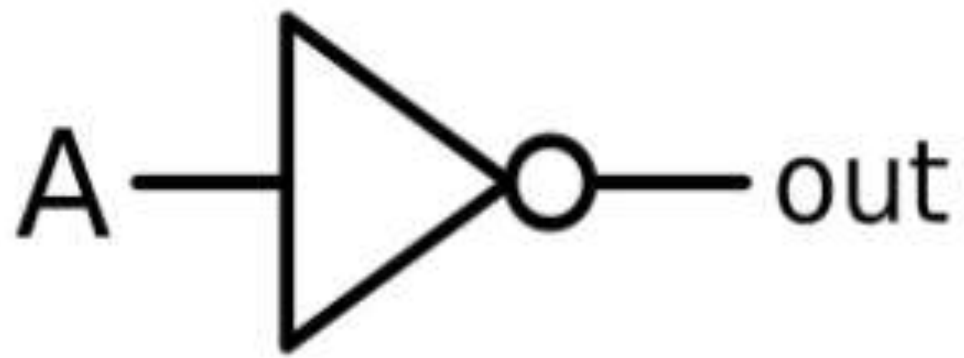
BASIC GATES

- Basic gates are fundamental building blocks of digital circuits.
- NOT gate (IC 7404): Outputs the opposite of its input.
- AND gate (IC 7408): Outputs true only when all inputs are true.
- OR gate (IC 7432): Outputs true when at least one input is true.

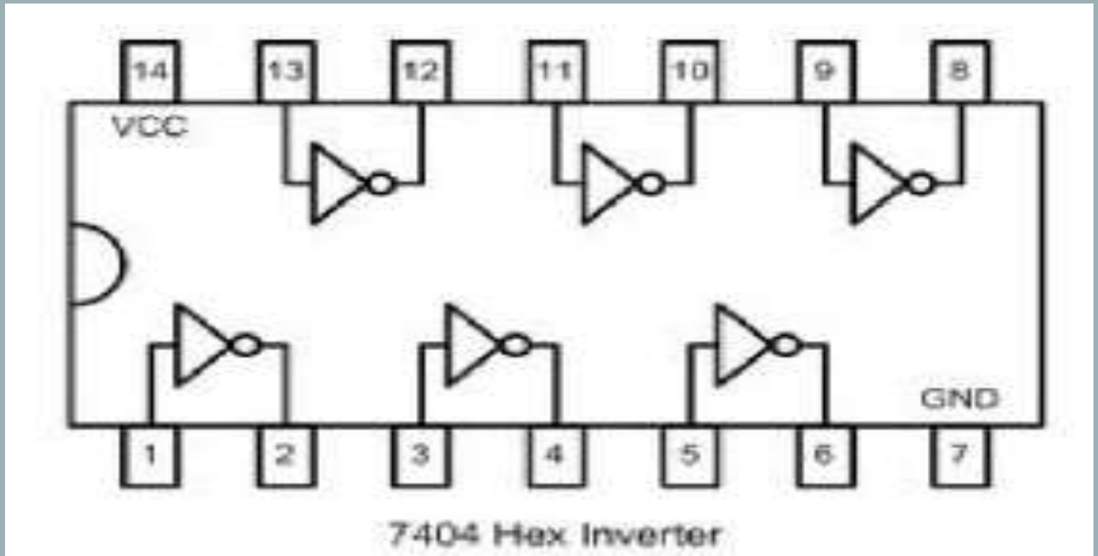
BASIC GATE – NOT GATE (IC 7404)

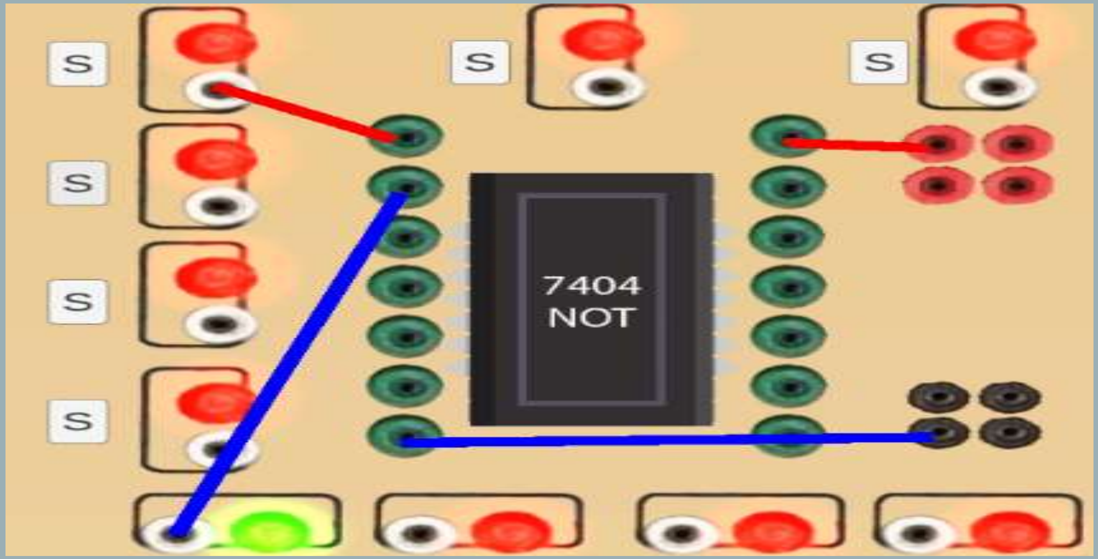
Truth Table

A (Input)	$Y = \overline{A}$ (Output)
0	1
1	0



BASIC GATE – NOT GATE (IC 7404)



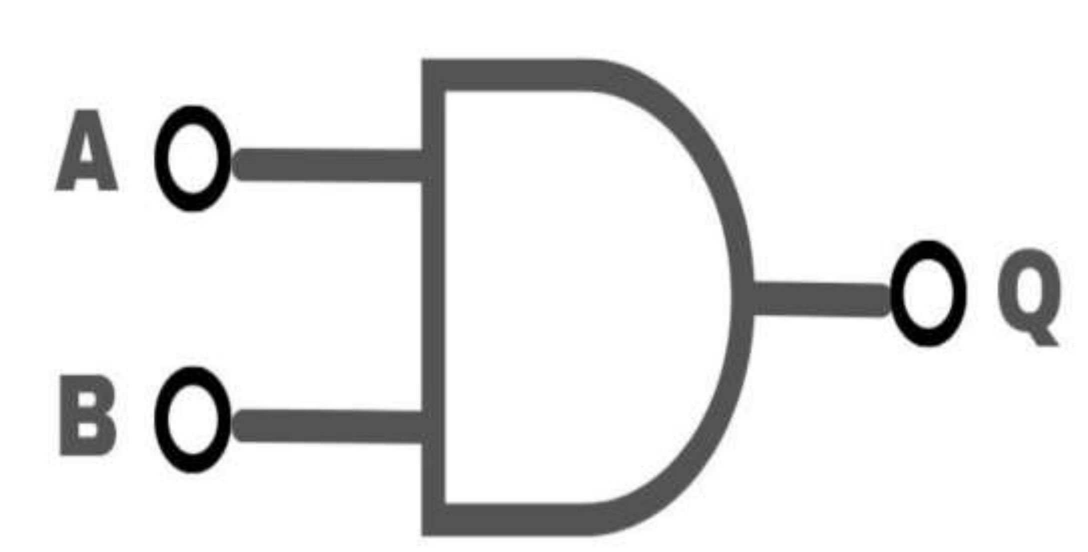


Video Reference - https://youtu.be/3WC_gcgBTHg

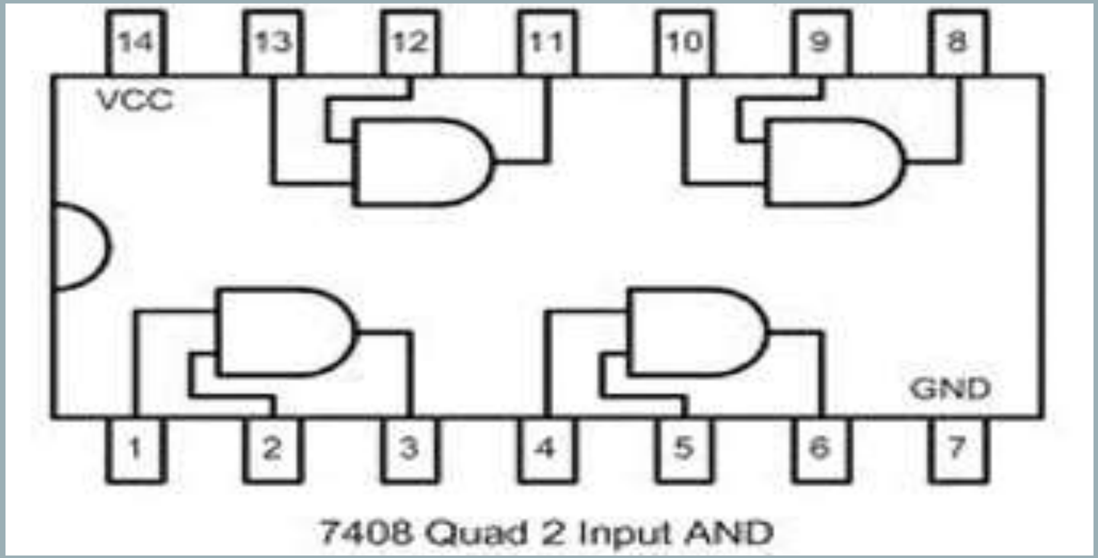
BASIC GATE – AND GATE (IC 7408)

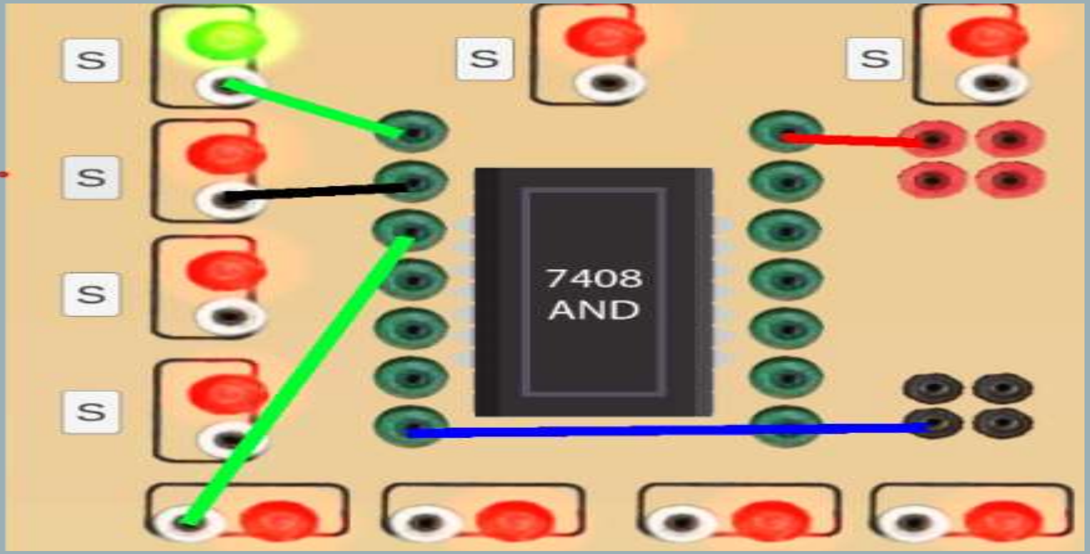
Truth Table

A (Input 1)	B (Input 2)	X = (A.B)
0	0	0
0	1	0
1	0	0
1	1	1



BASIC GATE – AND GATE (IC 7408)





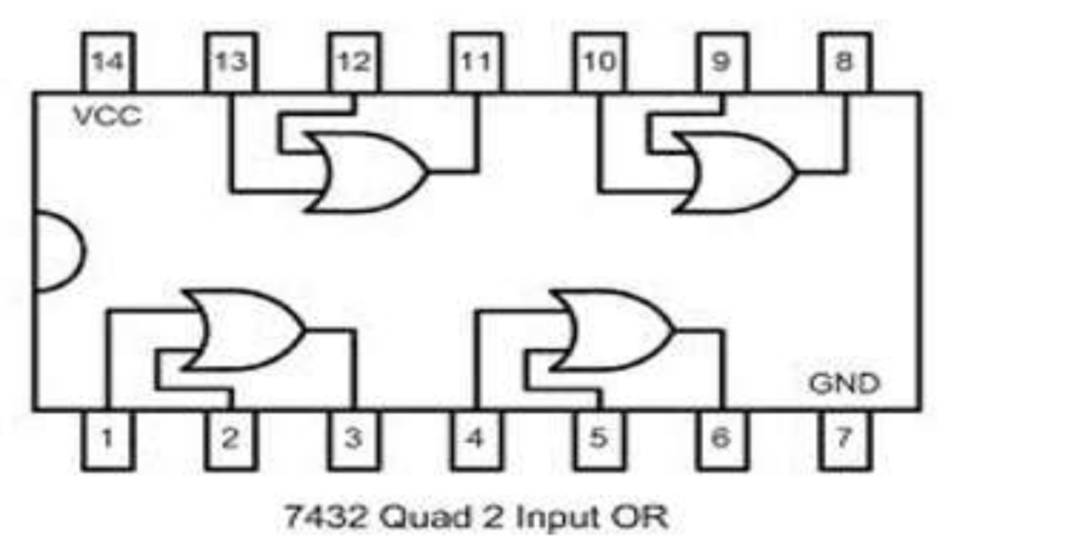
Video Reference - https://youtu.be/3WC_gcgBTHg

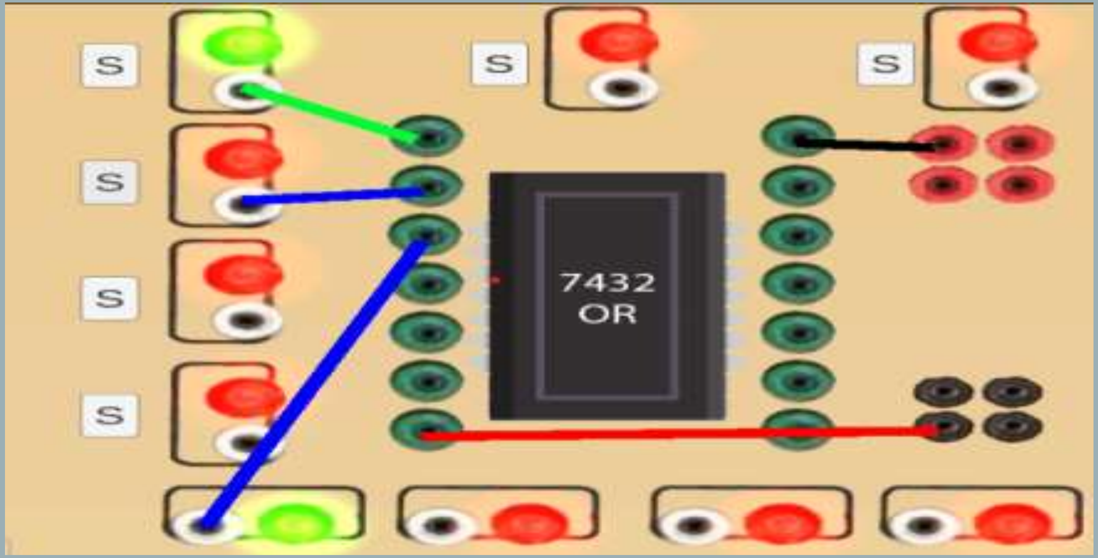
BASIC GATE – OR GATE (IC 7432)

Truth Table

Input A	Input B	Output
0	0	0
0	1	1
1	0	1
1	1	1

BASIC GATE – OR GATE (IC 7432)



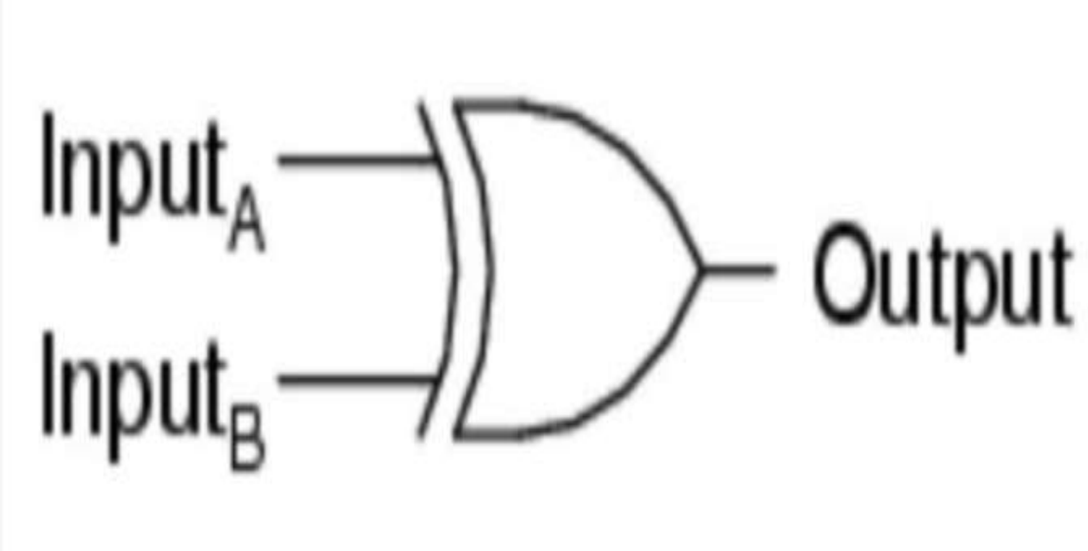


Video Reference - https://youtu.be/3WC_gcgBTHg

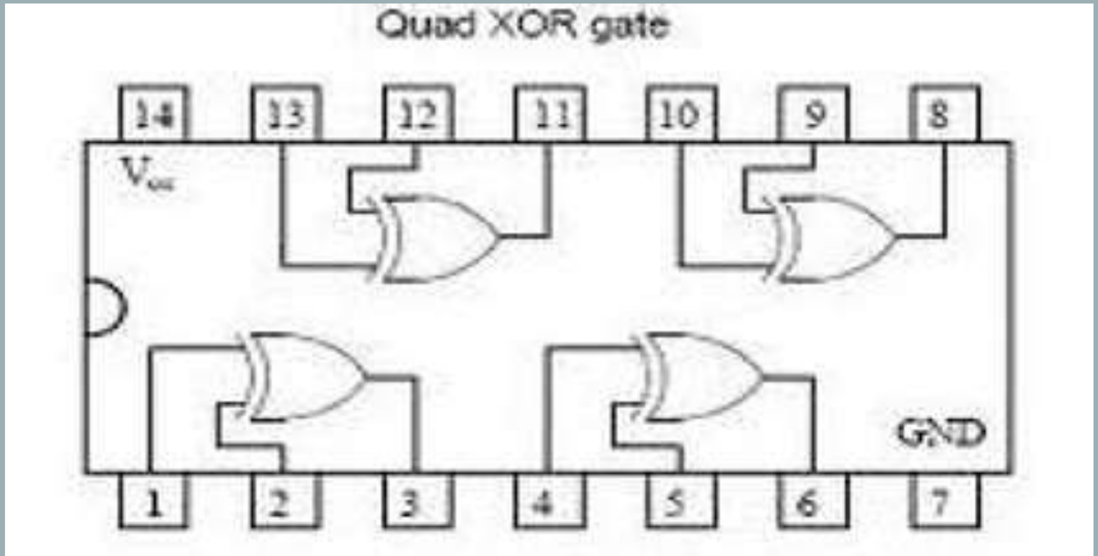
XOR GATE (IC 7486)

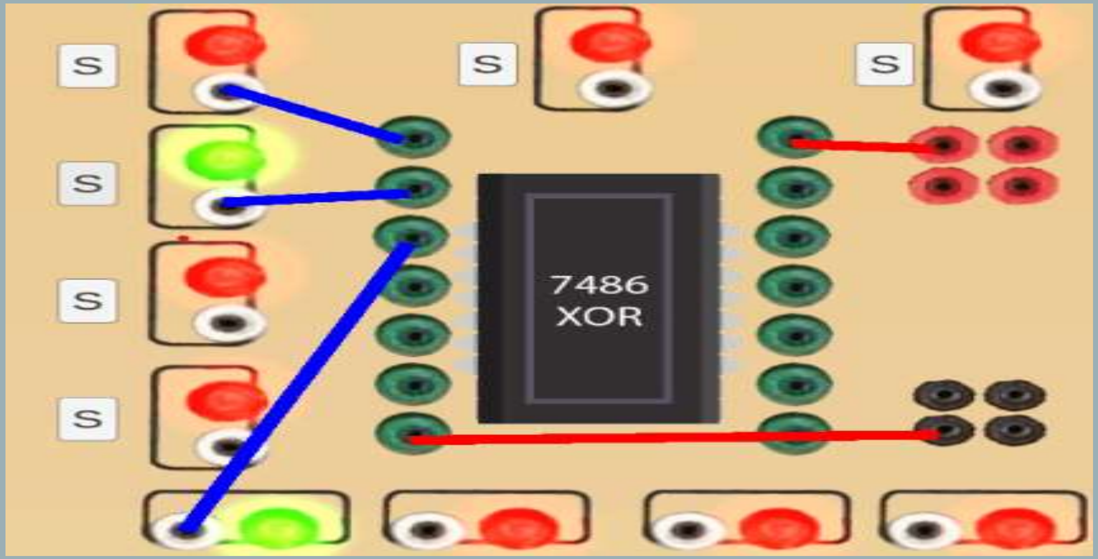
Truth Table

A (Input 1)	B (Input 2)	X = A'B + AB'
0	0	0
0	1	1
1	0	1
1	1	0



XOR GATE (IC 7486)





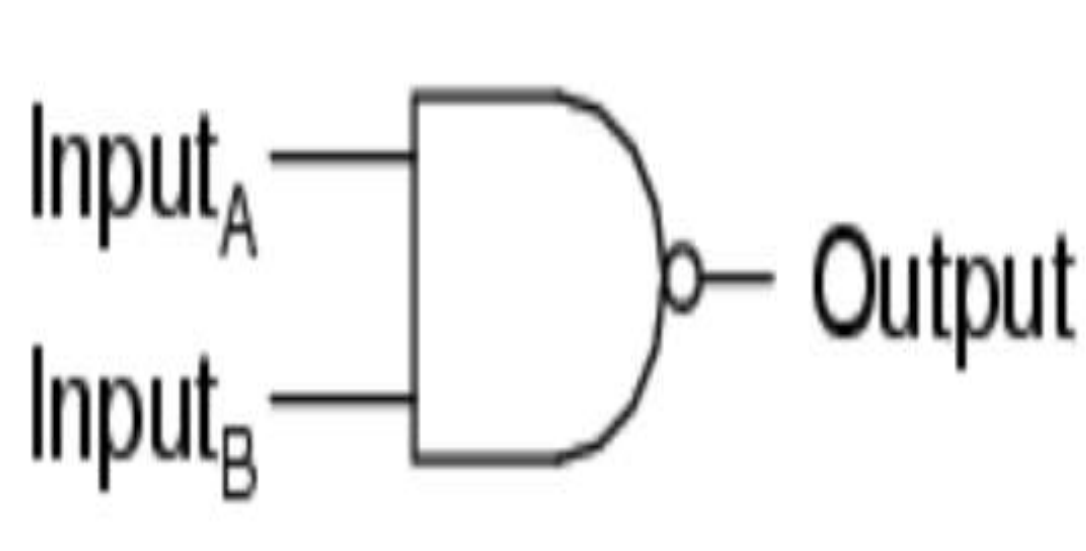
UNIVERSAL GATES

- Universal gates can be used to implement any other logic gate.
- NAND gate (IC 7400): Can implement AND, OR, and NOT functions.
- NOR gate (IC 7402): Can implement AND, OR, and NOT functions.

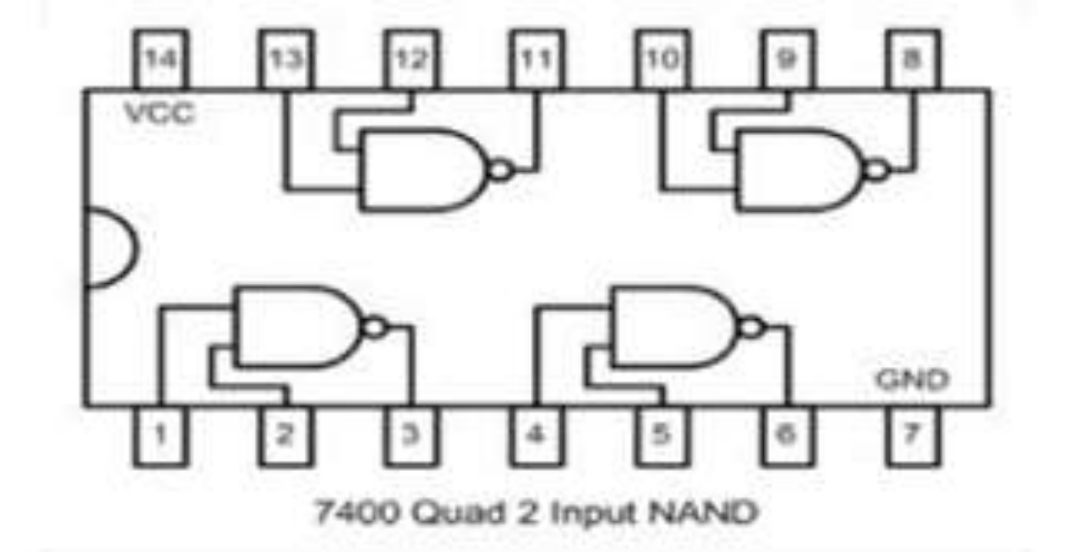
UNIVERSAL GATE – NAND GATE (IC 7400)

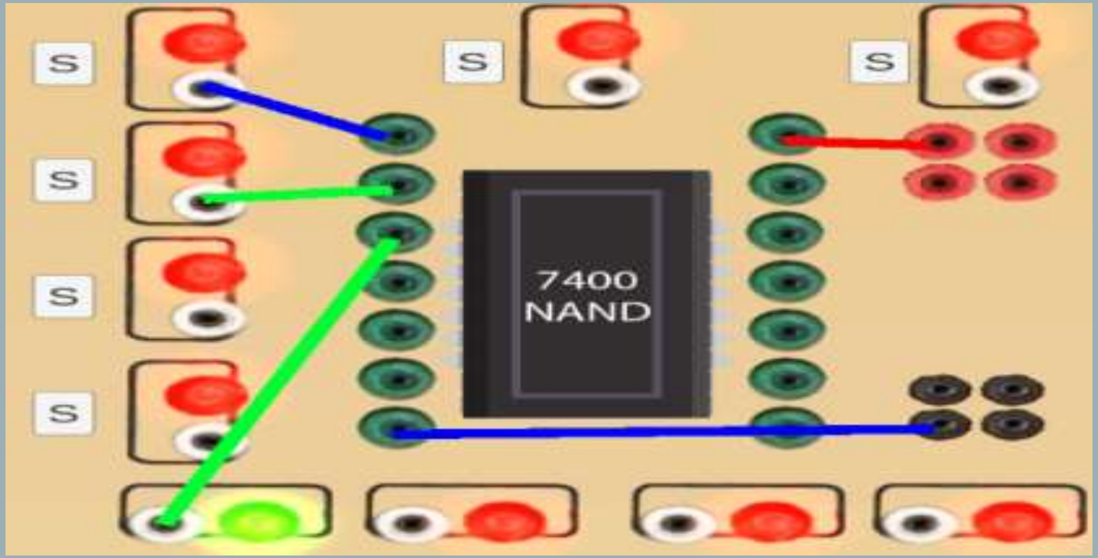
Truth Table

Input A	Input B	X = (A.B)’
0	0	1
0	1	1
1	0	1
1	1	0



UNIVERSAL GATE – NAND GATE (IC 7400)



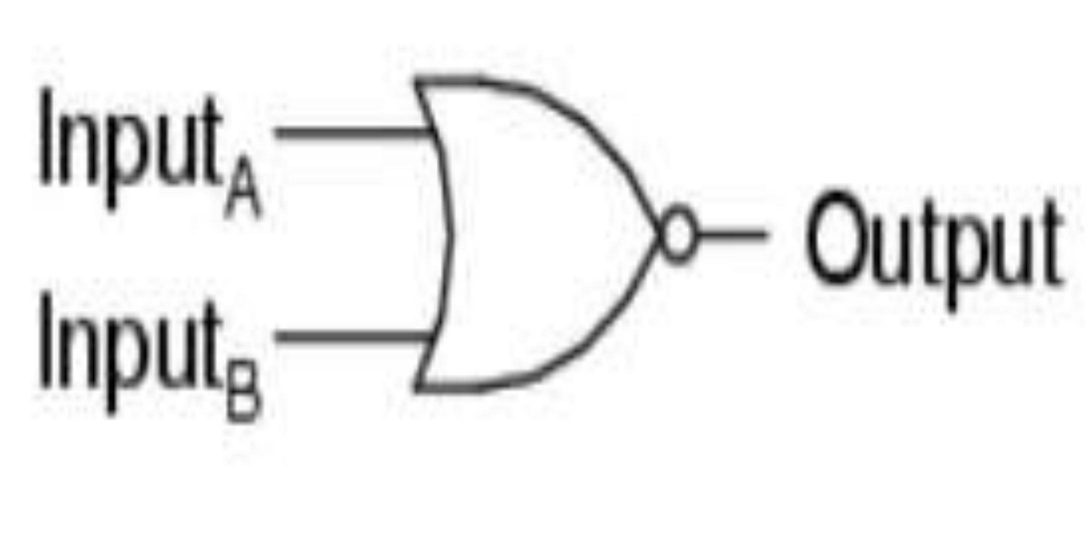


Video Reference - https://youtu.be/G1lWlpj-Bayg

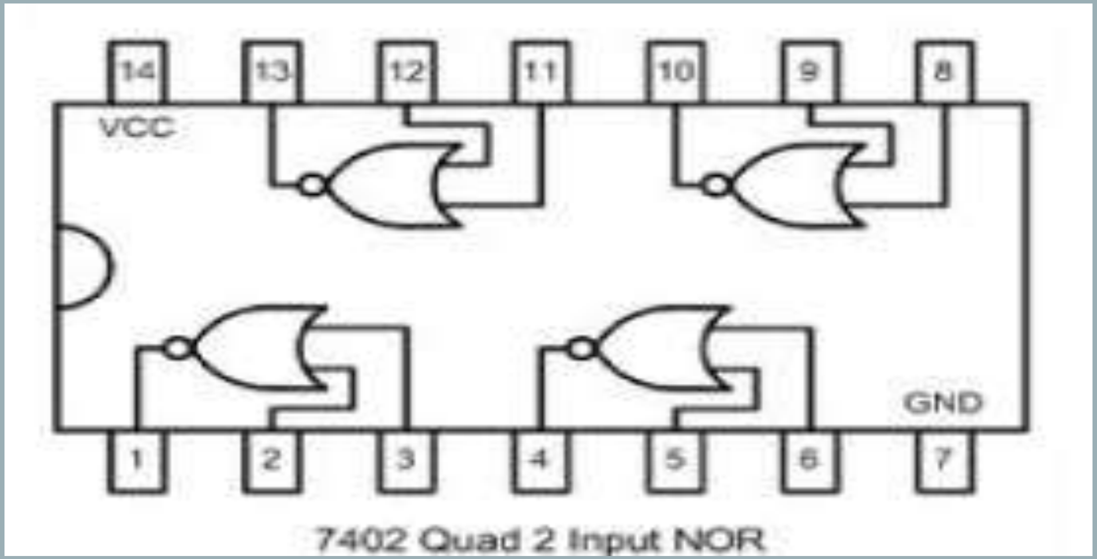
UNIVERSAL GATE – NOR GATE (IC 7402)

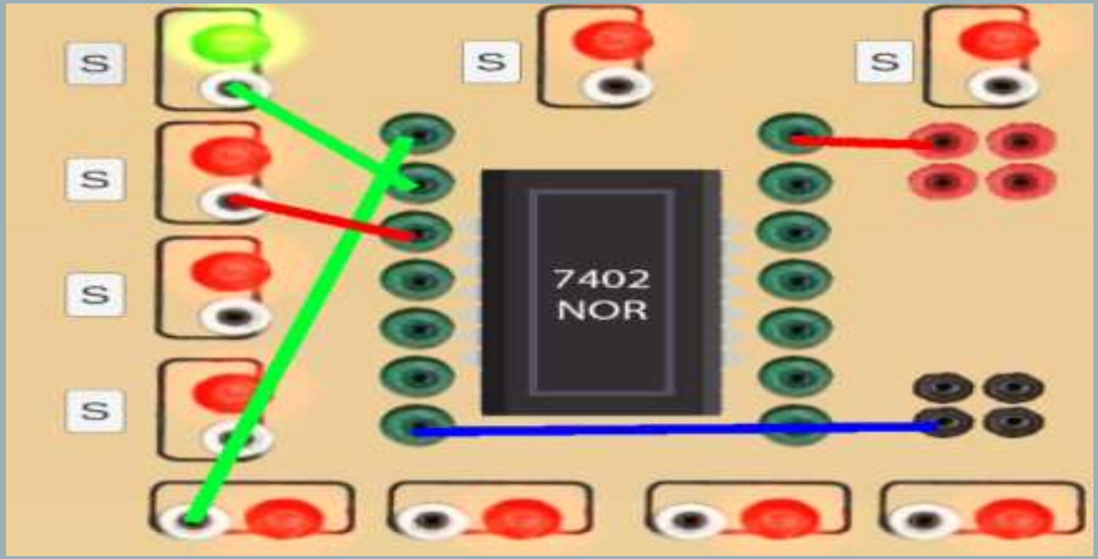
Truth Table

Input A	Input B	0 = (A + B)'
0	0	1
0	1	0
1	0	0
1	1	0



UNIVERSAL GATE – NOR GATE (IC 7402)





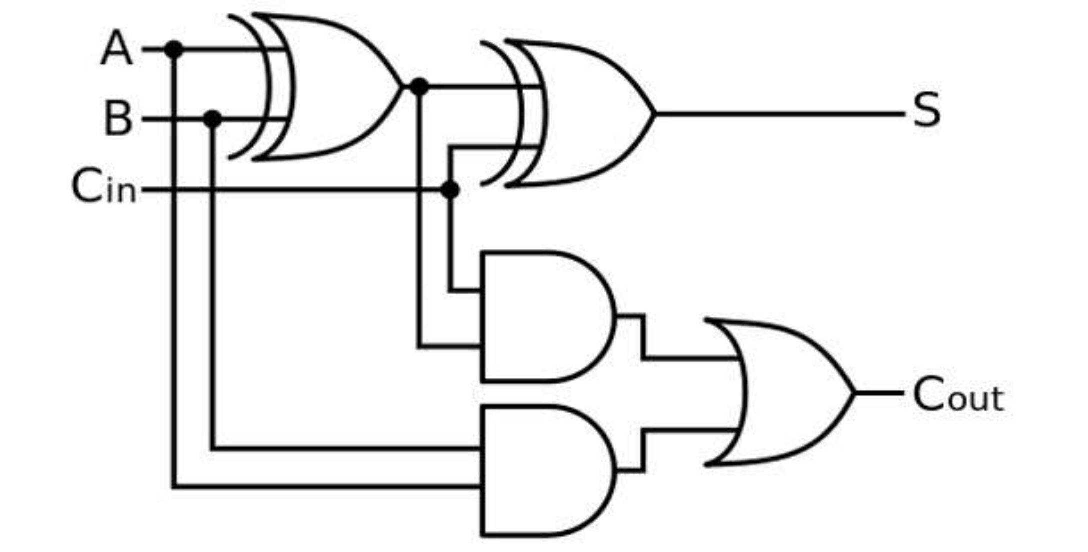
Video Reference - https://youtu.be/G1lWlpj-Bayg

ADDER SUBTRACTOR CIRCUIT

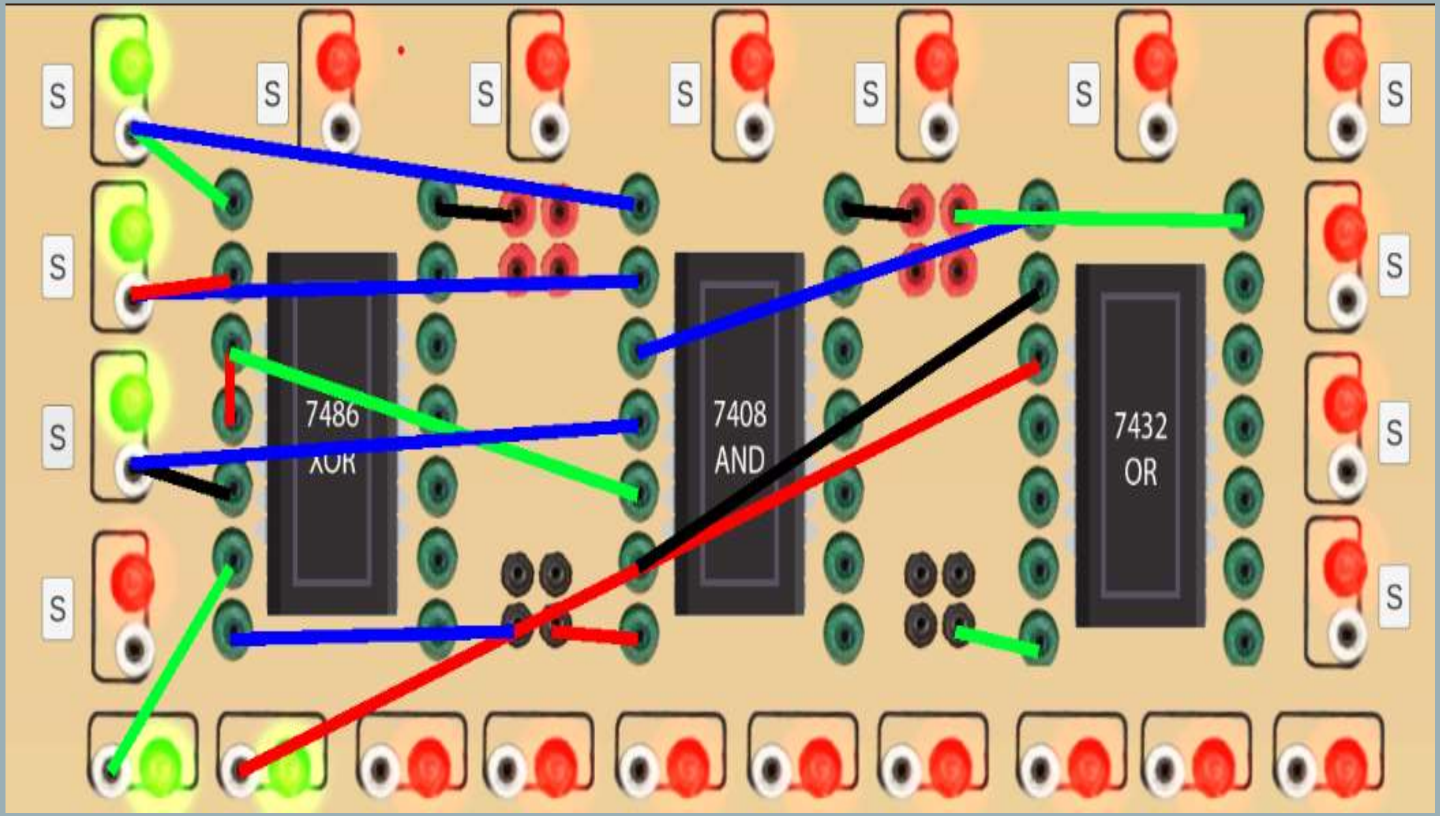
- An adder-subtractor circuit performs both addition and subtraction operations on binary numbers.
- Full adder: Adds three binary inputs and produces a sum and carry output.
- Half subtractor: Subtracts two binary inputs and produces a difference and borrow output.

FULL ADDER

A	B	C_{in}	SUM (S)	C_{out}
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1



FULL ADDER

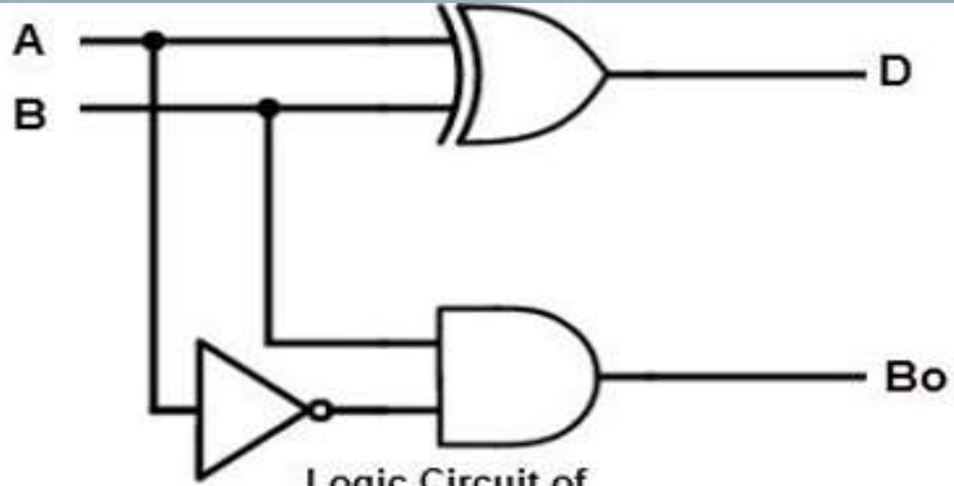


Video Reference - https://youtu.be/jCh8tFqPx9k

HALF SUBTRACTOR

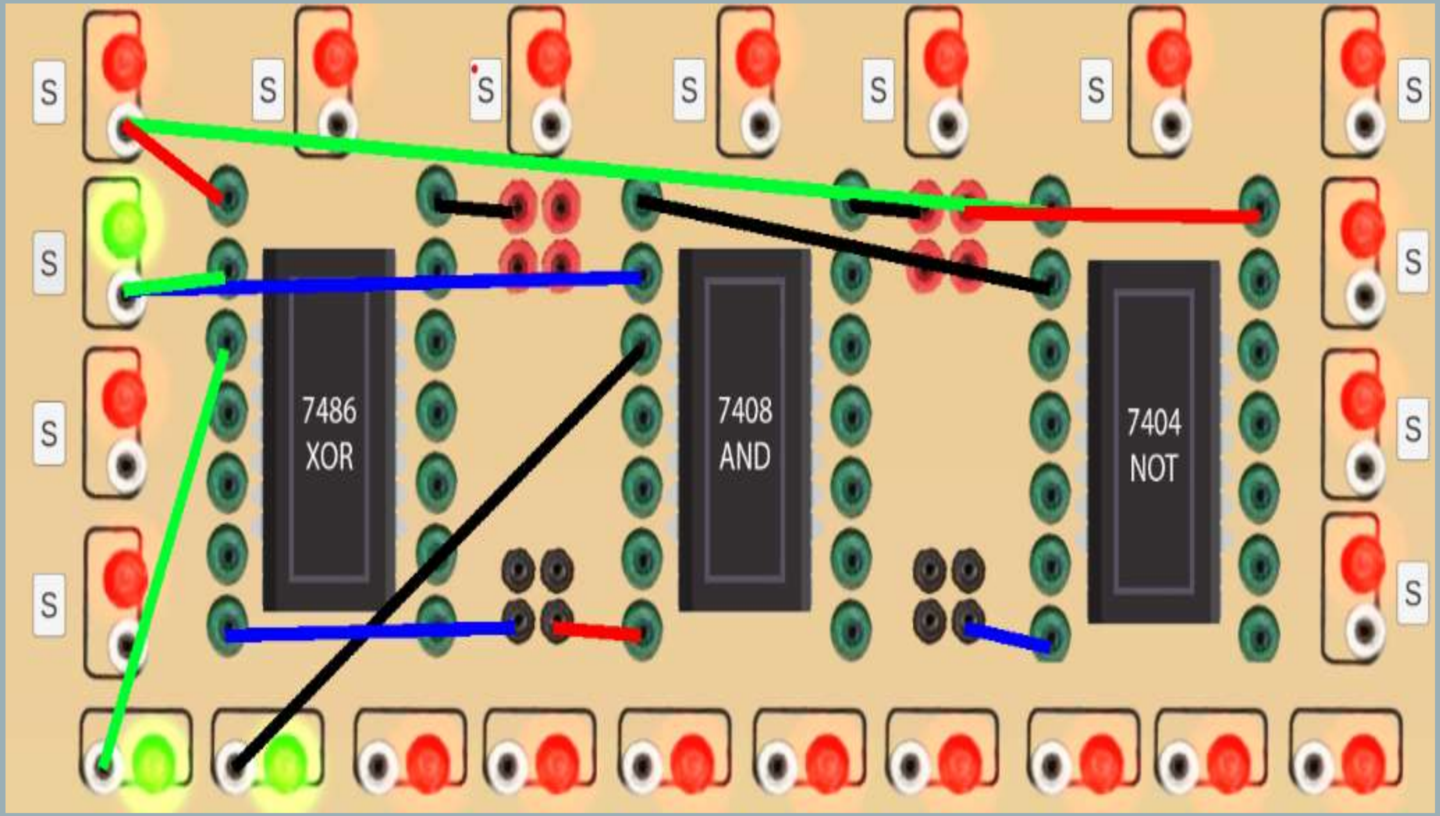
A	B	D	B_0
0	0	0	0
0	1	1	1
1	0	1	0
1	1	0	0

Truth Table



Logic Circuit of
Half Subtractor

HALF SUBTRACTOR



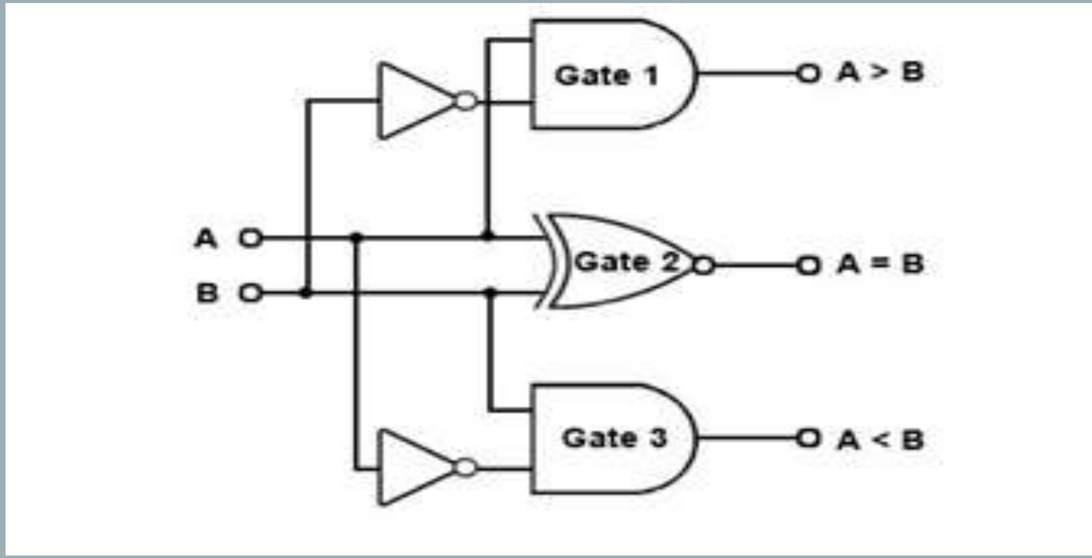
Video Reference - https://youtu.be/jCh8tFqPx9k

CODE CONVERTER AND MAGNITUDE COMPARATOR CIRCUIT

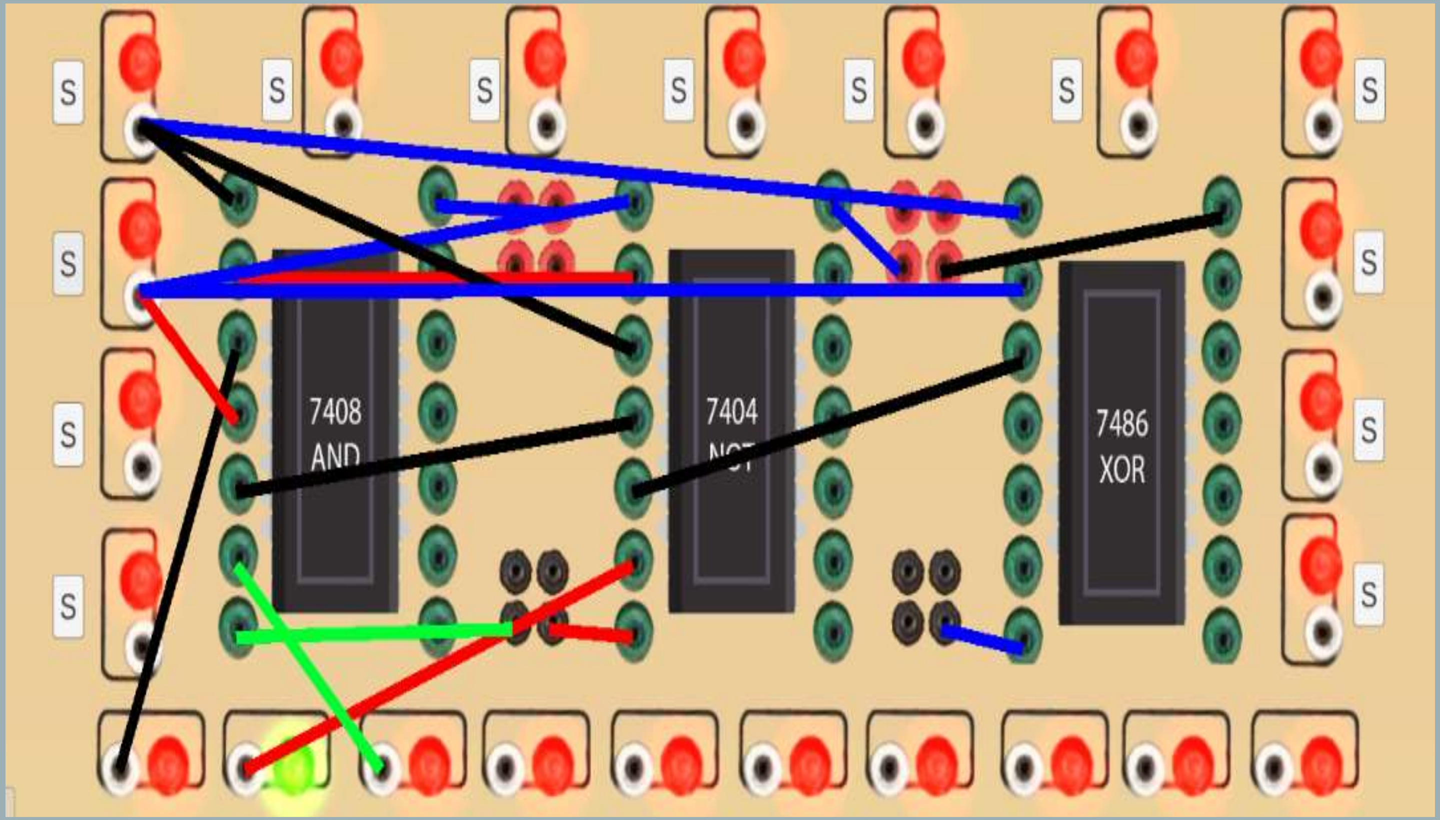
- A code converter circuit transforms one digital code to another, such as binary to BCD or Gray code.
- A magnitude comparator circuit compares the relative magnitudes of two binary numbers and produces output indicating their relationship (greater than, less than, or equal).
- The Excess-3code for a decimal digit is the binary combination corresponding to the decimal digit plus 3.

MAGNITUDE COMPARATOR

A	B	A<B	A=B	A>B
0	0	0	1	0
0	1	1	0	0
1	0	0	0	1
1	1	0	1	0



MAGNITUDE COMPARATOR



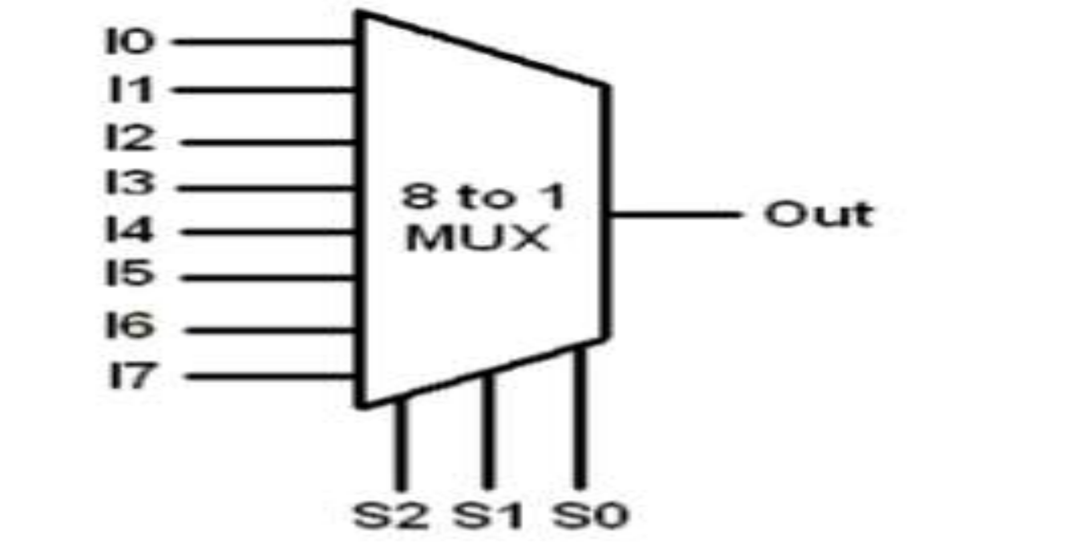
Video Reference - https://youtu.be/HUaKC1RYCxY

DATA PROCESSING CIRCUIT

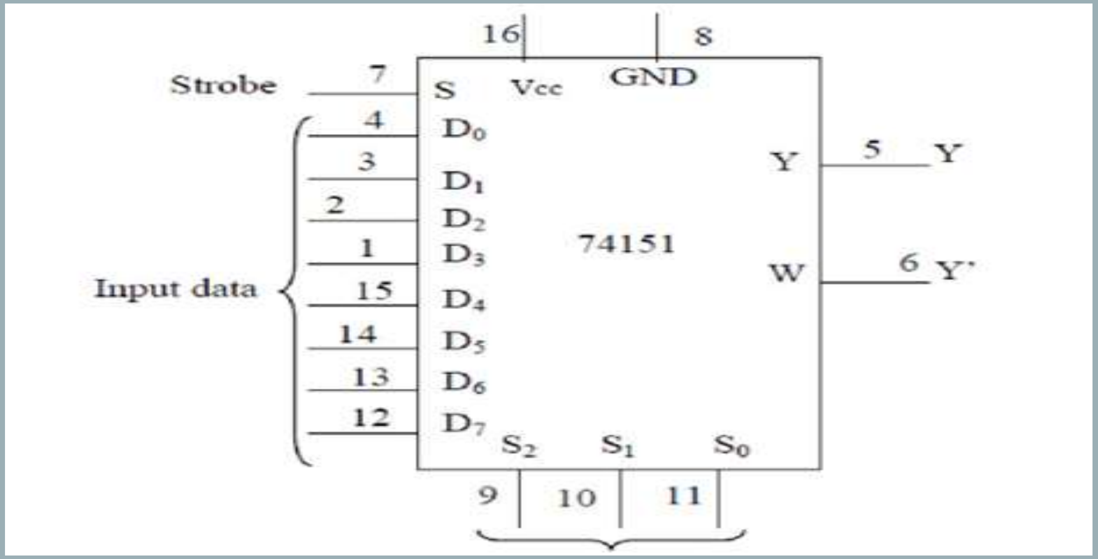
- A data processing circuit manipulates digital data according to specified operations, such as addition, subtraction, or logical functions.
- An 8:1 multiplexer selects one of eight input data sources and forwards it to a single output based on control signals.

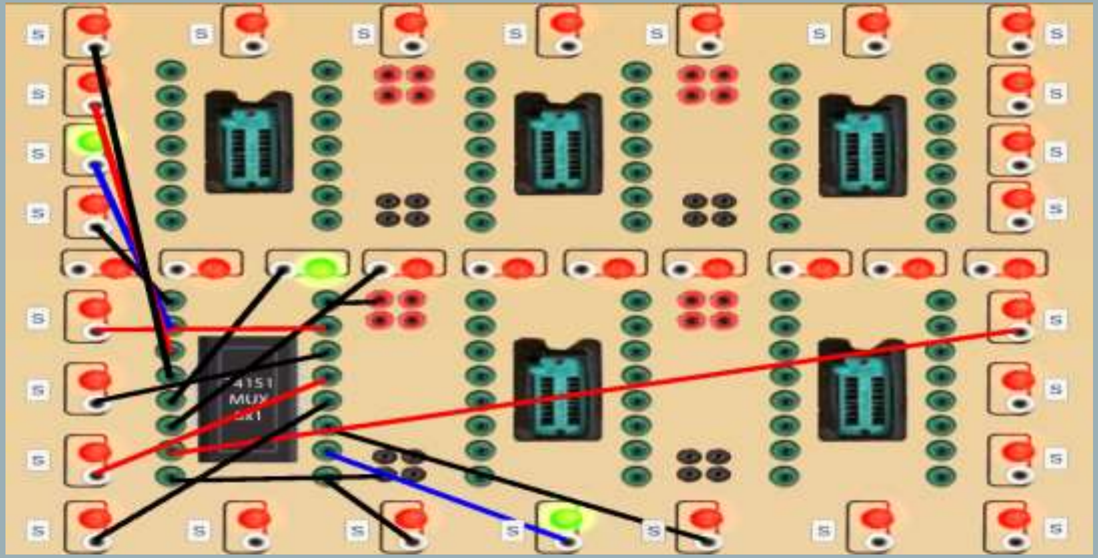
DATA PROCESSING CIRCUIT – 8:1 MUX – IC 74151

Select Lines			Output
S2	**S1**	**S0**	**Out**
0	0	0	I0
0	0	1	I1
0	1	0	I2
0	1	1	I3
1	0	0	I4
1	0	1	I5
1	1	0	I6
1	1	1	I7



DATA PROCESSING CIRCUIT – 8:1 MUX – IC 74151





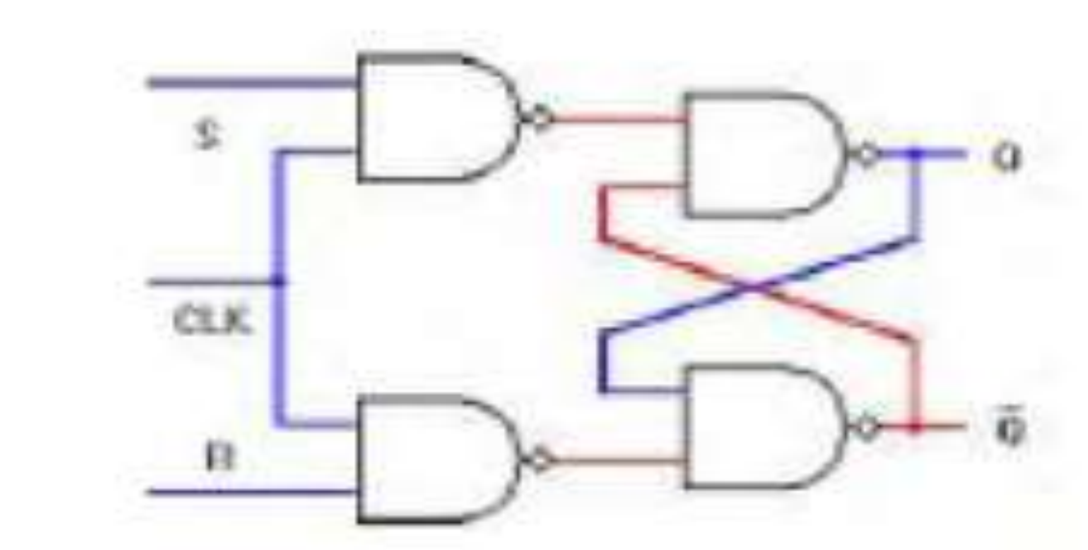
Video Reference - https://youtu.be/QohxwFDptnI

FLIP FLOP – SR FLIP FLOP AND D FLIP FLOP

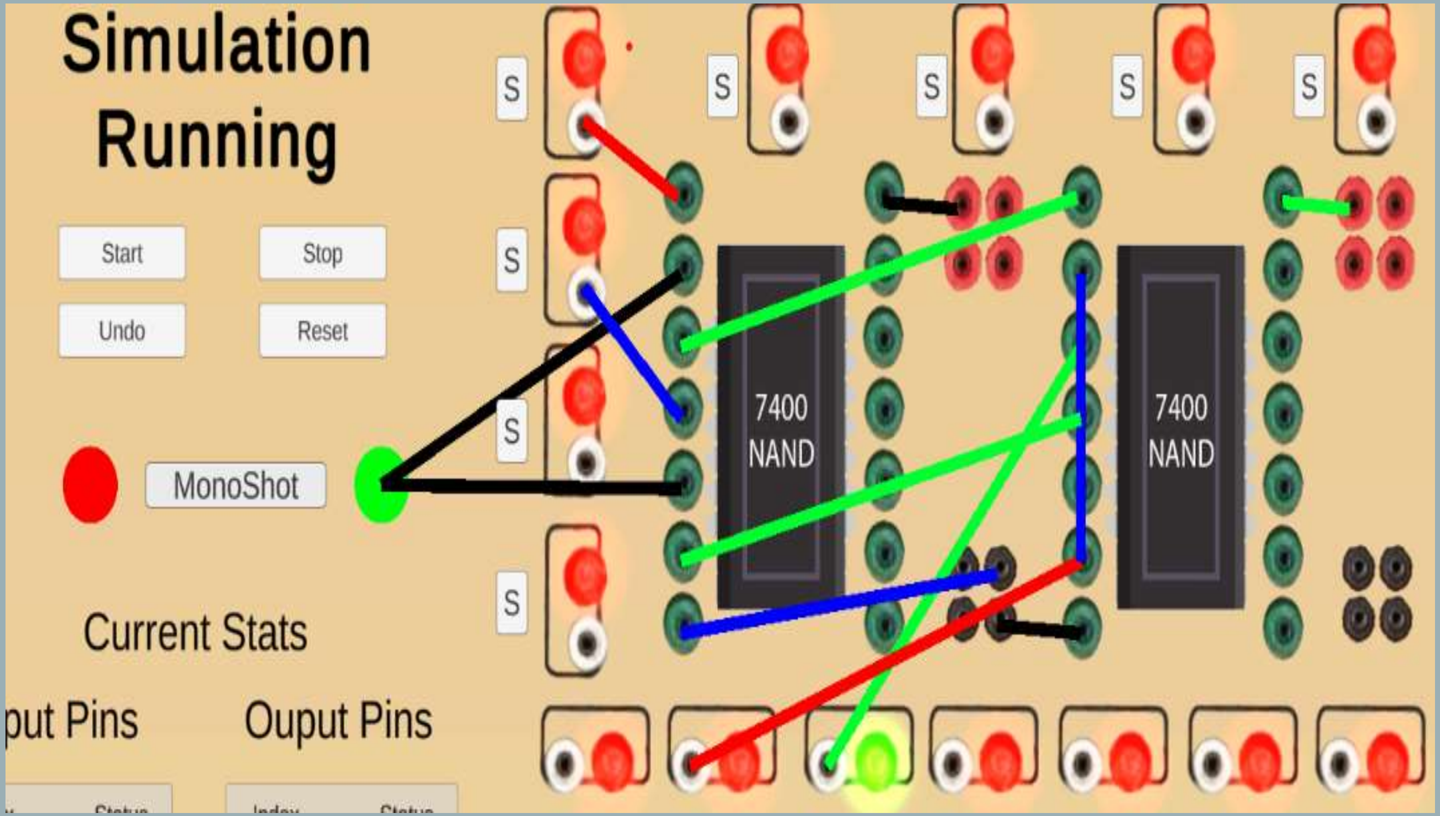
- Flip-flops are digital circuits capable of storing binary states, used as memory elements in sequential logic circuits.
- A SR flip-flop stores one bit of data and has two inputs: Set (S) and Reset (R), which toggle its output.
- A D flip-flop, or data flip-flop, stores one bit of data and has a single input (D) that sets its state when the clock input transitions.

FLIP FLOP – SR FLIP FLOP

S	R	Q	Q+
1	1	0	0
1	1	1	1
0	1	X	0
1	0	X	1
0	0	X	1



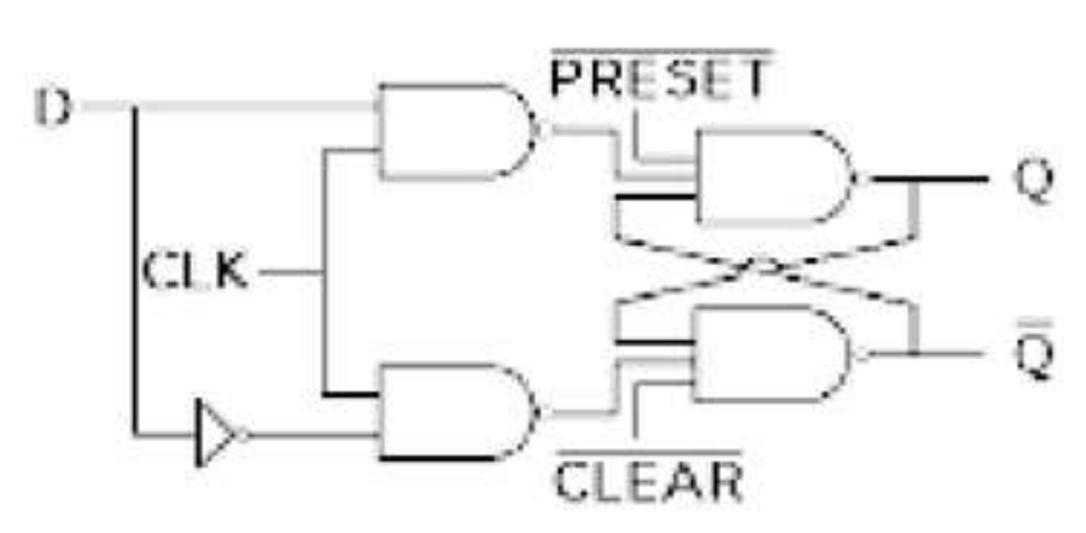
FLIP FLOP – SR FLIP FLOP



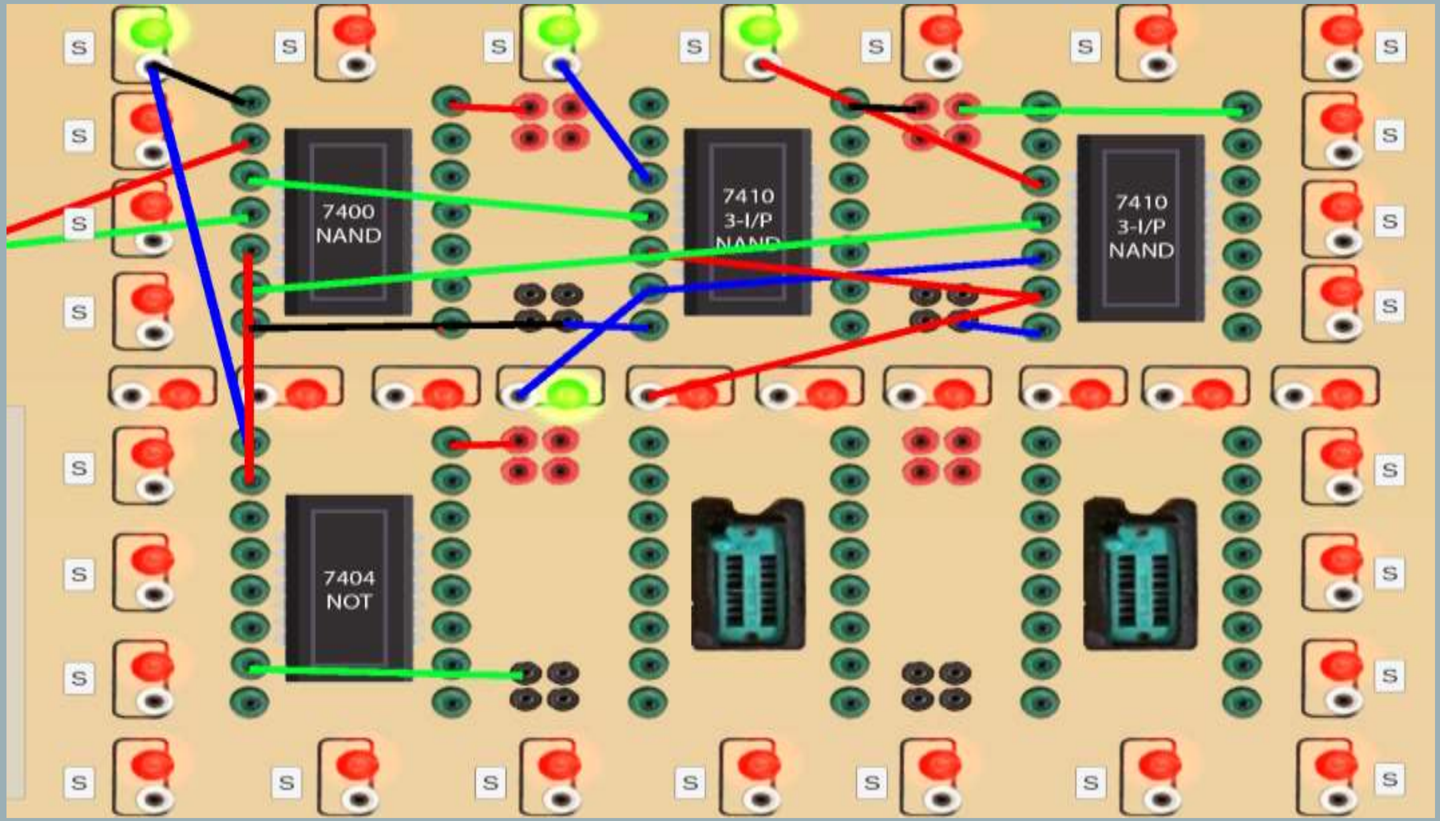
Video Reference - https://youtu.be/bBxNEddS9hQ

FLIP FLOP – D FLIP FLOP

Clock	D	Q	Q'	Description
↓ » 0	X	Q	Q'	Memory no change
↑ » 1	0	0	1	Reset Q » 0
↑ » 1	1	1	0	Set Q » 1



FLIP FLOP – D FLIP FLOP



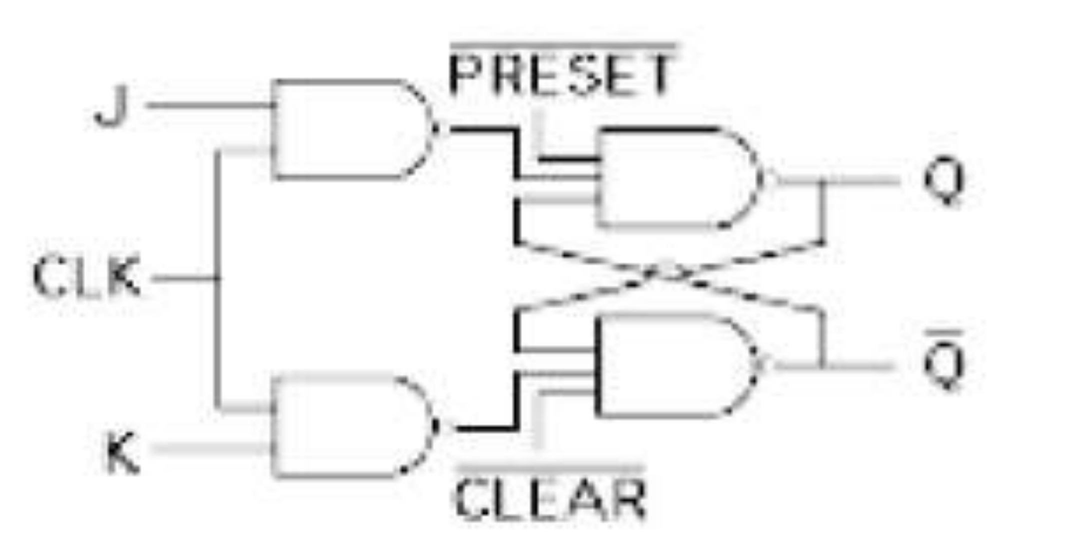
Video Reference - https://youtu.be/GGVUtY_PyZY

FLIP FLOP – JK FLIP FLOP AND T FLIP FLOP

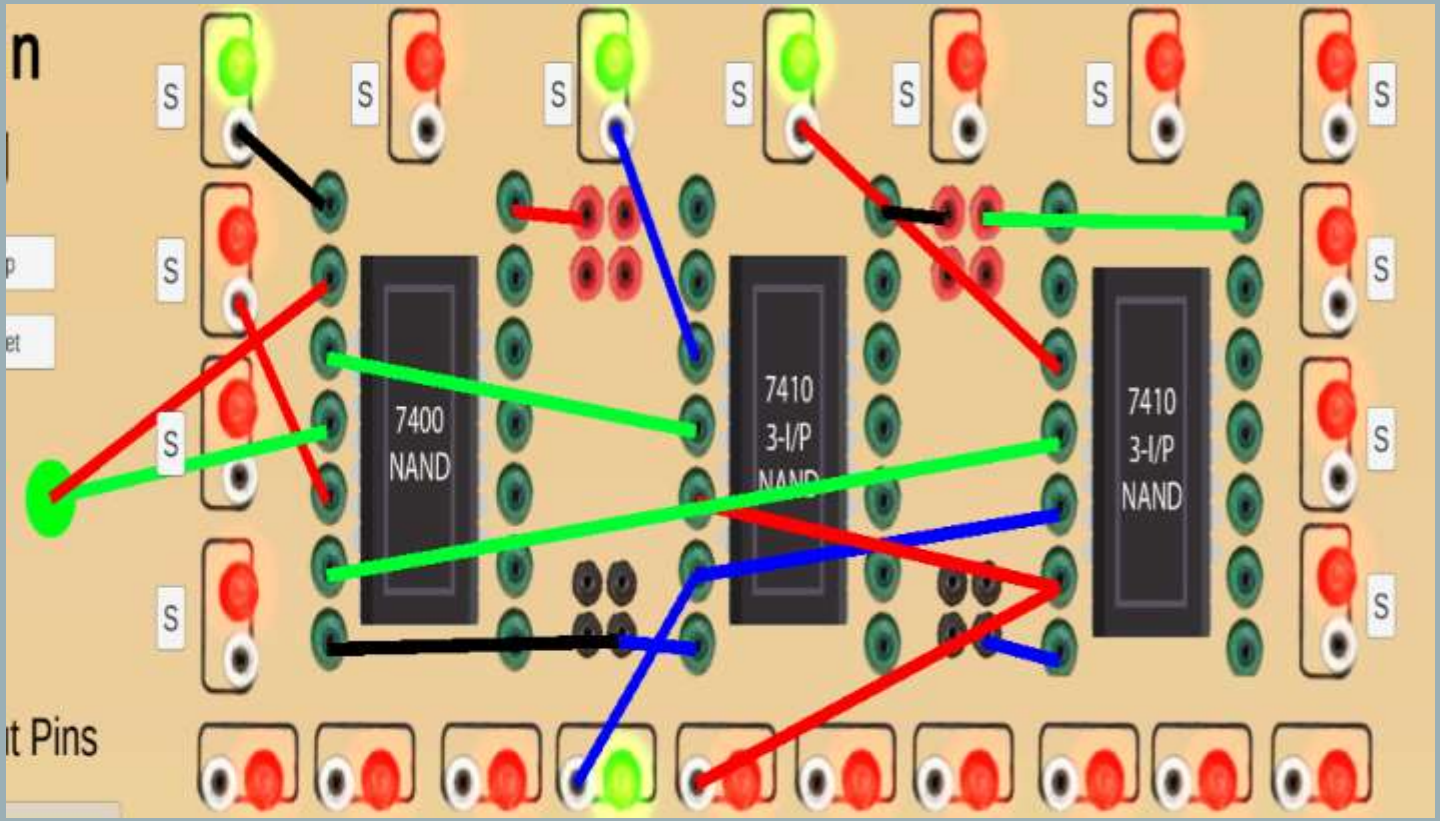
- Flip-flops are digital circuits capable of storing binary states, used as memory elements in sequential logic circuits.
- A JK flip-flop is a sequential logic circuit capable of toggling its output based on its inputs and previous state.
- A T flip-flop is a digital circuit that toggles its output between two states based on its input and clock signal.

FLIP FLOP – JK FLIP FLOP

Clock	J	K	Q_{n+1}	State
0	x	x	Q_n	
1	0	0	Q_n	Hold
1	0	1	0	Reset
1	1	1	1	Set
1	1	1	$\overline{Q}_n$	Toggle



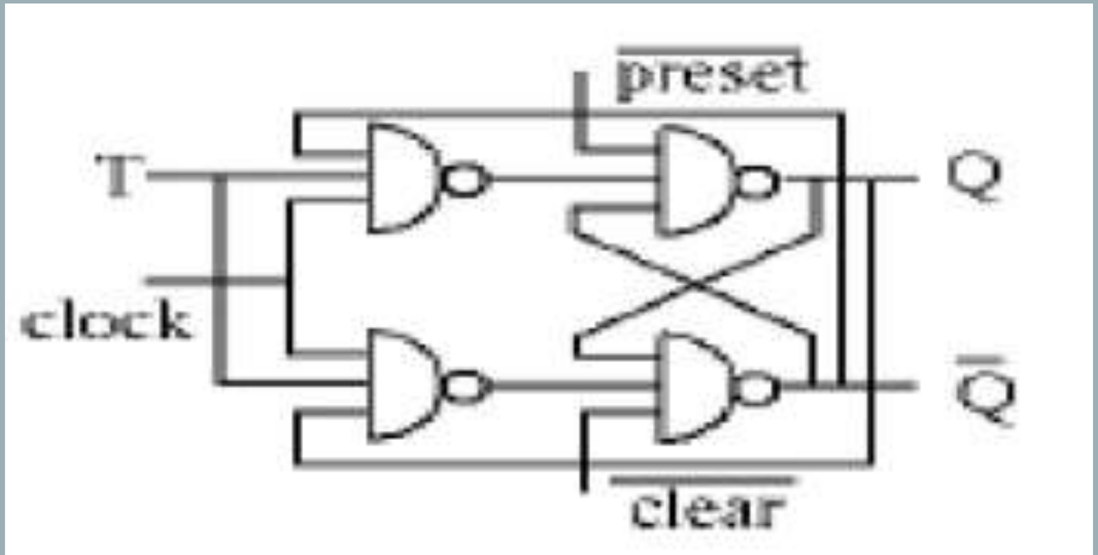
FLIP FLOP – JK FLIP FLOP



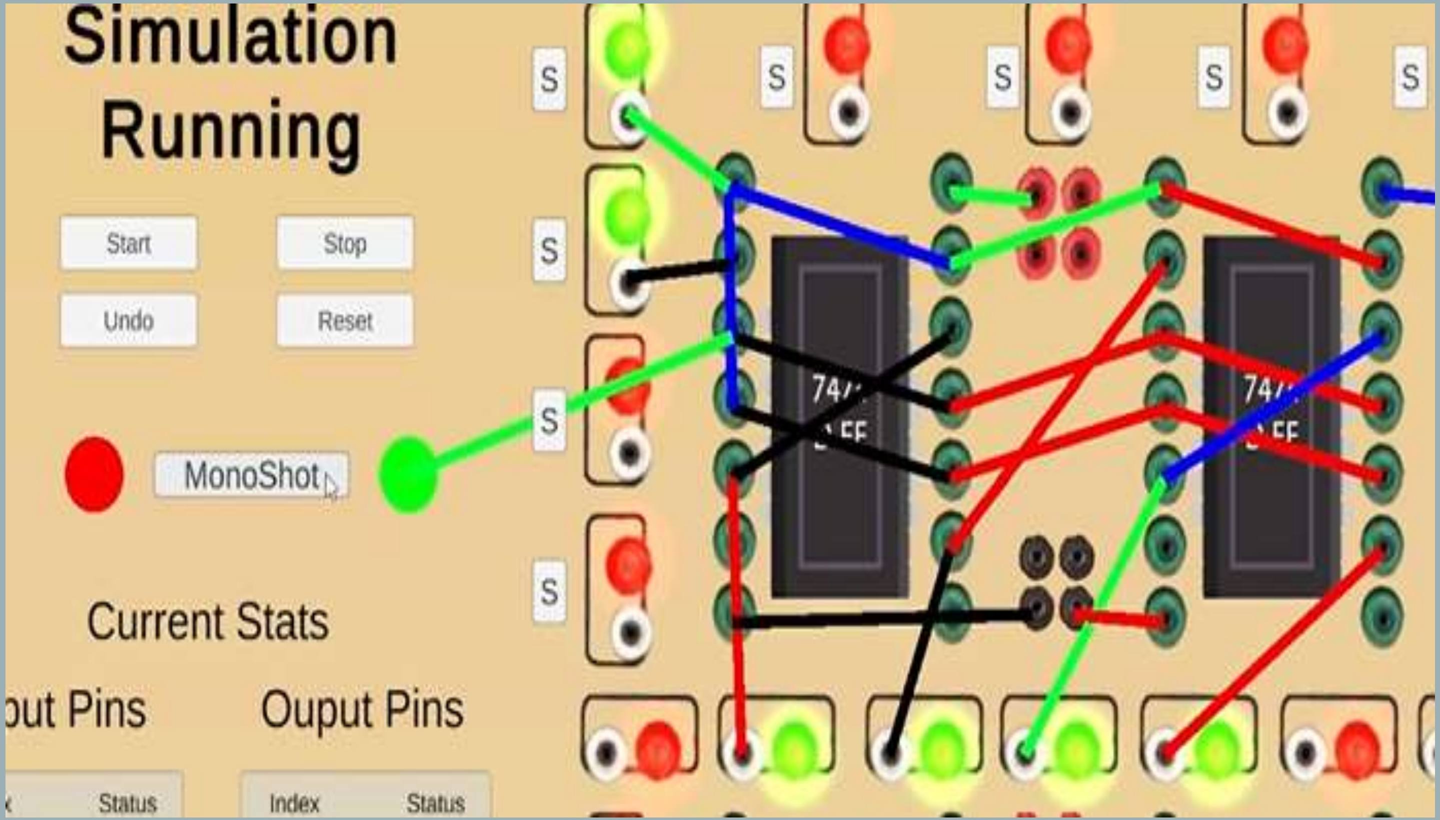
Video Reference - https://youtu.be/nPQj0gH09RU

FLIP FLOP – T FLIP FLOP

	Previous		Next	
T	Q	Q'	Q	Q'
0	0	1	0	1
0	1	0	1	0
1	0	1	1	0
1	1	0	0	1



FLIP FLOP – T FLIP FLOP



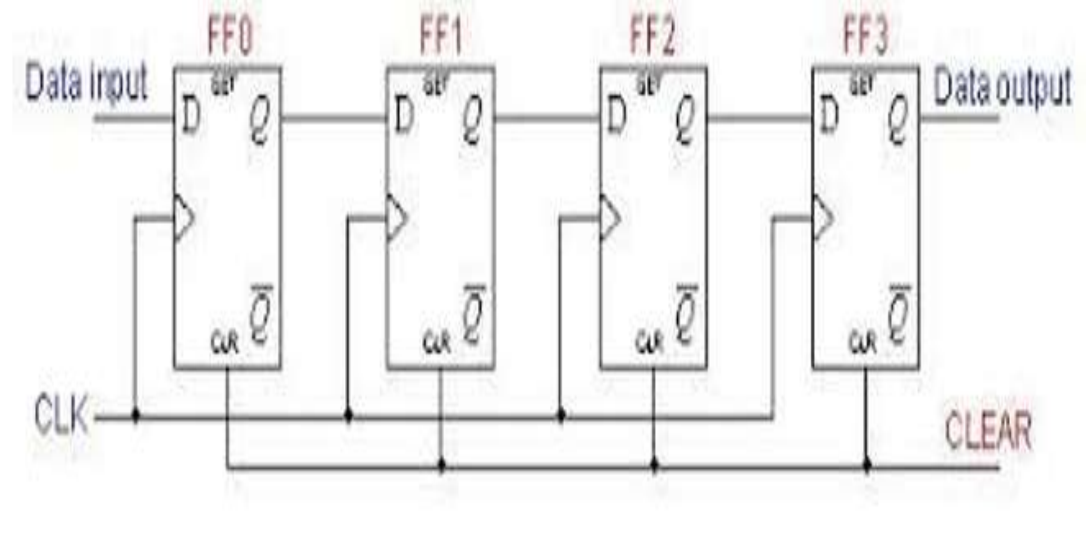
Video Reference - https://youtu.be/Jn01ggVlMok

SHIFT REGISTERS

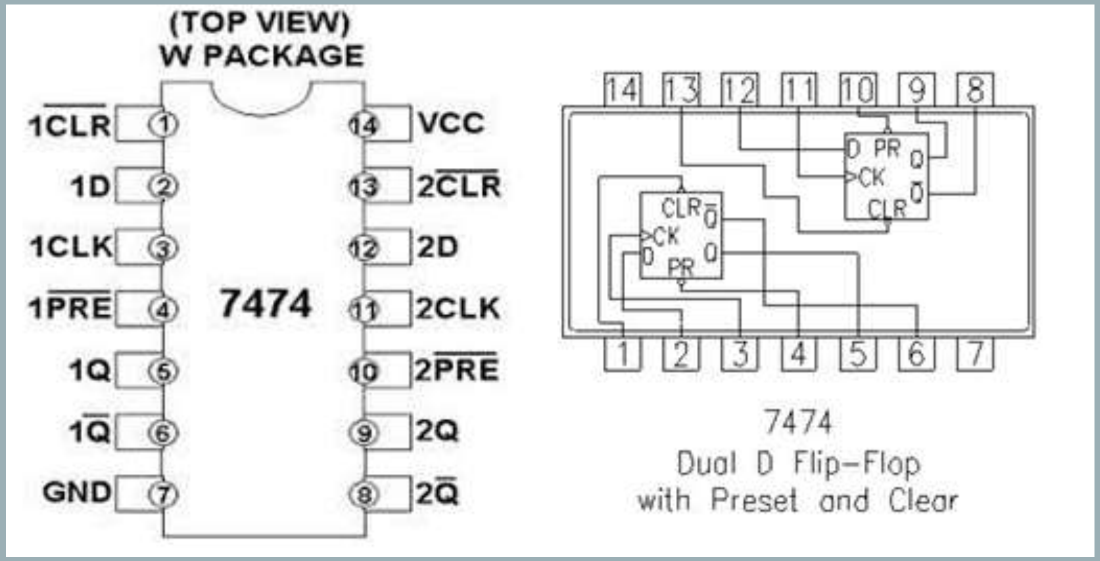
- Shift registers are sequential digital circuits used to store and shift data serially or in parallel within electronic systems.
- SISO (Serial-In Serial-Out) shift register shifts data in and out serially, maintaining a single data stream.
- PISO (Parallel-In Serial-Out) shift register loads parallel data and outputs it serially, one bit at a time.

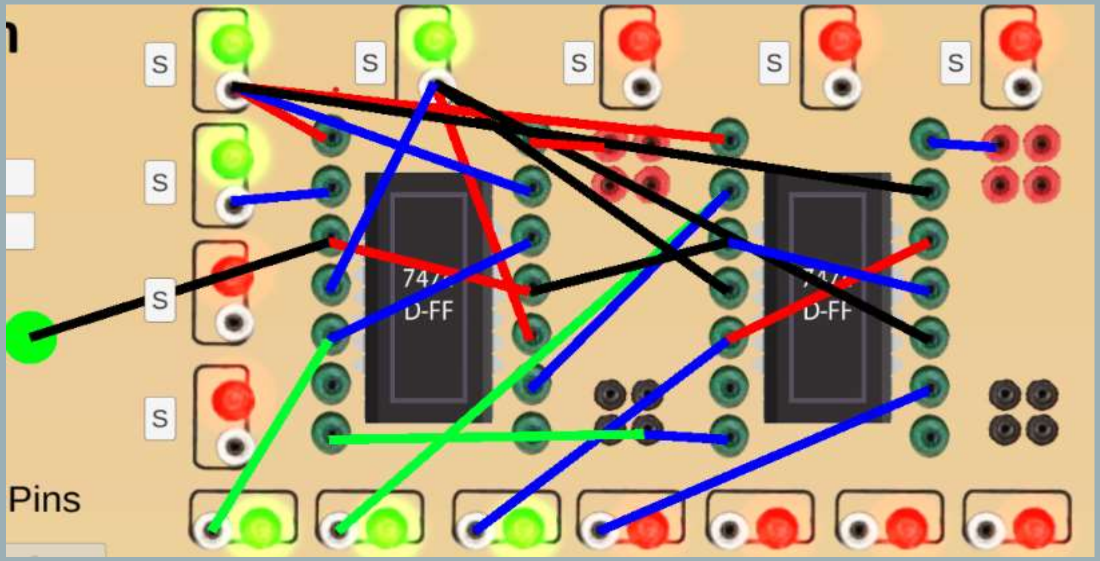
SHIFT REGISTER – SISO (IC 7474)

Input (SI)	Clock Pulse	Shift Register				Serial Output (SO)
		Q_0	Q_1	Q_2	Q_3	
0	↑	0	-	-	-	-
1	↑	1	0	-	-	-
1	↑	1	1	0	-	-
0	↑	0	1	1	0	0
1	↑	1	0	1	1	1
0	↑	0	1	0	1	1



SHIFT REGISTER – SISO (IC 7474)

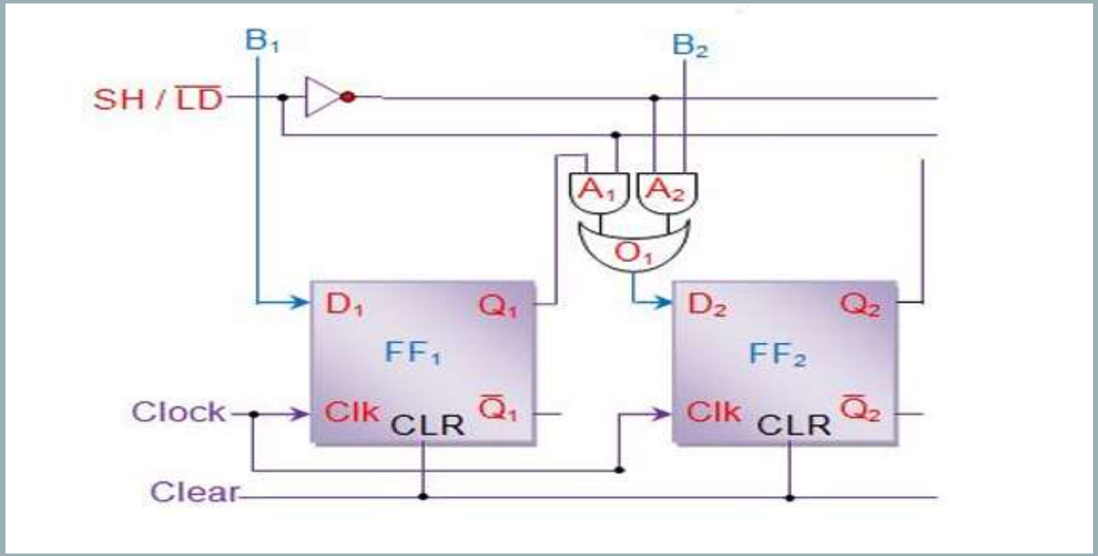




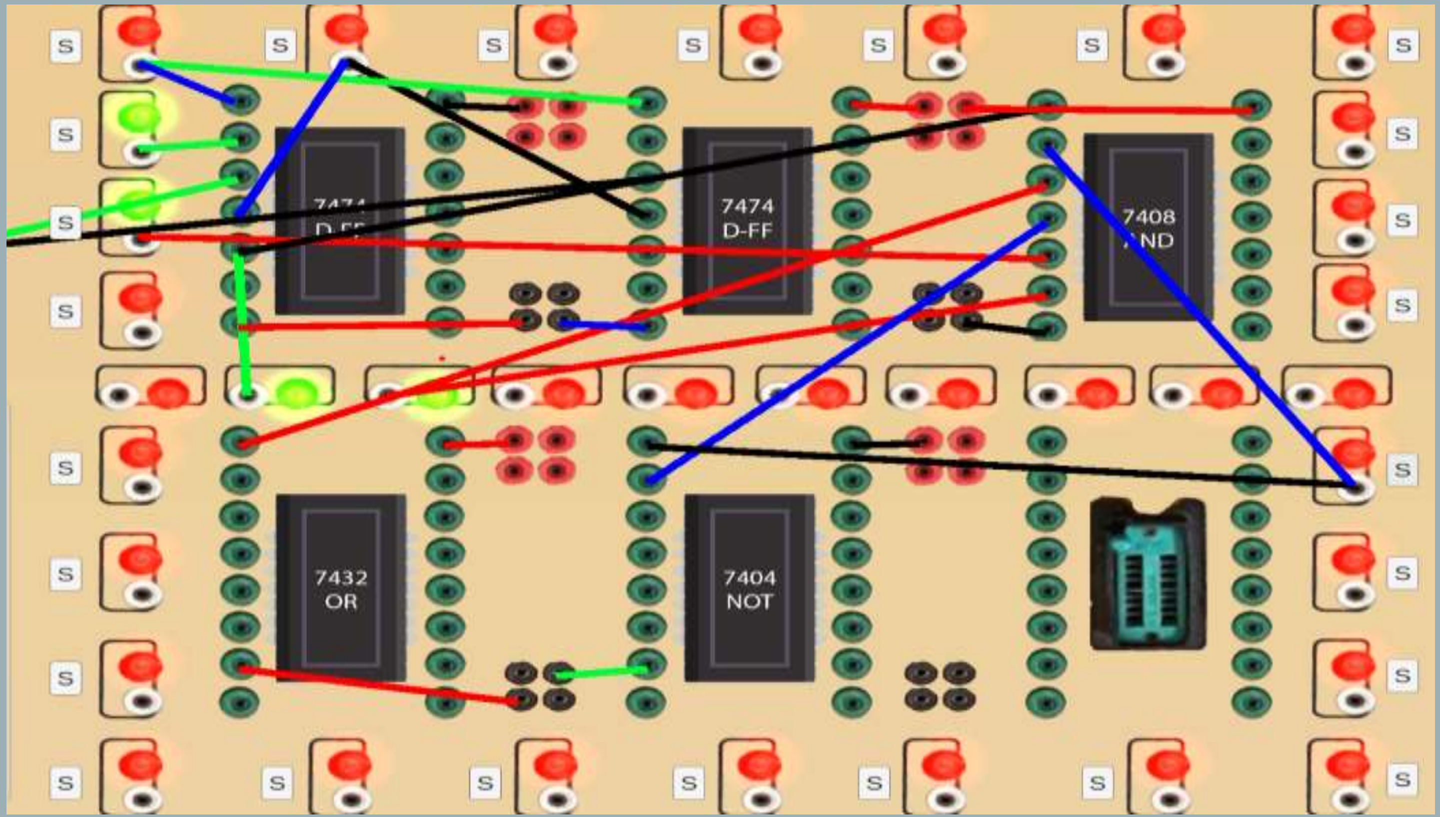
Video Reference - https://youtu.be/yfyaXbC6rZ4

SHIFT REGISTER – PISO

Load/ (Shift)	Clock Pulse	Inputs				Serial Output (SO)
		D_0	D_1	D_2	D_3	
1	↑	0	1	0	1	1
0	↑	0	0	1	0	0
0	↑	0	0	0	1	1
0	↑	0	0	0	0	0
1	↑	1	1	0	1	1



SHIFT REGISTER – PISO

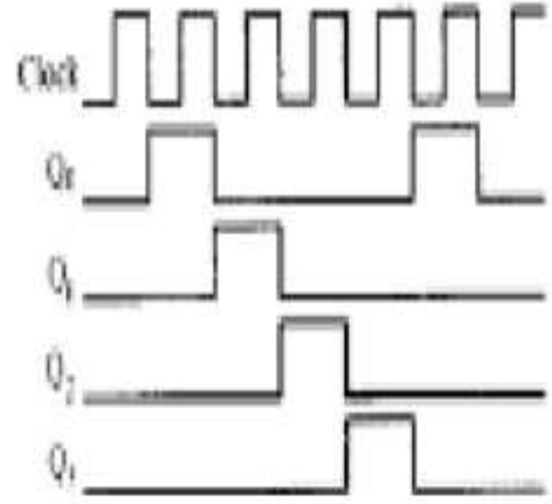


Video Reference - https://youtu.be/5JvidObNaJc

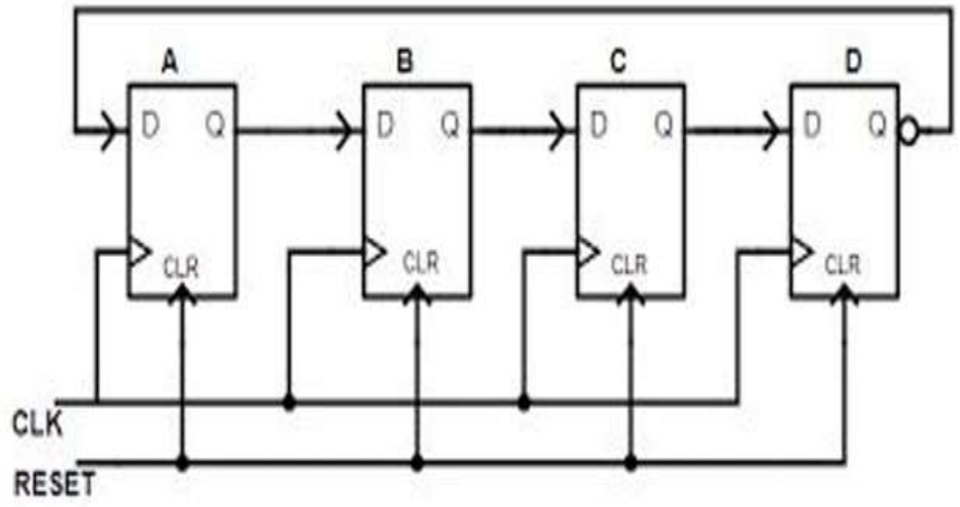
RING COUNTER

- Shift registers are sequential digital circuits used to store and shift data serially or in parallel within electronic systems.
- A Ring Counter is a type of shift register where the output of each stage is connected to the input of the next, creating a circular shifting pattern of binary values.

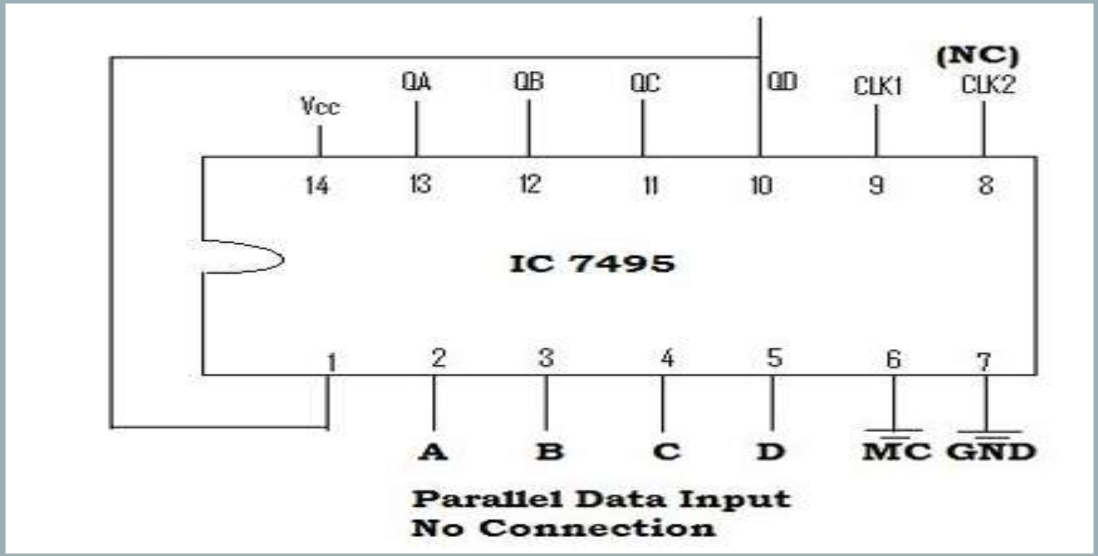
RING COUNTER – IC 7495

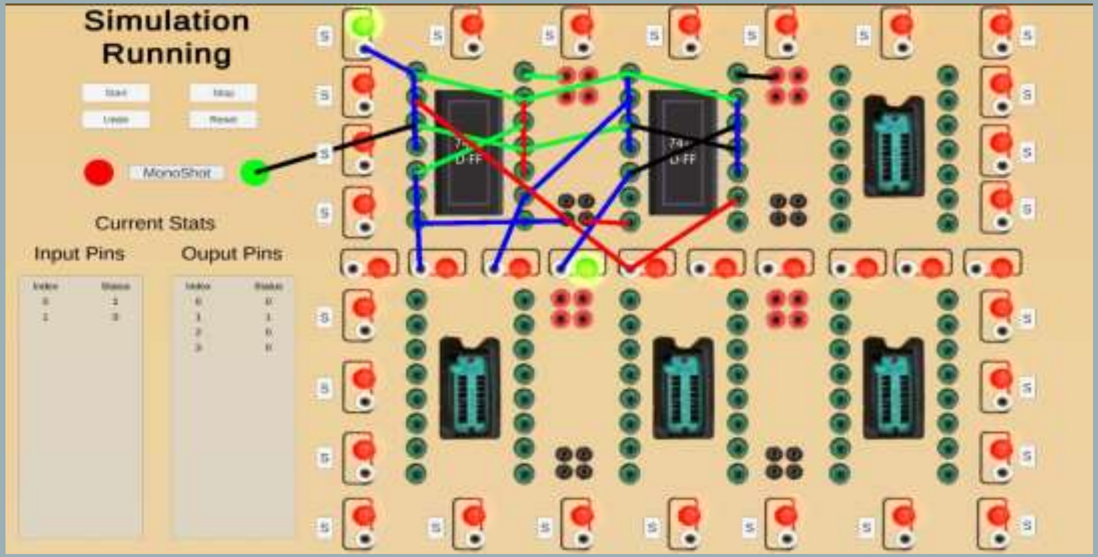


Clk	Q_0	Q_1	Q_2	Q_3
1	1	0	0	0
2	0	1	0	0
3	0	0	1	0
4	0	0	0	1



RING COUNTER – IC 7495



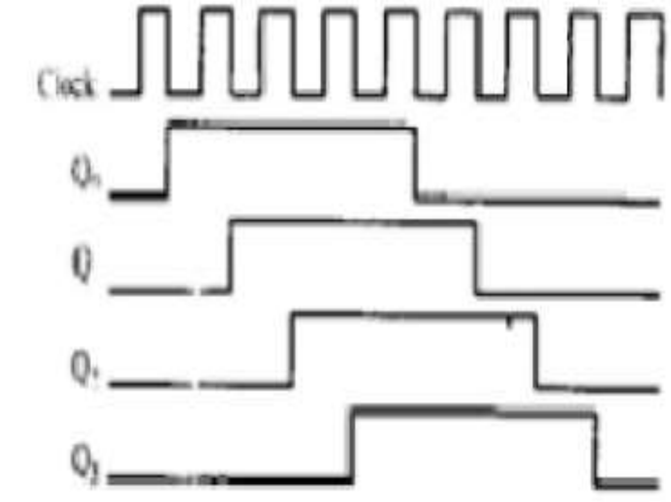


Video Reference - https://youtu.be/Uiam6Edjju4

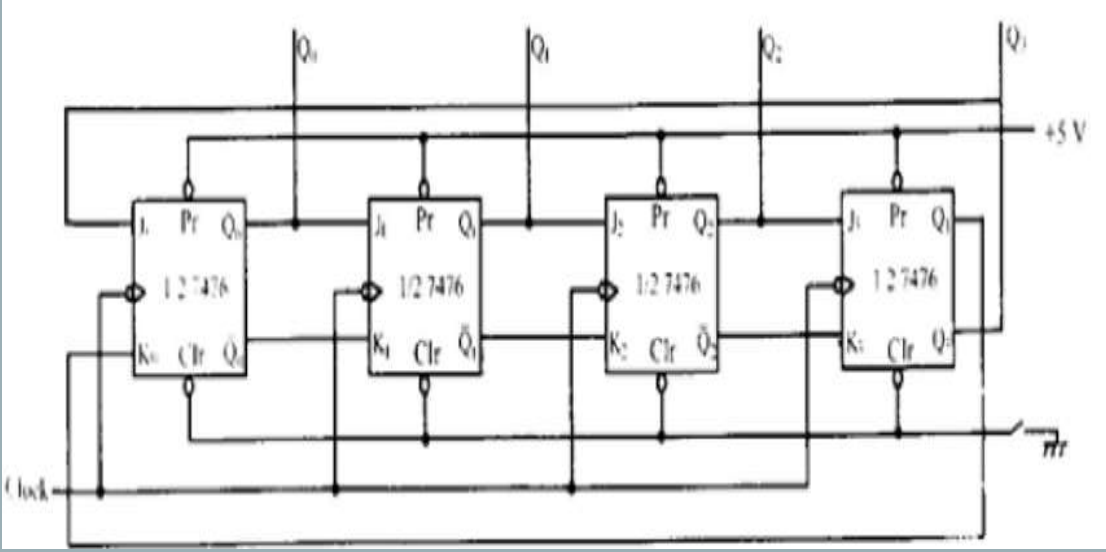
JOHNSON COUNTER

- Shift registers are sequential digital circuits used to store and shift data serially or in parallel within electronic systems.
- A Johnson counter, also known as a twisted-ring counter, is a type of shift register where the output of each stage is complemented and fed back to the input of the previous stage, resulting in a sequence of binary values with fewer states than a standard shift register.

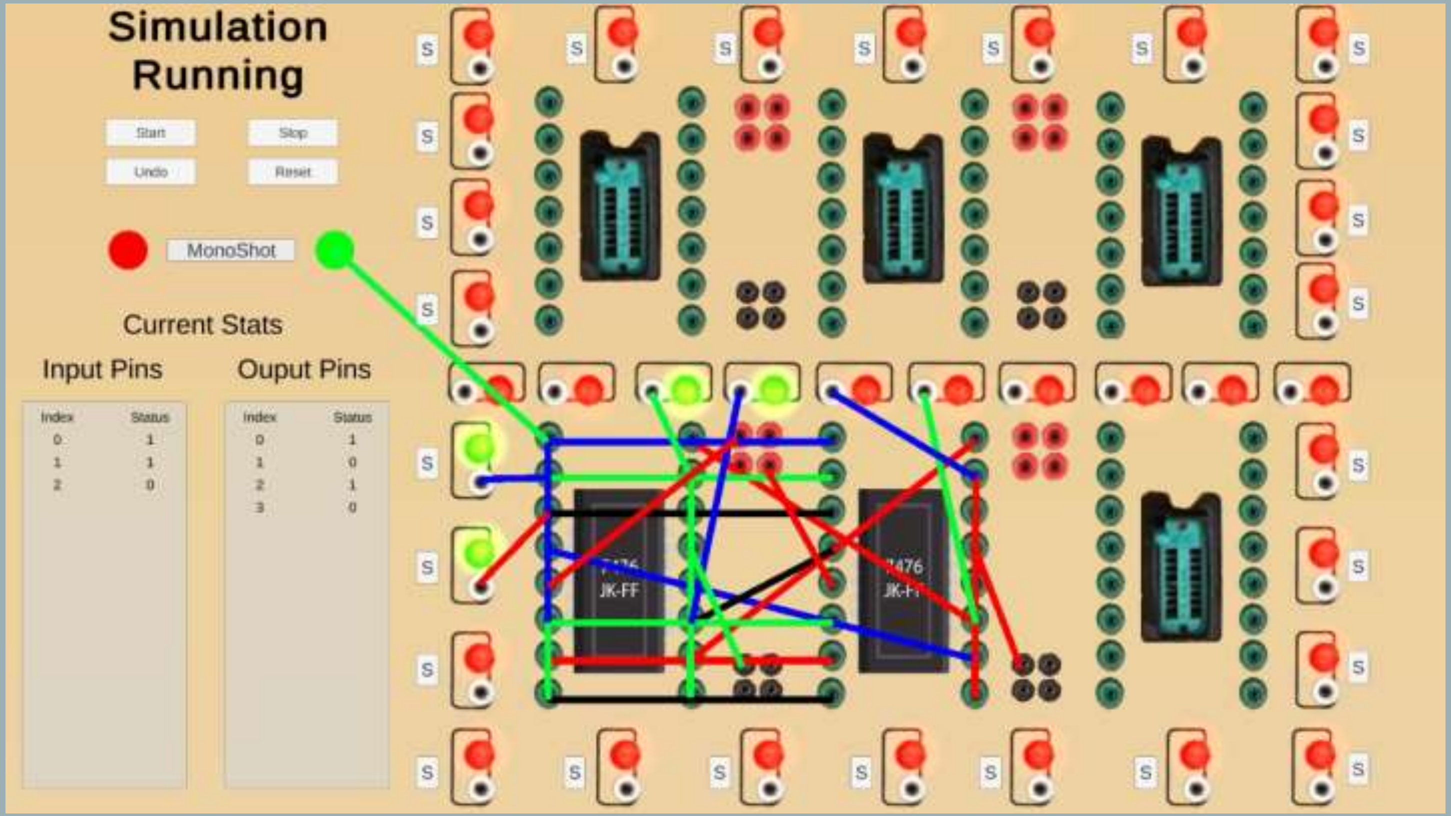
JOHNSON COUNTER



Clk	Q_0	Q_1	Q_2	Q_3
0	0	0	0	0
1	1	0	0	0
2	1	1	0	0
3	1	1	1	0
4	1	1	1	1
5	0	1	1	1
6	0	0	1	1
7	0	0	0	1



JOHNSON COUNTER



Index	Status
0	1
1	1
2	0

Index	Status
0	1
1	0
2	1
3	0

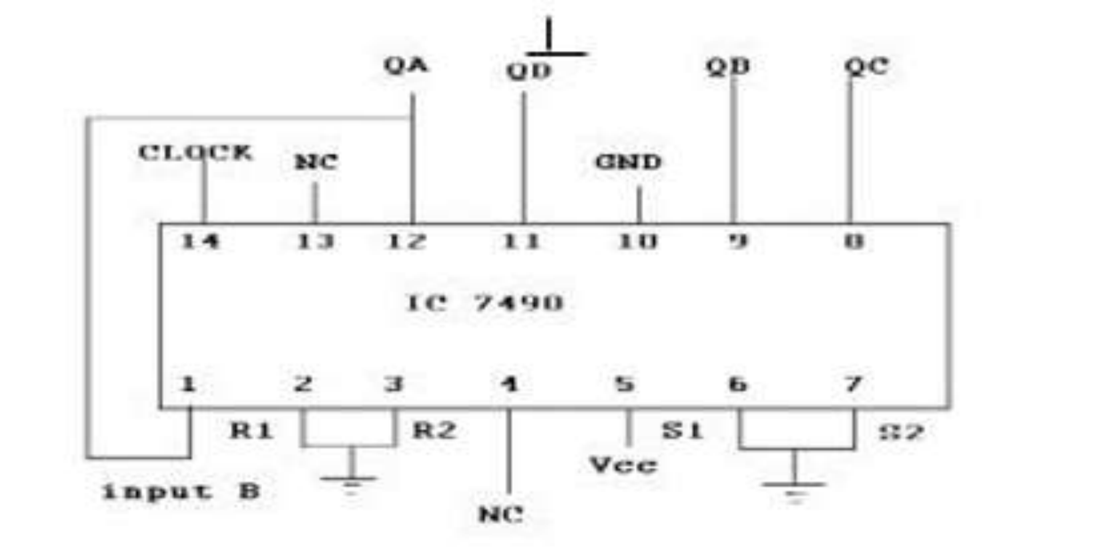
Video Reference - https://youtu.be/OXQa5t9WyHk

ASYNCHRONOUS COUNTER

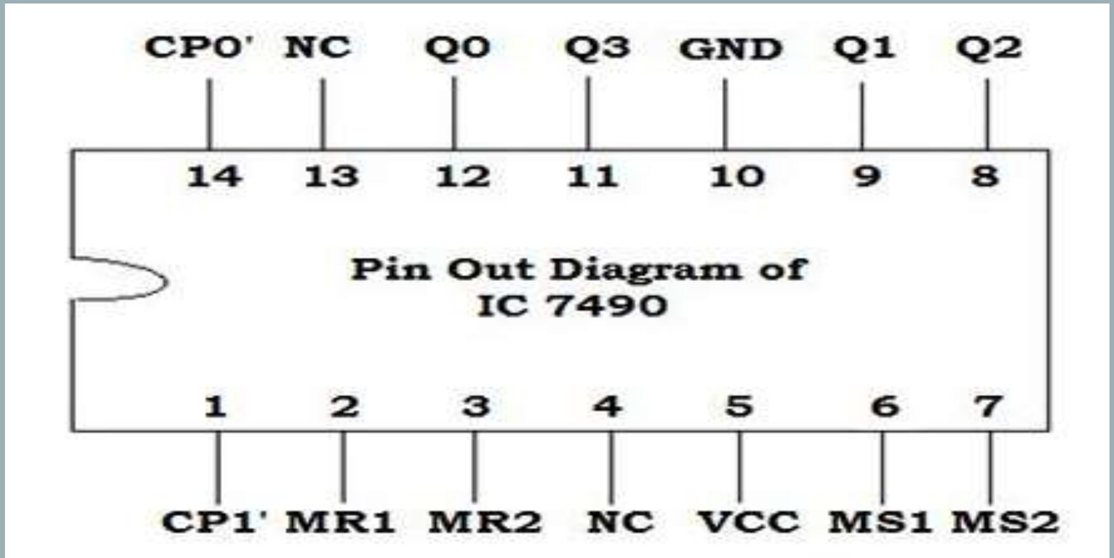
- An asynchronous counter uses individual flip-flops triggered by their own clock signals, allowing each stage to change state independently.
- A mod 10 (decade) counter counts from 0 to 9 before resetting, commonly used in digital clocks and decimal applications.
- Mod 8, mod 5, and mod 7 counters count up to their respective modulus values before resetting, useful in various counting applications where specific sequence lengths are required. They can be implemented using Mod 10 Counter.

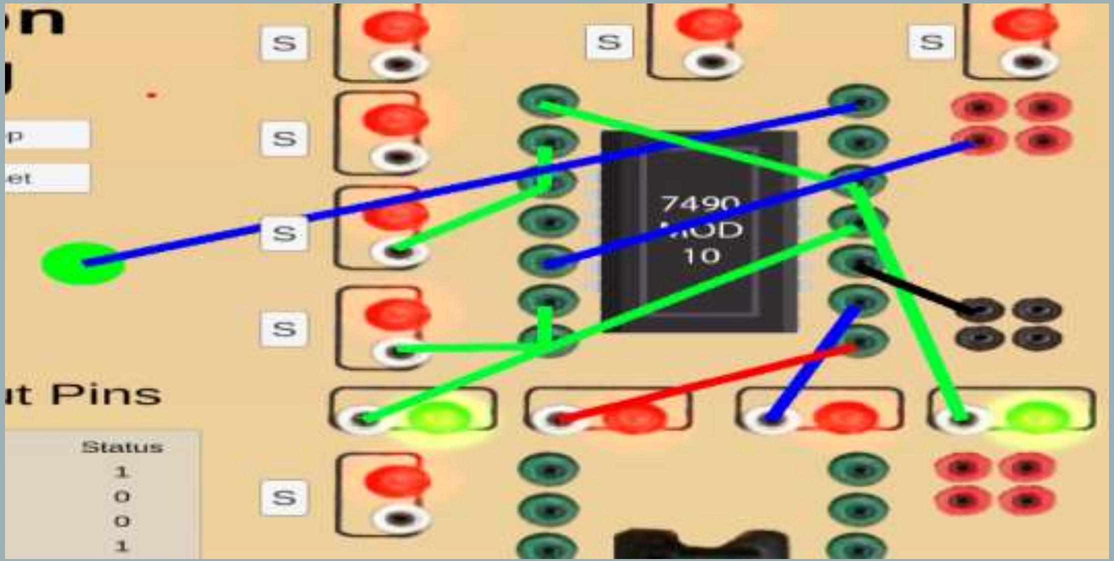
MOD 10/ DECADE COUNTER – IC 7490

CLK	Q_d	Q_c	Q_b	Q_a
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1



MOD 10/ DECADE COUNTER – IC 7490

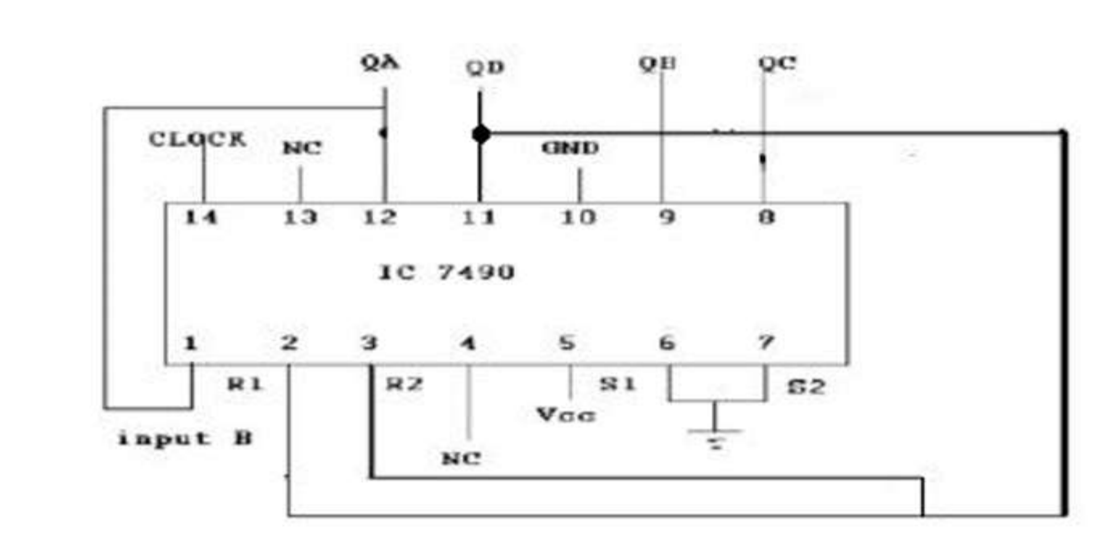




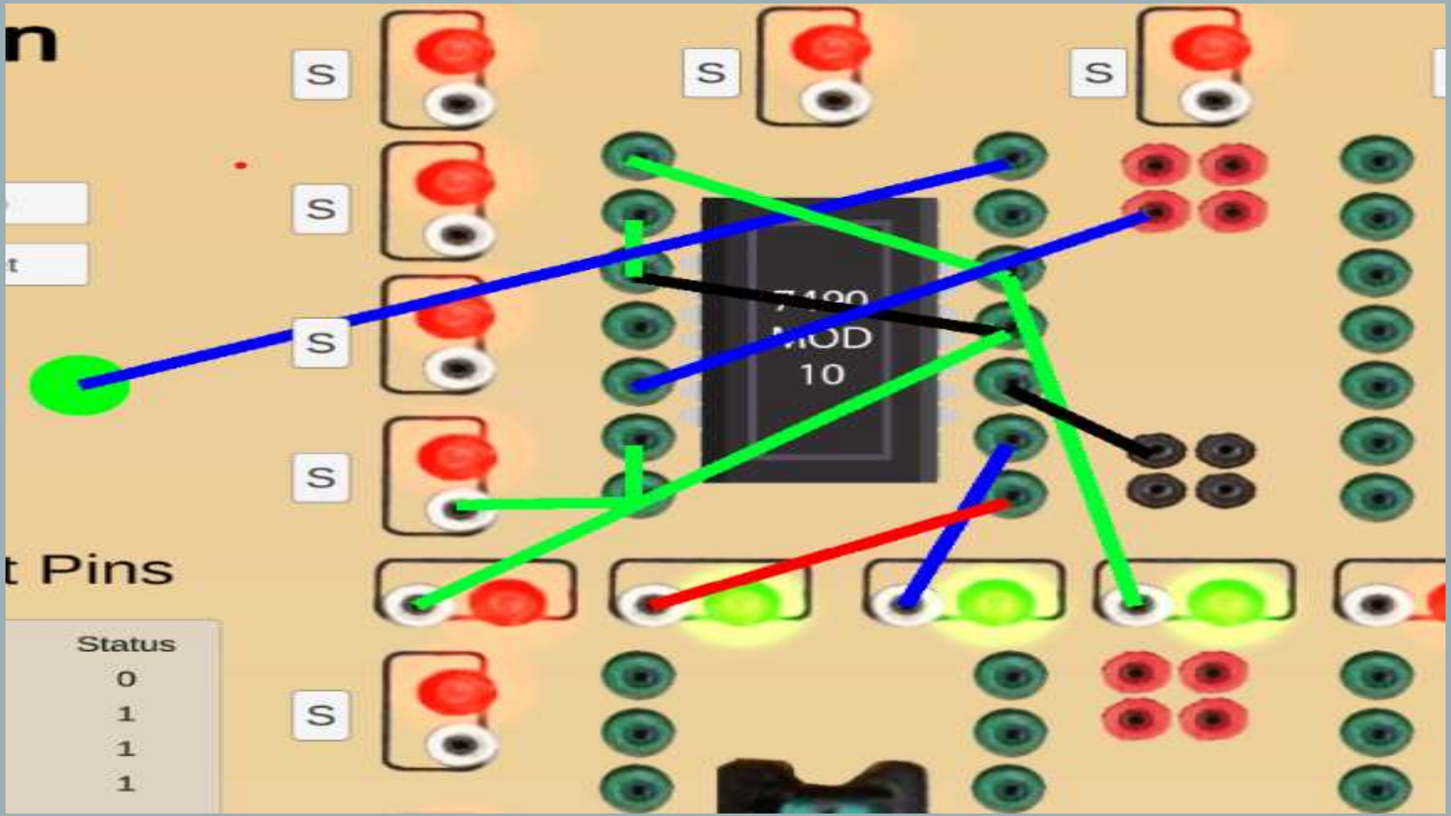
Video Reference - https://youtu.be/rq-xwlMHTxw

MOD 8 COUNTER

CLK	Q_d	Q_c	Q_b	Q_a
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0



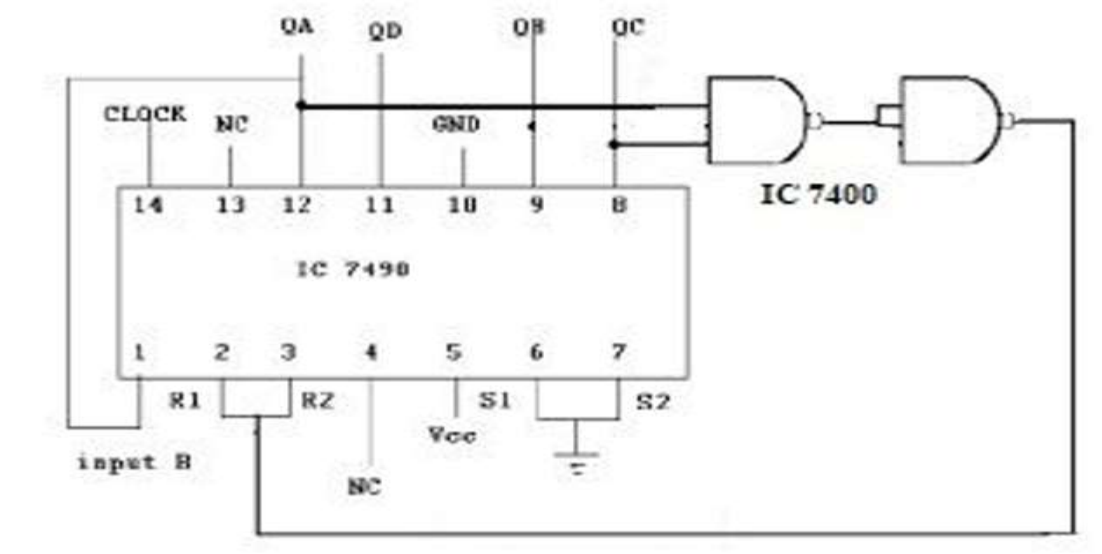
MOD 8 COUNTER



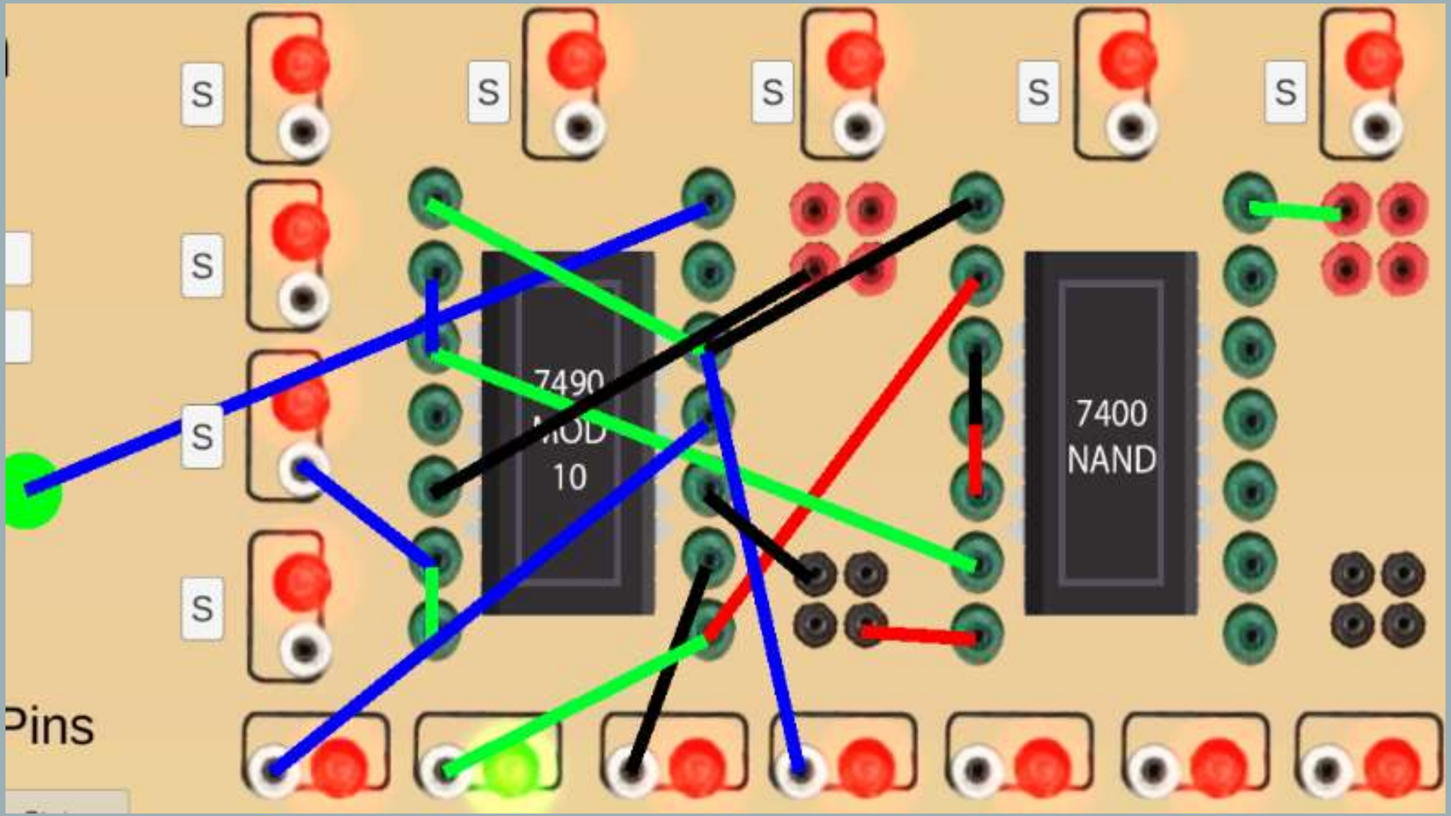
Video Reference - https://youtu.be/SFdlqgU8Gn4

MOD 5 COUNTER

CLK	Q_d	Q_c	Q_b	Q_a
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1



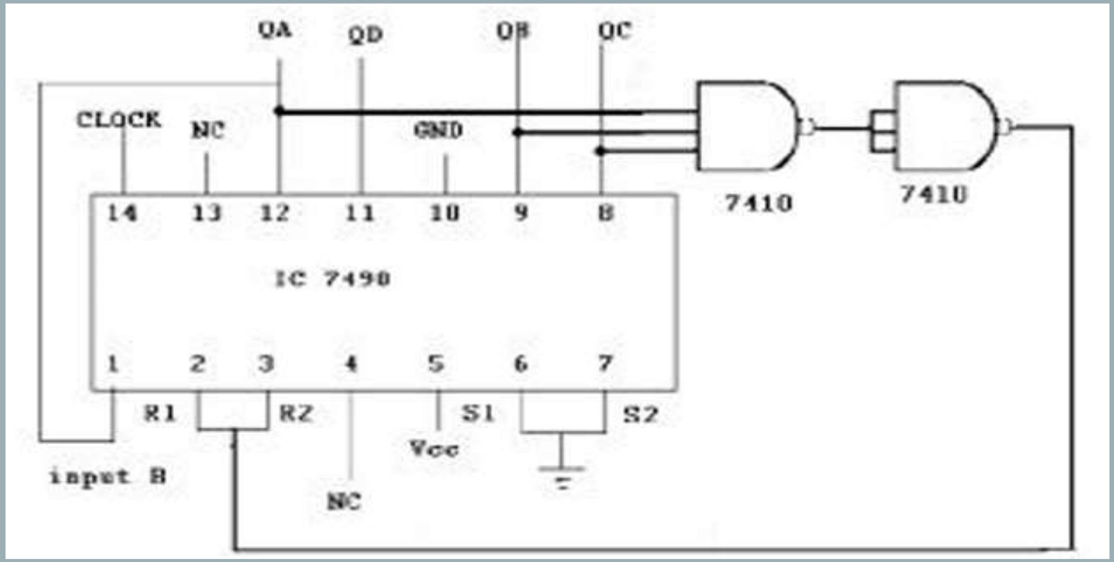
MOD 5 COUNTER



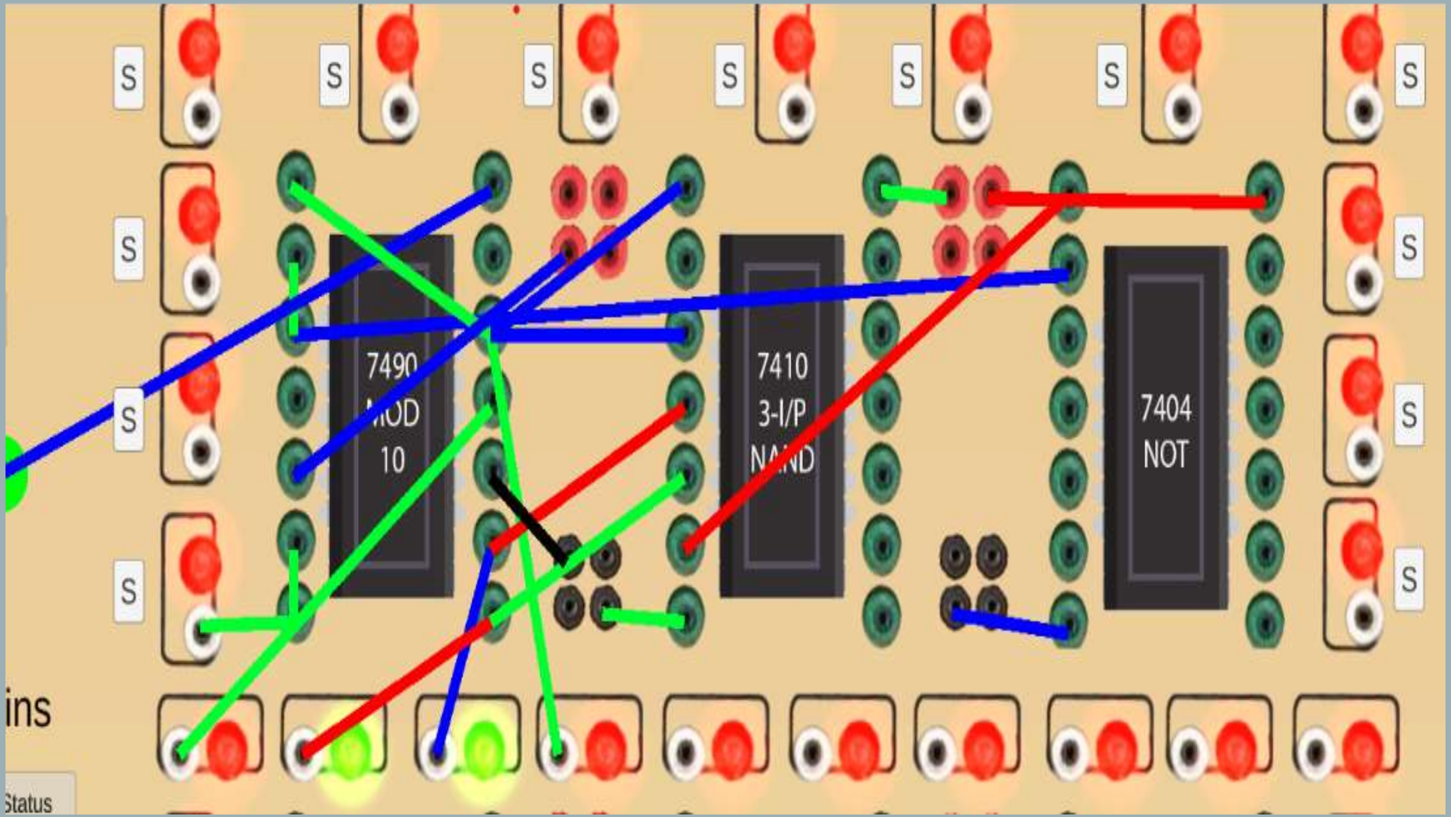
Video Reference - https://youtu.be/vVb86u_AZhg

MOD 7 COUNTER

CLK	Q_d	Q_c	Q_b	Q_a
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1



MOD 7 COUNTER



Video Reference - https://youtu.be/ykBIbfEDYz4

Ready to Dive In? Simulation Starts Now!