A HARDWARE DESIGN AND IMPLEMENTATION OF SR FLIPFLOP USING QUAD 2-POSITIVE INPUT NAND GATES

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NEW HORIZON
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A MINI PROJECT

REPORT

Submitted by

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In partial fulfillment for the award of the degree of

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ELECTRICAL AND ELECTRONICS ENGINEERING

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Bonafide Certificate

This is to certify that, **Sankeerthini. D**, **Saranya. S** and **Vishnupriya. G. G** bearing University Seat numbers **1NH18EE742**, **1NH18EE743,** and **1NH18EE757** respectively have submitted the Mini Project report titled "Hardware Description and Implementation of SR Flip Flop using Quad 2 Input NAND Gates" in partial fulfilment for the course of EEE department. The report has been prepared as per the given format and is approved for submission and presentation.

Signature of,	Signature of,
Guide	Head of Department (HOD)
Dr. Singaravelan	**Dr. S. Ramkumar**
	Electrical and Electronics (EEE)

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Acknowledgment

It is always a fine pleasure to remind the faculties and staff of New Horizon College of Engineering for their sincere guidance we have received to uphold and successfully present our Mini project.

Firstly, we would like to thank our parents for providing us encouragement, enthusiasm and invaluable assistance to us. Without them, this wouldn't have been a mere success.

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Abstract

The introduction of modern coding or the binary number system is dated back to the early 1700s when the English version translated from the article 'Explication de l'Arithmétique Binaire' by Gottfried Leibniz shows the use of only two characters, 1 and 0. Under the further study of his article, the theory of Boolean Algebra using Logic Gates was set into the display by George Boole's publication, 'The Mathematical Analysis of Logic'.[1]The research and development of binary language gave birth to a number of devices required for the storage of data and implementation of the same. Flip Flops are one such majorly introduced devices which are not only used for data storage, but also as feedback and memory-based device. Random Access Memory, commonly abbreviated and referred to as RAM is a digital data storage device that is used in computers, digital control systems, and information processing systems from which the data can be recovered as preferred.[2] Flip Flops are storage devices that are used in RAMs for making memories of the stored information which can be of any length and can be stored for as long as required having no specific duration of time and can be delivered whenever required. The flip flops are also used to store data in registers where one flip flop stores one bit of data and many such flip flops work cordially forming the register. In these registers, further, the data can be serially or parallelly loaded. SR Flip Flop is a simple binary input bistable sequential logic circuit which can be constructed using NOR, NAND or AND-OR gates individually. In this project, we will demonstrate the working of the flip flop using quad 2-positive input NAND gates IC SN74HC00.

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Introduction

It is interesting to revisit the history of one of the major branches of study, 'Digital Electronics' which majorly stepped into the field during the invention of the first-ever electronics computer known as 'Electronic Numerical Integrator and Calculator' commonly abbreviated as 'ENIAC' back in the mid-1400s. However, the introduction of Binary coding dates back to the early 1600s when Gottfried introduced the world of the language of 1s and 0s. As conceptually explained by the Oxford English Dictionary, the introduction of Binary Arithmetic first appeared in English in the year 1796 in 'A Mathematical and Philosophical Dictionary'.[3] Binary Language, as we are already familiar with, deals with primordially only two symbols; 1 and 0. Since both the digits are a part of the decimal system, in Binary language, they are precisely defined by the use of subscript '2'. For example, $(1011)_2$represents a binary system. The introduction of the binary system has led us to the path of one of the major subjects of research and study 'Digital System Design' which deals with the study of Electronic devices and Binary coding. The subject also deals with binary circuiting and theories. The establishment of Binary Language has guided us to the two significant logic circuiting in study; Combinational and Sequential Logic Circuits. Combinational Logic Circuits or the time-independent circuits are circuits that deal with a collection of the basic logic gates whose output depends only on the current or initial inputs.

Input → Combinational Logic → Output →

Chart. 1. Combinational Logic Circuits

Sequential Logic Circuits, compared to Combination Logic, is a collection of memory elements which are often referred to as ‘Flip Flops’. These circuits are capable of storing the data in the form of memory. Thus, they can be defined as circuits whose output depends not only on the current input but only on the past input. The presence or addition of a feedback mechanism and a memory element to combinational logic gives birth to sequential logic circuits. They also depend on clock pulse noted to the use of flip flops.

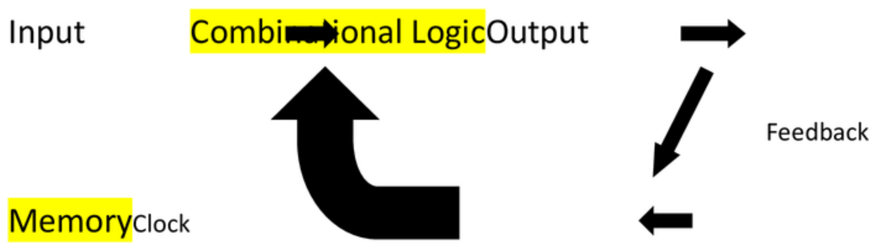


Chart. 2. Sequential Logic Circuits

William Eccles and F.W. Jordan, two English physicists, invented the first-ever electronic flip flop in the early 1900s comprising of two vacuum tubes as the active elements which were introduced in the ‘Logical Designing’ of digital computers.[4] Furthermore, an elaborate classification of flip flops also came into the picture under classifications based on the presence of clock pulse as Synchronous and Asynchronous. In the generalized description, the simple ones excluding the clock pulse are termed as ‘Latches’ and including the clock,the pulse has been classified as ‘Flip Flops’. There are four types of flip flops; SR Flip Flop, JK Flip Flop, D Flip Flop, and T Flip Flop. These flip flops differ on the basis of the values remembered or retained in the memory i.e., the fate of the current input. In D Flip Flops, the current input becomes the value of the Data or D input for that instant. In T Flip Flops, the current input value may either toggle or it may remain the same depending on the Toggle or

T input. JK and SR Flip Flop are very similar except when the inputs are high. In the case of JK Flip Flops, when both the inputs, J or Jump and K or Kill are high i.e., 1, the output is inverted or toggling. However, in case of SR Flip Flops, when both the inputs S or Set and R or Reset are high i.e., 1, the output state is undefinable commonly referred to as 'Indeterminate State' as both the inputs are high which is controversial as they must be the complement of each other. This drawback is versed as an improvement of the SR Flip Flop in JK Flip Flop.

Flip Flops are made using latches but including the clock pulse which is absent in them. The presence of a clock pulse. Flip Flops are edge-triggered whereas latches are level triggered; thus, the output of Flip Flops is selective i.e., obtained when the clock pulse is high. This gives an advantage for Flip Flops over latches where chances of having the race condition become high and also latches are highly sensitive. For this project, we will be studying the designing and working of SR Flip Flops in detail. SR flip flop is a basic bistable sequential logic circuit which has one-bit memory upon which it is capable of either, 'SET' the device or 'RESET' the device.SR flip flops can be constructed using both NOR or NAND. Its, however, mainly studied by its construction using NAND gates. In the project, we are demonstrating the construction and working of SR flip flop using a clock pulse.SR flip flop has 3 inputs, the two given outputs and the current output represented as S, R, and Q. The memory of the current output is stored, thus flip flops are sequential logic circuits. For SR NAND, the inputs are taken inverted, that is, taken as active low values to avoid affecting the working of the device because NAND inputs are required to be 1. The memory or the feedback initial output is remembered and retained even after the inputs are given changed. The S input will be 1 to SET the output state and the R input will be 1 to RESET the output state to low. So, definingly, the output state of the SR flip flop changes when the SET and RESET states are complementary to each other.In the project, the SET and the RESET switches along with the clock pulse will be controlled to verify the output states. We are using the IC SN74HC00 quad NAND gate which has 4 NAND gates inside.LM7805 is additionally used to alter the input voltage 9V to required circuit voltage 5V. The IC is designed such that, it can accept a maximum current of 6V only, hence a voltage regulator is used. A series of resistors are used to protect the LEDs from the high currents. 2 Push buttons are used to control the inputs S' and R'. Also, an additional switch for clock pulse is used. Using the input S' and R' and the application of clock pulse, the outputs Q and Q' and obtained and verified with the truth tables. Thus, an SR flip flop using a NAND gate is constructed and demonstrated.

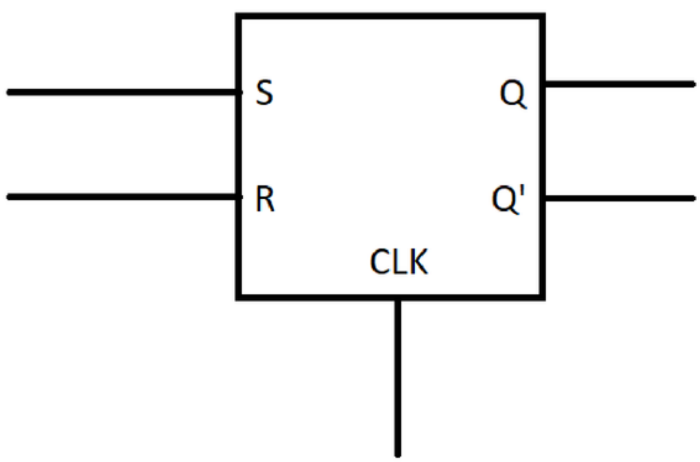


Fig. 1. Block Diagram of SR Flip Flop

Components

- IC SN74HC00 (Quad NAND gate)
- LM7805
- Tactile switch- 2 inputs
- Tactile switch- clock pulse
- 2 LEDs
- 9V battery
- Resistors- 1k- 3
- Resistors- 220- 2
- Bread-board
- Connecting wires

Component Description

- IC SN74HC00

IC SN74HC00 is a quad NAND gate, having 4 NAND gates inside. The NAND gates are all independently connected. The device is a 2 input IC. The IC is designed to sustain a low voltage within the range of 2V to 6V. The current flow is also having a maximum range in the order of microamps. Thus, the IC is highly sensitive and is strictly required to be monitored and controlled through voltage regulators to moderate the voltage inputs to the accepted range and resistors are used to control and nullify the current suppliedto the IC.Any devices or applications requiring high-speed NAND gate operations use this IC. The transition times of the chip is pretty less and is used for high-speed applications. High-frequency systems and devices can also be moderated by the IC.

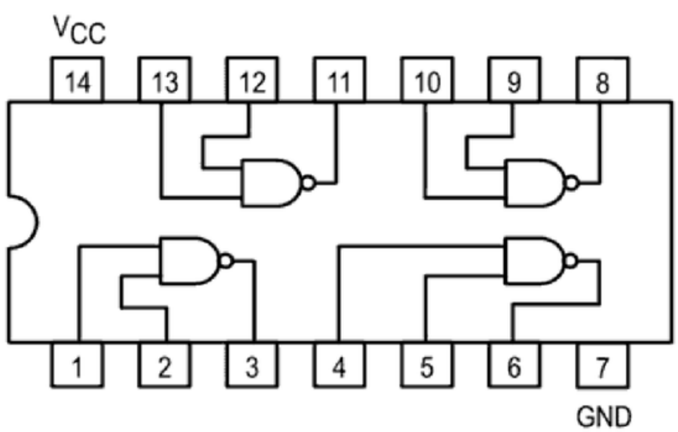


Fig. 2. Pin Diagram of IC SN74HC00

[5]

- LM 7805 voltage regulator

The next and the last stage before load, in a power supply system, is the Regulator part.LM 7805 is a voltage regulator whose output is 5 volts. In a general basic circuit, the voltage value fluctuates regularly. For this purpose, voltage regulators are used. They help to maintain a constant voltage. 78XX is the general IC forms where XX represents the output voltage. Hence, 5 volts. The input voltage can be as high as 34 to 36 volts. It has three pins, one is the input, the middle is the general ground and the third is the output. The difference between the input and the output voltage is perceived as energy in the form of heat. Hence, in circuiting, LM 7805 is preferred to be added with a heat sink, as without it, the device will be damaged.This device can also be used as a current regulator and had many other applications such as minor circuiting and mobile phones.

Fig. 3. LM7805 Voltage Regulator

[6]

- Tactile Switch

It is a momentary switch designed to give a tactile response. The switch is contained in a metal case that can be used to connect or mount on breadboards or PCBs.

Fig. 4. Tactile Switch

[7]

- Resistor

We are familiar with the concept of current, voltage, resistance and their relation as stated by Ohm’s law. The flow of charge is defined as current. This current flow in a conductor which basically flows of electrons in the conductor is dealt with opposition by the atoms of the element of the conductor present in them which leads to collision of the atoms with the electrons flowing in the conductor. This opposition offered by the conductor to the flow of electrons or current is termed as ‘Resistance’ or the ‘Resistive Force’. Resistors are the most fundamental and commonly used of all the electronic components which provide resistance to the flow of current in the circuit, to the point where they are almost taken for granted but they play a vital role within a circuit. They regulate or resist the flow of electrons (current) through them by using the type of conductive material from which they are composed. Resistors can be connected in series or parallel fashion differing or dividing the current or voltage through them. Resistor is very helpful in circuiting as they tend to control high currents and help in mainlining a low current wherever required. For example, they resist and minimized the current when used along with LEDs to protect them from high damaging current. They also protect IC chips which can withstand possibly very low currents with a maximum range in the power of microamps thus protecting the devices from damage.

Fig.5. Resistor

[8]

- LEDs

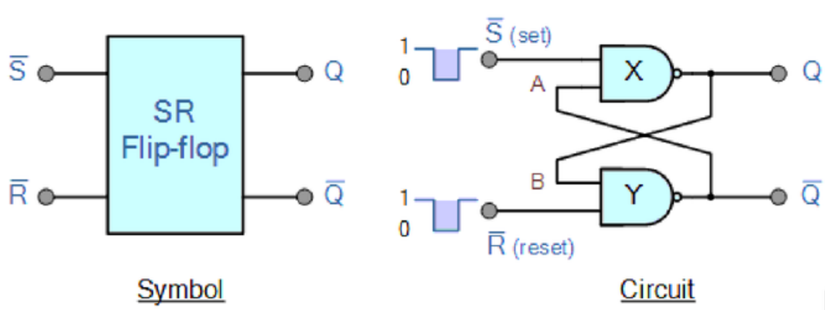
LED as it stands for refers to Light Emitting Diodes. LED is a diode through which the current flows, it is accompanied by the production of light. The electrons when combining with the holes in the semiconductor release energy in the form of photons. The colour of the LED light is determined by the amount of energy utilized or required by the LEDs for the crossing of the conduction band gap in the semiconductor device. The light of the LED, unlike a laser, is neither highly monochromatic nor it is coherent and the colour can be perceived distinctly by the human eye. Alongside this, LEDs have many applications like IR control.

[9]

Fig. 6. LEDs

SR flip flop

SR flip flop also can be referred to as an SR latch, which is a simple basic sequential logic circuit. It has a one-bit memory. It's a bistable device with two inputs; one referred to as the 'SET' input notated as 1 and the other is the 'RESET' input notated as 0.SR stands for 'SET-RESET'. The resetting of the flip flop back to its original state is done by the reset function where the output of Q is altered as 0 or 1 based on the initial condition. The original or the initial state of the flip flop is retained in the memory.The NAND gate SR flip flop provides feedback as obtained from the given two inputs as output which is retained as the opposing input. Thus, it is used for memory storage of a single bit in storage circuiting. The SR flip flop has three inputs, one is the SET and the other is the RESET and the last being the initial or current output Q. This output is what is stored in the memory as feedback. The final output is thus dependent on the initial or the current output. One of the simplestdemonstrations of the working of the SR flip flop is using a simple 2 input NAND gate. The inputs and circuiting are connected or interlinked in such a way the, the output of one gate is going to act as the feedback or the input for the other gate. There are two given inputs S and R and the corresponding outputs Q and Q' are obtained.



[10]

Fig. 7. SR Flip Flop Circuit and Symbol

In the above circuit, we consider different possibilities of inputs:

When both S and R are 1, the outputs Q and Q’ and 0 and 1 respectively. The current and past input remain the same and hence this state is also referred to as the no change state.

S=1, R=1—Q=0, & Q’ =1

When S is high and R is low, the output Q’ is high by the gate Y. This output acts as the input for gate X and the output Q is determined as low since both S and Q’ are high. This state is referred to as the SET state of the flip flop since the next state output remains high.

S=1, R=0—Q=0, Q’=1

When S is low and R is high, the output Q is high by the gate X. This output acts as the input for gate Y and the output Q’ is determined as low since both R and Q are high. This state is referred to as the RESET state of the flip flop since the next state output remains low.

S=0, R=1—Q=1, Q’=0

When both the inputs S and R are 0, it is counted as the invalid or indeterminate state since the value of both Q and Q’ are 1 which is not practically possible as both Q and Q’ must be the complement of each other.

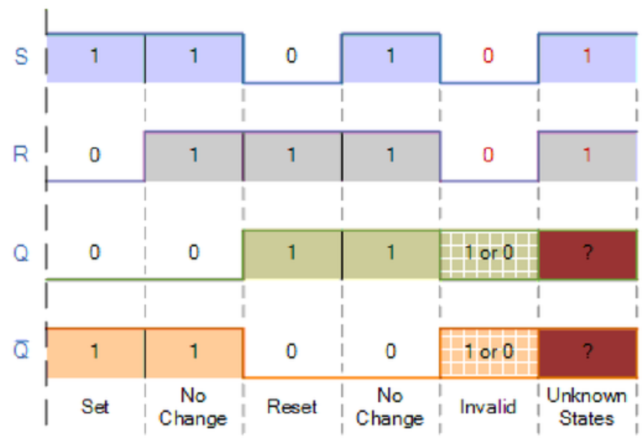
S=0, R=0—Q & Q’= 1

The indeterminate state in the JK flip flop is compensated as a toggle state.

SR flip flop can be used for the debounce circuit.

S’	R’	Q	Q’
1	1	0	1
1	0	0	1
0	1	1	0
0	0	∞	∞

Table. 1. SR Flip Flop Truth Table



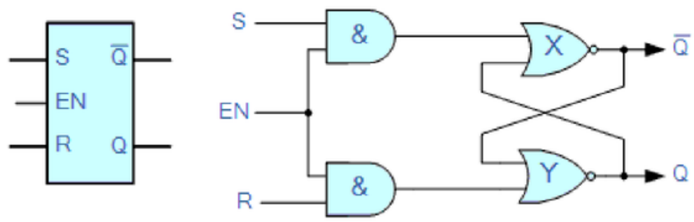
[11]

Fig. 8. Timings Diagram of SR Flip Flop

Sometimes, in the flip flop, it is preferred or wanted that the output changes or alters only under certain conditions irrespective or independent of the input of S and R. We can connect the two NAND gates of the SR flip flop as one input forming the Gated SR flip flop. This input is often referred to as the ENABLE. Using this input, the output Q changed only when the

ENABLE input is high and thus can be considered or referred to as the clock input (CLK) making the device level based sensitive.

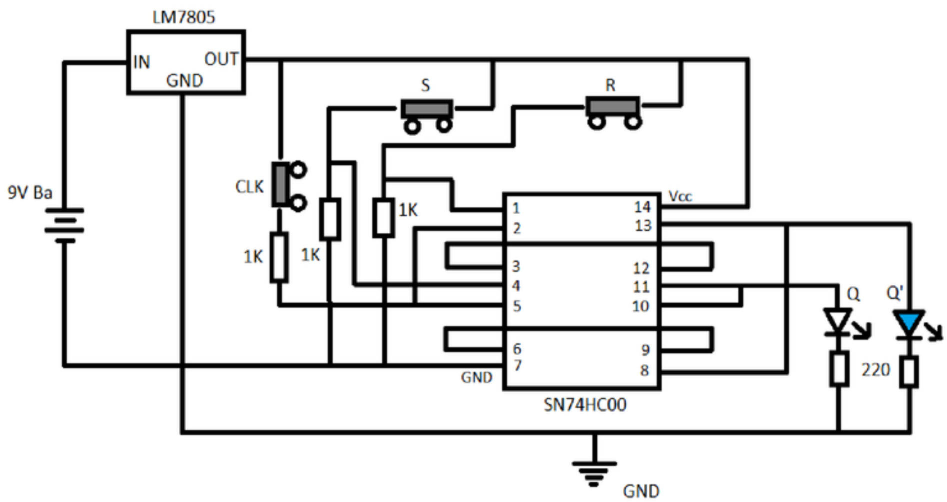
When the EN or the clock is low, the outputs Q and Q' remain 0 irrespective of the applied input of S and R. When the EN is high, it acts as a normal working SR flip flop.



[12]

Fig. 9. Gated SR Flip Flop

Software circuiting of SR Flip Flop



IC SN74HC00 is used for the circuit which contains internally independently connected 4 NAND gates. As seen in the circuit, the 14th pin is connected as Vcc and the 7th pin if grounded. The inputs S and R are connected using switches to the pins 1 and 4. Resistances are used to control the flow of current and moderate it. The clock pulse is given from the pins 2 and 5 and is connected as another switch.

The outputs if Q and Q' are taken from the pins 10, 11 and 12 respectively. The outputs are obtained as LED light colors. Resistors are used to protect the LEDs from high current.

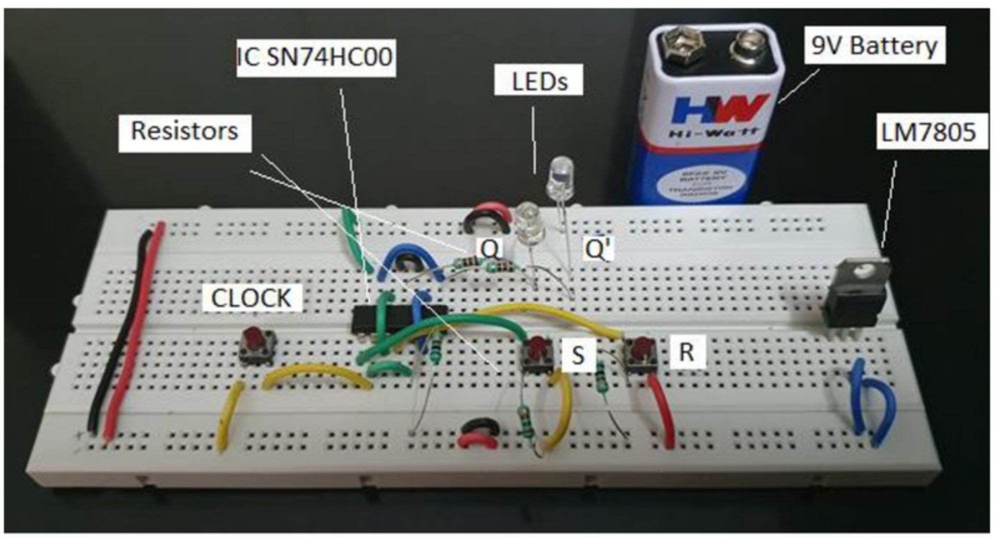
Along with the main circuit, additionally, a voltage regulator LM7805 is used. The voltage regulator is used to drop down the 9V of the battery to 6V or lower since the IC SN74HC00 is strictly operable only within the voltage range of 2 to 6V and low current in the order of microamps.

The circuit is connected completely and a working SR flip flop is demonstrated.

The clock along with the set or reset switches is pressed simultaneously to visualized the LED's glow.

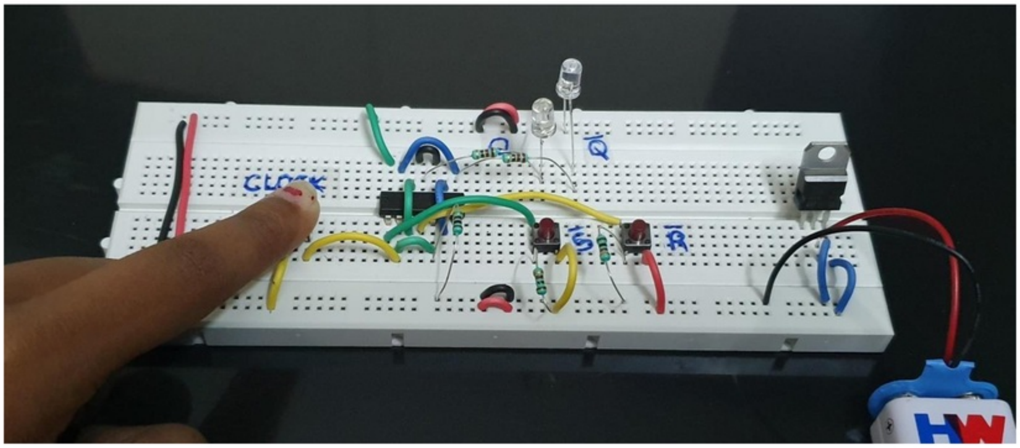
When the clock is high and when the respective S and R are given, the outputs of the circuit are obtained as Q and Q'.

Pictorial figure of circuit

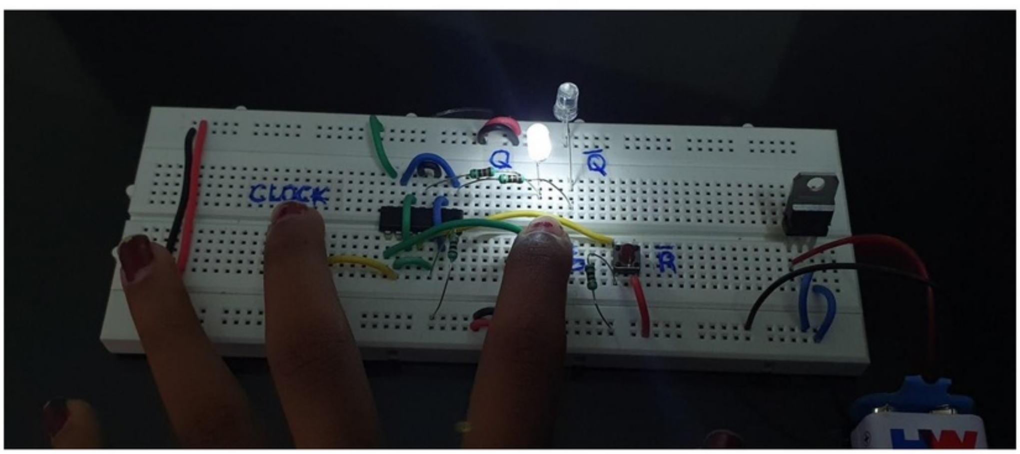


Conditions with Pictorial Description

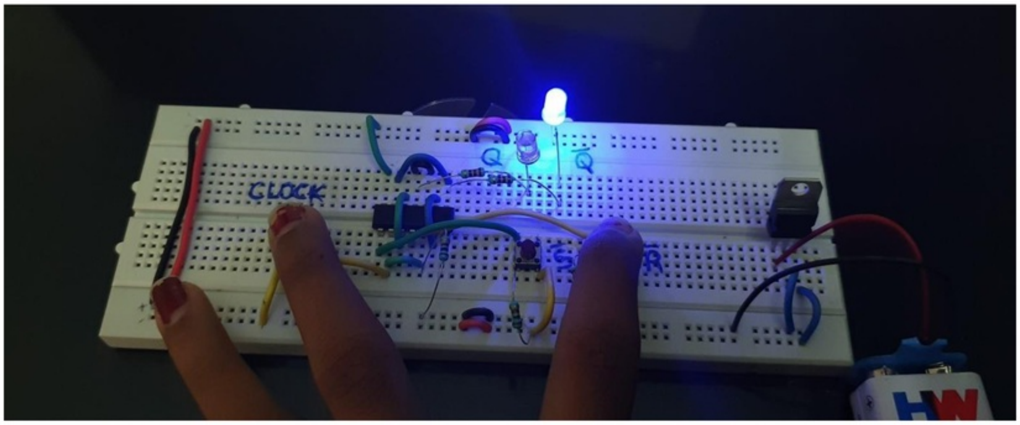
1. When the clock pulse is applied i.e., CLK=1, and S=R=0, Q=0, Q'=1



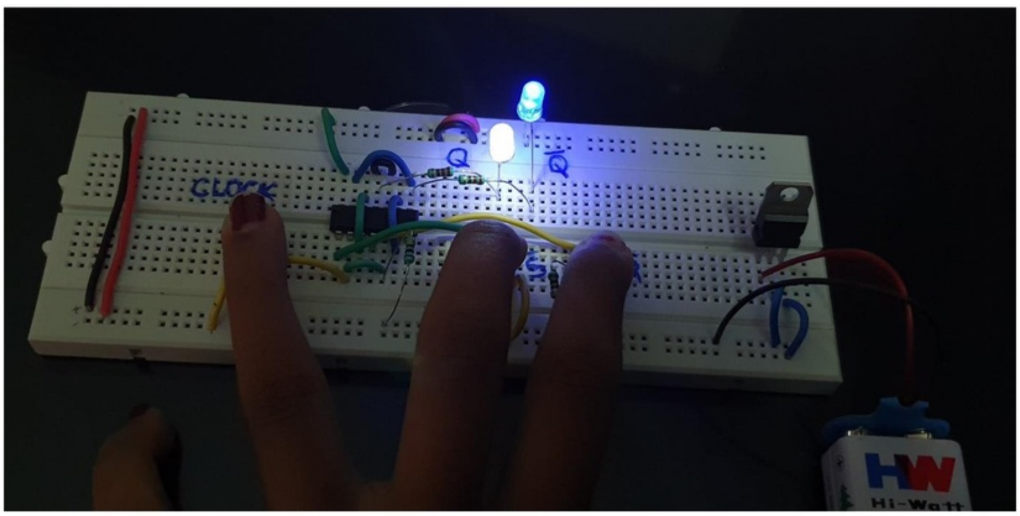
2. When CLK=1, S=1, and R=0, Q=1 and Q'=0.



3. When CLK=1, S=0, and R=1, Q=0 and Q'=1.



4. When CLK=1, S’=R’=1, Q=Q’=1 which is the invalid state



Application and Conclusion

- SR flip flops are used for the construction ofthe debounce circuit.

  Hardware debouncing technique uses an S-R latch to avoid bounces in the circuit along with the pull-up resistors. S-R circuit is the most effective of all debouncing approaches.

- SR can also be used to construct shift registers.
- It can also be used for the construction of counters.
- SR Flip flops are used in delay circuits.
- N counters have a prominent use of all kinds of flip flops.

SR flip flops are very useful storage devices that can be used in many applications. Flip Flops are very useful because of their ability to story the memory and produce feedback. The study and construction of SR flip flop using NAND gates, NOR gates, making of gated SR flip flops is a huge field in digital electronics. JK flip flops are used as a supplement of SR since they produce toggle output compared to SR flip-flop's indeterminate output.

References

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[2] Flip Flops Circuit Types and Applications/ Application of Flip Flops/ RAM/

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Image Reference

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[8] [9] Google Images/ en.wikipedia.org

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Certificate

We, the students of semester 3, section B of the EEE Department, thank our guide Dr, Singaravelan sir and the respected faculties for the support and guide in the presentation and performance of our mini-project. We are grateful for the opportunity to present the project.

We thank the teachers for the educations and theoretical knowledge they have engulfed in use and the never-ending support we have received from the EEE department staff forms an enormous backbone for our successful presentation of the project on this day.

We look forward to being assigned more projects and the heartful guidance of all the staff.

Thank you,

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3	Antonella Bogoni, Gianluca Berrettini, Paolo Ghelfi, Antonio Malacarne, Gianluca Meloni, Luca Poti, Jing Wang. "Chapter 15 All-Optical Flip-Flops Based on Semiconductor Technologies", InTech, 2010 Publication	<1%
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