NITTE EDUCATION TRUST | N.M.A.M. INSTITUTE OF TECHNOLOGY
(An Autonomous Institution affiliated to Visvesvaraya Technological University, Belagavi)
Nitte – 574 110, Karnataka, India

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

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A Project report on

UNIVERSAL SHIFT REGISTER

AND

JOHNSON COUNTER

Submitted By

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CERTIFICATE

This is to certify that ***BHUVAN P - 4NM21EC029, BHUVANESH - 4NM21EC030, BINDU NAIK - 4NM21EC031*** *bonafide students of N.M.A.M. Institute of Technology, Nitte have submitted a project report entitled "****UNIVERSAL SHIFT REGISTER AND JOHNSON COUNTER****" as part of the Project based Digital System Design Lab, in partial fulfillment of the requirements for the award of Bachelor of Engineering Degree in Electronics and Communication Engineering during the year 2022-2023.*

Name of the Examiner	**Signature with date**
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ABSTRACT

The project involves the simulation and design of a universal shift register and a Johnson counter using a 4:1 multiplexer which is used to select the operations (like SISO, PISO, PIPO, SIPO), IC555 Timer is used to give clock pulse and D flip-flops along with combinational circuits are used to shift the data and perform the particular operation. The output is taken through series of LED.

TABLE OF CONTENTS

Chapter 1

INTRODUCTION

Shift registers and Johnson counters are important building blocks in digital electronics, as they allow for the storage, transfer, and manipulation of binary data. Shift registers are used to perform hold operation, serial-to-serial, serial-to-parallel, parallel-to-parallel, parallel-to-serial data conversions, right-shift, left-shift, circular-right-shift, circular-left-shift, parallel-loading while Johnson counters are cyclic shift registers that generate a sequence of binary states.

The need for versatile and compact digital circuits has led to the development of universal circuits that can perform multiple functions. In this project, we present a digital circuit that combines the functionality of both a shift registers and a Johnson counter, offering a flexible solution for those who require both operations in their applications.

The design of the circuit makes use of a 4:1 multiplexer, which allows the user to switch between shift register and Johnson counter modes of operation. The data is stored in D flip-flops, while the shifting and operation functions are performed using combinatorial circuits. The circuit design is simulated mobile application (Logic Circuit Sim Professional) tool to verify its functionality and performance.

1.1 Register, Counter and Flip-Flop

Flip-Flop: These are the building blocks of sequential circuit, which are built from the latches.

Register: A register is a digital electronic circuit that stores and processes data by means of flip-flops or other electronic components.

Counter: A counter is a digital electronic circuit that stores and processes data by counting the number of pulses or events that it receives as input.

1.2 Types Of Register

There are two main classifications of register

- Shift Register: A shift register is a digital electronic component used for storing and manipulating a sequence of binary data. The data is stored in a series of flip-flops, and the contents of the register can be shifted by one or more positions to the left or right.
    - Serial-in, Serial-out (SISO) Shift Registers: In this type of shift register, data is shifted into the register one bit at a time, and the data is shifted out one bit at a time.
    - Serial-in, Parallel-out (SIPO) Shift Registers: In this type of shift register, data is shifted into the register one bit at a time, and all the data bits are available in parallel at the output.
    - Parallel-in, Serial-out (PISO) Shift Registers: In this type of shift register, data is loaded into the register in parallel, and the data is shifted out one bit at a time.

- Storage Register: A storage register in digital electronics is a type of register used for storing binary data.
    - Parallel-in, Parallel-out (PIPO) Shift Registers: In this type of shift register, data is loaded into the register in parallel, and all the data bits are available in parallel at the output.

1.3 Directional Shift Register

- UNIDIRECTIONAL SHIFT REGISTER: A unidirectional shift register is a type of shift register that can shift the data in a single direction. It is a shift register where data is loaded serially one bit at a time, and shifted out at the same rate.
- BIDIRECTIONAL SHIFT REGISTER: A bidirectional shift register is a type of shift register that can shift data in either direction, left or right. This allows for more versatile data manipulation and can be useful in a variety of digital circuit applications.
- UNIVERSAL SHIFT REGISTER: A universal shift register is a type of digital circuit that can perform various shifting operations, such as left shift, right shift, and parallel load. It typically contains a number of flip-flops, which are used to store data, as well as a series of control inputs that are used to configure the circuit to perform different types of shifting operations.

1.4 Johnson Counter

A Johnson counter is a type of ring counter, a digital circuit that consists of a series of flip-flops (here D flip-flop) connected in a feedback configuration. In a Johnson counter, the output of each flip-flop is connected to the input of the next flip-flop in the series, with the last flip-flop's output being connected back to the input of the first flip-flop. The binary outputs of the flip-flops are shifted by one position with each clock pulse, creating a cyclical sequence of binary values.

Chapter 2

DESIGN AND IMPLEMENTATION

2.1 CIRCUIT DIAGRAM/ BLOCK DIAGRAM

A simple Shift Register can be made using only D-type flip-Flops, one flip-Flop for each data bit. The output from each flip-Flop is connected to the D input of the flip-flop at its right. Shift registers hold the data in their memory which is moved or “shifted” to their required positions on each clock pulse.

2.1.1 Universal Shift Register

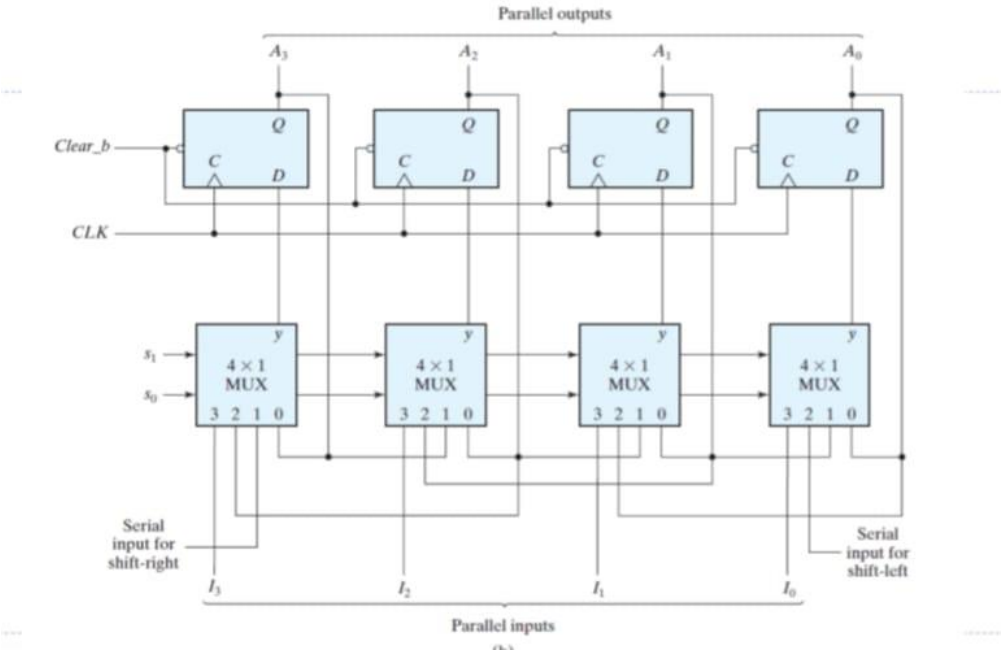

Figure 2.1.1 Universal Shift Register Diagram

S1	S0	Register Operation
0	0	Hold
0	1	Shift Right
1	0	Shift Left
1	1	Parallel Load

The above truth table for Figure 2.1.1

The design of the Figure 2.1.1 is as follows

- S0 and S1 are the selected pins that are used to select the mode of operation of this register. It may be shift left operation or shift right operation or parallel mode.
- Pin-0 of first 4×1 Mux is fed to the output pin of the first flip-flop. Observe the connections as shown in the figure.
- Pin-1 of the first 4X1 MUX is connected to serial input for shift right. In this mode, the register shifts the data towards the right.
- Similarly, pin-2 of 4X1 MUX is connected to the serial input for shift-left. In this mode, the universal shift register shifts the data towards the left.
- I1 is the parallel input data given to the pin-3 of the first 4×1 MUX to provide parallel mode operation and stores the data into the register.
- Similarly, remaining individual parallel input data bits are given to the pin-3 of related 4X1 MUX to provide parallel loading.
- A1, A2, A3, and A4 are the parallel outputs of D flip-flops, which are associated with the 4×1 MUX.

2.1.2 Universal Shift Register

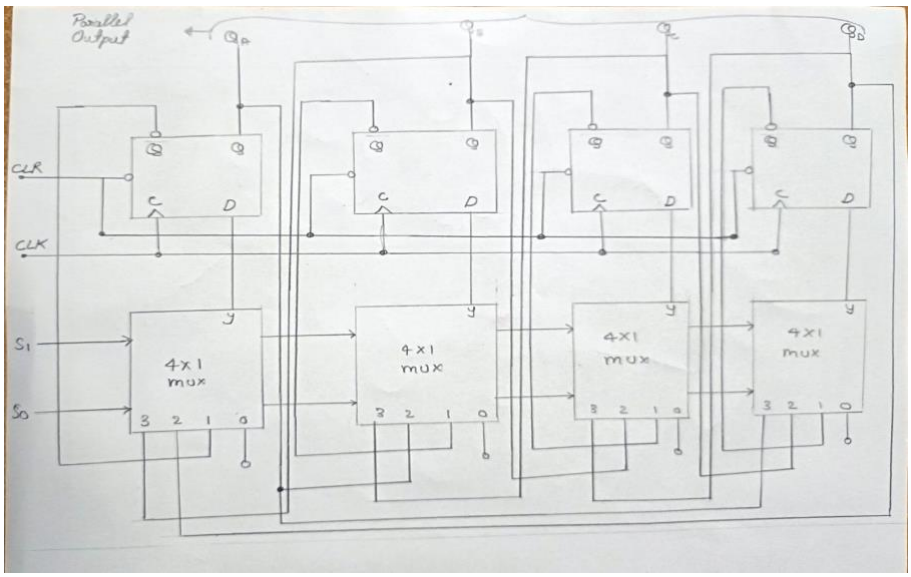

Figure 2.1.2 Universal Shift Register Diagram (consisting of possible operation)

S1	S0	Register Operation
0	0	Synchronous Clear
0	1	Complement Contents
1	0	Circular Shift Right
1	1	Circular Shift Left

The above truth table for Figure 2.1.2

The design of the Figure 2.1.2 is as follows

- S0 and S1 are the selected pins that are used to select the mode of operation of this register. It may be shift left operation or shift right operation or parallel mode.

- Pin-0 of first 4×1 Mux is fed to the ground. Observe the connections as shown in the figure.
- Pin-1 of the first 4X1 MUX is connected to the compliment of the output of the first D flip-flop.
- Pin-2 of 4X1 MUX is connected to the serial input for shift-right. In this mode, the universal shift register shifts the data towards the right where the first output of the D flip-flop is given to pin-2 of the last 4X1 MUX such that it circulates the data, hence circular shift-right.
- Pin-3 of 4X1 MUX is connected to the serial input for shift-left. In this mode, the universal shift register shifts the data towards the left where the last output of the D flip-flop is given to pin-3 of the first 4X1 MUX such that it circulates the data, hence circular shift-left.
- QA, QB, QC, and QD are the parallel outputs of D flip-flops, which are associated with the 4×1 MUX.

2.1.3 4-bit Mod-8 Johnson Counter from D flip-flop

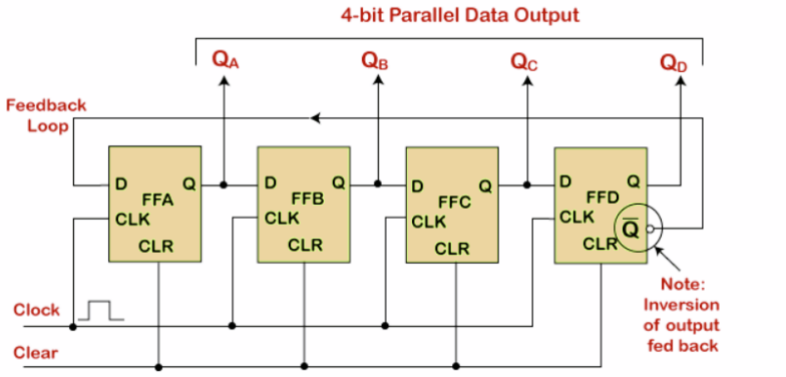

Figure 2.1.3 Johnson Counter Circuit Diagram

The design of 4-bit Johnson Counter is as follows

- The 4-bit Johnson counter, it contains 4 D flip-flops, which is called 4-bit Johnson counter. It has preset and clear pins to initialize or start and reset the counted.

- Reset pin acts as an on/off switch. So, the flip-flops can be enabled by clicking the Reset switch.
- CLK pin is used to observe the changes in the output of the flip-flops.

2.1.4 Universal Shift Register as Johnson Counter

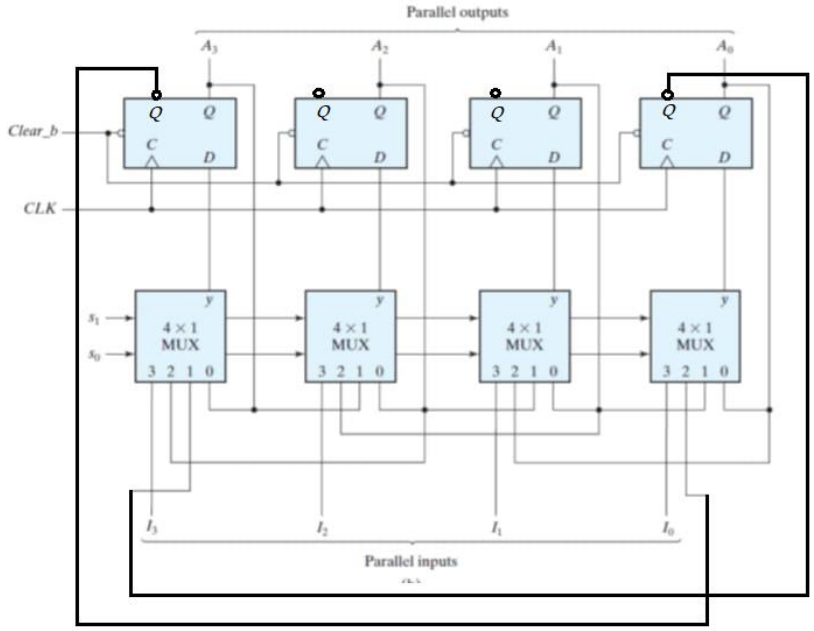

Figure 2.1.4 Universal Shift Register as Johnson Counter Diagram

- The design is same as that of Figure 2.1.1, but
- Pin-2 of 4X1 MUX is connected to the serial input for shift-right. In this mode, the universal shift register shifts the data towards the right where the first compliment output of the D flip-flop is given to pin-2 of the last 4X1 MUX such that it circulates the data and Pin-3 of 4X1 MUX is connected to the serial input for shift-left. In this mode, the universal shift register shifts the data towards the left where the last compliment output of the D flip-flop is given to pin-3 of the first 4X1 MUX such that it circulates the data, hence circular shift-left.
- Hence operates as a Johnson Counter.

2.2 COMPONENTS USED

2.2.1 SOFTWARE

A mobile application (Logic Circuit Sim Professional) were used to design and simulate the circuit.

2.2.2 HARDWARE

The components used in this project include

Components	**Specification /Type**	**Quantity**
D flip-flop	IC 7474	2
4X1 MUX	IC74153	2
Timer IC	IC 555	1
LED	DC-3V	4
Resistor	220 ohm	4
	1K ohm	1
Switches	On/off	2
	Push button	3
	DIP switch	3
Potentiometer	Load bearing up to 5K ohm	1
Capacitor	100 uF	1
	0.1 uF	1
Breadboard		2

2.3 WORKING

2.3.1 Universal Shift Register

The working of Universal Shift Register from the figure 2.1.1 is as follows

- From the above figure 2.1.1, selected pins the mode of operation of the universal shift register. Serial input shifts the data towards the right and left and stores the data within the register.
- Clear pin and CLK pin are connected to the flip-flop.
- I0, I1, I2, I3 are the parallel inputs while A0, A1, A2, A3 are the parallel outputs of flip-flops
- When the input pin is active HIGH, then the universal shift register loads / retrieve the data in parallel. In this case, the input pin is directly connected to 4×1 MUX
- When the input pin (mode) is active LOW, then the universal shift register shifts the data.
- When the input pin (mode) is connected to GND (Ground), then the universal shift registers act as a Bi-directional shift register.
- If the selected pins S0= 0 and S1 = 0, then this register doesn't operate in any mode. That means it will be in a Hold state even though the clock pulses are applied.
- If the selected pins S0 = 0 and S1 = 1, then this register transfers or shifts the data to left and stores the data.
- If the selected pins S0 = 1 and S1 = 0, then this register shifts the data to right and hence performs the shift-right operation.
- If the selected pins S0 = 1 and S1 = 1, then this register loads the data in parallel. Hence it performs the parallel loading operation and stores the data.

2.3.2 Johnson Counter

The working of Johnson Counter from the Figure 2.1.3 is as follows

Clock Pulse No	FFA	FFB	FFC	FFD
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

- The input value of ‘D’ is the inverted output of the last flip-flop.
- The ‘CLK’ is used to count the states or cycles of the counter, which is in the closed-loop.
- The clear pin is used to clear the output.
- As the data will be rotating around a continuous closed loop, a counter can also be used to detect various patterns or values within the data.
- For example, when there is a clock pulse, the output pattern of the flip-flops would be 1000, 1100, 1110, 1111, 0111, 0011, 0001
- When there is no clock pulse, the output will be 0000.

2.3.3 Universal Shift Register as Johnson Counter

- From the above figure 2.1.4, selected pins the mode of operation of the universal shift register.
- Clear pin and CLK pin are connected to the flip-flop.
- I0, I1, I2, I3 are the parallel inputs while A0, A1, A2, A3 are the parallel outputs of flip-flops
- When the input pin is active HIGH, then the universal shift register loads / retrieve the data in parallel. In this case, the input pin is directly connected to 4×1 MUX
- When the input pin (mode) is active LOW, then the universal shift register shifts the data.
- When the input pin (mode) is connected to GND (Ground), then the universal shift registers act as a Bi-directional shift register.
- If the selected pins S0= 0 and S1 = 0, then this register doesn't operate in any mode. That means it will be in a Hold state even though the clock pulses are applied.
- If the selected pins S0 = 0 and S1 = 1, then this register transfers or shifts the data to left and the last compliment output of the D flip-flop is given to pin-2 of the first 4X1 MUX such that it circulates the data.
- If the selected pins S0 = 1 and S1 = 0, then this register shifts the data to right and the first compliment output of the D flip-flop is given to pin-2 of the last 4X1 MUX such that it circulates the data.
- If the selected pins S0 = 1 and S1 = 1, then this register loads the data in parallel. Hence it performs the parallel loading operation and stores the data.
- Hence the working of Johnson Counter from a Universal Shift register.

Chapter 3

RESULT AND DISCUSSION

The simulation results of the universal shift register and Johnson counter circuit showed that the circuit performed as expected for both shift register and Johnson counter modes of operation. The circuit was tested for different data inputs, clock periods, and number of stages and the results demonstrated its functionality and efficiency.

The results of the simulation confirmed that the circuit design was successful in combining the functionality of both a shift register and a Johnson counter. The use of a 4:1 multiplexer to switch between the modes of operation provides a flexible solution for those who require a specific function in their applications. The use of D flip-flops to store the data and combinatorial circuits to perform the shifting and operation functions makes the circuit simple and efficient.

In conclusion, the universal shift registers and Johnson counter circuit provides a versatile and efficient solution for those who require both shift register and Johnson counter functionality in their applications. The results of the simulation demonstrate the feasibility of the circuit and its potential for use in real-world applications.

There is scope for further improvements to the circuit design, such as the addition of a control unit to enable the user to switch between the different modes of operation more easily. The circuit can also be implemented using physical components to verify its performance in real-world applications.

Chapter 4

CONCLUSION

The universal shift registers and Johnson counter circuit designed provides a versatile and efficient solution for combining both shift register and Johnson counter functionality in applications. Application like micro-controllers for I/O expansion, serial-to-serial converter, parallel-to-parallel data converter, serial-to-parallel data converter, serial – to – serial data transfer, parallel data transfer, as a memory element in digital electronics like computers, time delay applications, as a frequency counters, binary counters.

The simulation results confirmed its feasibility and potential for use in real-world applications. The circuit's design, utilizing a 4:1 multiplexer and D flip-flops with combinatorial circuits, makes it simple and efficient. This project highlights the importance of continued research and development in the field of digital electronics.

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