PROJECT BASED LAB REPORT

On

Design of 3-bit Gray code counter using J-k flip-flop

Submitted in partial fulfilment of the

Requirements for the award of the Degree of

Bachelor of Technology

In

COMPUTER SCIENCE AND ENGINEERING

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COMPUTER ORGANISATION AND ARCHITECTURE

CERTIFICATE

This is to certify that this project based lab report entitled **“Design of 3-bit Gray code counter using J-k flip-flop”** is a bonafide work done by Md. Sahil Afrid Farookhi (150030590); Md. Gousia Nasreen (150030592); M. Raghu Vamsi (150030606) in partial fulfilment of the requirement for the award of degree in **BACHELOR OF TECHNOLOGY** in **Computer Science and Engineering** during the academic year 2015-2016.

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DEPARTMENT OF COMPUTER SCIENCE ENGINEERING

DECLARATION

We hereby declare that this project based lab report entitled **"Design of 3-bit Gray code counter using J-k flip-flop"** has been prepared by us in partial fulfilment of the requirement for the award of degree "**BACHELOR OF TECHNOLOGY in COMPUTERSCIENCE AND ENGINEERING**" during the academic year 2015-2016.

I also declare that this project based lab report is of our own effort and it has not been submitted to any other university for the award of any degree.

Date: 27th October, 2016

Place: Vaddeswaram.

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GRAY CODE

The **reflected binary code** (**RBC**), also known as **Gray code** after Frank Gray, is a binary numeral system where two successive values differ in only one bit(binary digit). The reflected binary code was originally designed to prevent spurious output from electromechanical switches. **Gray Code** is one of the most important codes. It is a non-weighted code which belongs to a class of codes called minimum change codes. In this codes while traversing from one step to another step only one bit in the code group changes. In case of Gray Code two adjacent code numbers differs from each other by only one bit. The idea of it can be cleared from the table given below. As this code it is not applicable in any types of arithmetical operations but it has some applications in analogue to digital converters and in some input/output devices.

Decimal	Binary	Gray	Gray as decimal
0	000	000	0
1	001	001	1
2	010	011	3
3	011	010	2
4	100	110	6
5	101	111	7
6	110	101	5
7	111	100	4

Fig: Gray as decimal table

Uses of Gray Code:

- Today, Gray codes are widely used to facilitate error correction in digital communications such as digital terrestrial television and some cable TV systems.
- Gray codes are used in position encoders (linear encoders and rotary encoders), in preference to straightforward binary encoding.
- Digital logic designers use Gray codes extensively for passing multi-bit count information between synchronous logic that operates at different clock frequencies.

J-K Flip Flop

This simple **JK flip Flop** is the most widely used of all the flip-flop designs and is considered to be a universal flip-flop circuit. The sequential operation of the JK flip flop is exactly the same as for the previous SR flip-flop with the same “Set” and “Reset” inputs. The difference this time is that the “JK flip flop” has no invalid or forbidden input states of the SR Latch even when S and R are both at logic “1”.

The **JK flip flop** is basically a gated SR flip-flop with the addition of a clock input circuitry that prevents the illegal or invalid output condition that can occur when both inputs S and R are equal to logic level “1”. Due to this additional clocked input, a JK flip-flop has four possible input combinations, “logic 1”, “logic 0”, “no change” and “toggle”. The symbol for a JK flip flop is similar to that of an SR Latch except for the addition of a clock input.

Circuit Diagram:

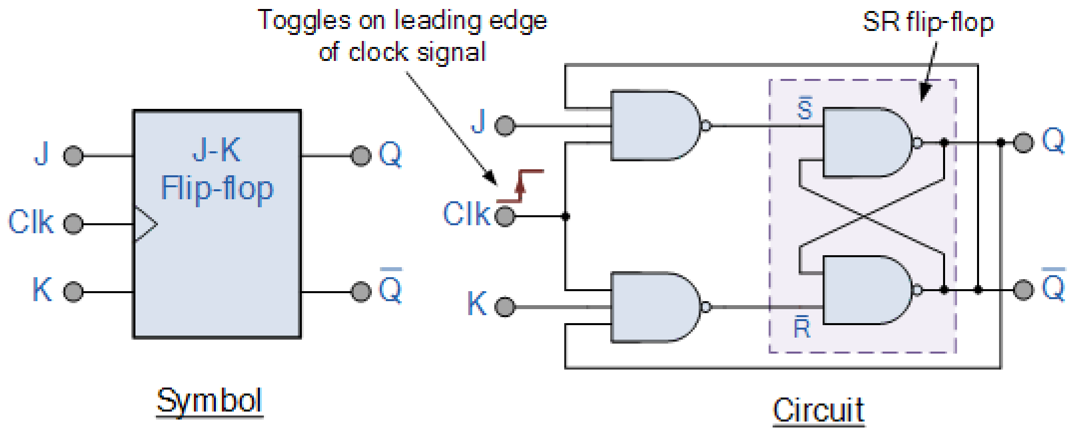

Fig: Symbol and Circuit of J-K Flip-Flop

Truth Table:

Truth Table

J	K	CLK	Q
0	0	↑	Q_0 (no change)
1	0	↑	1
0	1	↑	0
1	1	↑	$\overline{Q}_0$ (toggles)

Fig: Truth Table for J-K Flip-Flop

Excitation Table:

Q Output		Inputs	
Present State	Next State	J_n	K_n
0	0	0	x
0	1	1	x
1	0	x	1
1	1	x	0

Fig: Excitation Table for J-K Flip Flop

Applications for J-K Flip Flop:

- The major application for Flip-Flop is a digital counter. It is used to count pulses or events and it can be made by connecting a series of flip flop. Counters can up to 2^n, where 'n' is number of flip flops.
- Flip Flops can also be used extensively to transfer the data.
- Flip Flop used is used in Frequency division. Flip Flop can divide the frequency of the wave form.

COUNTERS

Counter is a sequential circuit. A digital circuit which is used for a counting pulses is known counter. Counter is the widest application of flip-flops. It is a group of flip-flops with a clock signal applied.

Counters are of two types.

- Asynchronous or ripple counters.
- Synchronous counters.

Synchronous counters:

If the "clock" pulses are applied to all the flip-flops in a counter simultaneously, then such a counter is called as synchronous counter. In synchronous counters, the clock inputs of all the flip-flops are connected together and are triggered by the input pulses. Thus, all the flip-flops change state simultaneously (in parallel).

Asynchronous Counter:

An asynchronous (ripple) counter is a single d-type flip-flop, with its J (data) input fed from its own inverted output. This circuit can store one bit, and hence can count from zero to one before it overflows (starts over from 0). This counter will increment once for every clock cycle and takes two clock cycles to overflow, so every cycle it will alternate between a transition from 0 to 1 and a transition from 1 to 0.

CIRCUIT DIAGRAM

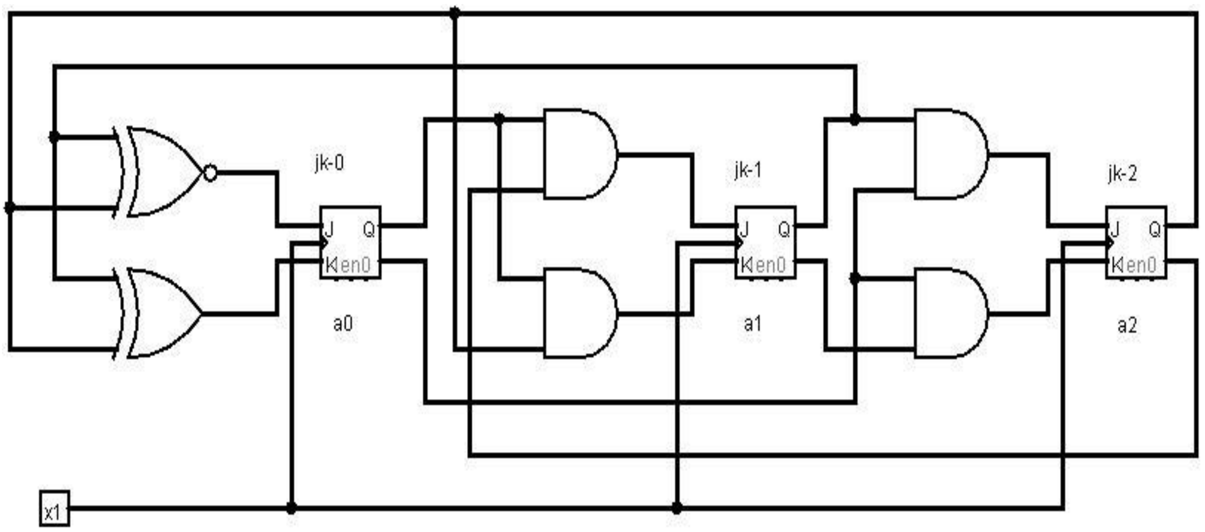

Fig: Circuit figure for 3-bit Gray Code Counter

CIRCUIT DESIGN

As we are designing the 3-bit Gray code counter using J-K Flip Flops. We should know the Truth table, Next State Table, Transition Table of J-K Flip Flop.

NEXT STATE TABLE

PRESENT STATE			NEXT STATE		
QC	QB	QA	QC	QB	QA
0	0	0	0	0	1
0	0	1	0	1	1
0	1	1	0	1	0
0	1	0	1	1	0
1	1	0	1	1	1
1	1	1	1	0	1
1	0	1	1	0	0
1	0	0	0	0	0

Fig: Next state table for J-K Flip-Flop

State transition table for 3-bit input j-k flip flop:

STATETRANSISTIONS			OUTPUT CONDITION			FLIP-FLOP INPUTS		
QC	QB	QA	QC	QB	QA	JC KC	JB KB	JA KA
0 → 0	0 → 0	0 → 1	R/H	R/H	S/T	0 X	0 X	1 X
0 → 0	0 → 1	1 → 1	R/H	S/T	S/H	0 X	1 X	X 0
0 → 0	1 → 1	1 → 0	R/H	S/H	R/T	0 X	X 0	X 1
0 → 1	1 → 1	0 → 0	S/T	S/H	R/H	1 X	X 0	0 X
1 → 1	1 → 1	0 → 1	S/H	S/H	S/T	X 0	X 0	1 X
1 → 1	1 → 0	1 → 1	S/H	R/T	S/H	X 0	X 1	X 0
1 → 1	0 → 0	1 → 0	S/H	R/H	R/T	X 0	0 X	X 1
1 → 0	0 → 0	0 → 0	R/T	R/H	R/H	X 1	0 X	0 X

Fig: State transition table for 3-bit input j-k flip flop

The Transition Table shows the flip-flop inputs required to make the counter go from the present state to the proper next state.

Each transition can be accomplished by two of the four possible conditions:

For S/T we see an entry of 0 → 1. This means we can have a 0 to 1 transition by Setting the flip-flop or by Toggling the flip-flop. For Set, J=1 and K = 0. For Toggle, J = 1 and K = 1. Therefore, J must be 1, but K can be 0 or 1. Since K can be either 0 or 1, the K input is X (Don't Care), we place 1 in the J column and X in the K column.

For S/H, the entry is 1 → 1. For Set, J = 1 and K = 0. For Hold, J = 0 and K = 0. Therefore, the flip-flop inputs for J and K is X 0.

For R/T, the entry is 1 → 0. For Set, J = 0 and K = 1. For Toggle, J = 1 and K = 1. Therefore, the flip-flop inputs for J and K is X 1.

For R/H, the entry is 0 → 0. For Set, J = 0 and K =1. For Hold, J = 0 and K = 0. Therefore, the flip-flop inputs for J and K is 0 X.

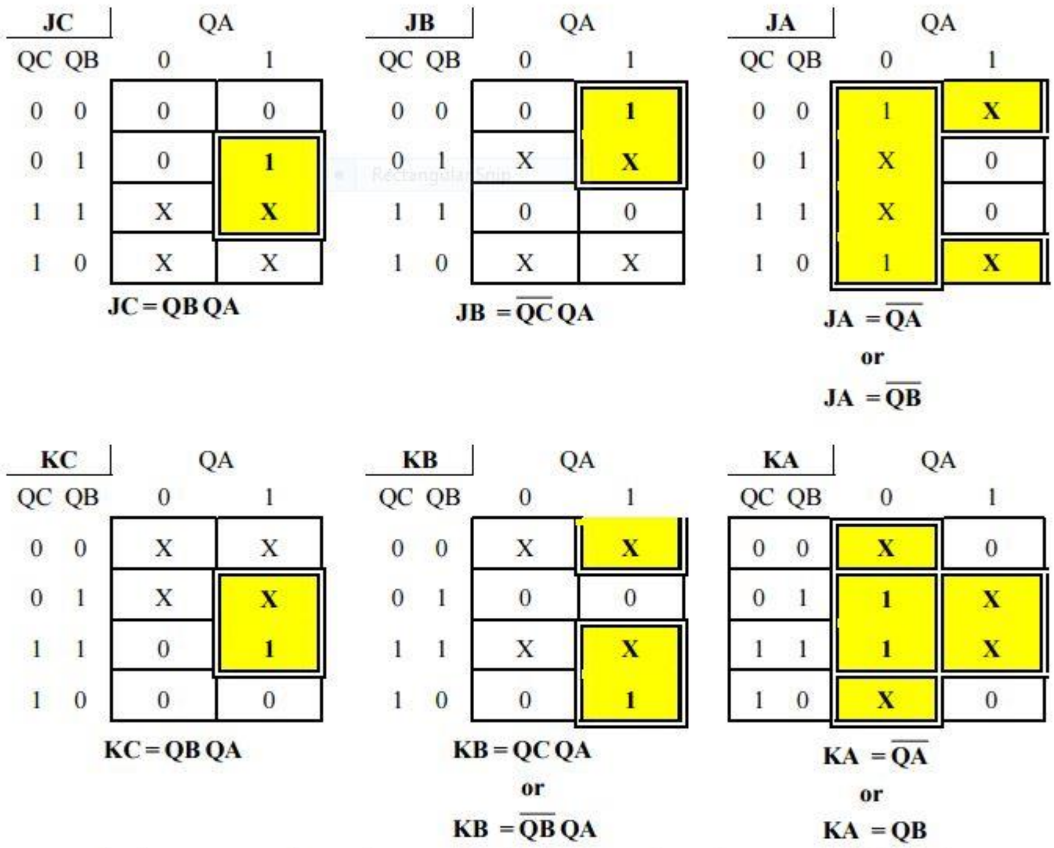

Fig: Transition Table of J-K Flip-Flop

By using the above equations, we get the circuit diagram for 3-bit gray code counter as shown below

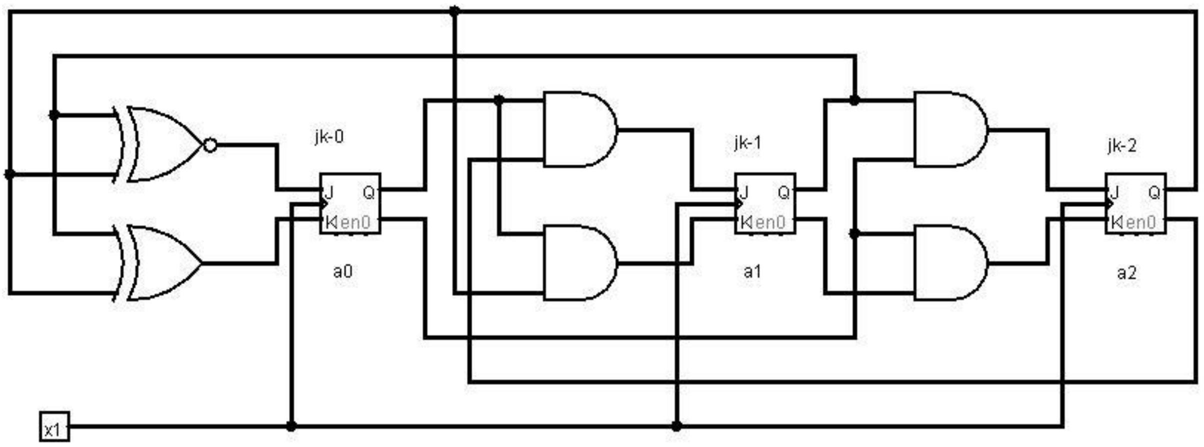

Fig: Circuit diagram of 3-Bit Gray Code Counter

WORKING

- The arrow in the center shows the direction of the counter.
- However, it is possible to progress through the state table in the reverse order. If we start at 000, the next state is 001.
- From 001 the next state is 011. We progress through all possible states until the sequence repeats. It is shown in a table.

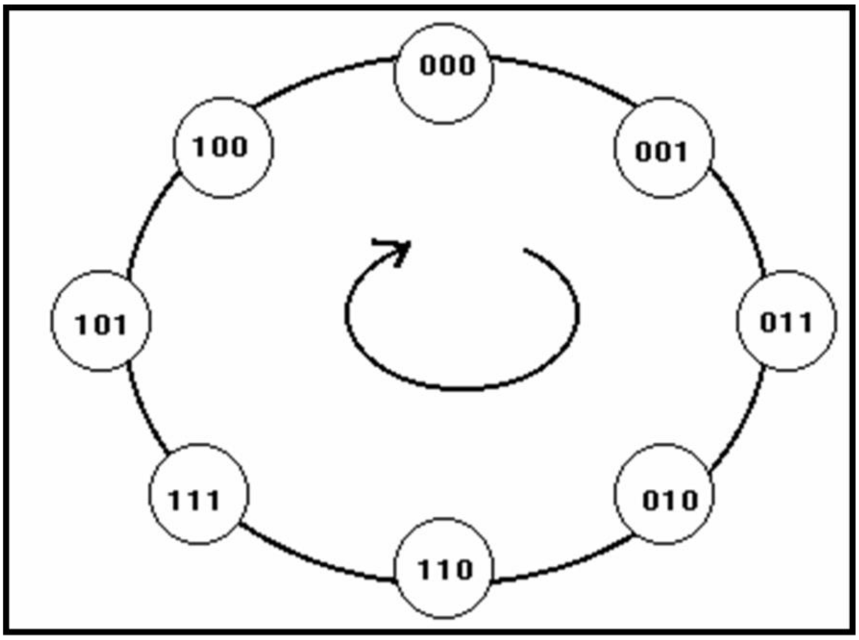

Fig: Counter Direction

APPLICATIONS

- **State machine construction:**

A device which can be in one of a set number of stable conditions depending on its previous condition and on the present values of its inputs.

CONCLUSION

A 3-bit Gray code counter is generated and verified using j-k flip-flops by logisim.

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