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| Group 2 |
| CST 2540 Group Coursework 2 G9 |
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14th April 2021

**INDIVIDUAL TASKS:**

**1.** We have a sequential circuit with two inputs (X1, X2) and one output (Z). Z is said to remain unchanged (either 1 or 0) unless certain input sequences take place. They are

1. X1 X2 = 01, 11 will result in Z = 0.
2. X1 X2 = 10, 11 will result in Z = 1.
3. X1 X2 = 10, 01 will result in Z = changed value (could be either 1 or 0, depending on the situation)

With respect to the above input sequences and condition of Z mentioned, a state graph for the sequential circuit has to be derived.

To start off, for six inputs (01,11,10,11,10,01) six states can be defined.

|  |  |  |
| --- | --- | --- |
| Previous Input (X1 X2) | Output (Z) | State Designation |
| 11 or 00 | 0 | S0 |
| 11 or 00 | 1 | S1 |
| 01 | 0 | S2 |
| 01 | 1 | S3 |
| 10 | 0 | S4 |
| 10 | 1 | S5 |

The input can either be 11 **or** 00 because neither input will start a changed sequence in output. From the input 00 or 11, the output can be in either of two basic states – 1 or 0. The output will remain latched unless an input aside from 00/11 is given.

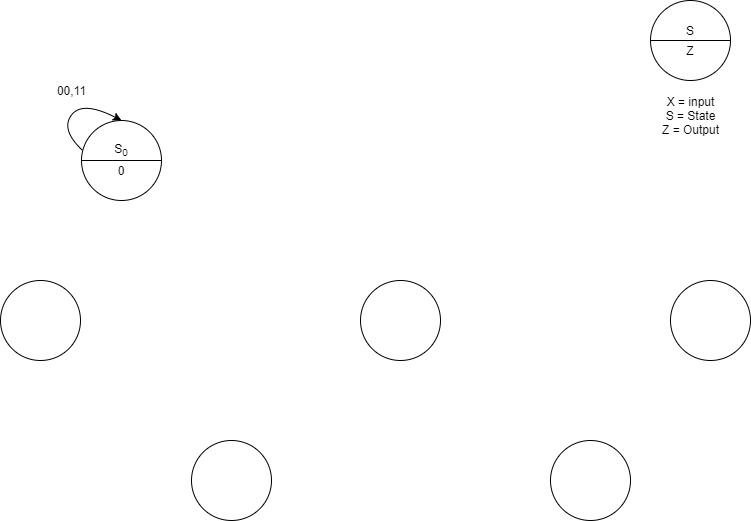
Now, a state table can be made: -

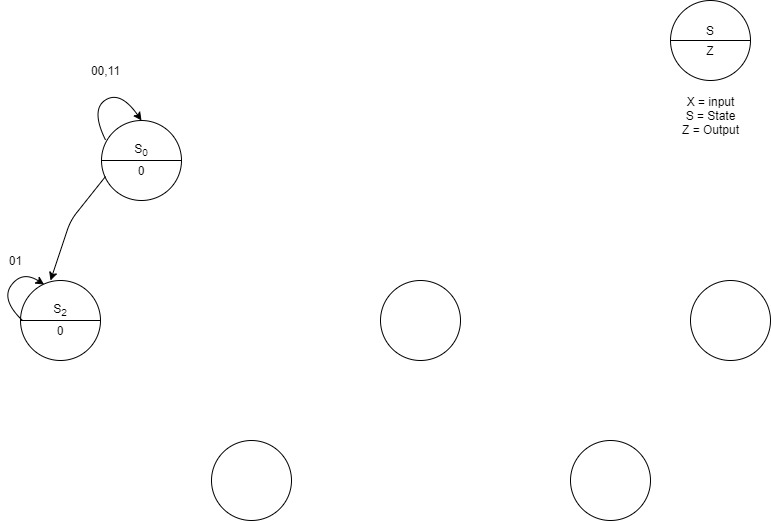
Next State

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| State Designation | Previous State | Output (Z) | 00 | 01 | 11 | 10 |
| S0 | 11 or 00 | 0 | 0 | 0 | 0 | 0 |
| S1 | 11 or 00 | 1 | 1 | 1 | 1 | 1 |
| S2 | 01 | 0 | 0 | 0 | 0 | 0 |
| S3 | 01 | 1 | 1 | 1 | 0 | 1 |
| S4 | 10 | 0 | 0 | 1 | 1 | 0 |
| S5 | 10 | 1 | 1 | 0 | 1 | 0 |

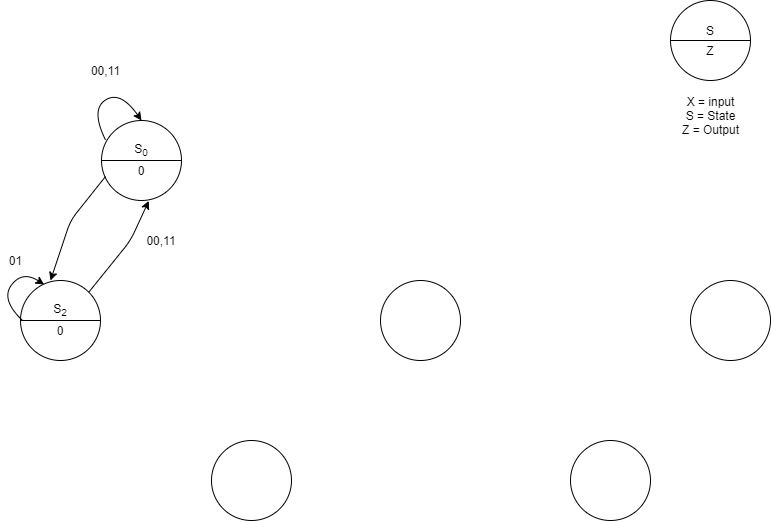
**S0 ROW**

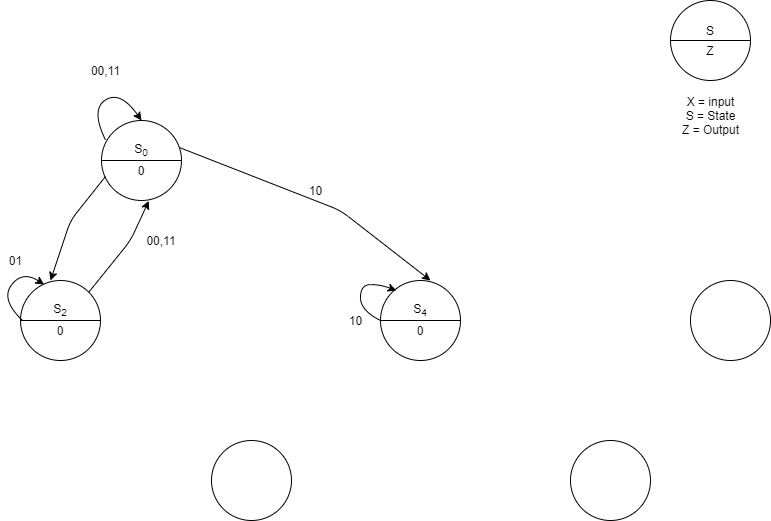
When 00 is received then the input sequence is 00,00, we go back to the same state (S0).



When 01 is received, then the input sequence is 00,01 we will move to S2 (output will be 0).

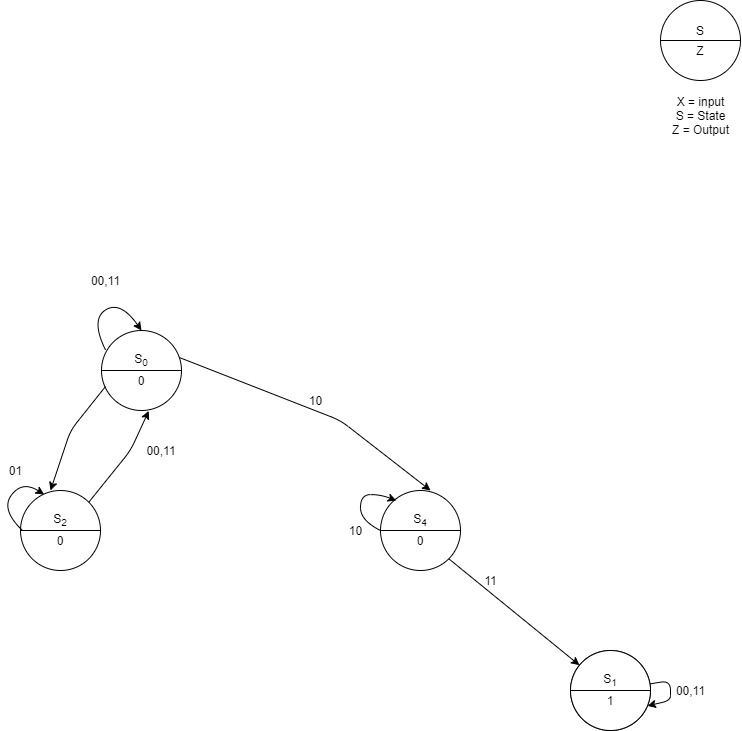
When 11 is received, then the input sequence is 00,11 and we go back to S0 (output is 0).



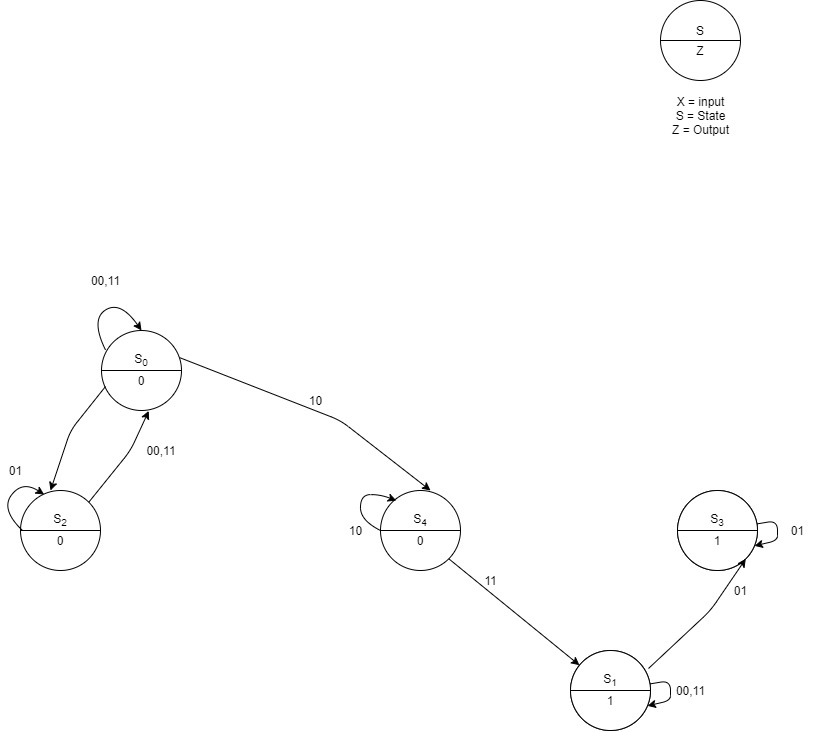
When 10 is received, the input sequence is 00,10 and so we go to S4 (output is 0).

**S1 ROW**

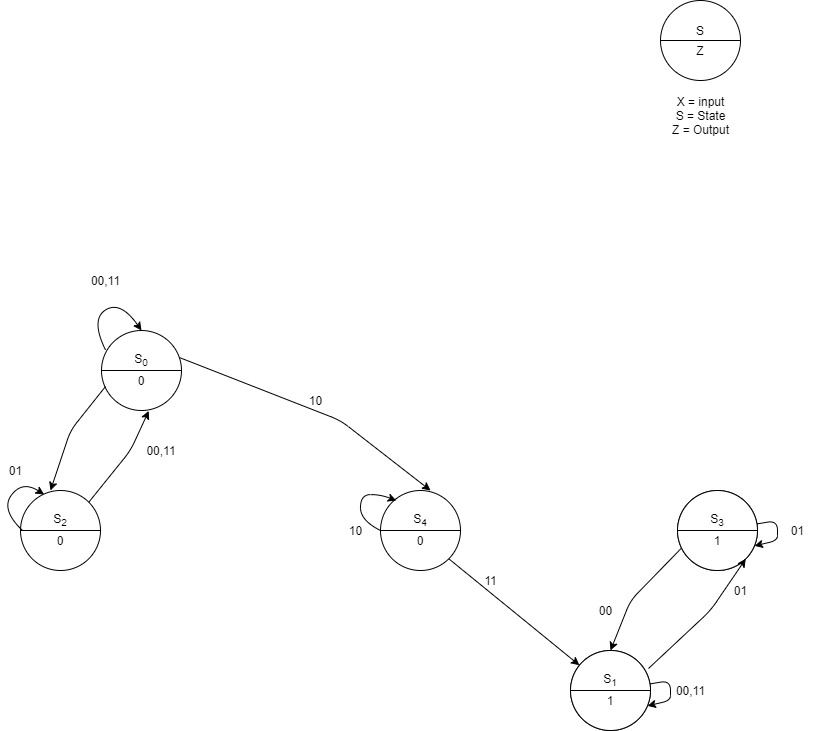
Moving on, when 00 is received, the input sequence is 00,11 and so we go to S1 and the output will now change to 1.



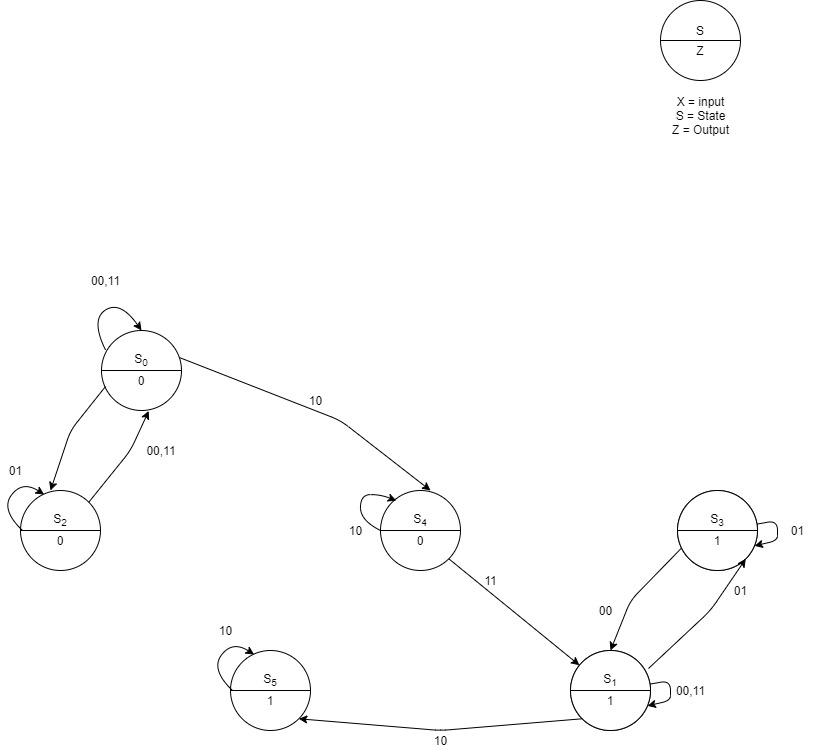
When 01 is received, the input sequence will be 11,01 and we will move to S3 (output will be 1).



When 11 is received, the input sequence becomes 11,11 and so we go back to S1. (output will be 1).

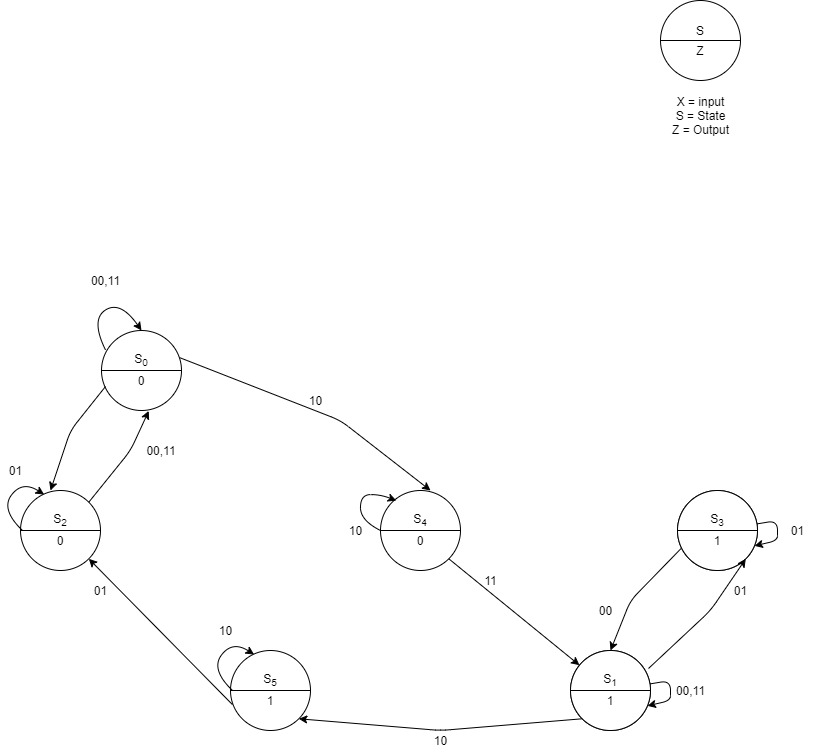


When 10 is received, the input sequence is 11, 10 and we move to S5 (output will be 1).



**S2 ROW**

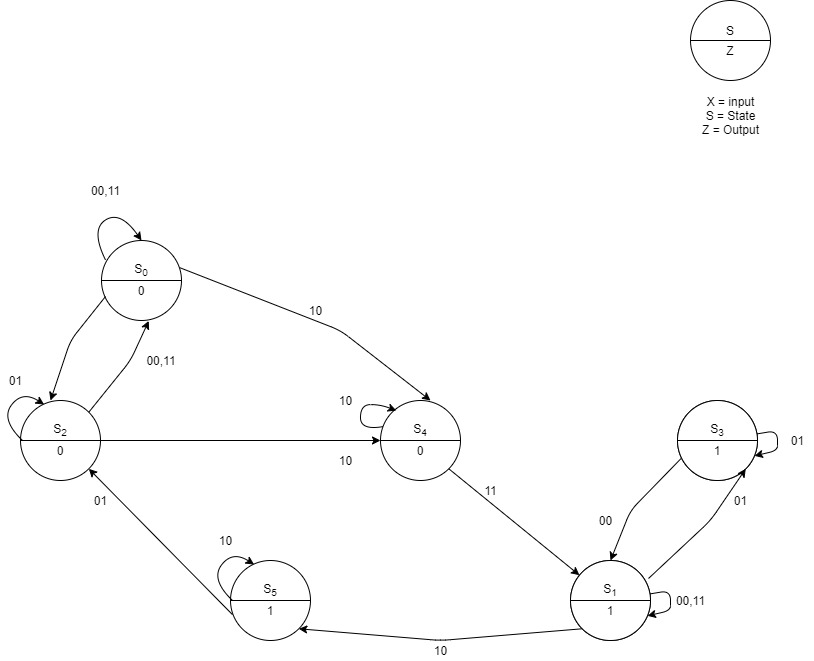
When 00 is received, the input sequence is 01,00 and we move to S0 because the output will be 0.



When 01 is received, the input sequence is 01, 01 and we move to S2 (output will be 0).

When 11 is received, the input sequence becomes 01, 11 and we go to S0 (output will be 0).

When 10 is received, the input sequence is 01, 10 and we go to S4 (output will be 0).

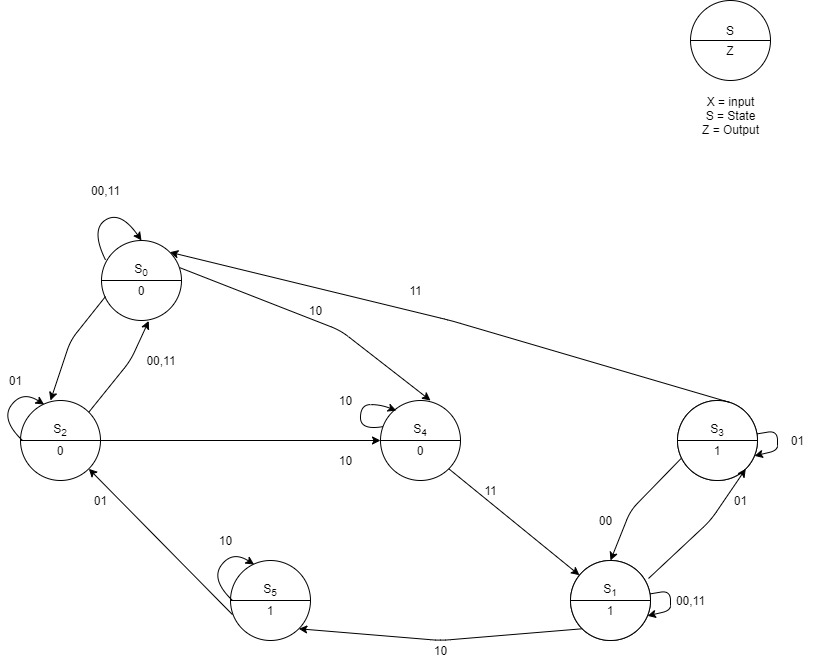


**S3 ROW**

When 00 is received, the input sequence is 01,00 and we go to S1 (output will be 1).

When 01 is received, the input sequence is 01, 01 and we go to S3 (output will be 1).

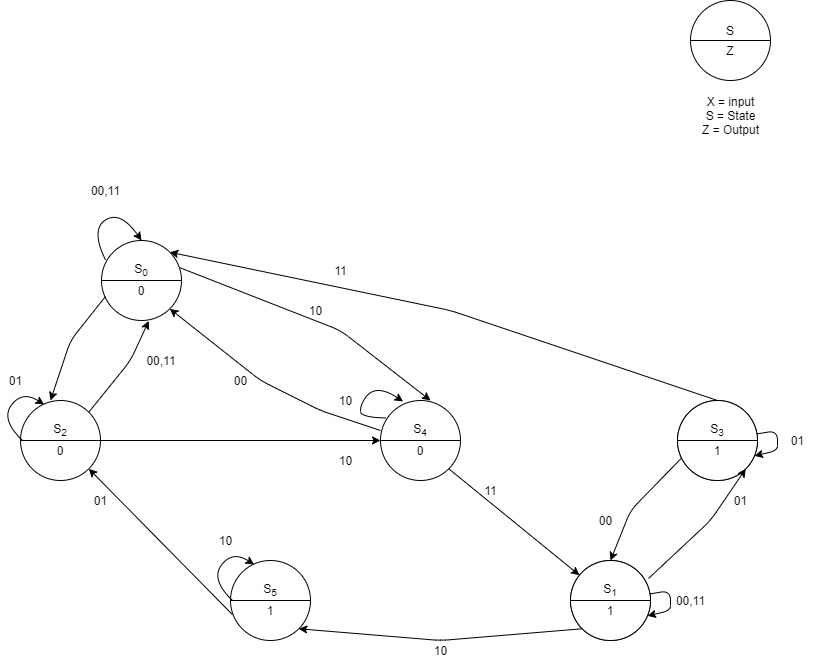
When 11 is received, the input sequence is 01, 11 and we go to S0 (output will be 0).



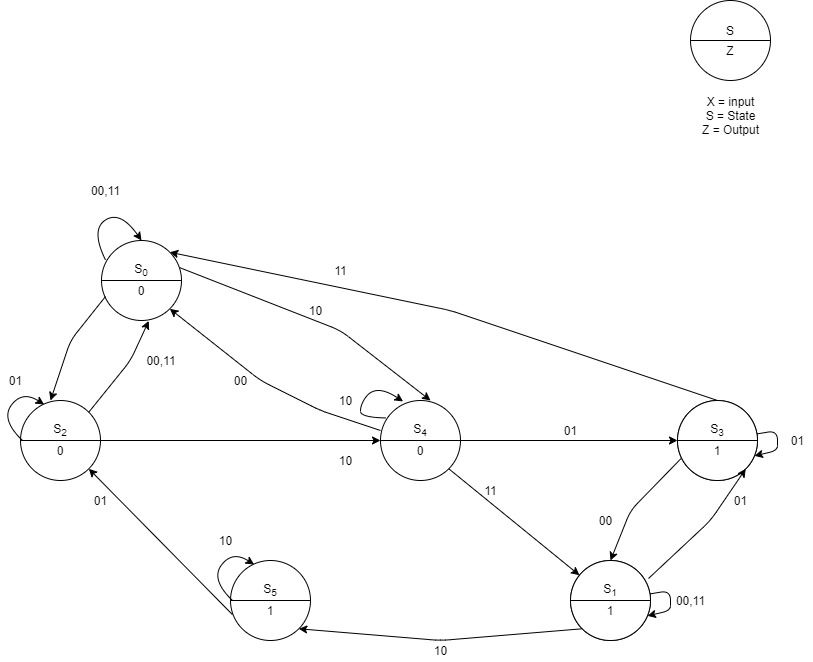
When 10 is received, the input sequence is 01, 10 and we move to S5 (output will be 1).

**S4 ROW**

When 00 is received, the input sequence is 10, 00 and we go to S0 (output will be 0).



When 01 is received, the input sequence is 10, 01 and we move to S3 (output will be 1).

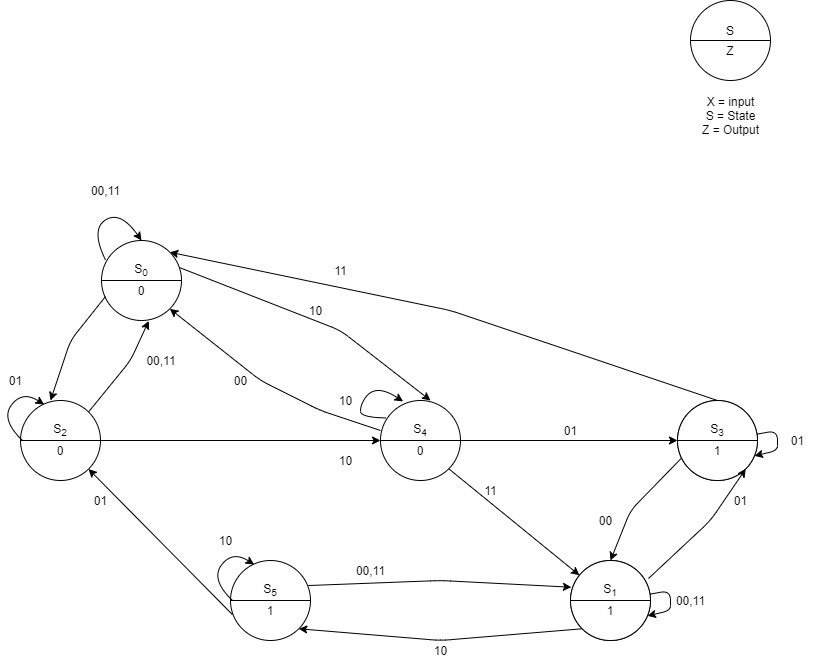


When 11 is received, the input sequence is 10, 11 and we move to S1 rather than moving to S0 because the output is 1.

When 10 is received, the input sequence is 10,10 and we move to S4 (output will be 0).

**S5 ROW**

When 00 is received, the input sequence is 10, 00 and we go to S1



When 01 is received, the input sequence is 10, 01 and we move to S2

When 11 is received, the input sequence is 10, 11 and we move to S1

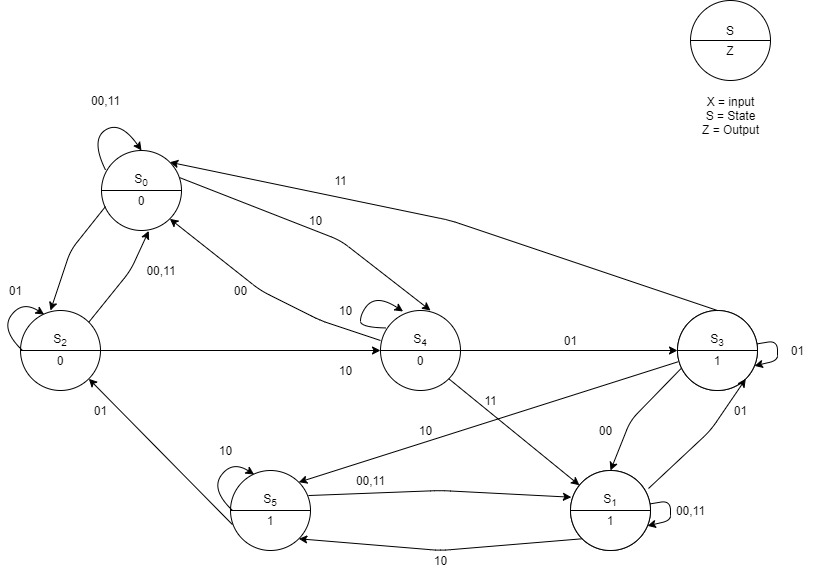
When 10 is received, the input sequence is 10,10 and we move to S5

A simpler version of the state table: -

Next State

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Previous Input | Output (Z) | 00 | 01 | 11 | 10 |
| S0 | 0 | S0 | S2 | S0 | S4 |
| S1 | 1 | S1 | S3 | S1 | S5 |
| S2 | 0 | S0 | S2 | S0 | S4 |
| S3 | 1 | S1 | S3 | S0 | S5 |
| S4 | 0 | S0 | S3 | S1 | S4 |
| S5 | 1 | S1 | S2 | S1 | S5 |

At last, the final State Graph: -



**2.** Following are non-valid BCD encodings for the decimal digits:

* 1010
* 1011
* 1100
* 1101
* 1110
* 1111

|  |  |
| --- | --- |
| State | Description |
| *S0* | *The 3 most recent bits are x00* |
| *S1* | *The 3 most recent bits are 001* |
| *S2* | *The 3 most recent bits are 010* |
| *S3* | *The 3 most recent bits are 011* |
| *S4* | *The 3 most recent bits are 101* |
| *S5* | *The 3 most recent bits are 110* |
| *S6* | *The 3 most recent bits are 111* |

The state machines would need to detect when the significant bits would be 101 or 11. The table below would define the states.

*Table 1*

I will use the states defined above and obtain the *Next State (N.S)* and the *Output (Z)* for the *Present State* and the *Input (X).*

Consider the *present state* as *S0*,

If the input is 1, then the *next state* is *S1* and the output is *Z = 0*.

If the input is 0, then the *next state* is *S0*and the output is *Z = 0.*

Consider the *present state* as *S1*,

If the input is 1, then the *next state* is *S3* and the output is *Z = 0.*

If the input is 0, then the *next state* is *S2* and the output is *Z = 0.*

Consider the *present state* as *S2*,

If the input is 1, then the *next state* is *S4* and the output is *Z = 0.*

If the input is 0, then the *next state* is *S0* and the output is *Z = 0.*

Consider the *present state* as *S3*,

If the input is 1, then the *next state* is *S6* and the output is *Z = 0.*

If the input is 0, then the *next state* is *S5* and the output is *Z = 0.*

Consider the *present state* as *S4*,

If the input is 1, then the *next state* is *S3* and the output is *Z = 1.*

If the input is 0, then the *next state* is *S2* and the output is *Z = 1.*

Consider the *present state* as *S5*,

If the input is 1, then the *next state* is *S4* and the output is *Z = 1.*

If the input is 0, then the *next state* is *S0* and the output is *Z = 1.*

Consider the *present state* as *S6*,

If the input is 1, then the *next state* is *S6* and the output is *Z = 1.*

If the input is 0, then the *next state* is *S5* and the output is *Z = 1.*

Using the explanation, below is the state table for the *Mealy Sequential circuit*:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| *Present State* | *Next State* | | | *Output* | |
|  | *X = 0*  *X = 1* | | | *X = 0*  *X =1* | |
| *S0* | *S1* | *S1* | 0 | | 0 |
| *S1* | *S2* | *S3* | 0 | | 0 |
| *S2* | *S0* | *S4* | 0 | | 0 |
| *S3* | *S5* | *S6* | 0 | | 0 |
| *S4* | *S2* | *S3* | 1 | | 1 |
| *S5* | *S0* | *S4* | 1 | | 1 |
| *S6* | *S5* | *S6* | 1 | | 1 |

**3.** The initial state, or reset state, is when neither the button has been pushed nor is Z high. This is S0. The next state would be S1, where the button is pushed and X is high, and Z is high for its first clock cycle. S2 would be Z’s second clock cycle while it is high. S3 would be its third, and S4 would be the fourth and final clock cycle where Z is high. During all 4 of Z’s high states, X is a don’t-care since Z remains high for these 4 states regardless of what X’s value is. S5 is where X is still 1 and Z returns to low, and the machine remains in this state as long as X stays pressed after Z is done with its clock cycles. Upon X going back to low (which means the button is no longer being pressed), the machine enters the reset state where X and Z are both low. Below is the state graph:

