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**Course Code:** CPE522

**Question:**

**Extract a state transition table from the state diagram below. Using a software tool to compute Quine Mccluskey’s minimization, obtain the minimal combinational Sum of Products for all outputs.**

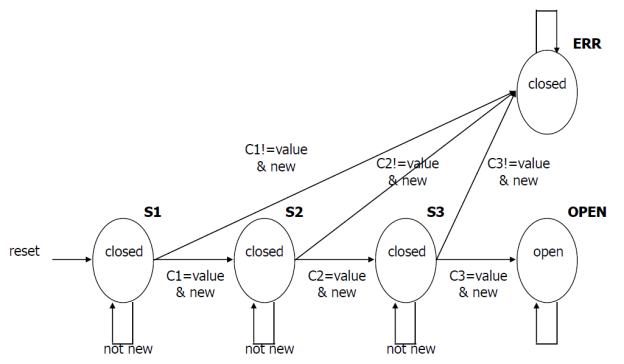


Fig. 1: Door Combination Lock State Diagram

**STATE TRANSITION TABLE**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Reset** | **New** | **Equal** | **Current State** | **Next**  **State** | **Next**  **Mux** | **Open / Closed** |
| 1 | ---- | ---- | ---- | S1 | C1 | closed |
| 0 | 0 | ---- | S1 | S1 | C1 | closed |
| 0 | 1 | 0 | S1 | ERR | ---- | closed |
| 0 | 1 | 1 | S1 | S2 | C2 | closed |
| 0 | 0 | ---- | S2 | S2 | C2 | closed |
| 0 | 1 | 0 | S2 | ERR | ---- | closed |
| 0 | 1 | 1 | S2 | S3 | C3 | closed |
| 0 | 0 | ---- | S3 | S3 | C3 | closed |
| 0 | 1 | 0 | S3 | ERR | ---- | closed |
| 0 | 1 | 1 | S3 | OPEN | \_\_ | closed |
| 0 | \_\_ | \_\_ | OPEN | OPEN | \_\_ | open |
| 0 | \_\_ | \_\_ | ERR | ERR | \_\_ | closed |

**Next we will encode the states that are symbolic in the implementation of the door lock system, which is shown in the table below**

|  |  |
| --- | --- |
| **SYMBOLS** | **ENCODING** |
| S1 | 000 |
| S2 | 001 |
| S3 | 010 |
| OPEN | 011 |
| ERR | 100 |
|  |  |
| C1 | 00 |
| C2 | 01 |
| C3 | 10 |

**STATE TRANSITION TABLE WITH ENCODED STATES**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Reset** | **New** | **Equal** | **Current State**  **(S1, S2, S3)** | **Next**  **State**  **(N1, N2, N3)** | **Next**  **Mux**  **(C1, C2)** | **Open / Closed** |
| 1 | ---- | ---- | ---- | 000 | 00 | 0 |
| 0 | 0 | ---- | 000 | 000 | 00 | 0 |
| 0 | 1 | 0 | 000 | 100 | ---- | 0 |
| 0 | 1 | 1 | 000 | 001 | 01 | 0 |
| 0 | 0 | ---- | 001 | 001 | 01 | 0 |
| 0 | 1 | 0 | 001 | 100 | ---- | 0 |
| 0 | 1 | 1 | 001 | 010 | 10 | 0 |
| 0 | 0 | ---- | 010 | 010 | 10 | 0 |
| 0 | 1 | 0 | 010 | 100 | ---- | 0 |
| 0 | 1 | 1 | 010 | 011 | ---- | 0 |
| 0 | ---- | ---- | 011 | 011 | ---- | 1 |
| 0 | ---- | ---- | 100 | 100 | ---- | 0 |

**Results**

The outputs are Next State (N1, N2, N3), Next Mux (C1, C2), and Open. The inputs are Reset, New, Equal and Current State (S1, S2, S3).

The software used to generate the QM minimisations can be located at the URL below: [**https://atozmath.com/KMap.aspx?q=quine**](https://atozmath.com/KMap.aspx?q=quine)

N1 (Next State)

Minterm = 16,17,18,4,12,20,28

Don't Care = 5,6,7,13,14,15,21,22,23,29,30,31

Variable = r, n, e, s1, s2, s3

Prime implicant chart

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **PIs\Minterms** | 4 | 12 | 16 | 17 | 18 | 20 | 28 | **r, n, e, s1, s2, s3** |
| 16,17,20,21 |  |  | X | X |  | X |  | 0 1 0 - 0 - |
| 16,18,20,22 |  |  | X |  | X | X |  | 0 1 0 - - 0 |
| 4,5,6,7,12,13,14,15,20,21,22,23,28,29,30,31 | X | X |  |  |  | X | X | 0 - - 1 - - |

Extracted essential prime implicants: 0--1--,010-0-,010--0

All extracted essential prime implicants: 0--1--,010-0-,010--0

Minimal Quine McCluskey Expression = **r’s1 + r’ne’s2’ + r’ne’s3’**

N2(Next State)

Minterm = 25,2,10,26,3,11,19,27

Don't Care = 5,6,7,13,14,15,21,22,23,29,30,31

Variable = R, N, E, S1, S2, S3

Prime implicant chart

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| PIs\Minterms | 2 | 3 | 10 | 11 | 19 | 25 | 26 | 27 | R, N, E, S1, S2, S3 |
| 25,27,29,31 |  |  |  |  |  | X |  | X | 0 1 1 - - 1 |
| 2,3,6,7,10,11,14,15 | X | X | X | X |  |  |  |  | 0 0 - - 1 - |
| 3,7,11,15,19,23,27,31 |  | X |  | X | X |  |  | X | 0 - - - 1 1 |
| 10,11,14,15,26,27,30,31 |  |  | X | X |  |  | X | X | 0 - 1 - 1 - |
| 5,7,13,15,21,23,29,31 |  |  |  |  |  |  |  |  | 0 - - 1 - 1 |
| 6,7,14,15,22,23,30,31 |  |  |  |  |  |  |  |  | 0 - - 1 1 - |

Extracted essential prime implicants: 00--1-,0---11,011--1,0-1-1-

All extracted essential prime implicants: 00--1-,0---11,011--1,0-1-1-

Minimal Quine McCluskey Expression = **R’N’S2+ R’S2S3 + R’NES3 + R’ES2**

N3 (Next State)

Minterm = 24,1,9,26,3,11,19,27

Don't Care = 5,6,7,13,14,15,21,22,23,29,30,31

Variable = R, N, E, S1, S2, S3

Prime implicant chart

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| PIs\Minterms | 1 | 3 | 9 | 11 | 19 | 24 | 26 | 27 | R, N, E, S1, S2, S3 |
| 24,26 |  |  |  |  |  | X | X |  | 0 1 1 0 – 0 |
| 26,27,30,31 |  |  |  |  |  |  | X | X | 0 1 1 – 1 - |
| 1,3,5,7,9,11,13,15 | X | X | X | X |  |  |  |  | 0 0 - - - 1 |
| 3,7,11,15,19,23,27,31 |  | X |  | X | X |  |  | X | 0 - - - 1 1 |
| 5,7,13,15,21,23,29,31 |  |  |  |  |  |  |  |  | 0 - - 1 – 1 |
| 6,7,14,15,22,23,30,31 |  |  |  |  |  |  |  |  | 0 - - 1 1 - |

Extracted essential prime implicants: 00---1,0---11,0110-0

All extracted essential prime implicants: 00---1,0---11,0110-0

Minimal Quine McCluskey Expression = **R’N’S3 + R’S2S3 + R’NES1’S3’**

C1 (Next Mux)

Minterm = 25,2,10

Don’t Care = 16,17,18,26,4,12,20,28,3,11,19,27,5,6,7,13,14,15,21,22,23,29,30,31

Variable = R, N, E, S1, S2, S3

Prime implicant chart

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| PIs\Minterms | 2 | 10 | 25 | R, N, E, S1, S2, S3 |
| 16,17,18,19,20,21,22,23 |  |  |  | 0 1 0 - - - |
| 17,19,21,23,25,27,29,31 |  |  | X | 0 1 - - - 1 |
| 2,3,6,7,10,11,14,15,18,19,22,23,26,27,30,31 | X | X |  | 0 - - - 1 - |
| 4,5,6,7,12,13,14,15,20,21,22,23,28,29,30,31 |  |  |  | 0 - - 1 - - |

Extracted essential prime implicants: 0---1-,01---1

All extracted essential prime implicants: 0---1-,01---1

Minimal Quine McCluskey Expression = **R’S2 + R’NS3**

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C2 (Next Mux)

Minterm = 24,1,9

Don’t Care = 16,17,18,26,4,12,20,28,3,11,19,27,5,6,7,13,14,15,21,22,23,29,30,31

Variable = R, N, E, S1, S2, S3

Prime implicant chart

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| PIs\Minterms | 1 | 9 | 24 | R, N, E, S1, S2, S3 |
| 1,3,5,7,9,11,13,15 | X | X |  | 00---1 |
| 1,3,5,7,17,19,21,23 | X |  |  | 0-0—1 |
| 16,18,20,22,24,26,28,30 |  |  | X | 01---0 |
| 16,17,18,19,20,21,22,23 |  |  |  | 010--- |
| 3,7,11,15,19,23,27,31 |  |  |  | 0---11 |
| 18,19,22,23,26,27,30,31 |  |  |  | 01--1- |
| 4,5,6,7,12,13,14,15,20,21,22,23,28,29,30,31 |  |  |  | 0--1-- |

Extracted essential prime implicants: 00---1,01---0

All extracted essential prime implicants: 00---1,01---0

Minimal Quine McCluskey Expression = **R’N’S3 + R’NS3’**

Open (Output)

Minterm = 3,11,19,27

Don’t Care = 5,6,7,13,14,15,21,22,23,29,30,31

Variable = R, N, E, S1, S2, S3

Prime implicant chart

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| PIs\Minterms | 3 | 11 | 19 | 27 | R, N, E, S1, S2, S3 |
| 3,7,11,15,19,23,27,31 | X | X | X | X | 0 - - - 1 1 |
| 5,7,13,15,21,23,29,31 |  |  |  |  | 0 - - 1 – 1 |
| 6,7,14,15,22,23,30,31 |  |  |  |  | 0 - - 1 1 - |

Extracted essential prime implicants: 0---11

All extracted essential prime implicants: 0---11

Minimal Quine McCluskey Expression = **R’S2S3**