**NAME: OKEAGU BONIFACE CHINECHEREM**

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**COURSE CODE: CPE522**

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Draw the state diagram and state transition table of a door combination lock and use a software that implements Quine-McCluskey to perform the minimization.

**STATE DIAGRAM:**

**ERR**

reset

not new

not new

not new

**OPEN**

**S2**

**S1**

**S3**

C1 != value

& new

C2 != value

& new

C3 != value

& new

C1 = value

& new

C2 = value

& new

C3 = value

& new

closed

closed

closed

open

**Diagram created using Microsoft Office Word**

**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 |

**STATE ENCODING:**

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

**STATE TRANSITION TABLE SHOWING ENCODED STATES:**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | | | **Current State** | | | **Next State** | | | **Next Mux** | |  |
| **R** | **N** | **E** | **S0** | **S1** | **S2** | **N0** | **N1** | **N2** | **C0** | **C1** | **Open** |
| 1 | \_\_ | \_\_ | \_\_ | \_\_ | \_\_ | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | \_\_ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | \_\_ | \_\_ | 0 |
| 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| 0 | 0 | \_\_ | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 |
| 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | \_\_ | \_\_ | 0 |
| 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 |
| 0 | 0 | \_\_ | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 |
| 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | \_\_ | \_\_ | 0 |
| 0 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | \_\_ | \_\_ | 0 |
| 0 | \_\_ | \_\_ | 0 | 1 | 1 | 0 | 1 | 1 | \_\_ | \_\_ | 1 |
| 0 | \_\_ | \_\_ | 1 | 0 | 0 | 1 | 0 | 0 | \_\_ | \_\_ | 0 |

N0, N1, N2, C0, C1 and Open are the outputs and the input variables are R, N, E, S0, S1, S2. [AtozMath’s Online Quine-McCluskey tool](http://atozmath.com/KMap.aspx?q=Quine) was used to find the minimal expression for each output and the following results were realized;

1. **N0**

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, S0, S1, S2

using Quine-McCluskey

[See solution here](http://atozmath.com/KMap.aspx?q=quine&q1=16%2c17%2c18%2c4%2c12%2c20%2c28%605%2c6%2c7%2c13%2c14%2c15%2c21%2c22%2c23%2c29%2c30%2c31%60r%2cn%2ce%2cs0%2cs1%2cs2%60sop&do=1#PrevPart)

**PRIME IMPLICANT CHART**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| PIs\Minterms | 4 | 12 | 16 | 17 | 18 | 20 | 28 | R, N, E, S0, S1, S2 |
| 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 – –, 0 1 0 – 0 –, 0 1 0 – – 0

All extracted essential prime implicants: 0 – – 1 – –, 0 1 0 – 0 –, 0 1 0 – – 0

Minimal Quine-McCluskey Expression =

1. **N1**

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, S0, S1, S2

using Quine-McCluskey

[*See solution here*](http://atozmath.com/KMap.aspx?q=quine&q1=25%2C2%2C10%2C26%2C3%2C11%2C19%2C27%605%2C6%2C7%2C13%2C14%2C15%2C21%2C22%2C23%2C29%2C30%2C31%60r%2Cn%2Ce%2Cs0%2Cs1%2Cs2%60sop&do=1)

**PRIME IMPLICANT CHART**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| PIs\Minterms | 2 | 3 | 10 | 11 | 19 | 25 | 26 | 27 | R, N, E, S0, S1, S2 |
| 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: 0 0 – – 1 –, 0 – – – 1 1, 0 1 1 – – 1, 0 – 1 – 1 –

All extracted essential prime implicants: 0 0 – – 1 –, 0 – – – 1 1, 0 1 1 – – 1, 0 – 1 – 1 –

Minimal Quine-McCluskey Expression =

1. **N2**

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, S0, S1, S2

using Quine-McCluskey

[*See solution here*](http://atozmath.com/KMap.aspx?q=quine&q1=24%2c1%2c9%2c26%2c3%2c11%2c19%2c27%605%2c6%2c7%2c13%2c14%2c15%2c21%2c22%2c23%2c29%2c30%2c31%60r%2cn%2ce%2cs0%2cs1%2cs2%60sop&do=1#PrevPart)

**PRIME IMPLICANT CHART**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| PIs\Minterms | 1 | 3 | 9 | 11 | 19 | 24 | 26 | 27 | R, N, E, S0, S1, S2 |
| 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: 0 0 – – – 1, 0 – – – 1 1, 0 1 1 0 – 0

All extracted essential prime implicants: 0 0 – – –1, 0 – – – 1 1, 0 1 1 0 – 0

Minimal Quine-McCluskey Expression =

1. **C0**

Minterm = 25, 2, 10

DontCare = 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, S0, S1, S2

using Quine-McCluskey

[*See solution here*](http://atozmath.com/KMap.aspx?q=quine&q1=25%2c2%2c10%6016%2c17%2c18%2c26%2c4%2c12%2c20%2c28%2c3%2c11%2c19%2c27%2c5%2c6%2c7%2c13%2c14%2c15%2c21%2c22%2c23%2c29%2c30%2c31%60r%2cn%2ce%2cs0%2cs1%2cs2%60sop&do=1)

**PRIME IMPLICANT CHART**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| PIs\Minterms | 2 | 10 | 25 | R, N, E, S0, S1, S2 |
| 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 –, 0 1 – – – 1

All extracted essential prime implicants: 0 – – – 1 –, 0 1 – – – 1

Minimal Quine-McCluskey Expression =

1. **C1**

Minterm = 24, 1, 9

DontCare = 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, S0, S1, S2

using Quine-McCluskey

[*See solution here*](http://atozmath.com/KMap.aspx?q=quine&q1=24%2c1%2c9%6016%2c17%2c18%2c26%2c4%2c12%2c20%2c28%2c3%2c11%2c19%2c27%2c5%2c6%2c7%2c13%2c14%2c15%2c21%2c22%2c23%2c29%2c30%2c31%60r%2cn%2ce%2cs0%2cs1%2cs2%60sop&do=1#PrevPart)

**PRIME IMPLICANT CHART**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| PIs\Minterms | 1 | 9 | 24 | R, N, E, S0, S1, S2 |
| 1, 3, 5, 7, 9, 11, 13, 15 | X | X |  | 0 0 – – – 1 |
| 1, 3, 5, 7, 17, 19, 21, 23 | X |  |  | 0 – 0 – – 1 |
| 16, 18, 20, 22, 24, 26, 28, 30 |  |  | X | 0 1 – – – 0 |
| 16, 17, 18, 19, 20, 21, 22, 23 |  |  |  | 0 1 0 – – – |
| 3, 7, 11, 15, 19, 23, 27, 31 |  |  |  | 0 – – – 1 1 |
| 18, 19, 22, 23, 26, 27, 30, 31 |  |  |  | 0 1 – – 1 – |
| 4, 5, 6, 7, 12, 13, 14, 15, 20, 21, 22, 23, 28, 29, 30, 31 |  |  |  | 0 – – 1 – – |

Extracted essential prime implicants: 0 0 – – – 1, 0 1 – – – 0

All extracted essential prime implicants: 0 0 – – – 1, 0 1 – – – 0

Minimal Quine-McCluskey Expression =

1. **OPEN**

Minterm = 3, 11, 19, 27

DontCare = 5, 6, 7, 13, 14, 15, 21, 22, 23, 29, 30, 31

Variable = R, N, E, S0, S1, S2

using Quine-McCluskey

[*See solution here*](http://atozmath.com/KMap.aspx?q=quine&q1=3%2C11%2C19%2C27%605%2C6%2C7%2C13%2C14%2C15%2C21%2C22%2C23%2C29%2C30%2C31%60r%2Cn%2Ce%2Cs0%2Cs1%2Cs2%60sop&do=1#tblSolution)

**PRIME IMPLICANT CHART**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| PIs\Minterms | 3 | 11 | 19 | 27 | R, N, E, S0, S1, S2 |
| 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 – – – 1 1

All extracted essential prime implicants: 0 – – – 1 1

Minimal Quine-McCluskey Expression =