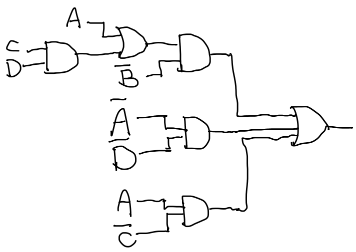
# Question 1 I

Saturday, 7 March 2020 6:20 pm

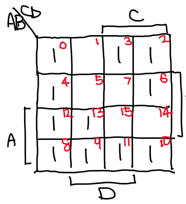
a) i) Literals = 8
Terms = 5
Complements = 4
GIC = 17

$\leftarrow \underbrace{\overline{B}(CD+A)} + \underbrace{\overline{A}\overline{D}} + \underbrace{A\overline{C}}$




Students may draw logic diagram to determine the GIC.


ii) Students can use the K-map to find the minterms for F:




$F = \Sigma m(0, 2, 3, 4, 6, 8, 9, 10, 11, 12, 13)$

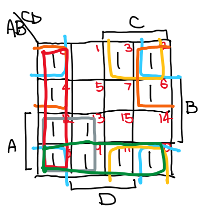
OR

$F = \overline{B}(CD+A) + \overline{A}\overline{D} + A\overline{C}$
$= \overline{B}CD + \overline{A}\overline{D} + A\overline{B} + A\overline{C}$
$= \overline{B}CD(A+\overline{A}) + \overline{A}\overline{D}(B+\overline{B})(C+\overline{C}) + A\overline{B}(C+\overline{C})(D+\overline{D}) + A\overline{C}(B+\overline{B})(D+\overline{D})$

iii)

| A | B | C | D | F | $m_i$ |
|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 1 | $m_0$ |
| 0 | 0 | 0 | 1 | 0 | $m_1$ |
| 0 | 0 | 1 | 0 | 1 | $m_2$ |
| 0 | 0 | 1 | 1 | 1 | $m_3$ |
| 0 | 1 | 0 | 0 | 1 | $m_4$ |
| 0 | 1 | 0 | 1 | 0 | $m_5$ |
| 0 | 1 | 1 | 0 | 1 | $m_6$ |
| 0 | 1 | 1 | 1 | 0 | $m_7$ |
| 1 | 0 | 0 | 0 | 1 | $m_8$ |
| 1 | 0 | 0 | 1 | 1 | $m_9$ |
| 1 | 0 | 1 | 0 | 1 | $m_{10}$ |
| 1 | 0 | 1 | 1 | 1 | $m_{11}$ |
| 1 | 1 | 0 | 0 | 1 | $m_{12}$ |
| 1 | 1 | 0 | 1 | 1 | $m_{13}$ |
| 1 | 1 | 1 | 0 | 0 | $m_{14}$ |
| 1 | 1 | 1 | 1 | 0 | $m_{15}$ |

iv)

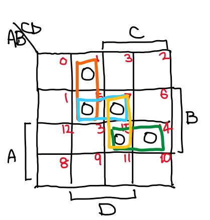



$F = A\overline{C} + \overline{A}\overline{D} + \overline{B}C$

PI: $A\overline{C}, \overline{A}\overline{D}, \overline{B}C, \overline{B}\overline{D}, \overline{C}\overline{D}, A\overline{B}$

EPI: $A\overline{C}, \overline{A}\overline{D}, \overline{B}C$

v)




$F = (A+C+\overline{D})(A+\overline{B}+\overline{D})(\overline{A}+\overline{B}+\overline{C})$

or $F = (A+C+\overline{D})(\overline{B}+\overline{C}+\overline{D})(\overline{A}+\overline{B}+\overline{C})$

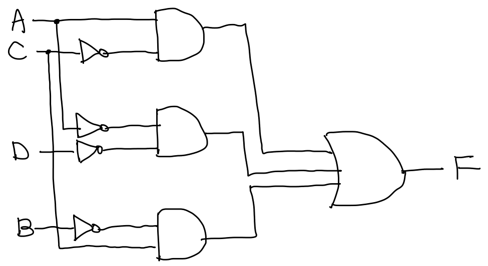
Essential Prime Implicants: $(A+C+\overline{D})$, $(\overline{A}+\overline{B}+\overline{C})$

Prime Implicants: $(A+C+\overline{D}), (\overline{A}+\overline{B}+\overline{C})(A+\overline{B}+\overline{D}), (\overline{B}+\overline{C}+\overline{D})$

vi) literals = 6
terms = 3
complements = 4
GIC = 13

Reduction of 4 GIC after optimisation

vii) $F = A\bar{C} + \bar{A}\bar{D} + \bar{B}C$



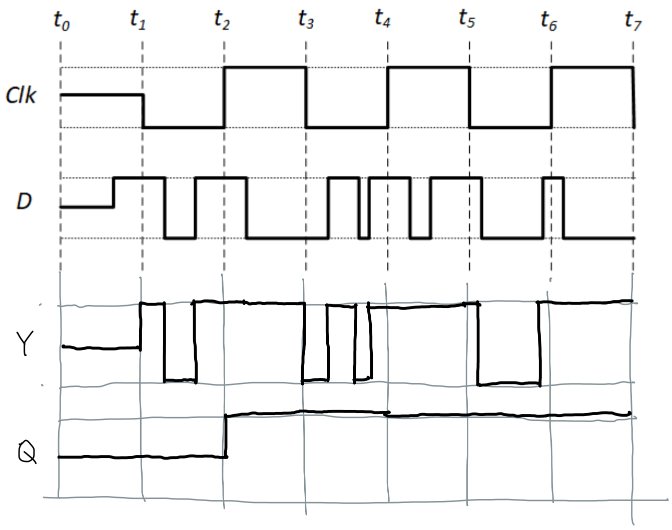

b)

| binary | hexadecimal | octal |
| --- | --- | --- |
| 1110101001.1 | 3A9.8 | 1651.4 |

$\underbrace{0011}_{3}\ \underbrace{1010}_{A}\ \underbrace{1001}_{9}\cdot\underbrace{1000}_{8}$ ← binary / ← hex

$\underbrace{001}_{1}\ \underbrace{110}_{6}\ \underbrace{101}_{5}\ \underbrace{001}_{1}\cdot\underbrace{100}_{4}$ ← binary / ← octal

c) A – D latch
B – Positive edge triggered D flip flop



Question 2 I

Saturday, 7 March 2020 8:31 pm

a) i) $A+B = A\oplus B + AB$

$$A\oplus B + AB = A\bar{B} + \bar{A}B + AB$$
$$= A\bar{B} + AB + AB + \bar{A}B$$
$$= A(\bar{B}+B) + B(A+\bar{A})$$
$$= A+B$$

ii) $$H(A,B,C) = A\bar{B} + AB\bar{C} + \bar{A}B$$
$$= A\oplus B + AB\bar{C}$$
$$= A\oplus B\oplus AB\bar{C} + (A\oplus B)(AB\bar{C})$$
$$= A\oplus B\oplus AB\bar{C} + (A\bar{B}+\bar{A}B)(AB\bar{C})$$
$$= A\oplus B\oplus AB\bar{C}$$

b) i)

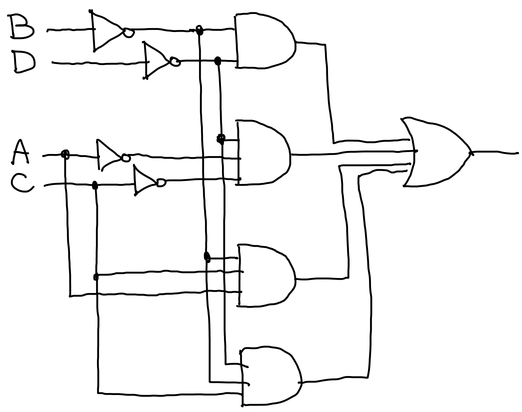
| AB \ CD | 00 | 01 | 10 | 11 |
|---|---|---|---|---|
| 00 | 1 | | | 1 |
| 01 | 1 | | 1 | |
| 10 | | | 1 | 1 |
| 11 | 1 | | 1 | 1 |

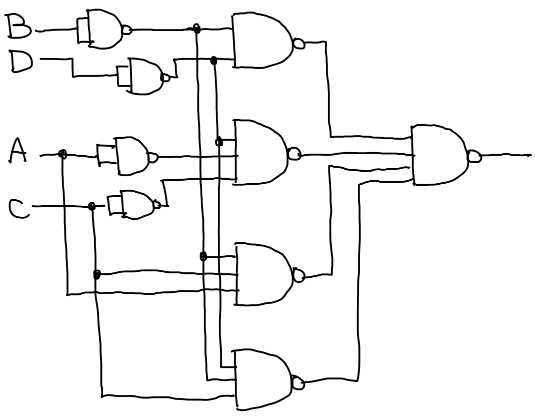
$\bar{A}\bar{C}\bar{D}$ $BCD$ $AC$ $\bar{B}\bar{D}$

$$G = \Pi M(1,3,5,6,9,12,13)$$
$$= \Sigma m(0,2,4,7,8,10,11,14,15)$$
$$= \bar{A}\bar{B}\bar{C}\bar{D} + \bar{A}\bar{B}C\bar{D} + \bar{A}B\bar{C}\bar{D} + \bar{A}BCD + A\bar{B}\bar{C}\bar{D} + A\bar{B}C\bar{D} + A\bar{B}CD + ABC\bar{D} + ABCD$$
$$+ A\bar{B}C\bar{D} + \bar{A}\bar{B}\bar{C}\bar{D} + ABCD$$

$$= \bar{B}\bar{D}(\bar{A}\bar{C} + \bar{A}C + A\bar{C} + AC) + AC(\bar{B}D + B\bar{D} + BD + \bar{B}\bar{D}) + \bar{A}\bar{C}\bar{D}(B+\bar{B}) + BCD(\bar{A}+A)$$
$$= \bar{B}\bar{D} + AC + \bar{A}\bar{C}\bar{D} + BCD$$

ii)




NAND only

c) i)

| A | B | C | D | Z | |
|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 1 | $Z = \bar{D}$ |
| 0 | 0 | 0 | 1 | 0 | |
| 0 | 0 | 1 | 0 | 1 | |
| 0 | 0 | 1 | 1 | 0 | |
| 0 | 1 | 0 | 0 | 1 | $Z = \bar{D}$ |
| 0 | 1 | 0 | 1 | 0 | |
| 0 | 1 | 1 | 0 | 1 | |
| 0 | 1 | 1 | 1 | 0 | |
| 1 | 0 | 0 | 0 | 1 | $Z = 1$ |
| 1 | 0 | 0 | 1 | 1 | |
| 1 | 0 | 1 | 0 | 1 | |
| 1 | 0 | 1 | 1 | 1 | |
| 1 | 1 | 0 | 0 | 0 | $Z = 0$ |
| 1 | 1 | 0 | 1 | 0 | |
| 1 | 1 | 1 | 0 | 0 | |
| 1 | 1 | 1 | 1 | 0 | |

| AB \ CD | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 00 | 1 | | | 1 |
| 01 | 1 | | | 1 |
| 11 | | | | |
| 10 | 1 | 1 | 1 | 1 |

AB select

$I_0 = \bar{D}$

$I_1 = \bar{D}$

$I_3 = 0$

$I_2 = 1$

CD select

$I_0 = \bar{A} + \bar{B}$

$I_1 = A\bar{B}$

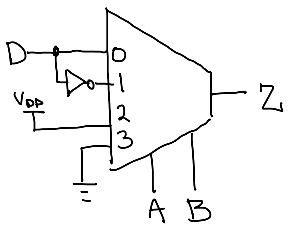
$I_2 = \bar{A} + B$

$I_3 = A\bar{B}$

Note: Using CD as select would not give the simplest design.

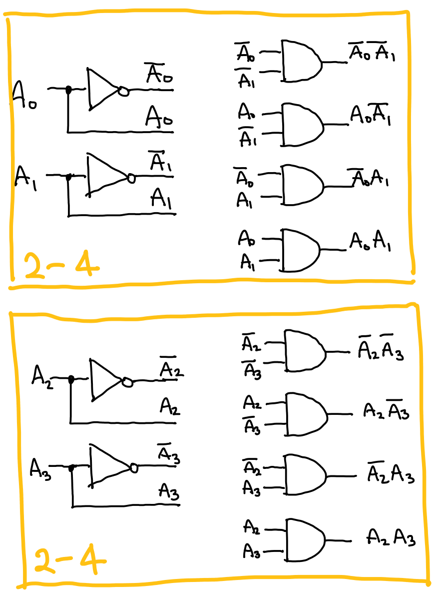
ii) $Z = \sum m(0, 2, 4, 6, 8, 9, 10, 11)$

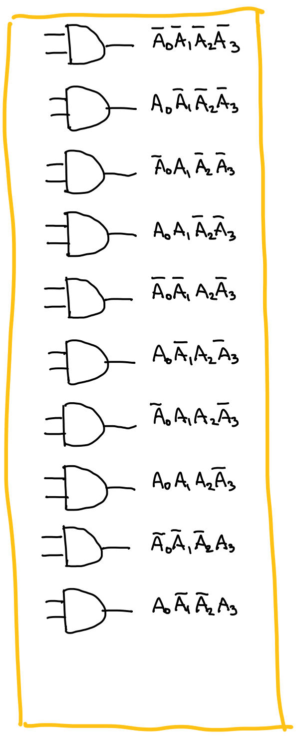
iii)




d)

Not required!

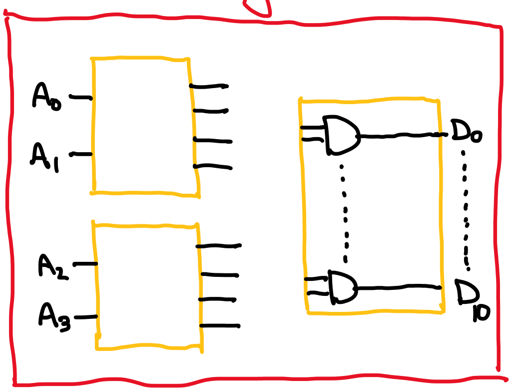



11 AND gates

GIC = 4 + 4×2 + 4×2 + 11×2 = <u>42</u>

Block diagram




Refer to Week 3 slide 51

- Input n is even, n = 4. Use $2^n$ AND gates driven by two decoders of output size $2^{n/2} = 4$. Since BCD is only from 0 to X, 16 − X − 1 AND gates will be redundant.