تقدم لجنة ElCoM الاكاديمية

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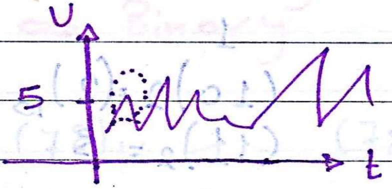
جزيل الشكر للطالب:

نمر عودة

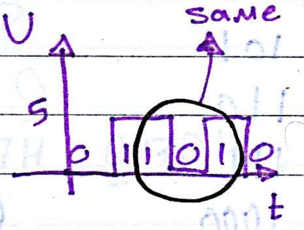
DATE 29.9.2015
Tuesday

- Analog
- Digital
- Number systems



Analog

Digital



off, false, No
0 (0_2.3)v
1 (2.87-5)v
(ON, True, yes)

$(5)_{10} = (101)_2$

ADC → Analog to Digital Converter
DAC → Digital to Analog Converter

Number systems:-

1. Decimal	2. Binary	3. Octal	4. Hexadecimal
0_9	0_1	0_7	0-9 , A_F=10_15
base = 10 (Radix)	base = 2	base = 8	base = 16

Decimal Binary Octal hexadecimal

Digital logic

Decimal	Binary	Octal	hexadecimal
0 1	0	0	0 1
2 3	1	1	2
4 5	$(10)_2=(2)_{10}$	2	3
6 7	$(11)_2=3$	3	4
8 9	100	4	5
10	101	5	6
11	110	6	7
12	111	7	8
13	1000	$(10)_8$	9
14	1001	11	A
15	1010	12	B
16	1011	13	C
17	●1100	14	D
	1101	15	E
عدد منازل أكبر	⋮	16	$(F)_{16}=(15)_{10}$
	⋮	17	$(10)_{16}=16$
		$(20)_8=(16)_{10}$	عدد منازل أقل

77 → Octal

100

DATE 1-10-2015
Thursday

Class 2

- Basic Defintion
- conversion Decimal ⇔ any system
- Conversion Octal ⇔ Binary
  hex ⇔ Binary

e.g → $(1011)_2$ ✓ $(78)_{16}$ ✓ $(78)_8$ ✗

B (Binary) 1011B   % 101
Q (Octal) 567 Q
H (Hexa) AB17H, 017Dh, # BC12, 0xAB89

* Bit = 1 0
  Nibble = 4 bits
  Byte = 8bits
  word = 16 bits = 2byte
  2^{10} = 1 Kilo = 1024
  2^{20} = 1 Mega = 1024x1024
  2^{30} = 1 Giga
  2^{40} = 1 Tera

* LSB = Least Significant Bit
  MSB = Most Significant Bit

eg: $(10110)_2$
MSB ↵ ↳ LSB

$(9101)_{10}$
MSB ↵ ↳ LSB

DATE 1-10-2015
Thursday

Class 2

Binary
Octal } → Decimal //weighted sum
hexa

e.g $(195)_{10}$

10^2	10^1	10^0	weight
1	9	5	factor

$= 10^0 * 5 + 10^1 * 9 + 1 * 10^2$

b = 10

e.g $(167)_8 \Rightarrow b = 8$

8^2	8^1	8^0	weight
1	6	7	factor

$7 * 8^0 + 6 * 8^1 + 1 * 8^2 = 7 + 48 + 64 = (119)_{10}$

e.g $(150)_6 \Rightarrow$ Decimal

$6^0 * 0 + 5 * 6^1 + 1 * 6^2$

$= 30 + 36 = (66)_{10}$

e.g $(FC7)_{16}$ b = 16

$= 7 * 16^0 + \underset{C}{\underset{\downarrow}{12}} * 16^1 + \underset{F}{\underset{\downarrow}{15}} * 16^2 = (4039)_{10}$

e.g $(\overset{8^1}{1}\overset{8^0}{7}.\overset{8^{-1}}{5}\overset{8^{-2}}{2})_8$ $= 1 * 8^1 + 7 * 8^0 + 5 * 8^{-1} + 2 * 8^{-2}$

Radix pt

$= (15.65625)_{10}$

DATE 1.10.2015
Thursday

Class 2

e.g $(101.01)_2 \Rightarrow$ Decimal

$1*2^2 + 0*2^1 + 1*2^0 + 0*2^{-1} + 1*2^{-2}$

$= 4+0+1+0+\frac{1}{4} = 5+\frac{1}{4} = (5.25)_{10}$

Decimal → { Binary, hex, Octal }

① Integer : ① Divide by the base (Repeated)
② look for the remainder

② Fraction : ① multiplation by the base (Repeated)
② look for the integer part

e.g $(8)_{10} \Rightarrow$ Binary القسمة للشيء الذي سنحوله

	Result	Reminder
8/2	4	0 → LSB
4/2	2	0
2/2	1	0
1/2	0	1 → MSB

$(8)_{10} = (1000)_2$

Class 2

e.g $(80)_{10} \rightarrow$ Octal

base 8

$80 / 8 = 10 \rightarrow 0 \rightarrow$ LSB
$10 / 8 = 1 \rightarrow 2$
$1 / 8 = 0 \rightarrow 1 \rightarrow$ MSB

$(80)_{10} = (120)_8$

e.g $(500)_{10} \rightarrow$ hex

$500 / 16 = 31$ 4 → LSB

$31 / 16 = 1$ 15

$1 / 16 = 0$ 1 → MSB

$(1F4)_{16}$

e.g $(50)_{10} \rightarrow$ binary

$50/2 \rightarrow 25$ 0
$25/2 \rightarrow 12$ 1
$12/2 \rightarrow 6$ 0
$6/2 \rightarrow 3$ 0
$3/2 \rightarrow 1$ 1
$1/2 \rightarrow 0$ 1

$(110010)_2$

Sunday

Class 3

Conversion → Fraction - Decimal → binary ✓
hex ✓
Octal ✓

→ On the Fly Conversion
→ Octal ⇔ binary
hex ⇔ binary
Octal ⇔ hex

Ex $(0.3)_{10}$ → Binary

		i.P
Sol →	0.3 * 2 = 0.6	0 → MSB
*	0.6 * 2 = 1.2	1
	0.2 * 2 = 0.4	0
	0.4 * 2 = 0.8	0
	0.8 * 2 = 1.6	1
*	0.6 * 2 = 1.2	1 → LSB

$(0.3)_{10} = (0.010011)_2$

e.g $(0.3)_{10}$ → Octal 5 digits

b = 8

	i.P
0.3 * 8 = 2.4	2 → MSB
0.4 * 8 = 3.2	3
0.2 * 8 = 1.6	1
0.6 * 8 = 4.8	4
0.8 * 8 = 6.4	6 → LSB

$(0.3)_{10} = (0.23146)_8$

Class 3

e.g $(0.3)_{10} \Rightarrow$ hex   b=16

$(0.3)_{10} = (??)_{16}$

$0.3 * 16 = 4.8$

$0.8 * 16 = 12.8$

$0.8 * 16 = 12.8$

$\vdots$

$(0.3)_{10} = (0.4CC----)_{16}$

e.g $(0.75)_{10} \Rightarrow$ Binary

Sol → $0.75 * 2 = 1.5$ → MSB

$0.5 * 2 = 1.0$

$0.0 * 2 = 0.0$ → LSB

$(0.75)_{10} = (0.11)_2$

e.g $(19.81)_{10} \Rightarrow$ binary   b=2

Integer part :-

$19/2 = 9$ 1 → LSB

$9/2 = 4$ 1

$4/2 = 2$ 0

$2/2 = 1$ 0

$1/2 = 0$ 1 → MSB

$= (10011)_2$

Fraction part →

$(0.81) * 2 = 1.62$ 1 → MSB

Related to the radix pt.

$0.62 * 2 = 1.24$ 1

$0.24 * 2 = 0.48$ 0

$0.48 * 2 = 0.96$ 0

$0.96 * 2 = 1.92$ 1 → LSB

$(19.81)_{10} = (10011.11001)_2$

CLASS 3

Decimal → Binary On the fly

$(8)_{10} \rightarrow \underbrace{\overset{2^3}{1}\quad \overset{2^2}{0}\quad \overset{2^1}{0}\quad \overset{2^0}{0}}$

$(4)_{10} \rightarrow \overset{2^2}{1}\,\overset{2^1}{0}\,\overset{2^0}{0}$

$(2)_{10} \rightarrow \overset{2^1}{1}\overset{2^0}{0}$

e.g $(9)_{10} \rightarrow (1\ 0\ 0\ 1)_2$

$8 + 1 = \boxed{9}$

On the fly → look for the gratest or equal digit ⟺ (equal or less than the given number)

e.g $(23)_{10}$

2^4	2^3	2^2	2^1	2^0
16	8	4	2	1
1	0	1	1	1

$(23)_{10} = (1\,0\,111)_2$

e.g $(37)_{10}$

2^5	2^4	2^3	2^2	2^1	2^0
32	16	8	4	2	1
1	0	0	1	0	1

$(37)_{10} = (100101)_2$

Class 3

Octal ⟺ Binary

① Binary → Octal

- start from the radix pt.
- divide the binary number to groups of 3
- (convert each group)

e.g 001 | 101 | 1001 . | 110

1 5 5 6

$(1101101.110)_2 = (155.6)_8$

e.g

octal	binary
0	000
1	001
2	010
3	011
4	100
5	101
6	110
7	111

$\boxed{2^3 = 8}$

② Octal → Binary

e.g $(517.2)_8$ → binary

divide to groups of 3

Sol → $(101001111.010)_2$

DATE 4-10-2015
Sunday

Class 3

hex ⇔ Binary — Same method but 4 groups

hex	binary
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001
A	1010
B	1011
C	1100
D	1101
E	1110
F	1111

DATE 6-10-2015

Tuesday

Class 4

hex ⇔ binary

Octal ⇔ hex

Eg $(F701.3)_{16} \Rightarrow$ Binary

Sol ⇒ $(1111\,0111\,0000\,0001 . 0011)_2$

eg $(0001\,0111\,0110\,1110\,0 . 1101\,1000)_2$ hex

① ① ① ① ①

$= (1 7 6 E . D 8)$

Octal ⇔ hex passing binary

↘ binary

eg $(F701.3)_{16} \Rightarrow$ Octal

Sol ⇒ $(1111\,0111\,0000\,0001 . 0011)_2$

to Octal ⇒ 001 111 011 100 000 001 . 001 100

$= (173401.14)_8$

e.g $(732.5)_8 \Rightarrow$ hex

Sol ⇒ to binary = $(111\,011\,010 . 101)_2$

to hex ⇒ 0001 1101 1010 . 1010

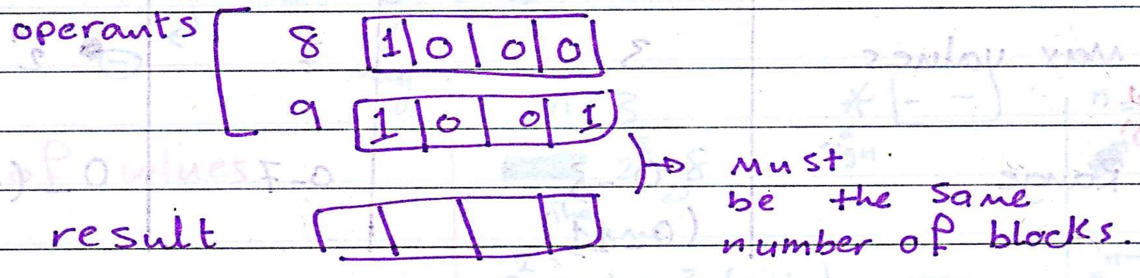
$= (1DA.A)_{16}$

DATE 6-10-2015

Class 4

"Arethmatic Operation" "Tuesday"

e.g



* Finit precision Numbers can be:

1- Unsigned
2- Signed → Magnitude
→ 1's complement
→ 2's Complement

\# Binary Codes : sequences of bits that refers to a certain values.

9 → 1001

n: # of digits

	decimal, n = 2	n = 3	
# of values	100	1000	10^n
Maximum value	99	999	$10^n - 1$
range	0-99	0-999	

DATE 6-10-2015
Tuesday

Class 4

	Binary , n=2	n=3	
# of values ✓ دا خانات	$2^2 = 4$	$2^3 = 8$	2^n
X Max values تعتمد على النظام	3	7	● $2^n - 1$
Range	0 - 3 (0 - 11)	0 - 7	$0 - (2^n - 1)$

* Signed Magnitude →

One digit reserved to the sign

0 → +ve
1 → -ve] MSB

n = 4

$\overset{\text{MSB}}{\underline{\quad}}$ __ __ __
↓
Sign bit

eg → n = 4 , $(7)_{10}$ ⇒ Signed magnitude.

$\underline{0}\ \underline{1}\ \underline{1}\ \underline{1}$
↙ +ve

$(-3)_{10}$ ⇒ $\underline{1}\ \underline{0}\ \underline{1}\ \underline{1}$
-ve ↙ ↙
حافظ على عدد المنازل.

$(+1)_{10}$ ⇒ $\underline{0}\ \underline{0}\ \underline{0}\ \underline{1}$
+ve ↙

Class 4

$n=4$

$+ve \leftarrow \underline{\underline{0}}\ 0\ 0\ 0 = +0$

$-ve \leftarrow \underline{\underline{1}}\ \underbrace{0\ 0\ 0}_{Mag} = -0$

	$n=3$	$n=4$	
# of values	$2^3=8$	$2^4=16$	2^n
Max	$2^2-1=3$ 011	$2^3-1=7$ 0111	$2^{n-1}-1$
Min	$-(2^2-1)=-3$ 111	$-(2^3-1)=-7$ 1111	$-(2^{n-1}-1)$
# of zero's	0 00 1 00 $\underline{\underline{2}}$	0000 1000 $\underline{\underline{2}}$	$\underline{\underline{2}}$

Thursday

Class 5

- unsigned
- signed Mag
- signed 1's complement
  2's complement. → Binary System.

1- Diminished Radix complement:

$B + (-B) = \underline{\underline{r^n - 1}}$

↓
complent of B

e.g $n=2$, $r=10$
$10^2 - 1 = \underline{99}$

e.g $n=2$, $r=10$, $B=51$ Find $-B$ $=48$

$99 - 51 = 48$

e.g $n=3$, $r=2$, Find $010 = (2)_{10}$

$r^n - 1 = 2^3 - 1 = 7 = (111)_2$
$7 - 2 = \underline{5}$

2 = 010
5 = $\underline{101}$ → (-2)

7 = 111

DATE 8-10-2015
Thursday

Class 5

- MSB represent the sign
  0 → +ve
  1 → -ve

e.g) Find $(-3)_{10}$ → 1's complement, n=5

Sol +ve 00011 → 3

-ve 11100 → -3

عكس العملية.

e.g) what is the number $(1011\ 01)_{1's}$ complement

$(0100\ 10) = 18$

∴ $(1011\ 01)_{1's\ complement} = -18$

* To find 1's complement convert 1 → 0
  0 → 1

e.g) write +17 in 1's complement. n=8

00010001

e.g) write Zero 1's complement n=4.
0000 +ve Zero
1111 -ve Zero

Class 5

eg) Find 1's complement 10110.101

sol → (01001.010)

signed 1's complement

	n=3	n=4	rule
# of values	$2^3=8$	$2^4=16$	2^n
Min	-3 → 100	-7	$-(2^{n-1}-1)$
Max	+3 → 011	+7	$+(2^{n-1}-1)$
# of zeros	000 111 2	2	2

Range = [Min - Max]

2's complent → $B + (-B) = r^n$

↓ complement of B

e.g) n=2, r=10, $10^2 = 100$

e.g) B= 51, (-B) = ?, n=2, r=10

-B= 49

MSB at least for the sign 0 → +ve

1 → -ve

- Find 2's complent. :-

① Find 1's comp. then add 1

② Start from LSB then move to the left until you find first 1, the convert the remaining.

Class 5

e.g) Find 2's complement for 001101

$\boxed{1}$ 001101 → 13

-13 ⇐ 110010 ← 1's comp.

$\underline{\quad\quad\quad 1^{+}}$

-13 ← 110011

2's complement.

$\boxed{2}$ 00 11 0$\underline{1}$ ↓

-13 (110011)

in 2's complement

e.g) 10100 Find 2's complement

$\boxed{1}$ 01011

$\underline{\quad\quad 1^{+}}$ 1+1 = 10 والباقي

0[illegible]100

$\boxed{2}$ 101$\underline{00}$ ↓ 2's complement.

01100

class 5

Thursday

e.g) write -5 in 2's complement , n=4

+5 = 0101

-5 = 1011

2's complement.

e.g) write +7 in 2's complement , n=5

Sol → $(00111)_{2's\ complement}$ #

e.g) Zero , n=4

0000 ↓

0000

$$\begin{array}{r} 0000 \\ 1111 \\ 1+ \\ \hline \text{[illegible]}00000 \end{array}$$

1

X

فوق ال ٤

1 Zero

DATE 11-10-2015

Class 6

2's Complement, Arithmetic operation. Sunday

unsigned, signed, 1's complement, 2's complement.

eg) n=4, 2's complement system.

-ve ← 1000 ↓

1000 = -8

n=5, 10000 = -16

n=3, 100 = -4

n=2, 10 = -2

2's complement system :

	n=3	n=4	rule
# of values	$2^3 = 8$	2^4	2^n
Min	100, = -4	1000, = -8	-2^{n-1}
Max	011, = 3	0111, = 7	$2^{n-1}-1$
Zero's	1 0000	0000	1

n=3 → # of values = 8 → 2^3

Binary Code :

↓	unsigned	signed Mag.	1's comp.	2's Comp.
0 0 0	0	+Ve zero	+Ve zero	0
0 0 1	1	+1	+1	1
0 1 0	2	+2	+2	2
0 1 1	3	+3	+3	3
1 0 0	4	-Ve zero	-3	-4
1 0 1	5	-1	-2	-3
1 1 0	6	-2	-1	-2
1 1 1	7	-3	-Ve zero	-1

DATE 11-10-2015
Sunday

Class 6

e.g) which of the following equal (11111010) 1's comp.

a) +5 x   b) -5 ✓   c) $(\underset{0101}{1011})$ 2's comp. ✓   d) $(\underset{00000101}{11111011})$ 2's ✓

e) (1000101) unsigned x   f) (10101) signed Mag. ✓

Sol → (111 111 010) → (000 000 101) = $\bigcirc\!\!\!\!-5$

Arithmetic Operation:

steps :-
1) Fix size of the operants
   - (sign extension)
2) Perform the operation (+)
   - if substraction then convert to addition
3) Check for overflow.
   - if (overflow) then the result is wrong.

e.g) +5 , n=7 unsigned.
0000101 (sign extension)

e.g) 00010 1's comp , n=8
0000 0010 = +2

e.g) 1010 = -5, 1's comp , n=8
1 111 1010 = -5

e.g) 10010 , 2's comp , n=8
11 110010 = -14

e.g) 0101 , 2's , n=8
0000 0101

DATE 11-10-2015

Sunday

class 6

e.g) $1\underbrace{0110}_{Mag}$, Signed Mag , n=8

$1\underbrace{000\ 0110}_{Mag}$

Always extend using Zero's in Signed Mag.

e.g) 1's comp $\underline{0}1010$

e.g) (5_2) , n=5 in 1's complement

$$\overset{Cin}{\overset{1\ 1\ 1}{}}$$

5+(-2) ⇒ (00101) 5 +2= 00010

(11101) $\overset{+}{}$ (2-) -2= 11101

Cout ← $\boxed{1}$00010

e.g)

$$\begin{array}{r} 1\ 1\ 1\ \ \ \\ 1111 + \\ 1011 \\ \hline 11010 \end{array}$$

Carry in ⇒ Cin = 0/1 } After MSB
Carry Out ⇒ Cout = 0/1

Cin ← $\boxed{1}$1

e.g)

$$\begin{array}{r} 011 \\ 001 + \\ \hline \end{array}$$

Cout=0 ← $\boxed{0}$100

$\boxed{0}$ → Cin

e.g)

$$\begin{array}{r} 1000 \\ 1000 \\ \hline \end{array}$$

Cout ← $\boxed{1}$0000

DATE 13-10-2015
Tuesday

Class 7

Overflow → Ov رمز

if Ov then the result is wrong.
(Result is out of the range that can be represented by the given # of bits.)

eg) n=3 → range in 1'S complement (-3 , +3)
-3 - 3 = -6 → Out of the range.

* Unsigned numbers Ov (Addition)

Ov if cout = 1

eg) n=5 , 16+8 = 24

$$\begin{array}{r} 10000 \\ 01000\ + \\ \hline \leftarrow \boxed{0}\,11000 \end{array}$$

Cout = 0 ←

* Signed 1'S Complement
if Cin ≠ Cout then OV (result is wrong)
else if Cin = Cout = 1
then discard Cout → Add 1 to the result.
إحذف

eg) Find -5 - 7 , n=5 , 1'S Complement.
+5 → 00101 → 11010 (-5)
+7 → 00111 → 11000 (-7)

$$-5+(-7) = \begin{array}{r} \boxed{1}1010 \\ 11000 \\ \hline \boxed{1}10010 \\ \text{X}\qquad 1\ + \\ \hline 10011 \end{array}$$

Cin = Cout

DATE 13-10-2015

Tuesday

Class 7

e.g) $\boxed{0}$
1001 1's Complement
1000 +
$\boxed{1}$1001

0110 → 6 → -6
0111 → 7 → -7 + = $\underline{\underline{-13}}$
[-7, +7] ← Not in Range

Cin ≠ Cout ∴ Ov

e.g)
0 11
0 1 0 1 1
1 0 1 1 0 0 + (-11) = 0

$\boxed{0}$ 1 1 1 1 1 → -0

Ov Signed 2's Complement.

if Cin ≠ Cout then Ov → result is wrong
else if Cin = Cout = 1 then discard Cout

e.g) $\boxed{1}$, 1
10110 + 2's Complement
11011
$\boxed{1}$10001 Cin = Cout = 1 → No $\underline{\underline{\text{Ov}}}$

∴ Ans: 10001 = -15
01111 = 15

10110 → 01010 = 10 ∴ -10
011011 → 00101 = 5 ∴ -5. -10 - 5 = -15

Class 8

Examples, Binary Code, unsigned substraction, Sunday

* Unsigned substraction.

→ Use 1's or 2's complement method.

eg) 25-25   2's , n=8

$$\begin{array}{r} 00011001 = 25 \\ +\ 11100111 = -25 \\ \hline \cancel{1}00000000 \end{array}$$

discard 1

= 00000000 = 0

No OV

Cin = Cout.

eg) $(0101)_2 - (1100)_2 = ?$, n=4

unsigned   2's complement

-1100 = + 0100

$$\begin{array}{r} \boxed{1} \\ 0101 \\ 0100 \\ \hline \boxed{0}\,1001 \end{array}$$

Cin ≠ Cout ∴ There is an OV

wrong

eg) 0001 - 0110 , n=4

unsigned   2's

-0110 = +1010 ⇒

$$\begin{array}{r} \boxed{0} \\ 0001 \\ 1010 \\ \hline \boxed{0}\,1011 \end{array}$$

Cin = Cout ∴ No OV.

Continued

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DATE 18-10-2015

Sunday

class 8

1011 = -(0101) = -5

e.g) $\underbrace{0101 - 0001}$ → unsigned 2's Comp

*-0001 = 1111 n = 4

$\boxed{1}$ 1 0 1

1 1 1 1 +

$\boxed{1}$ 0 1 0 0 = 0100

x

$C_{in} = C_{out}$ → There is no OV

eq) $\underbrace{11 - 10.11}$ → unsigned 2's complement n=8

[illegible] = [illegible]

0000 11. 0 0

0000 10 . 1 1 −

= 0 000 11. 0 0

1 1 1 1 01. 0 1 +

$\boxed{1}$ 0 0 0 0 0 0 . 0 1

= 000000.01

$C_{in} = C_{out}$

No OV

Class 8

Sunday

ASCII →

n: # of bits

# of possible values or character $= 2^n$

e.g) $n=7$ For Ascii

$2^7 = 128$

e.g) $A = (65)_{10} = (41)_{16} = (0\underbrace{\boxed{1000001}}_{7\ bits})$

Parity Check

Binary Codes

e.g) $B = (66)_{10} = (42)_{16} = (0100\ 0010)_2$

e.g) $x = \#$ of character $= 76$ Find n ?

Sol → $x = 76 = 2^n$

$\log 76 = n \log 2 \rightarrow n = \log 76 / \log 2 = 6.24$

$\therefore \boxed{n=7}$ The ceiling

OR → $2^6 < 76 < 2^{\boxed{7}}$

$64 < 76 < 128$

$n = 7$

DATE 20-10-2015
Tuesday

class 9

- BCD, Gray Code, Logic gates:-

Eg) $(1998)_{10}$ → 10001 1001 0111 1000) BCD

BCD → Binary Coded Decimal, A-F Not exist X

* Groups of 4

* BCD → Decimal

Eg) 1011 0111

B 7

Can't be BCD, wrong Code x

Ex) (1001 1000 0011) BCD → Decimal

$(9\ 8\ 3)_{10}$

[1] 1 Byte stores 2 BCD digits 8 bits (packed)

[2] 1 Byte store 1 BCD (unpacked)

LSB

MSB 0000

* Gray Code →

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

DATE 20-10-2015
Tuesday

Class 9

To convert

① - Start from LSB
- if the next bit is 1 then convert the curent else (if=0) do nothing

Ex) 1 1 0 1 1 Binary ↓

1 0 1 1 0 Code (Gray)

XOR → $f = x \oplus y$; f = 1 if we have odd # of 1's.

x	y	f
0	0	0
0	1	1
1	0	1
1	1	0

② - Copy MSB
- for each smaller
$G[i] = B[i] \oplus B[i+1]$

Ex) i = 4 →

i	4	3	2	1	0
B	1	1	0	1	1

i=4 G[4] = 1

i=3 $G[3] = B[3] \oplus B[4] = 1 \oplus 1 = 0$

i=2 $G[2] = B[2] \oplus B[3] = 0 \oplus 1 = 1$

i=1 $G[1] = B[1] \oplus B[2] = 1 \oplus 0 = 1$

i=0 $G[0] = 1 \oplus 1 = 0$

∴ G = 1 0 1 1 0

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Class 9

* Gray → Binary

- Start from MSB
- $B[i] = B[i+1] \oplus G[i]$

Ex)

i		4	3	2	1	0
G	=	1	0	1	1	0

B = ?

i = 4 $B[4] = 1$
i = 3 $B[3] = B[4] \oplus G[3] = 1 \oplus 0 = 1$
i = 2 $B[2] = B[3] \oplus G[2] = 1 \oplus 1 = 0$
i = 1 $B[1] = B[2] \oplus G[1] = 0 \oplus 1 = 1$
i = 0 $B[0] = B[1] \oplus G[0] = 1 \oplus 0 = 1$

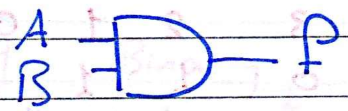
B = 11011

Class 10

- AND, OR, NOT/INV, NAND, NOR, XOR, XNOR

AND: The Output is 1 if all inputs are 1

$F = A.B = AB$



Truth Table :-

AB	F
0 0	0
0 1	0
1 0	0
1 1	1

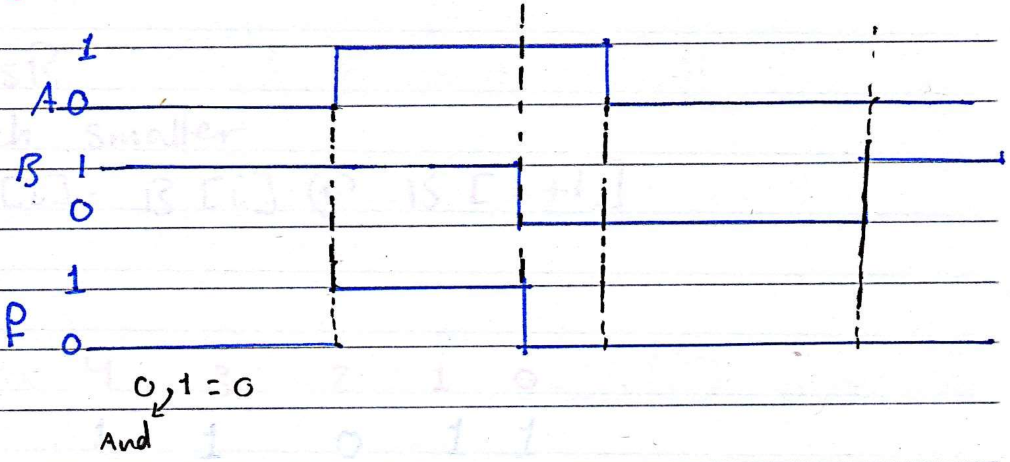
# of inputs $= 2^n$

$n = 2$

Timing digram :-

given

input



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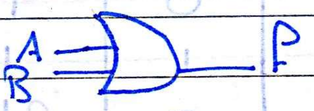
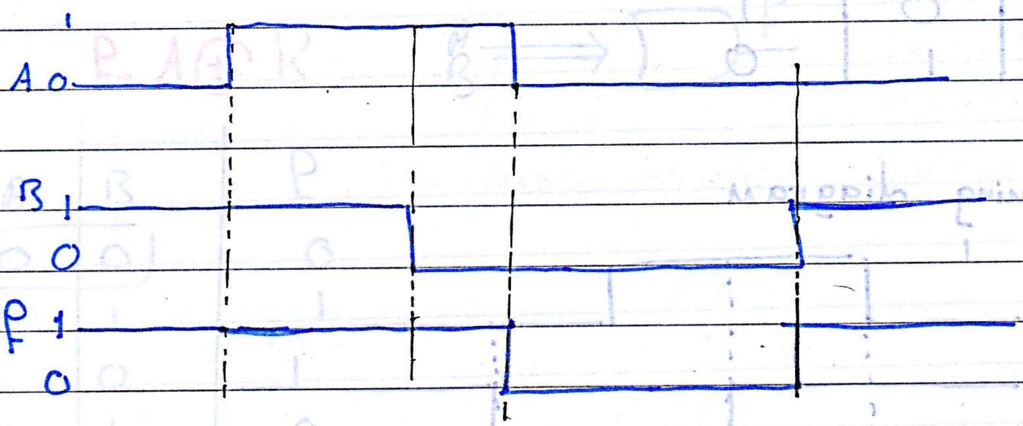
Class 10

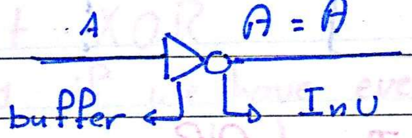
OR : The Output is 1 if any of the inputs is 1

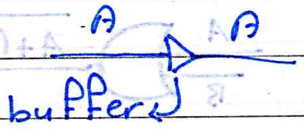


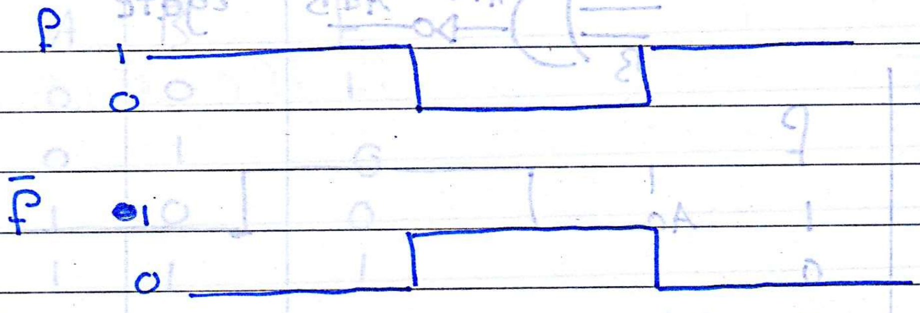


Inv / NOT (One input)

1 → 0
0 → 1

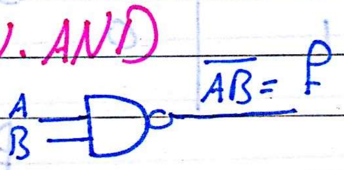




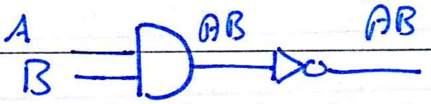


NAND : Not AND , Inv. AND

$F = A \uparrow B = \overline{A.B} = \overline{AB}$



1 gate



2 gates

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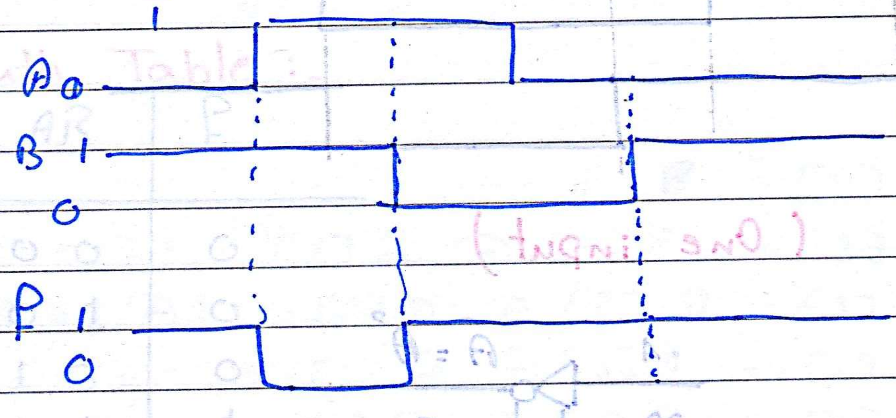
Class 10

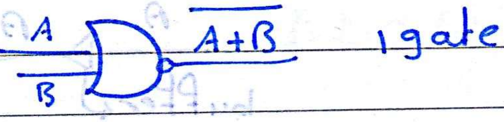
A	B	$P = \overline{AB}$
0	0	1
0	1	1
1	0	1
1	1	0

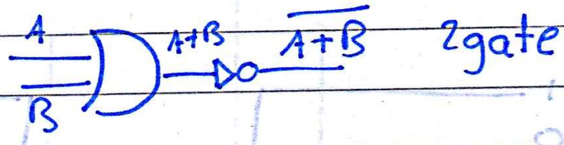
* Timing diagram



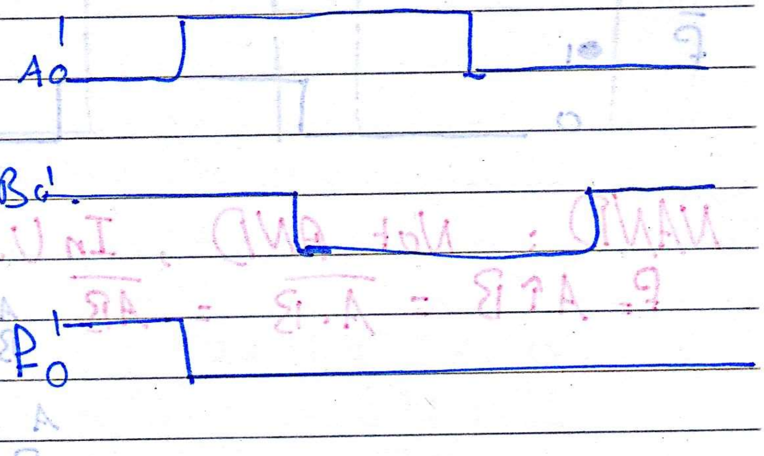
NOR: NOT OR / InV OR

$P = A \downarrow B = \overline{A+B}$





A	B	P
0	0	1
0	1	0
1	0	0
1	1	0

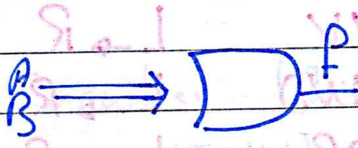


Class 10

- Exclusive OR (XOR)

: Output is 1 if we have Odd # of 1's in the input.

$F = A \oplus B$



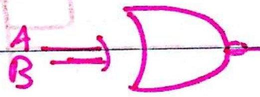
even

A	B	F
0	0	0
0	1	1
1	0	1
1	1	0

- XNOR : Not XOR

The Output is 1 if we have even # of 1's

(Comperator)



$F = \overline{A \oplus B}$

$F = \overline{A \oplus B}$

A	B	F
0	0	1
0	1	0
1	0	0
1	1	1

Class 10

* Describing Logic circuits → gives me the circuit and I give him $f = ?$

Steps:-

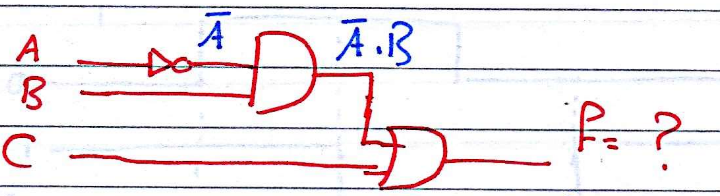
① Start by INV L → R

② Implement AND L → R

③ Implement OR L → R

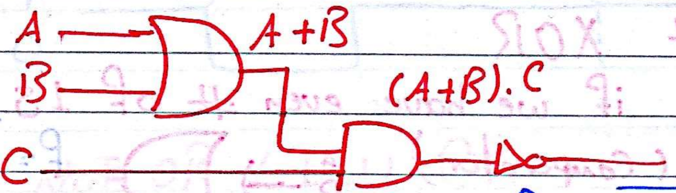
④ Paranthesis enforce periority.

Ex)



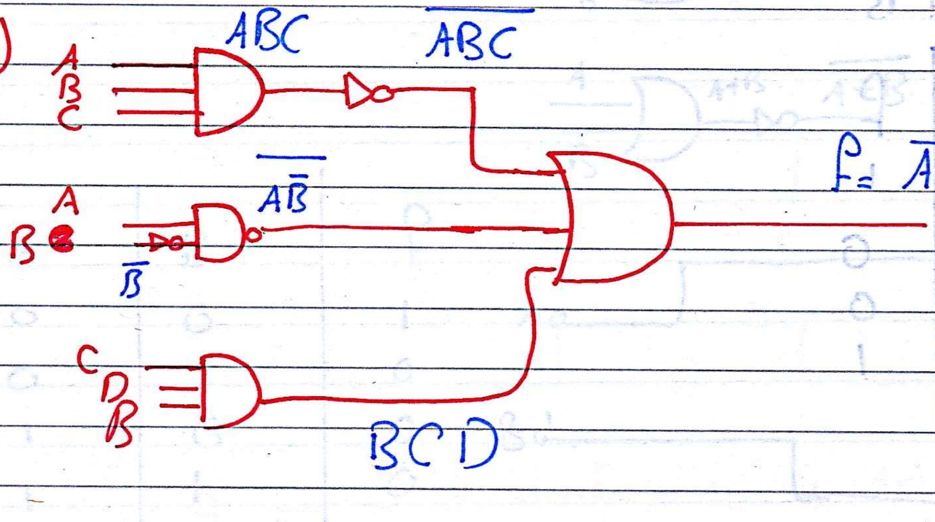
$f = (\bar{A}.B) + C$

Ex)



$f = \overline{(A+B).C}$

Ex)



$f = \overline{ABC} + \overline{A\bar{B}} + BCD$

class 11

- Evaluating boolean expression.
- Implementing logic Circuit
- Extending gates to multiple inputs.

* Evaluating logic Circuits:- (given boolean expression)

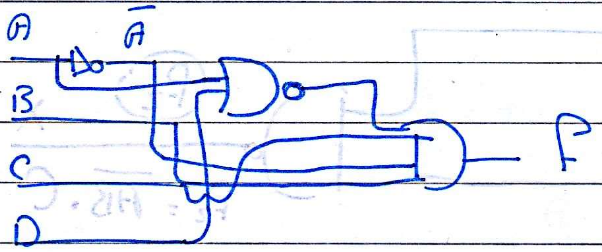
① Evaluate all inversions (INV)
② " " AND operations
③ " " OR "
④ Peranthesis have the priority.

Ex) $F = \bar{A}BC\ (A+D)$, $A=0$, $B=1$, $C=1$, $D=1$

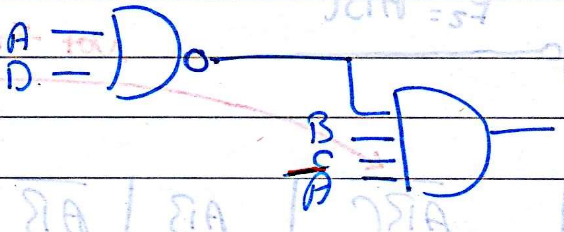
$F = ?$

$F = (\bar{0})(1)(1)\overline{(0+1)}$

$= (1)(1)(1)(0) = \underline{\underline{0}}$

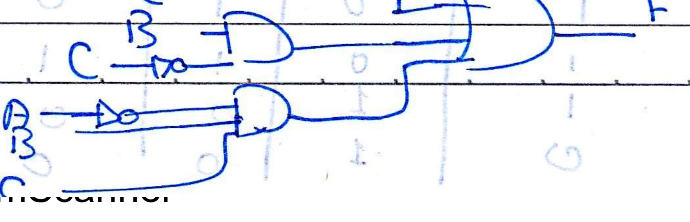


OR →



Ex) $F = AC + B\bar{C} + \bar{A}BC$, $A=1$, $B=0$, $C=1$

$F = 1(1) + 0(0) + (0)(0)(1) = 1 + 0 + 0 = 1$



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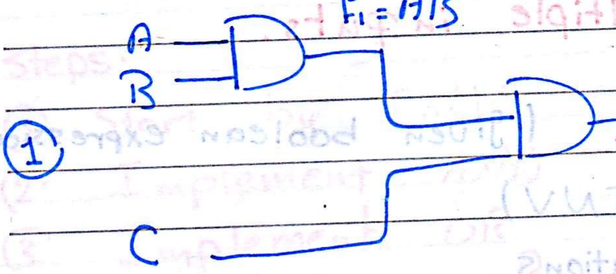
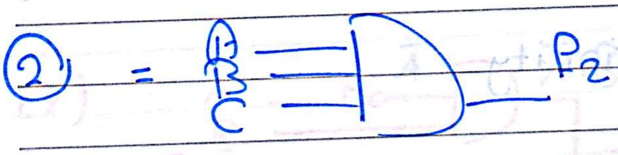
Class 11

* Extension to multiple Inputs.

$P_1 = AB$ $\qquad P_2 = ABC$



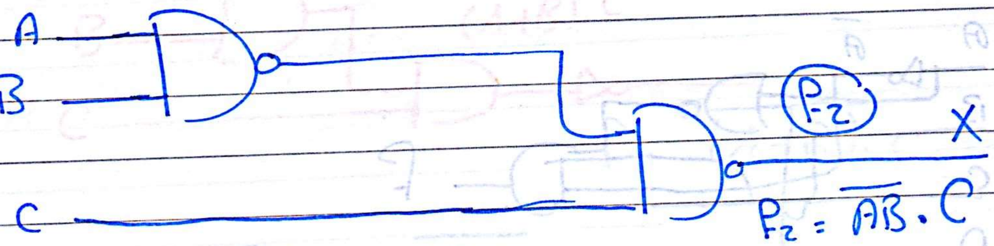
$P_2 = (AB)C = A(BC)$
$= ABC$



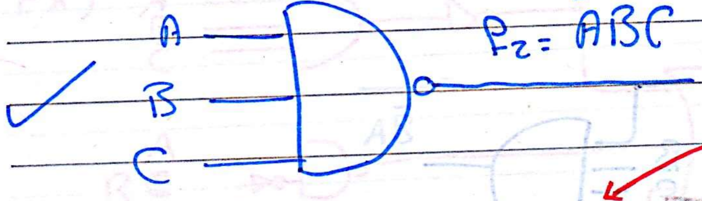
* Could be with AND, OR, XOR, XNOR

* NAND, NOR

$P_1 = \overline{AB}$, $P_2 = \overline{ABC}$



$P_2 = \overline{AB}\cdot C$



$P_2 = \overline{ABC}$

Not the Same

A	B	C	$\overline{ABC}$	AB	$\overline{AB}$	$\overline{AB}.C$	$\overline{\overline{AB}.C}$
0	0	0	1	0	1	0	1
0	0	1	1	0	1	1	0
0	1	0	1	0	1	0	1
0	1	1	1	0	1	1	0
1	0	0	1	0	1	0	1
1	0	1	1	0	1	1	0
1	1	0	1	1	0	0	1
1	1	1	0	1	0	0	0

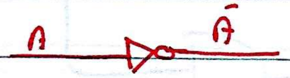
Class 11

H.W) Does $F = \overline{(\overline{A+B}) + C}$ equal $\overline{A+B+C}$

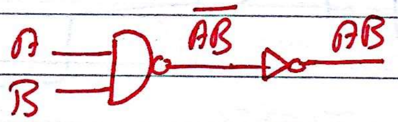
Class 11

- NAND Only → (+ INV)

INV

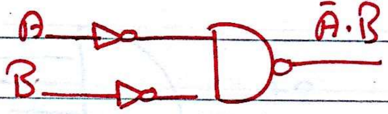


AND



✓

OR



$\overline{\bar{A}\cdot\bar{B}} = \bar{\bar{A}} + \bar{\bar{B}} = A+B$

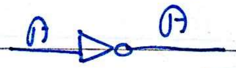
DeMorgan's law:-

$\overline{A\cdot B} = \bar{A} + \bar{B}$

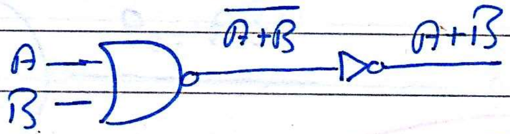
$\overline{A+B} = \bar{A}\cdot\bar{B}$

- NOR Only → (+ INV)

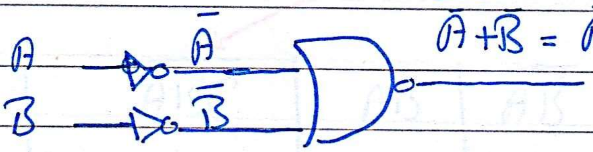
INV



OR



AND



$\overline{\bar{A}+\bar{B}} = \bar{\bar{A}}\cdot\bar{\bar{B}} = A\cdot B$

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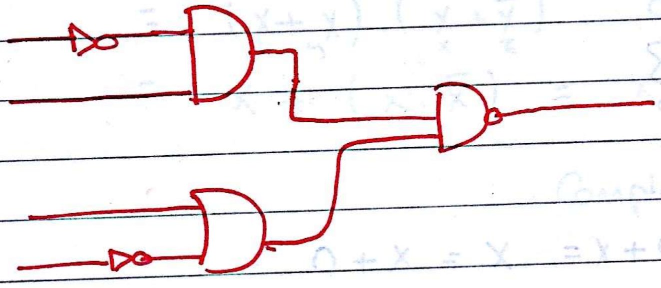
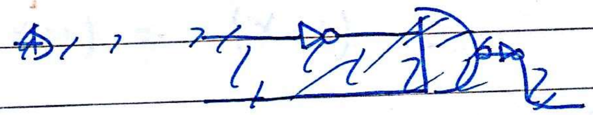
Class 11

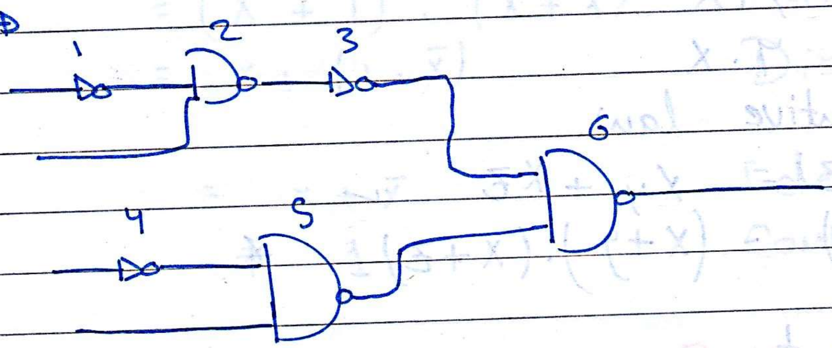
Ex) How many gates using NAND Only to build the following circuit.



~~Sol1~~

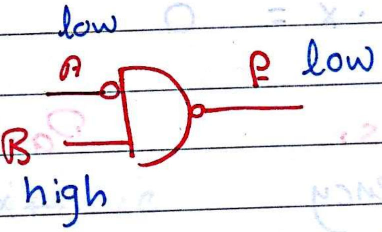


Sol →



6 gates

- Active high / low
  input ← → output



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Class 12 →

Tuesday

Postulates, Theorems, Examples

$x, y \in B = \{0, 1\}$

1_ Closure

$x+y \in B$
$x.y \in B$

2_ Identity $0+x = x = x+0$
$1.x = x = x.1$

3_ Commutative

$x+y = y+x$
$x.y = y.x$

* 4_ Distributive law.

$x(y+z) = xy + xz$ ✓
$x + (yz) = (x+y).(x+z)$ *

5_ Complement

$x+\bar{x} = 1$
$x.\bar{x} = 0$

* Theorems:_	Part A	Part B
1_ Idempotency	$x+x = x$	$x.x = x$
2_ NULL Element	$x+1 = 1$	$x.0 = 0$
3_ Involution	$\bar{\bar{x}} = x$, $(x')' = x$	
4_ Associative	$(x+z)+y = x+(z+y)$	$(x.y).z = x.(y.z)$
5_ DeMorgan's law	$\overline{x+y} = \bar{x}.\bar{y}$	$\overline{x.y} = \bar{x}+\bar{y}$
* 6_ Absorption	$x + xy = x$	$x.(x+y) = x$

class 12

Tuesday

Ex) $x + x = x$, Prove

$(x+x) = (x+x).1$ identity

$= (\underset{x}{x} + \underset{y}{x}).(\underset{x}{x} + \underset{z}{\bar{x}})$ complement, distributive

$= x + (x.\bar{x}) = x + 0 = x$

Complement Identity

Ex) $x+1 = 1$, Prove

$(x+1) = (x+1) . 1$ Identity

$= (x + 1) . (x + \bar{x})$ Complement

$= x + (1 . \bar{x})$ Distributive

$= x + \bar{x}$ Identity

$= 1$ Complement.

Ex) $x + xy = x$, Prove

$x(1+y) = x \cdot 1 = x$

OR →

Identity ← $x.1 + xy = x$

$= x(1+y)$ → Distibutive

$= x.1$ → Null

$= x$ → Identity

Ex) $\overline{A.B.C} = \bar{A} + \bar{B} + \bar{C}$

Ex) $\overline{A.B + \bar{C} + D} = \overline{AB} . \overline{\bar{C}} . \overline{D} = \overline{AB} . C . \overline{D}$

$= (\bar{A} + \bar{B}) . C . \bar{D}$

Class 12

Ex) $\overline{(\bar{A}+B) . C . D}$

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

$= A \bullet \bar{B} + \bar{C} + \bar{D}$

* Simplification :

① Reduce circuit size

② Equivalancy proof

- Techniques

$\boxed{1}$ Combining terms →

Literal ← $\textcircled{X}Y + X\bar{Y} = X$ → $X(Y+\bar{Y}) = X . 1 = X$

$XY + XYZ = XY$

Ex) $ab\bar{c} + abc$

$ab(\bar{c}+c) = \underline{\underline{ab}}$

$\boxed{2}$ Adding Redundat terms →

$a\bar{b}c + abc + \bar{a}bc$

$= a\bar{b}c + abc + abc + \bar{a}bc$

$= ac(\bar{b}+b) + bc(a+\bar{a})$

$= ac + bc$

$\boxed{3}$ Eliminating terms.

$X + XY = X$ $\square + \square \ldots\ldots = \square$

"Class 13"

Ex) $\bar{a}b\bar{c} + bcd + bd + \bar{a}b$

X X

$bd + \bar{a}b$

[4] Eliminating Literal

$x + \bar{x}Y = x + Y \quad = (\bar{x} + x) \cdot (x + Y) = x + Y$

$\bar{x} + xY = \bar{x} + Y$

Ex) $\bar{A}B + \bar{A}\bar{B}\bar{C}\bar{D} + ABC\bar{D}$

$= \bar{A}(B + \bar{B}\bar{C}\bar{D}) + ABC\bar{D}$

$= \bar{A}(B + \bar{C}\bar{D}) + ABC\bar{D}$

$= \bar{A}B + \bar{A}\bar{C}\bar{D} + ABC\bar{D}$

$= B(\bar{A} + A\cancel{B}C\bar{D}) + \bar{A}\bar{C}\bar{D}$

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

$= \bar{A}B + BC\bar{D} + \bar{A}\bar{C}\bar{D}$ ✓

* Canonical Forms.

- How to represent Boolean functions?

Standard form (2 Levels)

1) Sum of Product (ANDing → Oring)

حالة خاصة ↓ - Sum of Minterms (Canonical form)

↓ a term that Contains all input

2) Product of Sum (ORing → ANDing)

حالة خاصة ↓ Product of Maxterms (an ORed term that Contains all inputs)

Non Standard.

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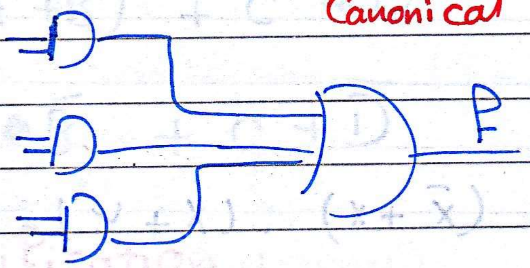
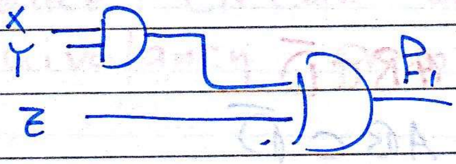
"Class 13"

Ex) $P_1 = xy + z$
$P = xyz + \bar{x}yz$ } → 2 Levels

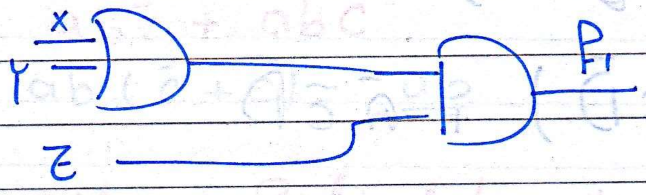
Canonical

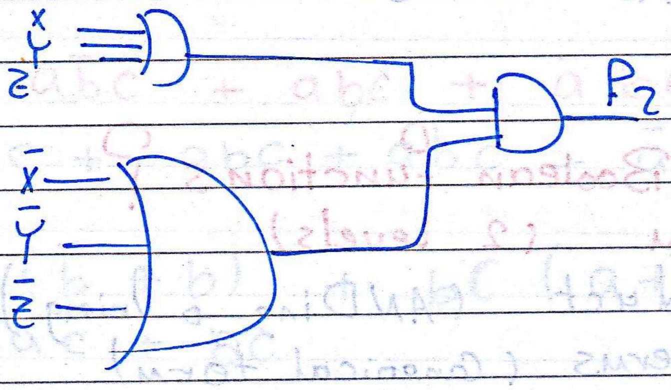


→ Sum of product



Ex) $P_1 = (x + y)(z)$
$P_2 = (x + y + z) \cdot (\bar{x} + \bar{y} + \bar{z})$





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• Class 13.

* Non standard

Ex) $F = (X+Y) \cdot Z + \bar{X}$

- Sum of Minterms

Given $(F(X,Y,Z))$

$XYZ \rightarrow F$

	X	Y	Z	F
m_0	0	0	0	0
m_1	0	0	1	1 ✓
m_2	0	1	0	1 ✓
m_3	0	1	1	0
m_4	1	0	0	0
m_5	1	0	1	1 ✓
m_6	1	1	0	0
m_7	1	1	1	0

- Look for 1s in F
- Find the Corresponding Minters
- Convert Minterm to variables (Inputs)
- i.e (X, Y, Z)

$$F = m_1 + m_2 + m_5$$
$$= \bar{X} \cdot \bar{Y} \cdot Z + \bar{X} \cdot Y \cdot \bar{Z} + X \cdot \bar{Y} \cdot Z$$

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"Class 14"

$F = \Sigma(1,2,5)$

$F(x,y,z) = \Sigma(1,2,5)$

* Prod~~ed~~uct of Maxterms :-

1) Look for zeroes in F.
2) Find Corresponding Maxterms.
3) Write Maxterm as x, y, z.

Ex) Given 13.1.

Max	x	y	z	F
	●			
M_0	0	0	0	0
M_1	0	0	1	1
M_2	0	1	0	1
M_3	0	1	1	0
M_4	1	0	0	0
M_5	1	0	1	1
M_6	1	1	0	0
M_7	1	1	1	0

write F as Product of Maxterms.

$F = M_0 . M_3 . M_4 . M_6 . M_7$

$= (x+y+z).(x+\bar{y}+\bar{z}).(\bar{x}+y+z).(\bar{x}+\bar{y}+z).(\bar{x}+\bar{y}+\bar{z})$

$= \Pi(0,3,4,6,7)$

DATE 1-11-2015
Sunday

Class 14

Ex) $F_1(x, y, z) = \Sigma(0,1,2,7)$
$F_2(x, y, z) = \pi(0,3,4)$
$F_3 = (F_1 + F_2)$

Find $\bar F_3$ as product of Maxterms?

$F_3 = \pi(\ldots)$?

	x	y	z	F_1	F_2	$F_3 = F_1 + F_2$	$\bar F_3$
0	0	0	0	1	0	1	0
1	0	0	1	1	1	1	0
2	0	1	0	1	1	1	0
3	0	1	1	0	0	0	1
4	1	0	0	0	0	0	1
5	1	0	1	0	1	1	0
6	1	1	0	0	1	1	0
7	1	1	1	1	1	1	0

$\bar F_3 = \pi(0, 1, 2, 5, 6, 7)$

$\bar F_3 = (x+y+\bar z).(x+\bar y+z).(\bar x+y+z).(\bar x+y+\bar z).(\bar x+\bar y+z).(\bar x+\bar y+\bar z)$

Ex) Find $\bar F$ if $F = \Sigma(1,6)$.

$\bar F = \Sigma(0,2,3,4,5,7)$
$\bar F = \pi(1,6)$

OR→ $F = \bar x \bar y z + x y \bar z$
$\bar F = (\bar x \bar y z + x y \bar z)'$

$= \overline{\bar x \bar y z} \cdot \overline{x y \bar z} = (x+y+\bar z) . (\bar x+\bar y+\bar z)$
$= \pi(1,6)$

Class 14

Duality principle →

- Convert $+ \rightarrow \cdot$
  $\cdot \rightarrow +$
- Convert $0 \rightarrow 1$
  $1 \rightarrow 0$

If this is done then the equality is still valid.

	(a)	(b)
A- Identity	$x+0=x$	$x.1=X$ ✓
B- Commitative	$x+Y=Y+x$	$X.Y=Y.X$ ✓
C- Distributive	$x(Y+Z)$ $=xY+xZ$	$x+Y.Z:$ $(x+Y).(x+Z)$ ✓
D- Complement	$\bar{x}+x=1$	$x.\bar{x}=0$

- $X \oplus Y = x\bar{Y} + \bar{X}Y$

$\overline{x \oplus y} = XY + \bar{X}\bar{Y}$
$= \bar{x} \oplus Y = x \oplus \bar{Y}$

$x \oplus 0 = x$
$x \oplus 1 = \bar{x}$
$X \oplus X = 0$
$X \oplus \bar{X} = 1$
$X \oplus Y = Y \oplus X$
$x(Y \oplus Z) = xY \oplus xZ$

DATE 3-11-2015
Tuesday

Class 15

Ex) $f = xy + \bar{z}$, write it in canonical form

$= xy\cdot 1 + \bar{z}$

$= xy\cdot(z+\bar{z}) + \bar{z}$

$= xyz + xy\bar{z} + \bar{z}$

$\bar{z} \Rightarrow \bar{z}\cdot 1\cdot 1 = \bar{z}\cdot(x+\bar{x})\cdot(y+\bar{y})$

$= (x\bar{z} + \bar{x}\bar{z})\cdot(y+\bar{y})$

$= xy\bar{z} + x\bar{y}\bar{z} + \bar{x}y\bar{z} + \bar{x}\bar{y}\bar{z}$

$f = xyz + xy\bar{z} + x\bar{y}\bar{z} + \bar{x}y\bar{z} + \bar{x}\bar{y}\bar{z}$

$f = \Sigma(7,6,4,2,0)$

$= \Sigma(0,2,4,6,7)$

Ex) $f = (x+y)\cdot z$ POS , write f in canonical form.

$\Rightarrow (x+y) \Rightarrow x+y+0 = (x+y)+z\cdot\bar{z}$

$= (x+y+z)\cdot(x+y+\bar{z})$

$z = (x+y+z)\cdot(\bar{x}+y+z)\cdot(x+\bar{y}+z)\cdot(\bar{x}+\bar{y}+z)$

$f = \pi(0,2,4,6,1)$

$= \pi(0,1,2,4,6)$

class 15

Ex) Prove $(x+y)\cdot(\bar{x}+z) = xz + \bar{x}y$

$2^3=8$

	x	y	z	x+y	$\bar{x}+z$	f $(x+y)\cdot(\bar{x}+z)$	A xz	B $\bar{x}y$	f A+B
0	0	0	0	0	1	0	0	0	0
1	0	0	1	0	1	0	0	0	0
2	0	1	0	1	1	1	0	1	1
3	0	1	1	1	1	1	0	1	1
4	1	0	0	1	0	0	0	0	0
5	1	0	1	1	1	1	1	0	1
6	1	1	0	1	0	0	0	0	0
7	1	1	1	1	1	1	1	0	1

∴ Equi. proved by truth table.

$f = \pi(0,1,4,6)$
$= \Sigma(2,3,5,7)$

$\bar{f} = \pi(2,3,5,7)$
$\bar{f} = \Sigma(0,1,4,6)$

class 15

Other sol →

$$(x+y)\cdot(\bar{x}+z) = x\cdot\bar{x} + x\cdot z + y\bar{x} + yz$$
$$= x\cdot z + \bar{x}y + yz\cdot 1$$
$$= x\cdot z + \bar{x}y + yz\cdot(x+\bar{x})$$
$$= x\cdot z + \bar{x}y + xyz + \bar{x}yz$$
$$= xz(1+y) + \bar{x}y(1+z)$$
$$= xz + \bar{x}y$$

Ex) $\overline{xy} \oplus zw$ * simplify
* write

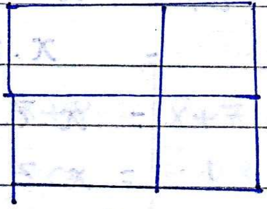
$$\overline{\overline{xy}} \oplus zw = xy \oplus zw$$
$$= xy\cdot\overline{zw} + \overline{xy}\cdot zw$$
$$= xy\cdot(\bar{z}+\bar{w}) + (\bar{x}+\bar{y})\cdot zw$$
$$= xy\bar{z} + xy\bar{w} + \bar{x}zw + \bar{y}zw$$

SOP

"Class 16"

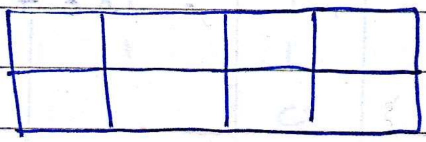
"Lecture 6"

Kmap



2inputs

3inputs



K_maps:_

1_ How to construct K_map

2_ Mapping the function
"Filling Kmap with function values"

3_ Simplification using K_map

\# Each K_map should have:_

1_ 2^n cells

2_ each cell represent 1 Minterm
Or 1 Maxterm

3_ in each row or colo. adjacent cells
differs by One literal

\# 2_inputs Kmap

i	x	y	f (given)
0	0	0	0
1	0	1	1
2	1	0	1
3	1	1	0

x \ y	0	1
0	m_0	m_1
1	m_2	m_3

→ 1) Truth table

x \ y	0	1
0	0	1
1	1	0

$f = x \oplus y$ → evaluate function 2)

$f = x\bar{y} + \bar{x}y$ → Canonical 3)

Class 16

Ex) $f(x, y) = x$
create the K_map

$x \backslash y$	0	1
0	0	0
1	1	1

4) standard

$m_0 = \bar{x}\bar{y}$
$m_2 = x\bar{y}$

$m_2 = x\bar{y}$
$m_3 = xy$

"3_inputs Kmap"

	x	y	z	f given
0	0	0	0	0
1	0	0	1	1
2	0	1	0	0
3	0	1	1	1
4	1	0	0	1
5	1	0	1	0
6	1	1	0	0
7	1	1	1	1

$x \backslash yz$	00	01	11	10
0	m_0	m_1	m_3	m_2
1	m_4	m_5	m_7	m_6

$m_1 = \bar{x}\bar{y}z$
$m_3 = \bar{x}yz$

$m_0 = \bar{x}\bar{y}\bar{z}$
$m_2 = \bar{x}y\bar{z}$

$y \backslash xz$	00	01	11	10
0	m_0	m_1	m_5	m_4
1	m_2	m_3	m_7	m_6

1)

$x \backslash yz$	00	01	11	10
0	0	1	1	0
1	1	0	1	0

2) $f = m_1 + m_3 + m_4 + m_7$
OR $f = M_0 \cdot M_2 \cdot M_5 \cdot M_6$

3) $f = x\bar{y}\bar{z} + \bar{x}z + yz$

DATE 8-11-2015
Sunday

Class 16

X \ YZ	00	01	11	10
0	0	1	1	0
1	1	0	1	0

4_Variables

X	Y	Z	W	F
0	0	0	0	0
0	0	0	1	1
0	0	1	0	1
0	0	1	1	0
0	1	0	0	0
0	1	0	1	0
0	1	1	0	1
0	1	1	1	1
1	0	0	0	1
1	0	0	1	1
1	0	1	0	0
1	0	1	1	0
1	1	0	0	1
1	1	0	1	0
1	1	1	0	1
1	1	1	1	0

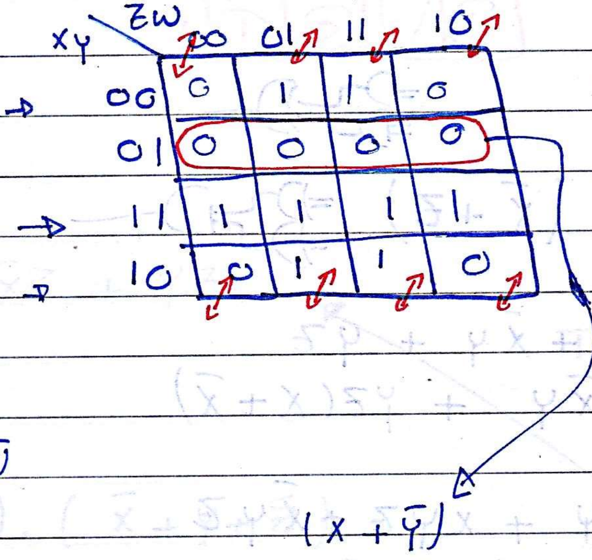
XY \ ZW	00	01	11	10
00	m_0	m_1	m_3	m_2
01	m_4	m_5	m_7	m_6
11	m_{12}	m_{13}	m_{15}	m_{14}
10	m_8	m_9	m_{11}	m_{10}

XY \ ZW	00	01	11	10
00	0	1	0	1
01	0	0	1	1
11	1	0	0	1
10	1	1	0	0

Class 17

Ex) $F(x, y, Z, w) = xy + \bar{y}w$

map → K-map



$xy \backslash Zw$	00	01	11	10
00	0	1	1	0
01	0	0	0	0
11	1	1	1	1
10	0	1	1	0

$(x + \bar{y})$

$m_8 = x\bar{y}\bar{Z}\bar{w}$

$m_0 = \bar{x}\bar{y}\bar{Z}\bar{w}$

* Simplification →

Grouping in K-map . SOP

1. Only Combine cells that have 1 in them
2. you Can Combine 1, 2, 4, 8, 16 ---- cells (2^n)
3. Each group will be 1 term (Anding) → SOP
   (ORing) → POS

* 4. As possible each cell must participate in 1 group Only , unless necessary

* 5. Start by grouping cells that have only 1 option (group)

DATE 10-11-2015 Tuesday

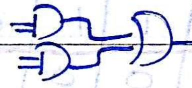
Class 17

Ex) Simplify :

x \ YZ	00	01	11	10
0	0	0	1	1
1	0	1	1	0

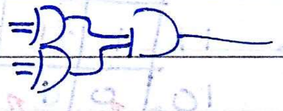
SOP

$F = XZ + \bar{X}Y$



POS

$F = (X+Y)\cdot(\bar{X}+Z)$



$= X\cdot\bar{X} + XZ + \bar{X}Y + YZ$

$= XZ + \bar{X}Y + YZ(X+\bar{X})$

$= XZ + \bar{X}Y + XYZ + \bar{X}YZ$

$= XZ(1+Y) + \bar{X}Y(1+Z)$

$= XZ + \bar{X}Y$

* After grouping check:-

1- Cover all 1's ??

2- Maximize group size ??

3- Minimize # of groups ??

Ex) Simplify

x \ Y	0	1
0	1	1
1	1	0

F=?

SOP=?

group size = 1 cell ∴ # 2 variable

group size = 2cells 1 variable

$F = \bar{X} + X\bar{Y}$

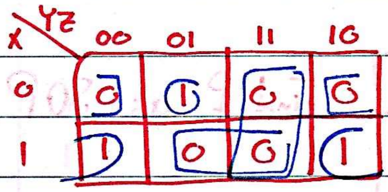
X

$F = \bar{X} + \bar{Y}$

DATE 12-11-2015
Thursday

"class 18"

Ex)



x\yz	00	01	11	10
0	0	1	0	0
1	1	0	0	1

Find f as SOP, POS

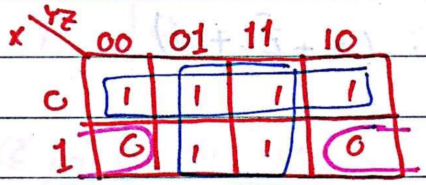
SOP →

$f = \bar{x}\bar{y}z + x\bar{z}$

POS →

$f = (x+z)\cdot(\bar{y}+\bar{z})\cdot(\bar{x}+\bar{z})$

Ex)



x\yz	00	01	11	10
0	1	1	1	1
1	0	1	1	0

Find f as SOP, POS

$f = \bar{x} + \bar{z}$ → SOP

$f = \bar{x} + z$ → POS

2 inputs K_Map

group size	# of literals
1 cell	2
2 cells	1
4 cells	0 ∴ f=1 or f=0

3 inputs K_Map

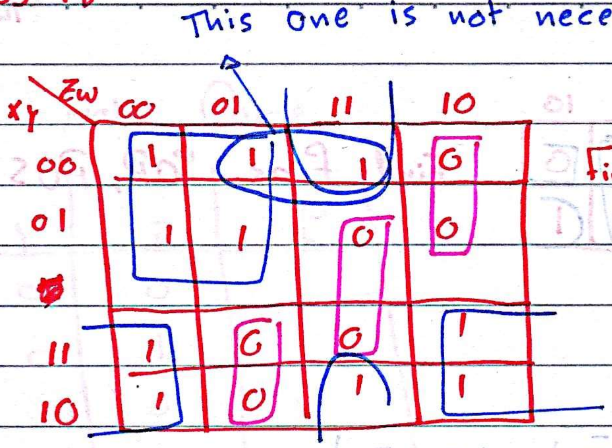
group size	# of literals
1 cell	3
2 cells	2
~~3~~4 cells	1
8 cells	0

4 inputs K_Map

group size	# of literals
1 cell	4
2 cells	3
4 cells	2
8 cells	1
16 cells	0

Class 18

Ex)


This one is not necessary X

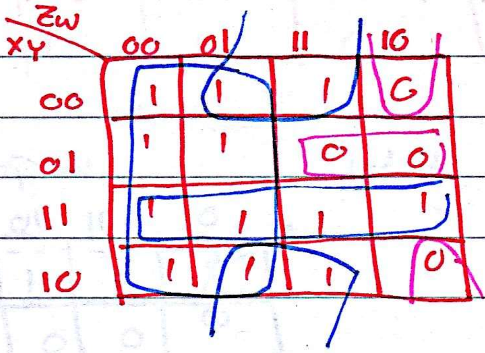
xy \ zw	00	01	11	10
00	1	1	1	0
01	1	1	0	0
11	1	0	0	1
10	1	0	1	1

Find f as SOP, POS

$f = \bar{x}\bar{z} + x\bar{w} + \bar{y}zw \rightarrow$ SOP

$f = (x + z + \bar{w}) \cdot (\bar{y} + \bar{z} + \bar{w}) \cdot (x + \bar{z} + w)$

Ex)



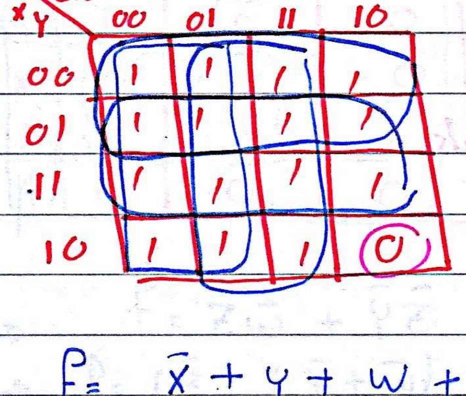
xy \ zw	00	01	11	10
00	1	1	1	0
01	1	1	0	0
11	1	1	1	1
10	1	1	1	0

Find f as SOP, POS

$f = \bar{z} + \bar{y}w + xy \rightarrow$ SOP

$f = (x + \bar{y} + \bar{z}) \cdot (y + \bar{z} + w)$

Ex)



xy \ zw	00	01	11	10
00	1	1	1	1
01	1	1	1	1
11	1	1	1	1
10	1	1	1	0

Find f as SOP, POS.

$f = \bar{x} + y + w + \bar{z} \rightarrow$ SOP

$f = \bar{x} + y + w + \bar{z} \rightarrow$ POS

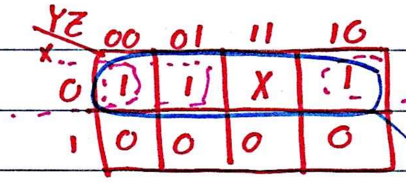
"Class 18"

* Don't Care

X	Y	Z	f
0	0	0	1
0	0	1	1
0	1	0	1
0	1	1	X
1	0	0	0
1	0	1	0
1	1	0	0
1	1	1	0

X → (I don't Care about it's value)

Ex)



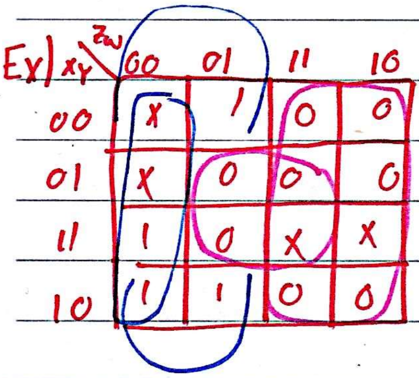
X \ YZ	00	01	11	10
0	1	1	X	1
1	0	0	0	0

→ $f = \bar{x}\bar{y} + \bar{x}\bar{z}$ if $x = 0$ X

→ Suppose $x = 1$ $f = \bar{x}$

* I don't have to cover all X's

Ex)



XY \ ZW	00	01	11	10
00	X	1	0	0
01	X	0	0	0
11	1	0	X	X
10	1	1	0	0

$f = \bar{z}\bar{w} + \bar{z}\bar{y}$ → SOP

$f = \bar{z}.(\bar{y} + \bar{w})$

f as SOP, POS

DATE 15-11-2015
Sunday

"Class 19"

- Analysis of boolean circuit

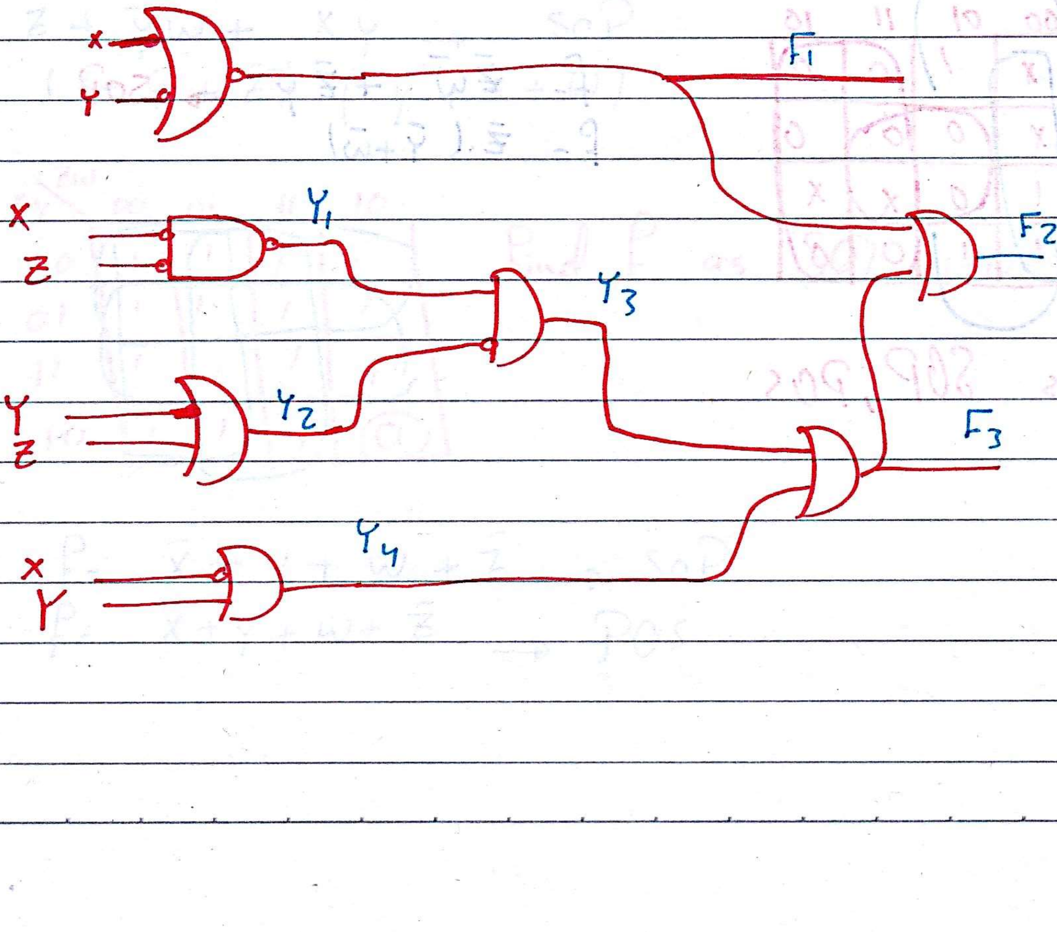
Analysis → Given circuit

- Boolean expression of this circuit
- Truth Table
- If possible Describe the function of the circuit.

Design → Given Description of the function → Circuit.

"Analysis of combinational circuits"

Ex)



DATE 15-11-2015
Sunday

Class 19

$F_1 = \overline{x+\bar{y}} = \bar{x}\cdot y$

$Y_1 = \overline{\bar{x}\cdot\bar{z}} = x+z$

$Y_2 = \overline{y+z}$

$Y_3 = Y_1 \cdot \overline{Y_2} = (x+z)\cdot(y+z)$

$Y_4 = \bar{x}+y$

$F_3 = Y_3 + Y_4 = \dots$

$F_2 = F_1 + F_3$

# of row: $2^n = M$

# of possible Functions $= 2^M = 2^{(2^n)}$

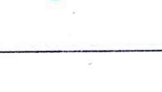
x	y	z	F_1	Y_1	Y_2	Y_3	F_2	F_3	Y_4
0	0	0	0	0	1	0	1	1	1
0	0	1	0	1	0	1	1	1	1
0	1	0	1	0	0	0	1	1	1
0	1	1	1	1	0	1	1	1	1
1	0	0	0	1	1	0	0	0	0
1	0	1	0	1	0	1	1	1	0
1	1	0	0	1	0	1	1	1	0
1	1	1	0	1	0	1	1	1	0

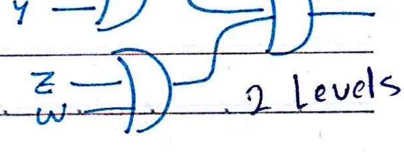
Design of combinational circuits →

// Limitation →

1. The available Logic gates, e.g. NAND, NOR Only
2. Restrictions on the number of inputs.

e.g. you Only have 2 inputs oR 2 gates, $f = x+y+z+w$

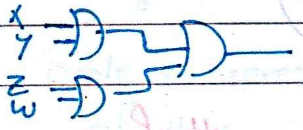




"Class 19"

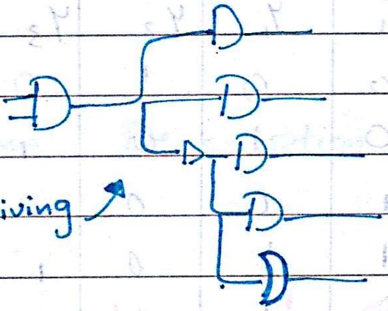
3- Propagation Delay

e.g, Delay should be $\leq 2d$



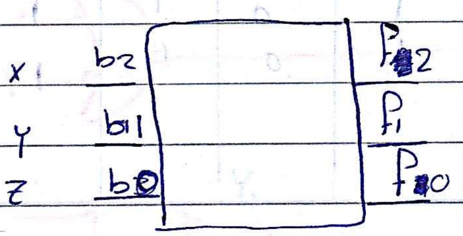
$d + d = 2d$

4- Driving Capebility



e.g 3 Driving

Ex) Design 3bit Binary to Gray Code Converter.



① Find Truth table
② Find boolean expression of outputs
③ Draw the circuit.

DATE 17-11-2015
Tuesday

Class 20

Binary			Gray Code		
x	y	z	g_2	g_1	g_0
0	0	0	0	0	0
0	0	1	0	0	1
0	1	0	0	1	1
0	1	1	0	1	0
1	0	0	1	1	0
1	0	1	1	1	1
1	1	0	1	0	1
1	1	1	1	0	0

$g_2 = x$

x \ yz	00	01	11	10
0	0	0	0	0
1	1	1	1	1

$g_1 = x\bar{y} + \bar{x}y$

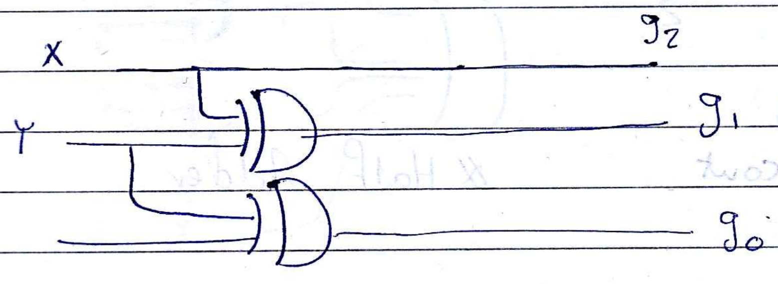
$= x \oplus y$

x \ yz	00	01	11	10
0	0	0	1	1
1	1	1	0	0

$g_0 = \bar{y}z + y\bar{z}$

$= y \oplus z$

x \ yz	00	01	11	10
0	0	1	0	1
1	0	1	0	1



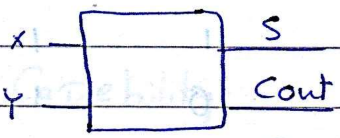
Class 20

Adder
- → Half Adder
- → Full Adder

X, Y

$$\begin{array}{r}1\\+1\\\hline 10\end{array}\qquad\begin{array}{r}1\\+0\\\hline 01\end{array}\qquad\begin{array}{r}0\\+1\\\hline 01\end{array}\qquad\begin{array}{r}0\\+0\\\hline 00\end{array}$$

Cout S



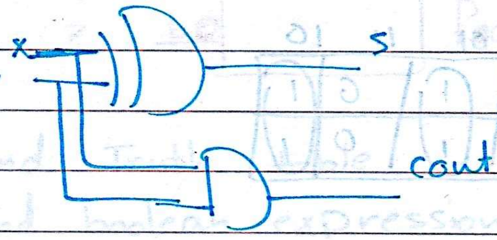
X	Y	cout	S
0	0	0	0
0	1	0	1
1	0	0	1
1	1	1	0

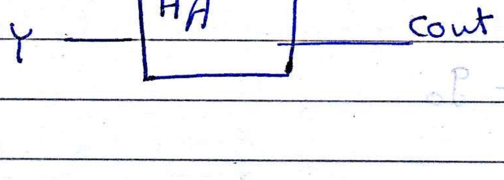
S = $X \oplus Y$

cout = $X \cdot Y$

X \ Y	0	1
0	0	1
1	1	0

$X\bar{Y} + \bar{X}Y$





X Half Adder

Class 20

Full Adder.

Cin	X	Y	Cout	S
0	0	0	0	0
0	0	1	0	1
0	1	0	0	1
0	1	1	1	0
1	0	0	0	1
1	0	1	1	0
1	1	0	1	0
1	1	1	1	1

S →

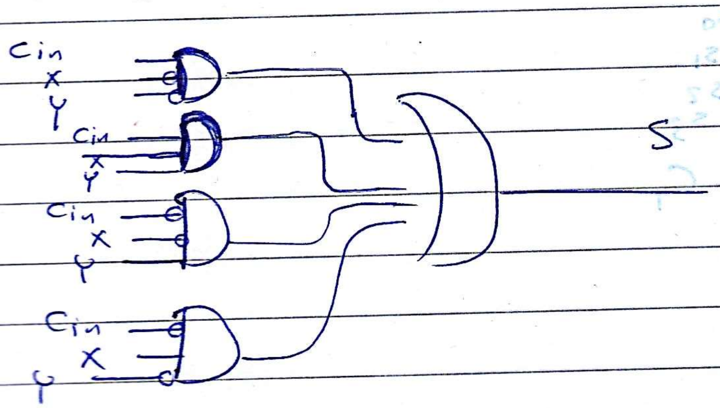
Cin \ XY	00	01	10	11
0	0	1	0	1
1	1	0	1	1

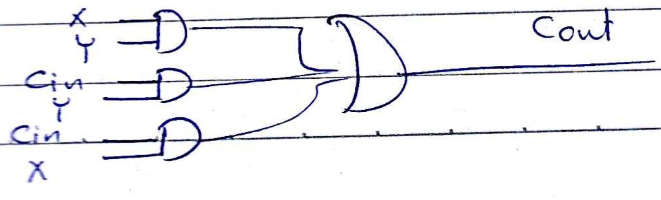
$S = C_{in}\bar{X}\bar{Y} + C_{in}XY + \overline{C_{in}}\,\bar{X}Y + \overline{C_{in}}\,X\bar{Y}$

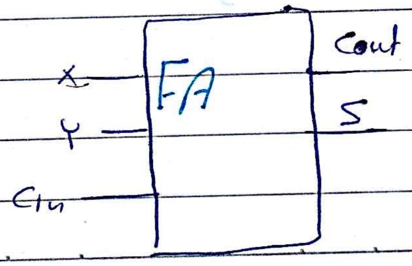
Cout →

Cin \ XY	00	01	10	11
0	0	0	1	0
1	0	1	1	1

$C_{out} = XY + C_{in}Y + C_{in}X$





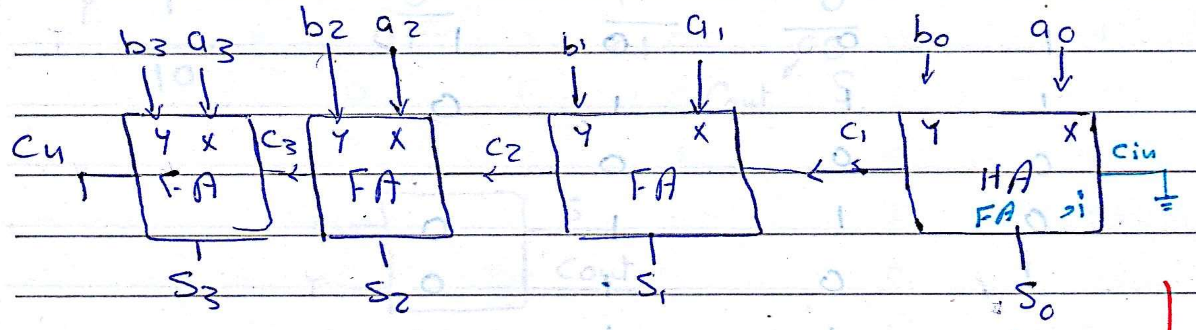


"Class 20"

Ex)

A = $\boxed{0}\ \boxed{0}\ \boxed{1}\ \boxed{1}$ = $\overset{0}{a_3}\ \overset{0}{a_2}\ \overset{1}{a_1}\ \overset{1}{a_0}$ → Example

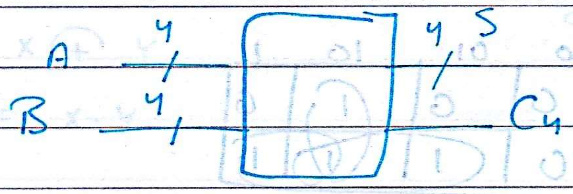
B = $\boxed{1}\ \boxed{1}\ \boxed{0}\ \boxed{1}$ = $\overset{1}{b_3}\ \overset{1}{b_2}\ \overset{0}{b_1}\ \overset{1}{b_0}$

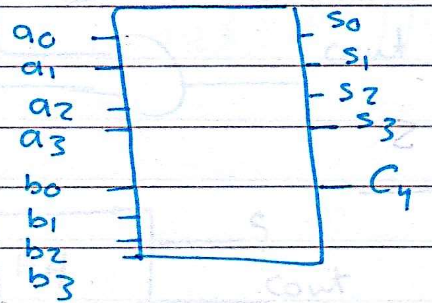


Binary Ripple Carry Adder

	C_3	C_2	C_1	
	a_3	a_2	a_1	a_0
	b_3	b_2	b_1	b_0
C_4	S_3	S_2	S_1	S_0

4 bit Adder





"class 21"

- Carry Look ahead adder
- Substractor
- Add/ sub.

$s_1 = a_1 \oplus b_1 \oplus c_1 = a_1\bar{b}_1\bar{c}_1 + a_1 b_1 c_1 + \bar{a}_1\bar{b}_1 c_1 + \bar{a}_1 b_1 \bar{c}_1$

$c_1 = a_0 \cdot b_0$

;

$S_1 = a_1\bar{b}_1\,\overline{a_0b_0} + a_1b_1\,a_0b_0 + \bar{a}_1\bar{b}_1\,a_0b_0 + \bar{a}_1b_1\,\overline{a_0b_0}$

$C_2 = a_1b_1 + a_1C_1 + b_1C_1$

$= a_1b_1 + a_1a_0b_0 + b_1\,a_0b_0$

- Substracter $\underline{\underline{2's}}$

$A - B = A + (-B)$

Ex) $A = 1010$

$B = 0011 \rightarrow$ $\qquad A - B = A + (-B)$

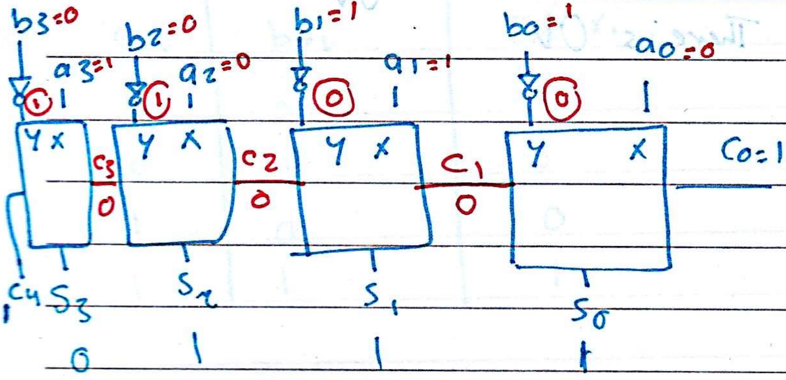
1100
1 +

1101

2's

0011
1100
1 +

1010 +



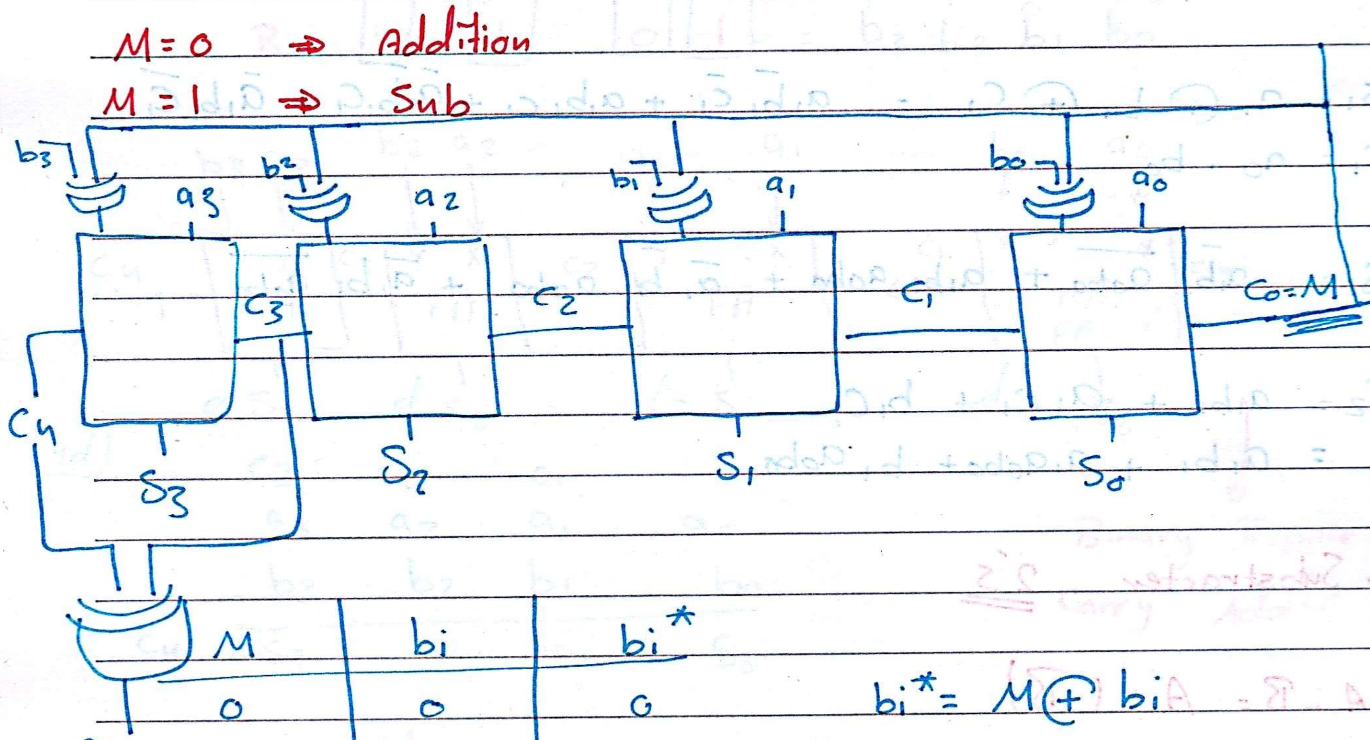
Class 21

Add / Sub

, I need one control signal

M = 0 ⇒ Addition

M = 1 ⇒ Sub



M	bi	bi*
0	0	0
0	1	1
1	0	1
1	1	0

$bi^* = M \oplus bi$

For OV →

C_3	C_4	OV
0	0	0 → no OV
0	1	1 → There is OV
1	0	1
1	1	0

$OV = C_3 \oplus C_4$

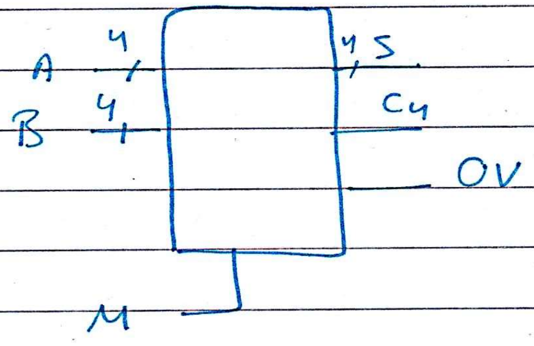
class 21

Ex) M=1 , A= 1011 , B = 0001 . find S= ?
C_4 = ??
OV= ??

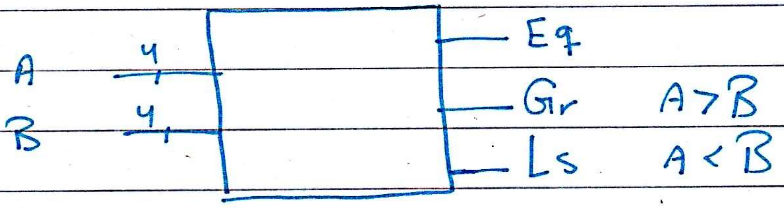
A + (-B)

1 1 1
1 0 1 1
1 1 1 1 +
1 1 0 1 0

S= 1010
C_4 = 1
OV= 0

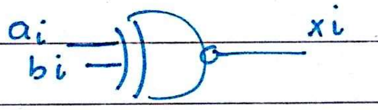


, Magnitude Comperator,



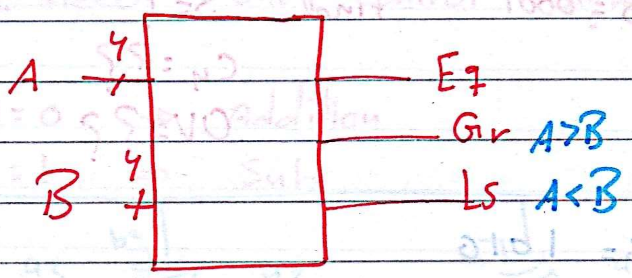
A > B
A < B

a_i	b_i	~~Eq~~ x_i
0	0	1
0	1	0
1	0	0
1	1	1



"Class 22"

Magnitude Comparator



Unsigned numbers

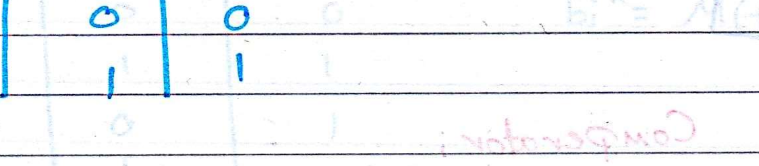
$A = a_3 \quad a_2 \quad a_1 \quad a_0$

$B = b_3 \quad b_2 \quad b_1 \quad b_0$

a_i	b_i	x_i
0	0	1
0	1	0
1	0	0
1	1	1

$i = 0, 1, 2, 3$

$x_i = a_i \oplus b_i$



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Tuesday

"Class 22"

Ex) 2 bits numbers

A= 1 0 Gr= 1
B= 0 0

Ex) A= 0 1 Gr= 0
B= 1 1

Ex) A= 1 1 Gr= 1
B= 1 0

Ex) A= 0 0 Gr= 0
B= 0 1

Booleam Expression

$Gr = (a_3 \cdot \overline{b_3}) + (x_3 \; a_2 \overline{b_2})$ SOP

$+ (x_3 x_2 \; a_1 \overline{b_1}) + (x_3 x_2 x_1 \; a_0 \overline{b_0})$

$A > B$

$A: a_3 \; a_2 \; a_1 \; a_0$

$B: b_3 \; b_2 b_1 \; b_0$

$Ls = \overline{Eq} \cdot \overline{Gr}$ $A < B$

„Class 22‟

- How to build FA From 2.H A

FA → $S = X \oplus Y \oplus C_{in}$

$C_{out} = XY + XC_{in} + YC_{in}$ „FA‟

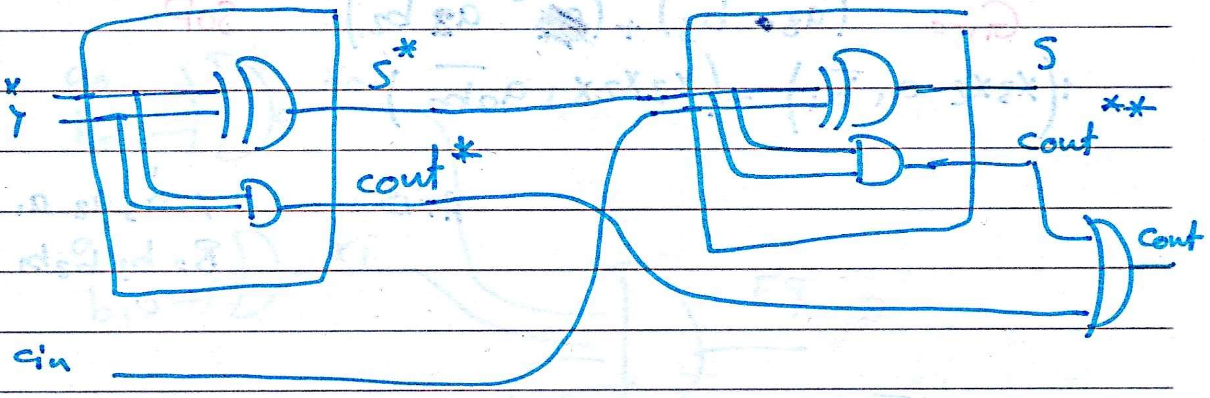
HA → $S = x \oplus y$

$C_{out} = xy$

* Build FA from two half Adders

~~xy~~

$$\begin{array}{r} x + \\ y \\ \hline S^{*} \\ C_{in} + \\ \hline S \end{array}$$



x	y	Cin	Cout	S
0	0	0	0	0
0	0	1	0	1
0	1	0	0	1
0	1	1	1	0
1	0	0	0	1
1	0	1	1	0
1	1	0	1	0
1	1	1	1	1

"Class 23"

Decoder → Combinational circuit that Convert a binary code to a binary value.

n - to - m Decoder
n: # of inputs , $m = 2^n$ (Max)

التقسيمات

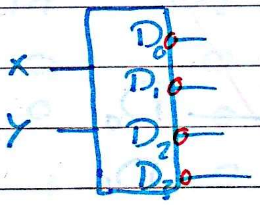
- Active high] decoder
- Active low]

- without Enable]
- with Enable]

- Enable active high]
- Enable active low]

2 - to - 4 Decoder

Active - Low

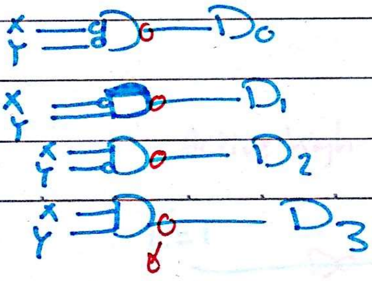


Active high

X	Y	D_0	D_1	D_2	D_3
0	0	1	0	0	0
0	1	0	1	0	0
1	0	0	0	1	0
1	1	0	0	0	1

D_0 - ⓪
D_1 - ①
D_2 - ②
D_3 - ③

$D_0 = \bar{x} . \bar{y}$, $D_1 = \bar{x} . y$, $D_2 = x . \bar{y}$, $D_3 = xy$



Active high   bubbles من غير Active low

,class 23,

Active _ Low

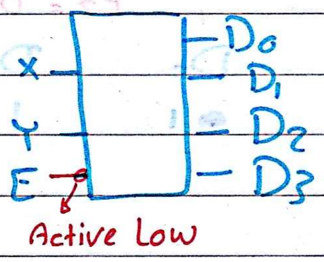
↙ Active low

x	Y	D_0	D_1	D_2	D_3
0	0	0	1	1	1
0	1	1	0	1	1
1	0	1	1	0	1
1	1	1	1	1	0

with enable active high 2 _ to _ 4

IF E=0 then decoder
⇒ inactive

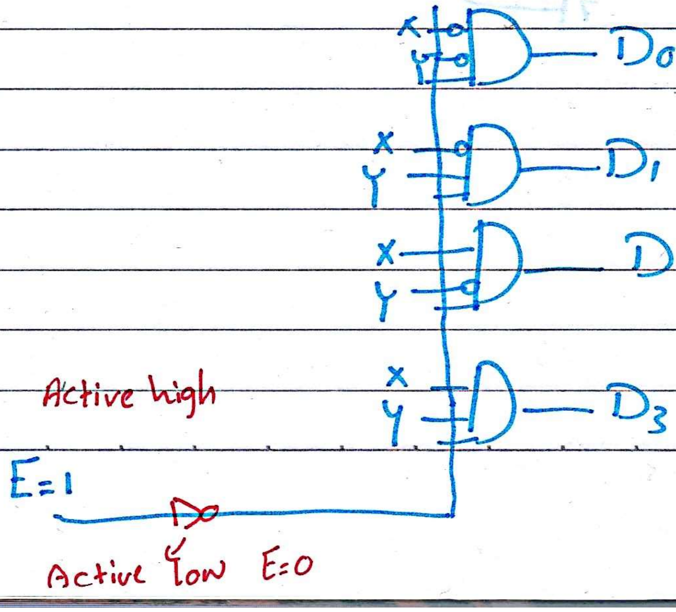
IF E=1 then decoder should work normally (active)



inactive decoder

E	x	Y	D_0	D_1	D_2	D_3
0	x	x	0	0	0	0
1	0	0	1	0	0	0
1	0	1	0	1	0	0
1	1	0	0	0	1	0
1	1	1	0	0	0	1

active decoder

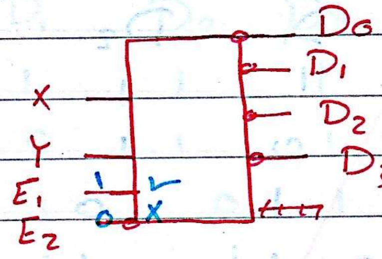


DATE 26-11-2015
Thursday

" Class 23 "

Ex) IF X=1 , Y=0

a) $E_1=1$, $E_2=1$



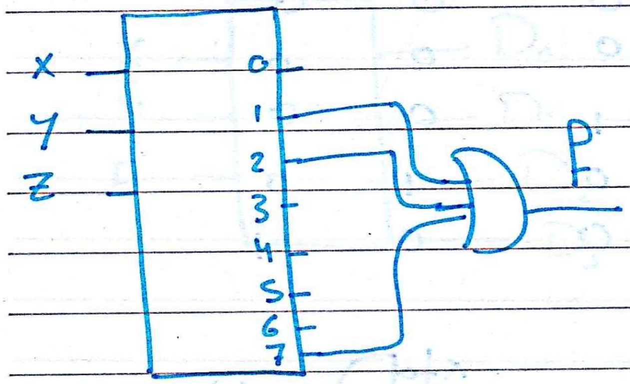
Find D_0, D_1, D_2, D_3 → inactive Low

1 1 1 1

b) $E_1=1$, $E_2=0$ → active Low

x	y	D_0	D_1	D_2	D_3
1	0	1	1	0	1

Ex) $F(x,y,z) = \Sigma(1,2,7)$ use 3_to_8 Decoder

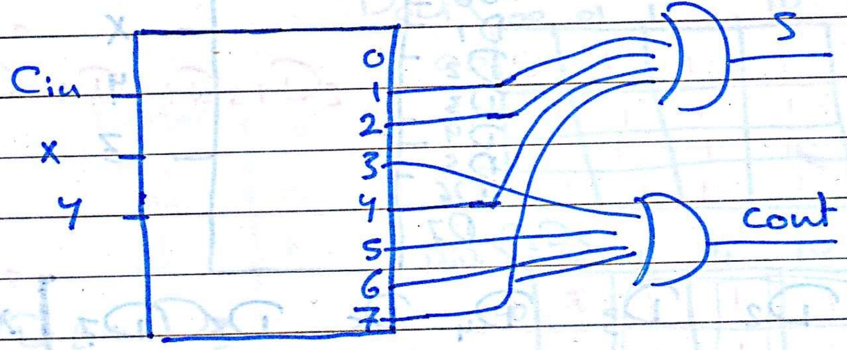


"Class 24"

Ex) $S = \Sigma(1,2,4,7)$ * represent Adder
$C_{out} = \Sigma(3,5,6,7)$ from decoder.

Cin	x	y	cout	S
0	0	0	0	0
0	0	1	0	1
0	1	0	0	1
0	1	1	1	0
1	0	0	0	1
1	0	1	1	0
1	1	0	1	0
1	1	1	1	1

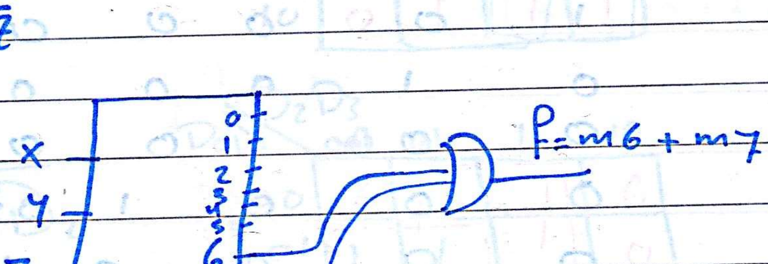
*



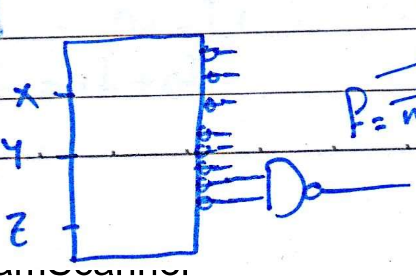
Ex) $f(x,y,z) = xy$ 3_to_8 Decoder

$f = xyz + xy\bar{z}$

$f = \Sigma(6,7)$



OR ->



$f = \overline{\overline{m6} \cdot \overline{m7}} = m6 + m7$

Class 24

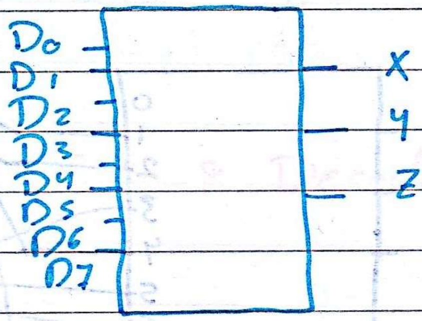
If decoder active high
Combine minterms using OR gates

If decoder active low
Combine minterms using NaND gates

If $\overline{f}$ put invertor after f.

- Encoder ⟶ A combinational circuit that converts a binary value to a binary code

m-to-n Encoder



D0	D1	D2	D3	D4	D5	D6	D7	X	y	Z
1	0	0	0	0	0	0	0	0	0	0
0	1	0	0	0	0	0	0	0	0	1
0	0	1	0	0	0	0	0	0	1	0
0	0	0	1	0	0	0	0	0	1	1
0	0	0	0	1	0	0	0	1	0	0
0	0	0	0	0	1	0	0	1	0	1
0	0	0	0	0	0	1	0	1	1	0
0	0	0	0	0	0	0	1	1	1	1

Class 24

$X = D_4 + D_5 + D_6 + D_7$

$y = D_3 + D_2 + D_6 + D_7$

$Z = D_1 + D_3 + D_5 + D_7$

4 to 2 Encoder (Priority Encoder)

D_0	D_1	D_2	D_3	x	y	V
0	0	0	0	X	x	0
1	0	0	0	0	0	1
$\overset{0}{1}$ ← x	1	0	0	0	1	1
x	x	1	0	1	0	1
x	x	x	1	1	1	1

V → Valid if V=0 then discard input (x, y)

If V=1 then take (x, y)

V →

$V = D_0 + D_1 + D_2 + D_3$

$D_0D_1 \backslash D_2D_3$	00	01	11	10
00	0	1	1	1
01	1	1	1	1
11	1	1	1	1
10	1	1	1	1

x →

$x = D_2 + D_3$

$D_0D_1 \backslash D_2D_3$	00	01	11	10
00	x	1	1	1
→ 01	0	1	1	1
→ 11	0	1	1	1
10	0	1	1	1

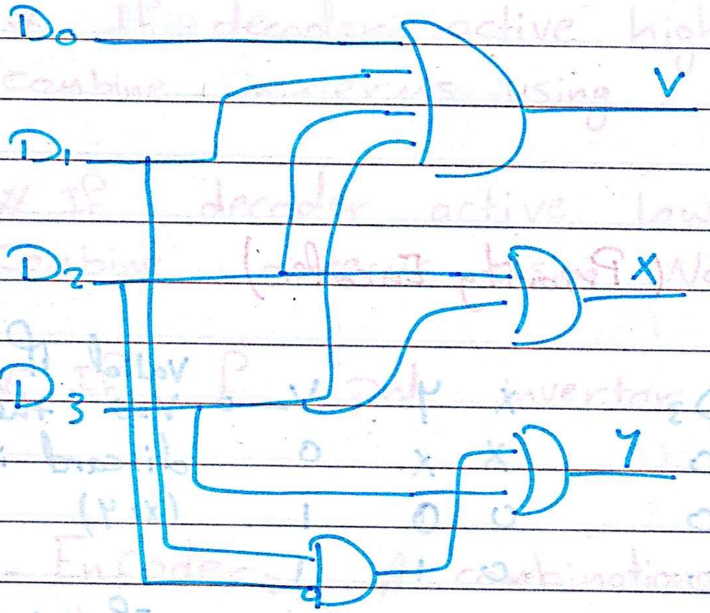
y →

$y = D_3 + D_1\overline{D_2}$

$D_0D_1 \backslash D_2D_3$	00	01	11	10
00	X	1	1	0
01	1	1	1	0
11	1	1	1	0
10	0	1	1	0

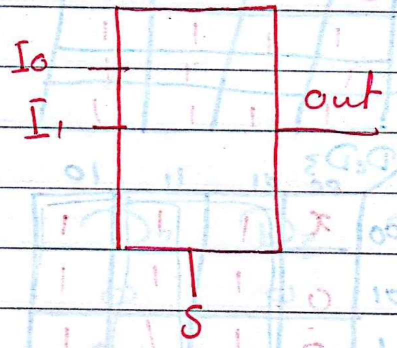
DATE 29-11-2015
Sunday

"Class 24"



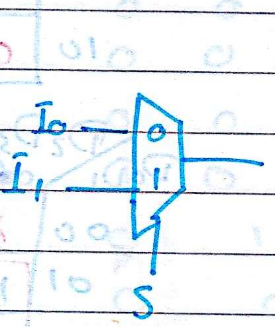
Multiplixers → (MUX)

- Combinational circuit that selects one of the input to be directed to the Output.



S	output
0	I_0
1	I_1

$I_0 = f(x, y, z)$



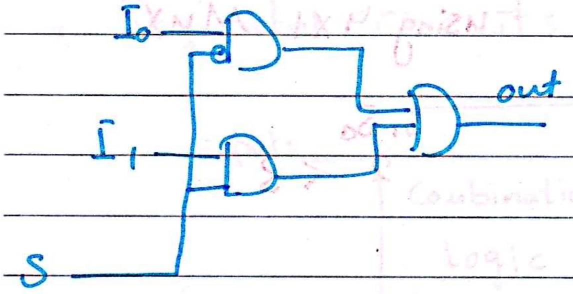
Out = $\bar{S} I_0 + S I_1$

S=0 → out = $\bar{0} I_0 + 0 I_1 = 1 I_0 + 0 = I_0$

S=1 → Out = $\bar{1} I_0 + 1 I_1 = 0 I_0 + I_1 = I_1$

DATE 1-12-2015
Tuesday

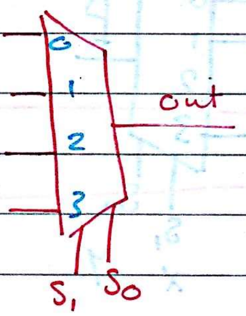
„class 25„



2x1 MuX

* 4 x1 MuX

	S_1	S_0	output
m_0 ←	0	0	I_0
m_1 ←	0	1	I_1
m_2 ←	1	0	I_2
m_3 ←	1	1	I_3



Select One input

$$Out = \underbrace{\bar{S_1}\bar{S_0}}_{m_0} I_0 + \underbrace{\bar{S_1}\, S_0}_{m_1} I_1 + \underbrace{S_1 \bar{S_0}}_{m_2} I_2 + \underbrace{S_1 S_3}_{m_3} I_3$$

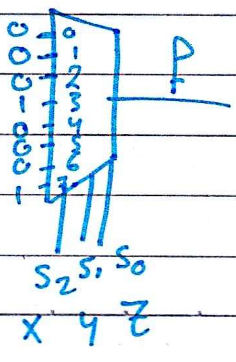
* How to use Mux to represent boolean function:-

① If # of variables in the function = # of selector Lines → Connect input to the select Lines

② If # of variables > # of selector Lines

Ex) $F(x,y,z) = yz$, use 8x 1 MuX

x	y	z	F
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	0
1	1	0	0
1	1	1	1



" Class 25 "

Ex) given →

	X	Y	Z	F
xy=00	0	0	0	0
	0	0	1	1
xy=01	0	1	0	1
	0	1	1	0
xy=10	1	0	0	1
	1	0	1	1
xy=11	1	1	0	0
	1	1	1	1

for 2x1

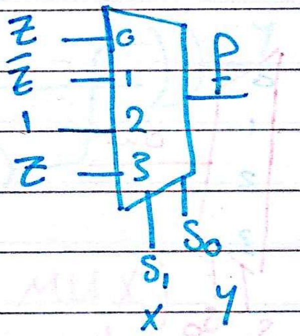
using 4x1 Mux

$S_1 S_0$

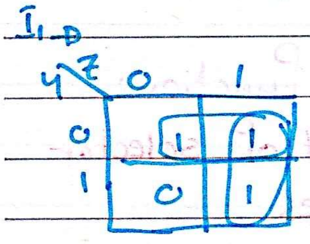
2 < 3

① Connect MSB to the the available Selector line

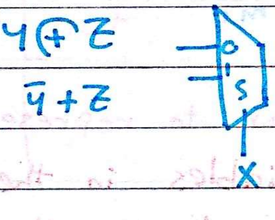
② Write inputs as function of remaining variables.

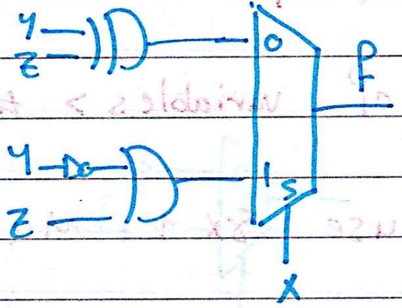


→ Using 2x1 Mux



$I_1 = \bar{y} + z$ →





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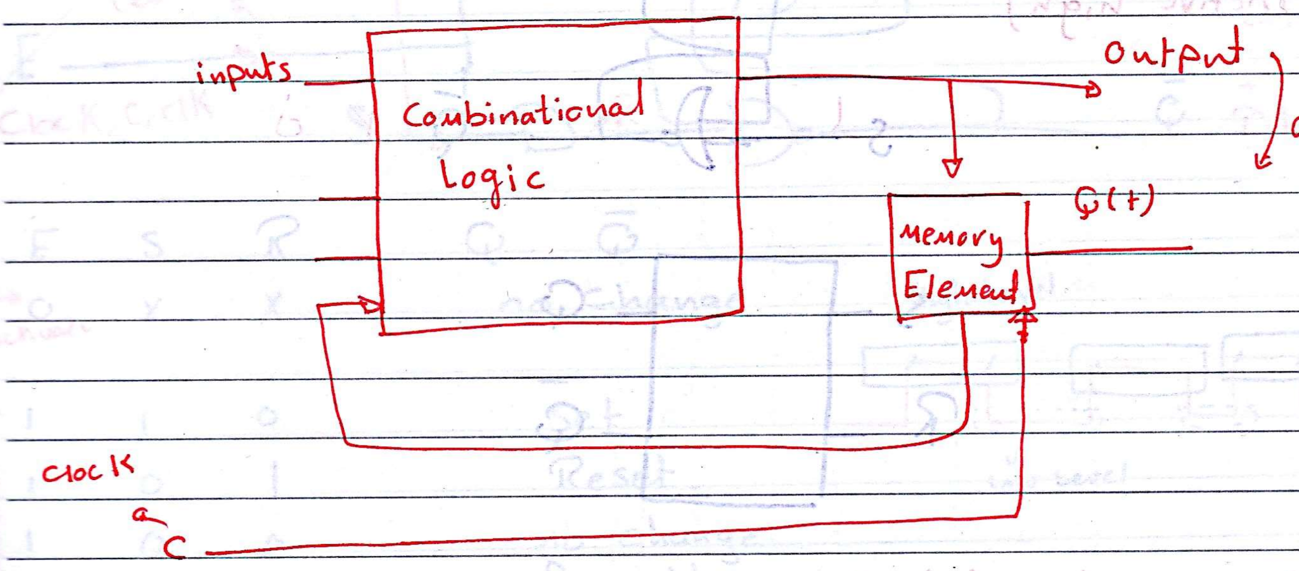
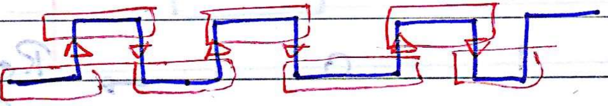
"class25"

→ Sequential Circuits

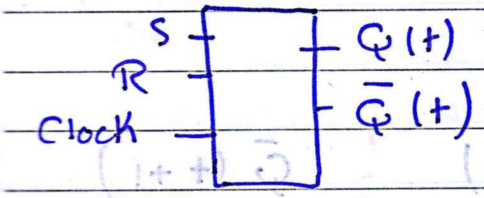


Q(t)	Q(t+1)
Current State	next State

* Clock , clK, C



Latch قفل
↳ Level sensitive
- High Level
- Low Level



Flip flop
- +ve edge
- -ve edge

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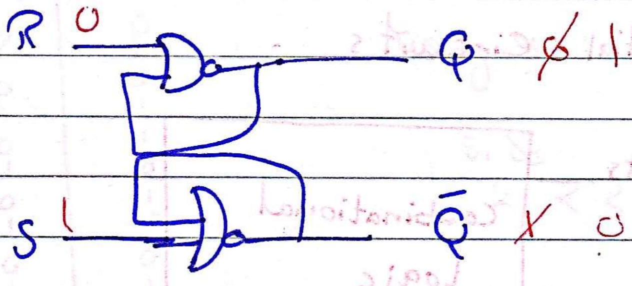
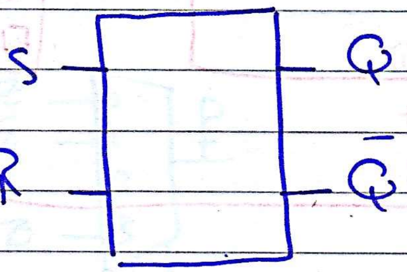
"Class 26"

SR Latch
(Active high)





S: Set / 1 / high
R: Reset / 0 / low

	S	R	Q	Q̄	
Set	1	0	1	0	→ Set
no change Latch	0	0	1	0	→ if previous Value was Set
Reset	0	1	0	1	→ Reset
no change Latch	0	0	0	1	→ if previous Value was Reset
Forbidden cell	1	1	0	0	

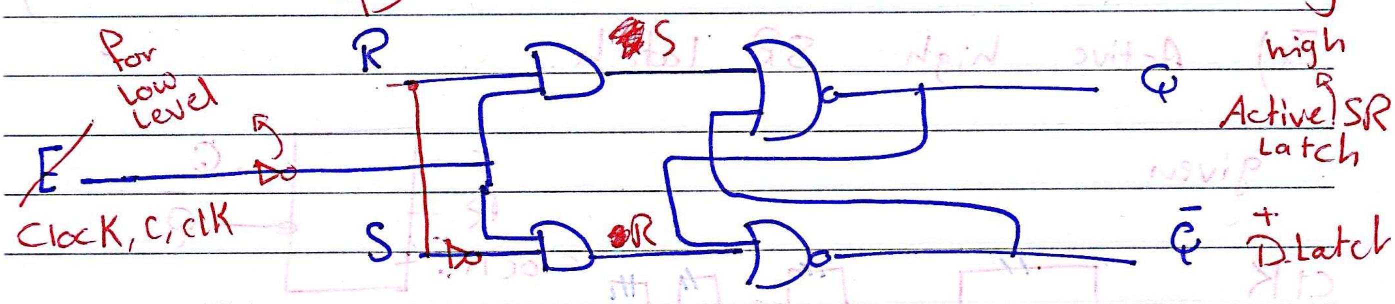
Ex) inputs

S	R	Q(t)	Q̄(t)	Q(t+1)	Q̄(t+1)
1	0	0	1	1	0
0	0	1	0	1	0

⋮

"class 26"

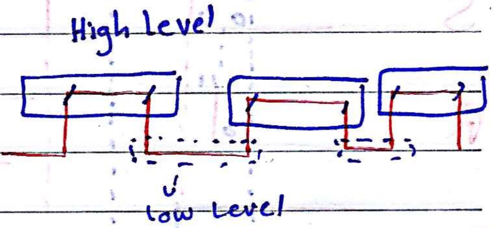
D → D-latch



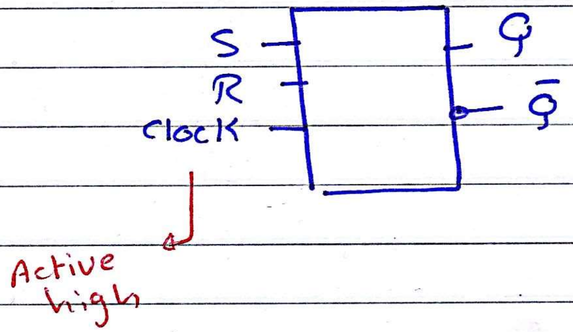
E	S	R	Q	Q̄
0	X	X	no change	
1	1	0	set	
1	0	1	Reset	
1	0	0	no change	
1	1	1	for bidden	

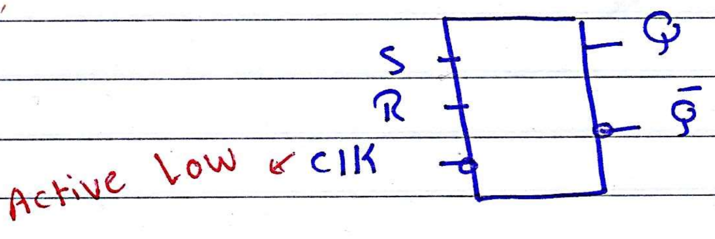
→ diactivate

→ activate SR



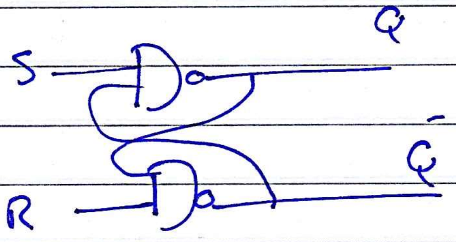
D	Q(t+1)	Q̄
0	0	1
1	1	0

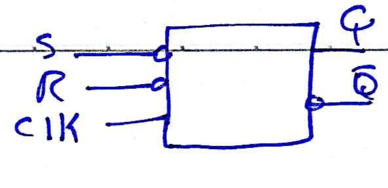




Active low $\overline{SR}$ latch

	S	R	Q	Q̄	
set	0	1	1	0	→ if after set
no change	1	1	1	0	
Reset	1	0	0	1	if after reset
no change	1	1	0	1	→
	0	0	For bidden		





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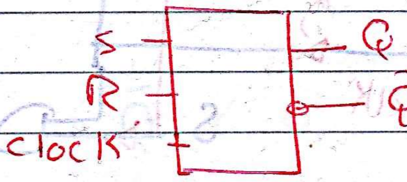
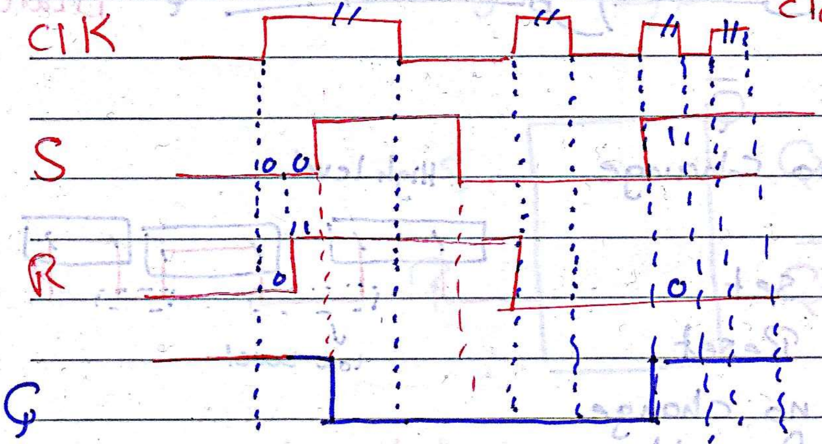
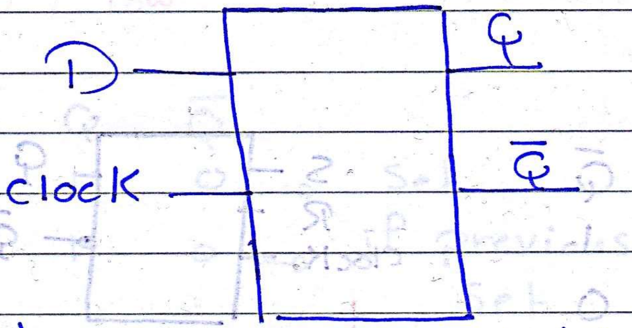
"class 26"

Ex) Active high SR latch.

given



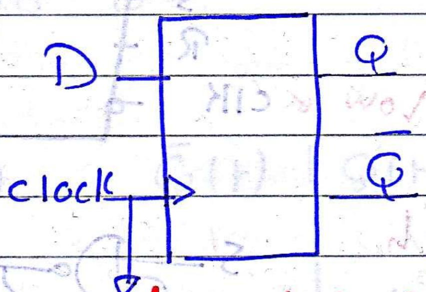


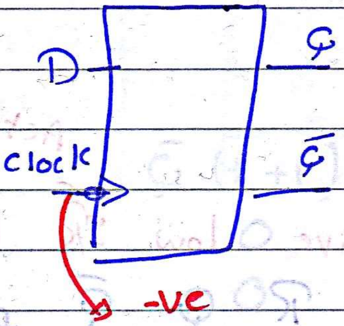


Latch

D	Q(t+1)
0	0
1	1

transmarent



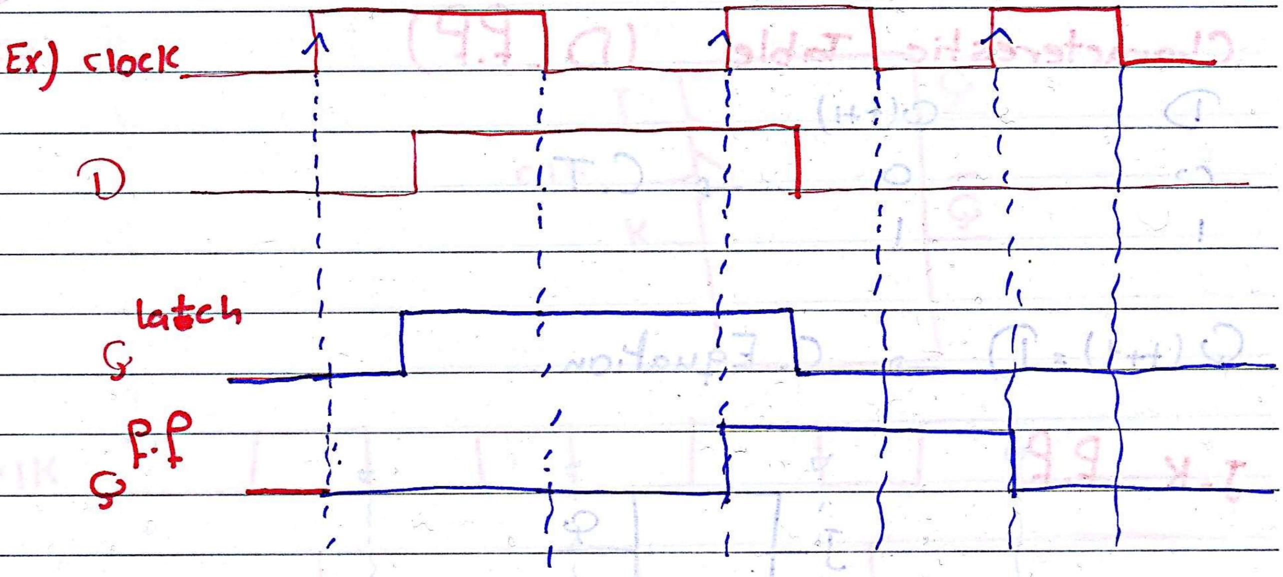


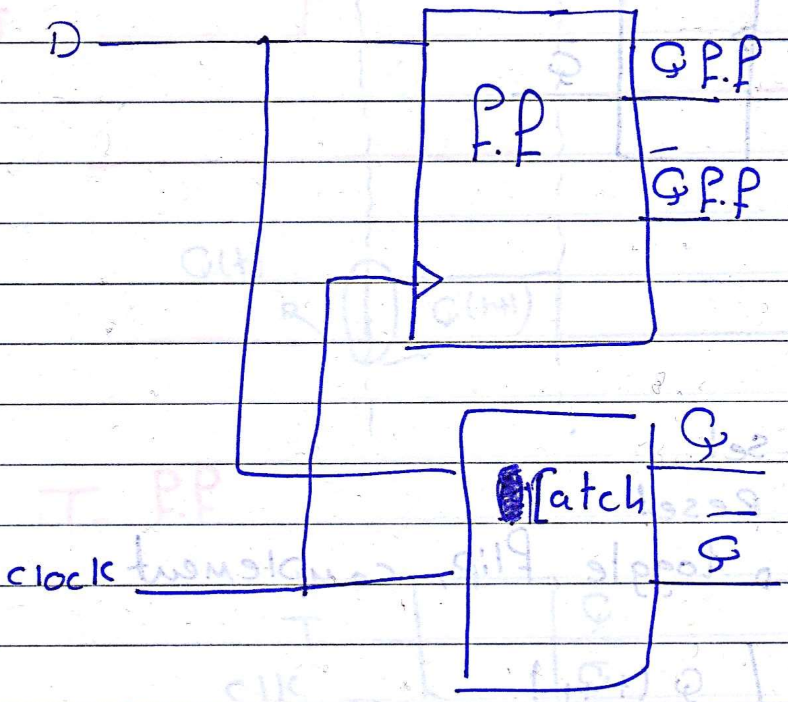
edge triggered
+ve

-ve

"Class 27"

Ex)





Flip-flops → D-F.F
JK F.F
T F.F

① Characterestic ~~flip~~ Table

② Characterestic equation

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"class 27"

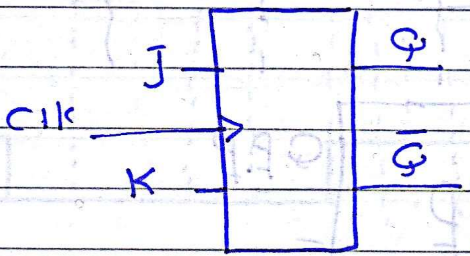
Characterestic Table (D_F.F)

D	Q(t+1)
0	0
1	1

→ C.T

$Q(t+1) = D$ → C. Equation

J.K F.F



C.Table

	J	K	Q(t+1)	
no change ←	0	0	Q(t)	
	1	0	1	→ Set
	0	1	0	→ Reset
	1	1	$\bar{Q}(t)$	→ toggle, flip, complement

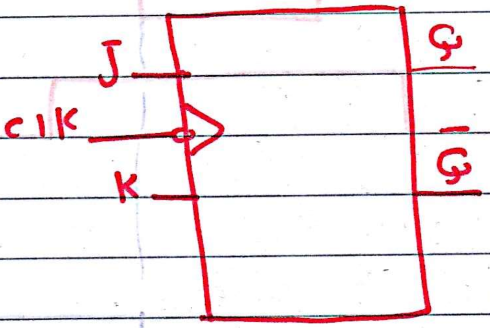
J	K	Q(t)	Q(t+1)	
0	0	0	0	→ no change
0	0	1	1	
0	1	0	0	→ Reset
0	1	1	0	
1	0	0	1	→ Set
1	0	1	1	
1	1	0	1	→ Toggle
1	1	1	0	

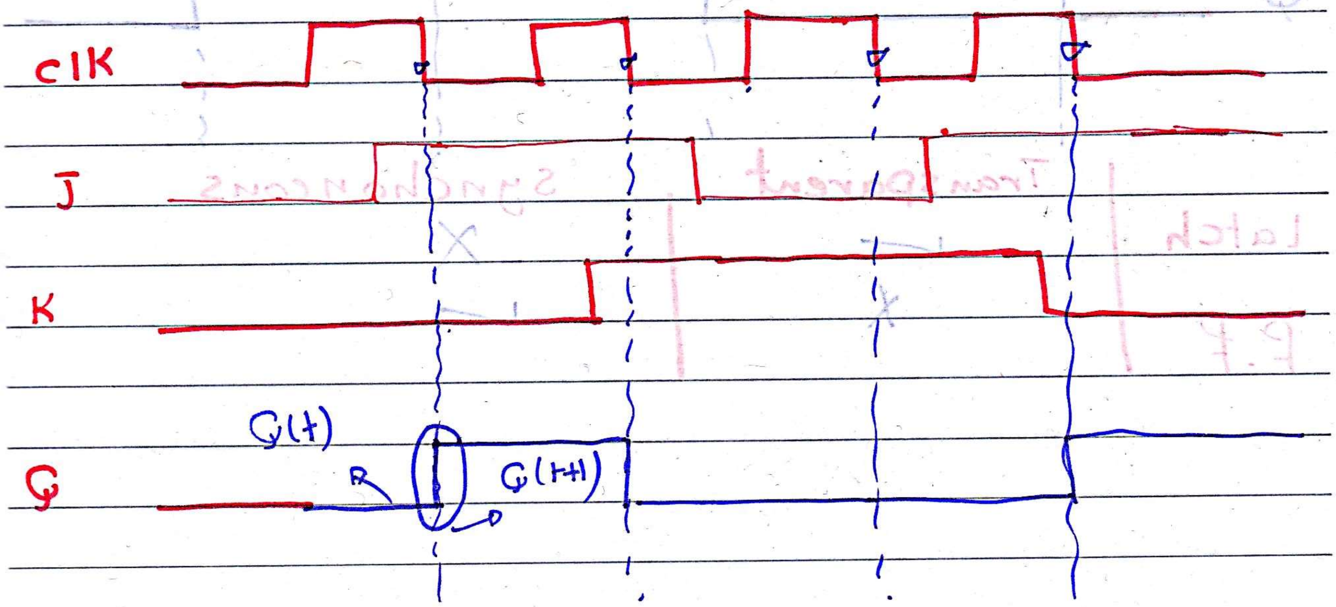
J \ KQ(t)	00	01	11	10
0	0	1	0	0
1	1	1	0	1

$Q(t+1) = \bar{K}Q(t) + J\bar{Q}(t)$

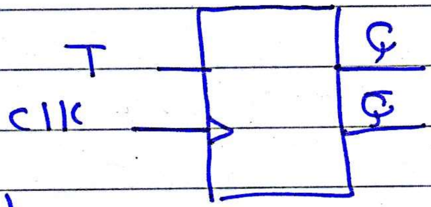
"class 27"

Ex)





→ T- F.F



T	Q (t+1)
0	Q (t) → no change
1	$\bar{Q}$ (t) → Toggle

T	Q	Q(t+1)
0	0	0
0	1	1
1	0	1
1	1	0

$$Q(t+1) = T \oplus Q$$
$$= T\bar{Q} + \bar{T}Q$$

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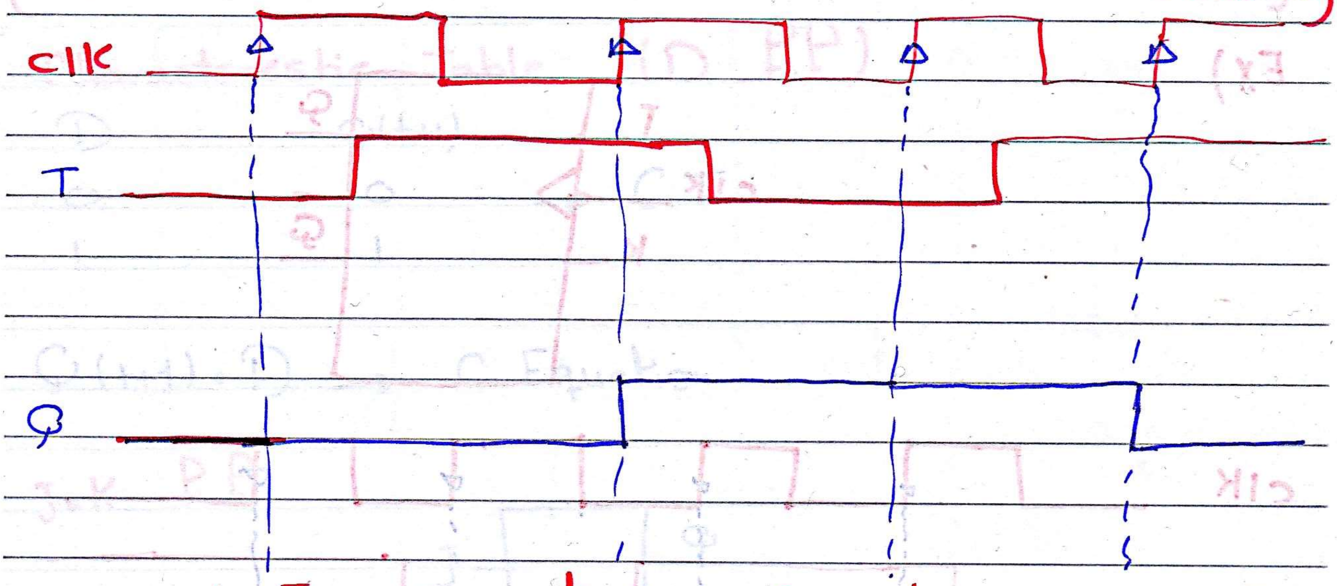
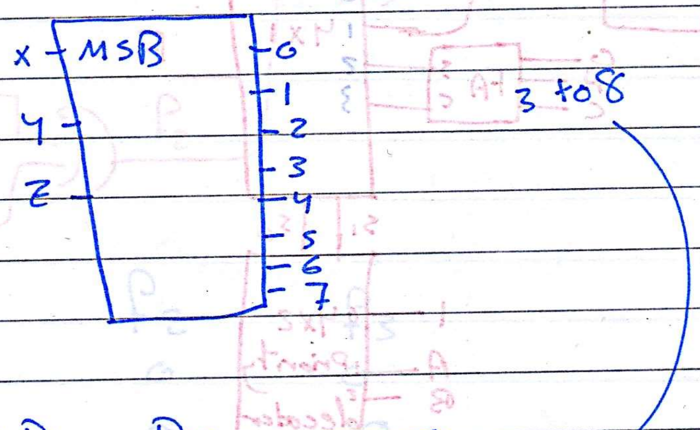
"class 27"

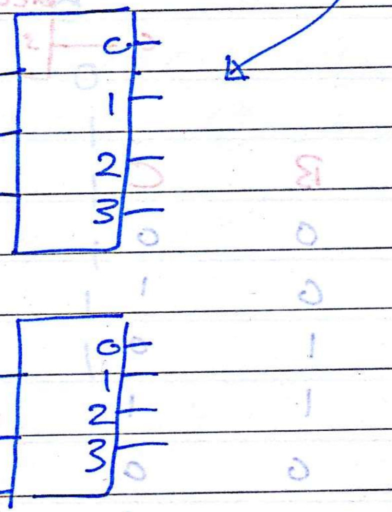


	Transparent	Synchoneous
latch	✓	X
F.F	X	✓

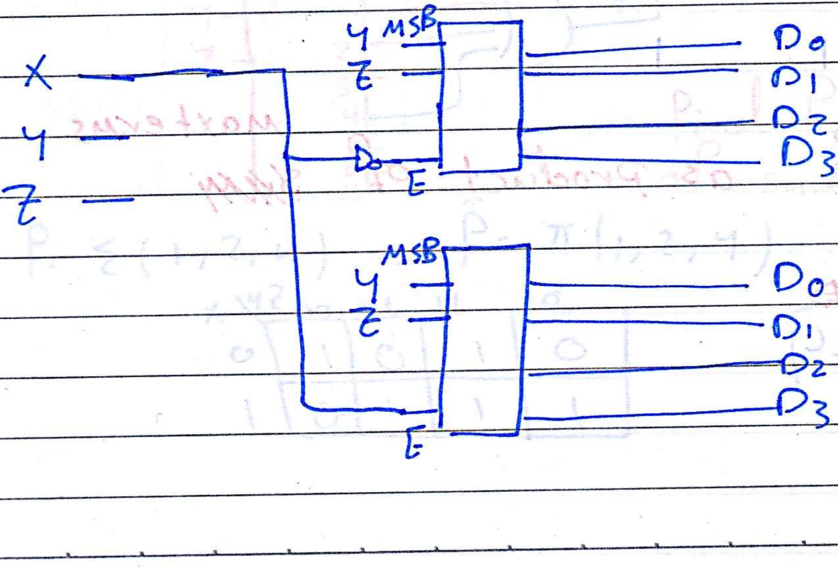
"Class 28"

Ex) Design 3-to-8 Decoder from 2-to-4 decoders with Enable.





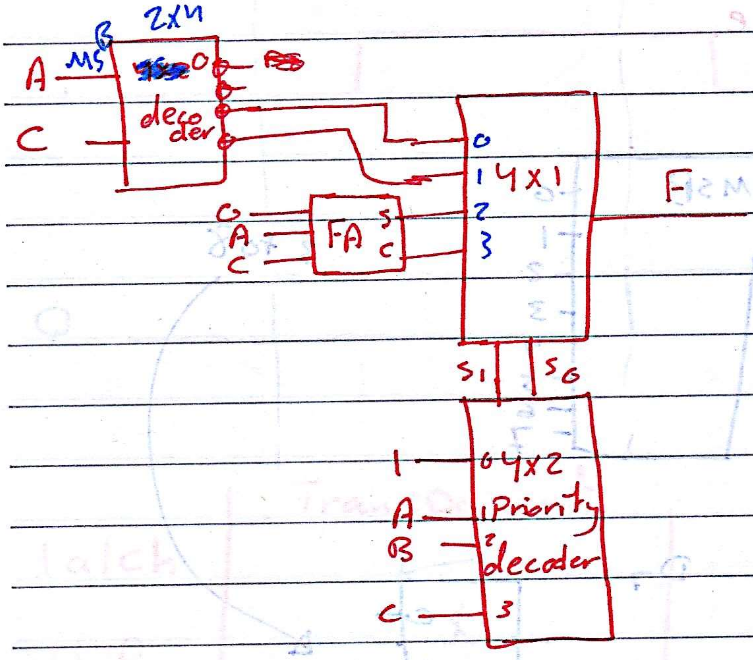
x	y	z	D0	D1	...	D7
MSB		LSB				
0	0	0	1	0	...	0
0	0	1	0	1	...	0
0	1	0	0	0	--	0
0	1	1	0	0	--	0
1	0	0	0	0	--	0
1	0	1	0	0	--	0
1	1	0	0	0	--	0
1	1	1	0	0	--	1



"Class28"

Ex) write F as SOP

Sum of Minterms.



A	B	C	F
0	0	0	1
0	0	1	0
0	1	0	0
0	1	1	0
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	1

Ex) Find F_3 as product of ~~SOP~~ maxterms

⟹

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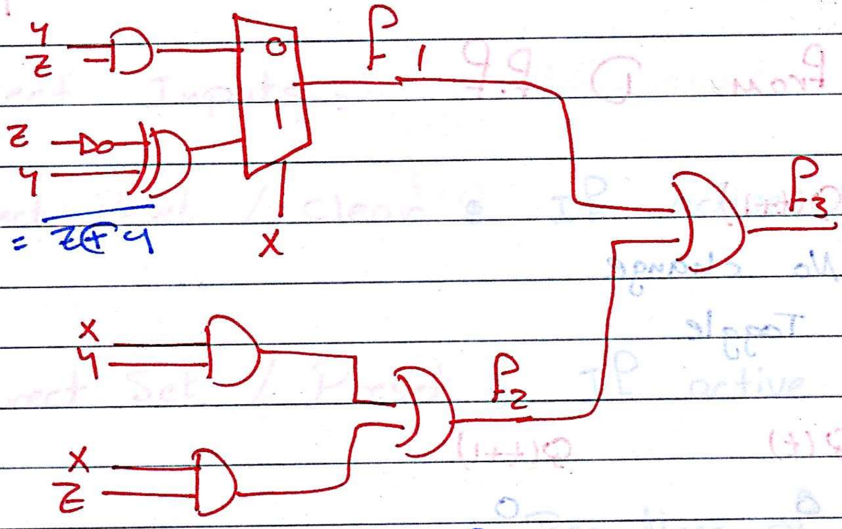
Class 28

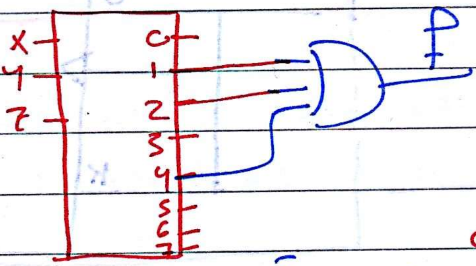


$\bar{z} \oplus y = \overline{z \oplus y}$

x	y	z	f_1	f_2	f_3
0	0	0	0	0	0
0	0	1	0	0	0
0	1	0	0	0	0
0	1	1	1	0	1
1	0	0	1	0	1
1	0	1	0	1	1
1	1	0	0	1	1
1	1	1	1	1	1

$f_3 = \pi(0,1,2)$

Ex)



find $\bar{f}$ as Product of sums (simplified)

$f = \Sigma(1,2,4) \rightarrow \bar{f} = \pi(1,2,4)$

x \ yz	00	01	11	10
0	1	0	1	0
1	0	1	1	1

$\bar{f} = (\bar{x}+y+z) \cdot (x+\bar{y}+\bar{z})$
$\cdot (x+\bar{y}+z)$

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"Class 29"

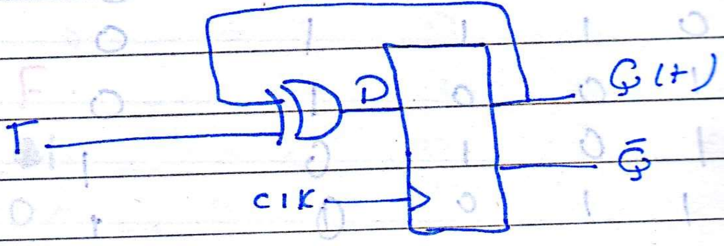
- T F.F from D F.F

T	$Q(t+1)$
0	No change
1	Toggle

T	$Q(t)$	$Q(t+1)$
0	0	0
0	1	1
1	0	1
1	1	0

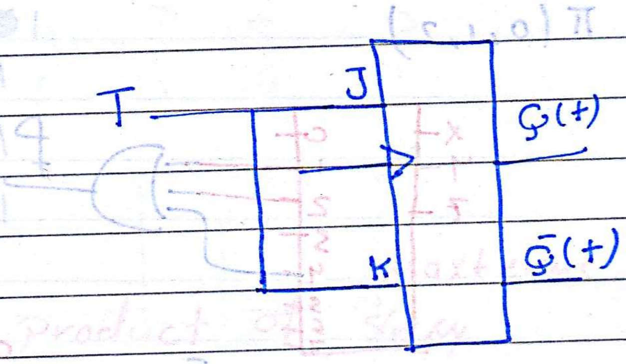
$Q(t+1) = Q \oplus T$

$Q(t+1) = D$



- T F.F from JK F.F

	T	JK
no change	0	0 0
Toggle	1	1 1



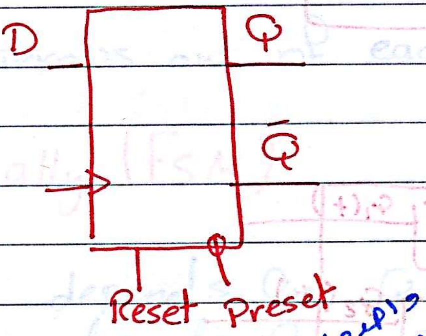
Class 29

- Direct Inputs →

① Direct Reset / Clear :- If active then Q = 0

② Direct Set / Preset :- If active then Q = 1

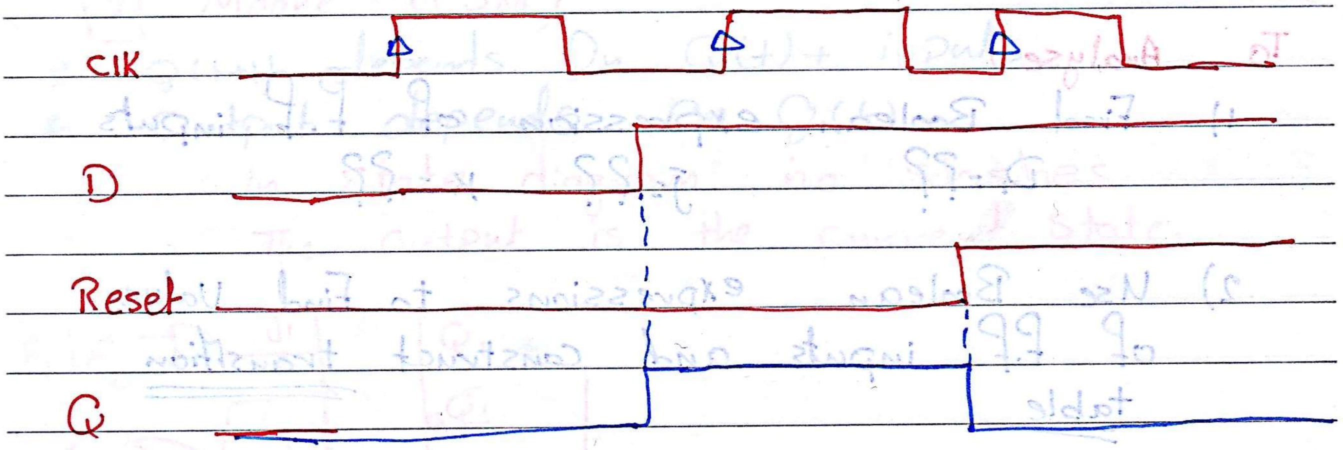
Regardless of the clk.



واحد منهم بس شغال.

Reset	D	Q
1	X	0
0	0	0
0	1	1

Ex) D f.f



Acti low

Preset	D	Q
0	X	1
1	0	0
1	1	1

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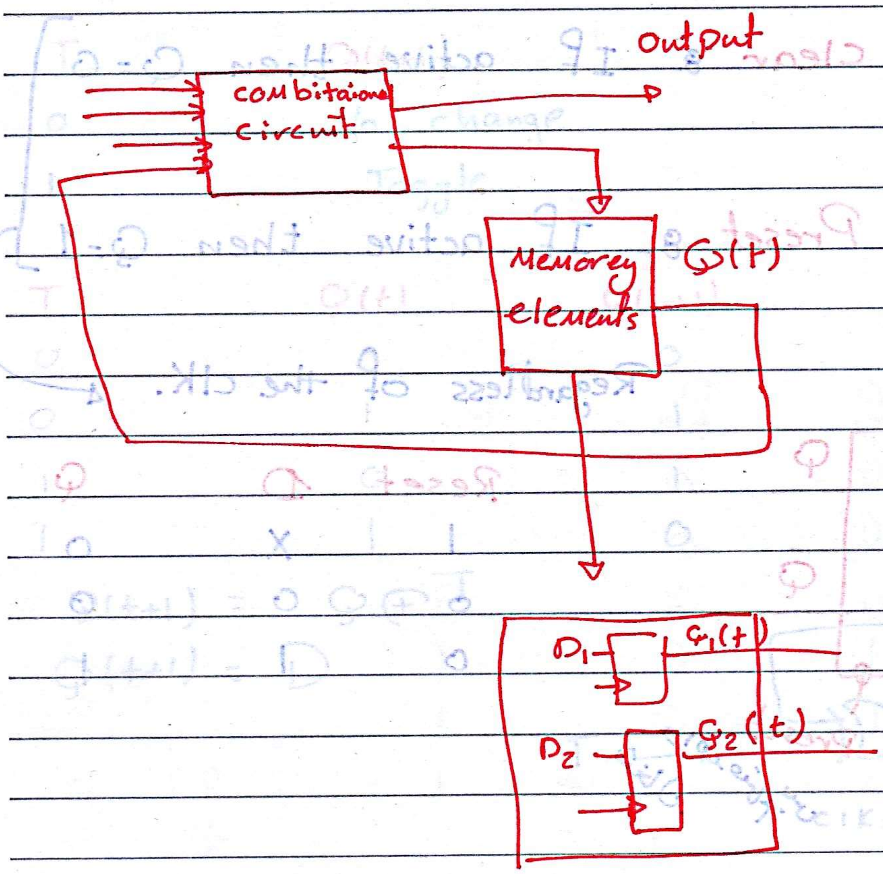
„Class 29„

Analysis of sequential circuits



To Analyse :-

1) Find Boolean expression of F.F inputs
$D_1 = ??$ $J = ??$ $K = ??$

2) Use Boolean expressions to Find Values of F.F inputs and construct transition table

Current state → # of F.F = m	inputs (external) n	nextstate	Output.

# of rows = 2^{n+m}

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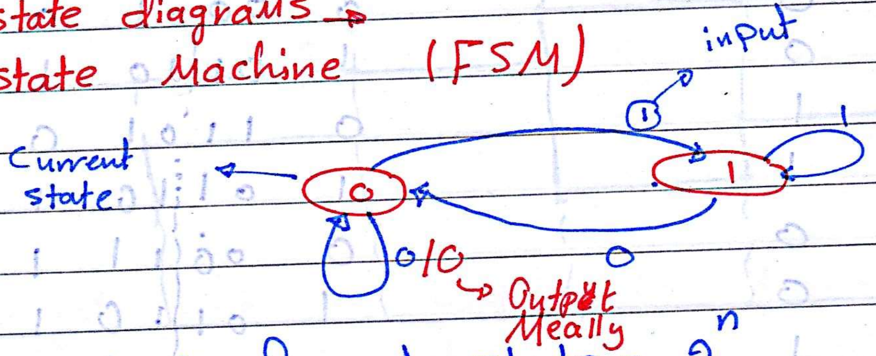
"Class 29"

3_ Find next state using Charasteristic table or equation + Output.

Types of state diagrams →

① Finite state Machine (FSM)



\# of arrows out of each state = 2^n, # of states ≤ 2^m

1 Meally (FSM)

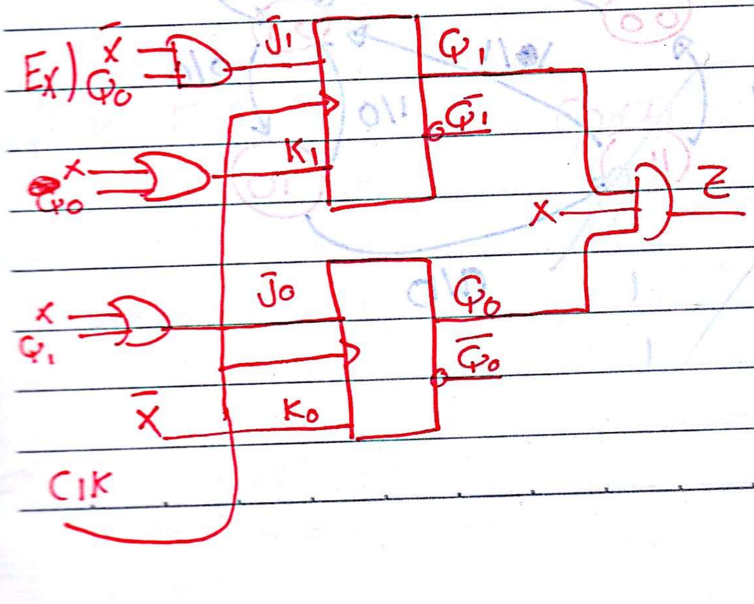
Q(t+1) depends On Q(t) + inputs
Output depends On Q(t) + inputs

2 Moore (FSM)

- * Q(t+1) depends On Q(t) + inputs
- * Output depends On Q(t)

in state diagram no slashes
The output is the current state.

Ex)



Class "30"

Current state		Inputs			next state		
Q_1	Q_0	X	J_1K_1	J_0K_0	$Q_1(t+1)$	$Q_0(t+1)$	Z
0	0	0	00	01	0	0	0
0	0	1	01	10	1	0	0
0	1	0	11	01	0	1	0
0	1	1	01	10	1	0	0
1	0	0	00	11	1	1	0
1	0	1	01	10	1	0	0
1	1	0	11	11	0	0	0
1	1	1	01	10	1	0	1

$J_1 = \bar{x} . Q_0$

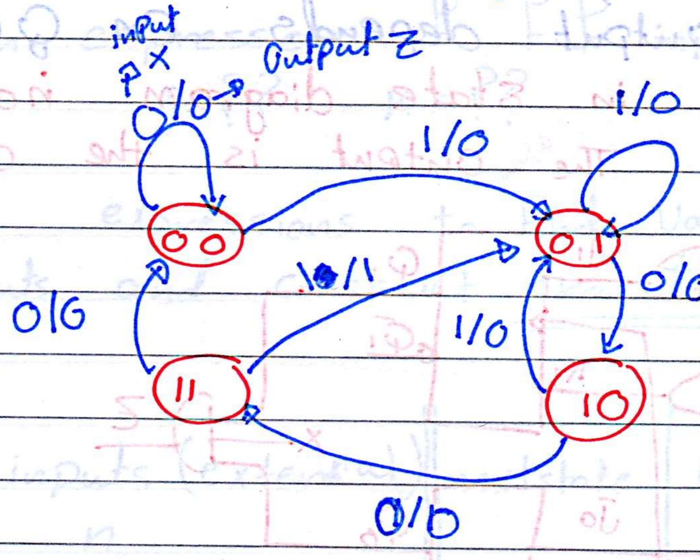
$K_1 = x + Q_0$

$J_0 = x + Q_1$

$K_0 = \bar{x}$

JK	Q(t+1)
00	no change
01	Reset
10	set
11	Toggle

$Z = x \, Q_1(t) . Q_0(t)$



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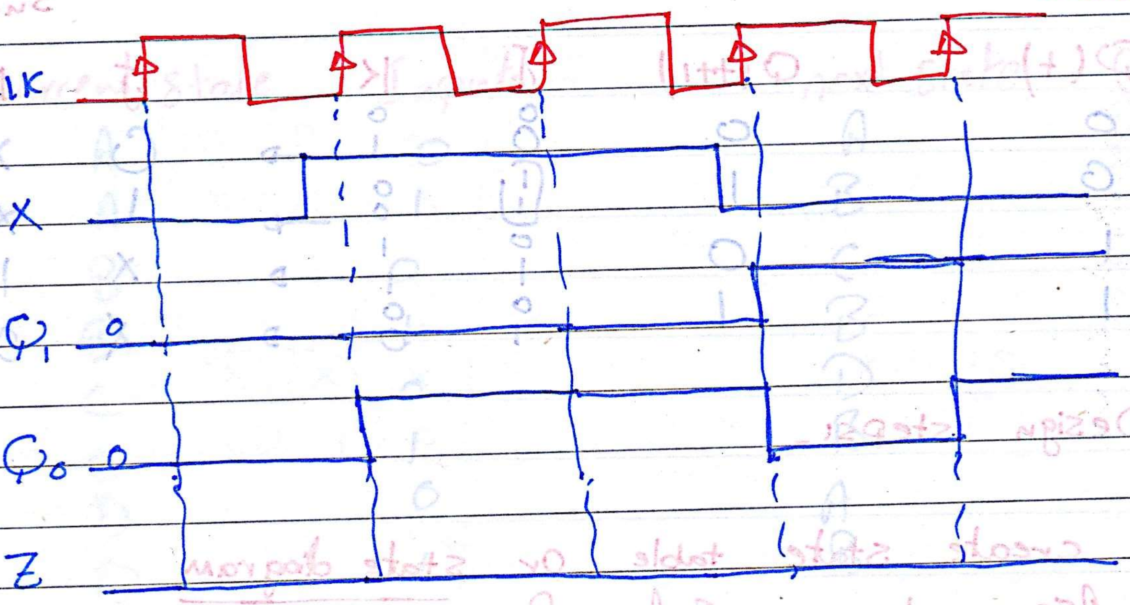
Class "30"



Excitation table

D_F.F

Q(t)	Q(t+1)	D=?
0	0	0
0	1	1
1	0	0
1	1	1

T_F.F

Q(t)	Q(t+1)	T
0	0	0
0	1	1
1	0	1
1	1	0

J-K_F.F

Q(t)	Q(t+1)	J	K
0	0	0 0	0 no change 1
0	1	1	0
1	0	0	1
1	1		

"Class 30"

Q(t)	Q(t+1)	J	K		J	K
0	0	0 0	0 1	→	0	X
0	1	1 1	0 0	→	1	X
1	0	0 1	1 1	→	X	1
1	1	0 1	0 0	→	X	0

Design steps:-

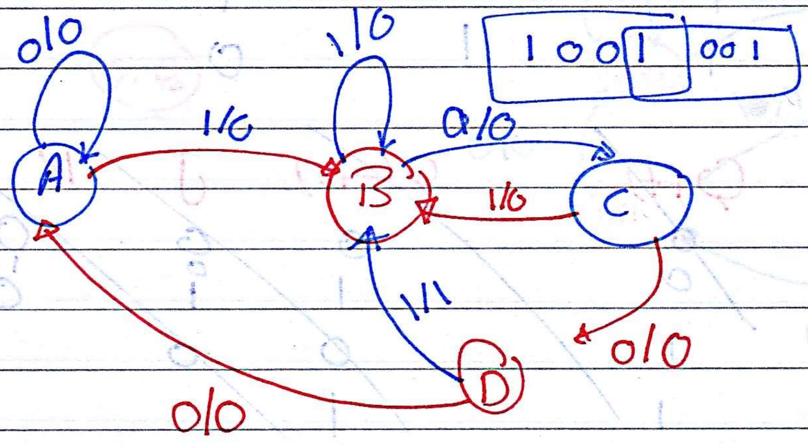
1- create state table or state diagram
2- Asign binary code for each state
→ I know # of F.F
3- ~~Generate~~ Find F.F Inputs from excitation table (Value)
4- Find simplified expression of F.F inputs (K-map)
5- Build the circuit.

Ex) Sequence Recognizer

input: 0000 11 00 1 0001 (1 2 3 4 5 6 7 8 9 10 11 12 13)

Output: 00000 00 01000

Pattern = "1001" (start, end)
Output = 1



A: none of the desired pattern bits appeared. "0"

B: We have already seen the first bit of the pattern

C:- Second bit of the pattern appeared.

D:- Third bit of the pattern appeared.

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"Class 31"

Current state	Inputs	next state	Output
A	0	A	0
A	1	B	0
B	0	C	0
B	1	B	0
C	0	D	0
C	1	B	0
D	0	A	0
D	1	B	1

	Q_1	Q_0
A	0	0
B	0	1
C	1	0
D	1	1

	Current state		Inputs	F.F Inputs		next state		Output
	Q_1	Q_0	X	J_1K_1	J_0K_0	Q_1	Q_0	Z
A	0	0	0	0X	0X	0	0	0
	0	0	1	0X	1X	0	1	0
B	0	1	0	1X	X1	1	0	0
	0	1	1	0X	X0	0	1	0
C	1	0	0	X0	1X	1	1	0
	1	0	1	X1	1X	0	1	0
D	1	1	0	X1	X1	0	0	0
	1	1	1	X1	X0	0	1	1

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"Class 31"

$J_1 = Q_0 \overline{X}$

$Q_1 \backslash Q_0X$	00	01	11	10
0	0	0	0	1
1	X	X	X	X

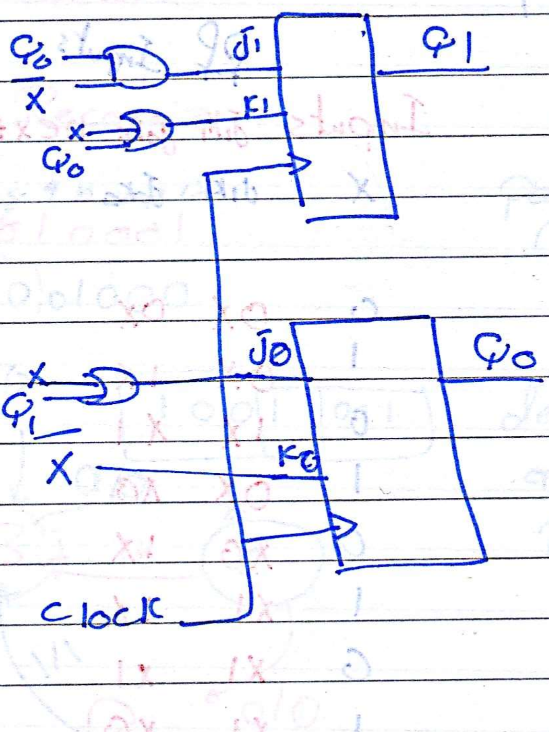
$K_1 = Q_0 + X$

$Q_1 \backslash Q_0X$	00	01	11	10
0	X	X	X	X
1	0	1	1	1

$J_0 = X + Q_1$

$Q_1 \backslash Q_0X$	00	01	11	10
0				
1				

$K_0 = \overline{X}$



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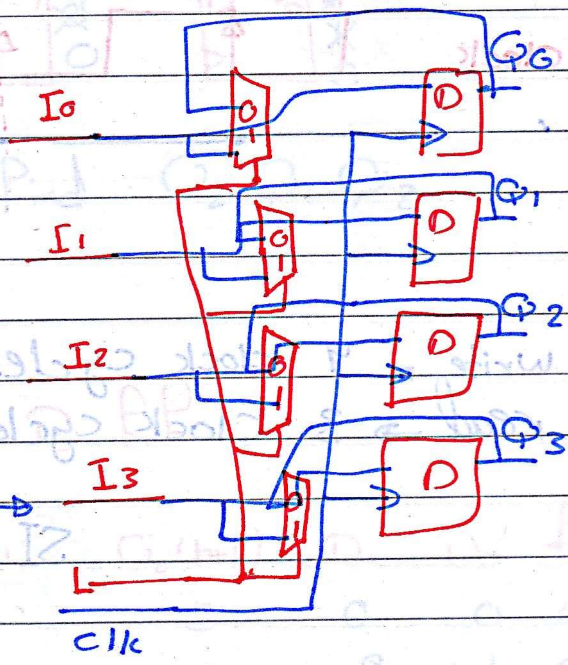
Registers

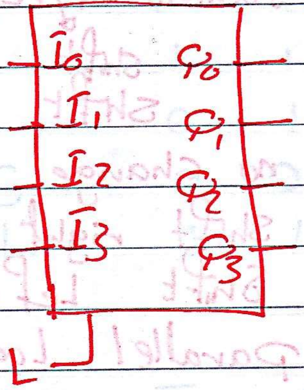
Parallel in / prallel Out 4-bits Register.

Input
1011
↓
MSB



write → 1 clock cycle

read → 0 clock cycle.



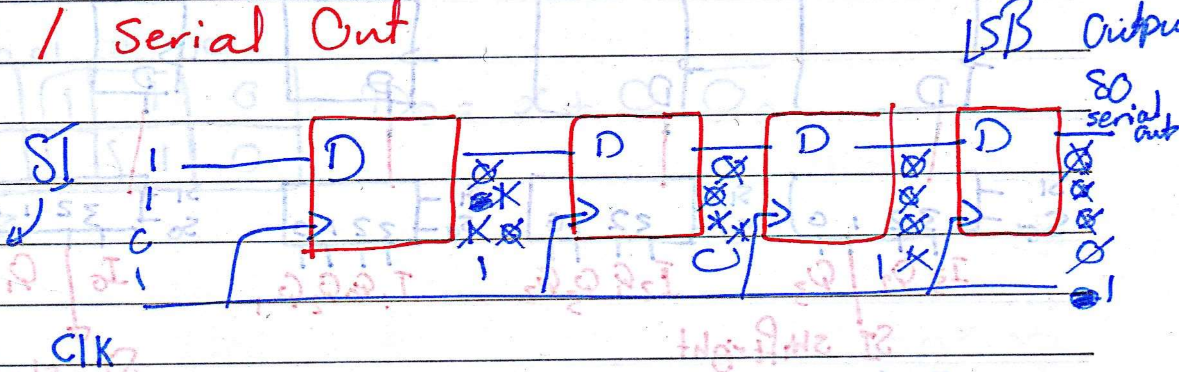
Sellector → L

0 → no change

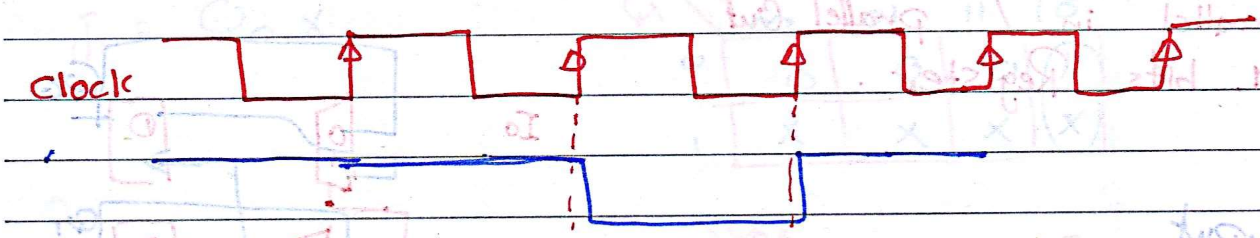
1 → load new data

Serial in / Serial Out

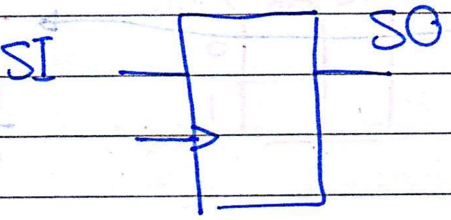
10 11
↓
MSB



„Registers„

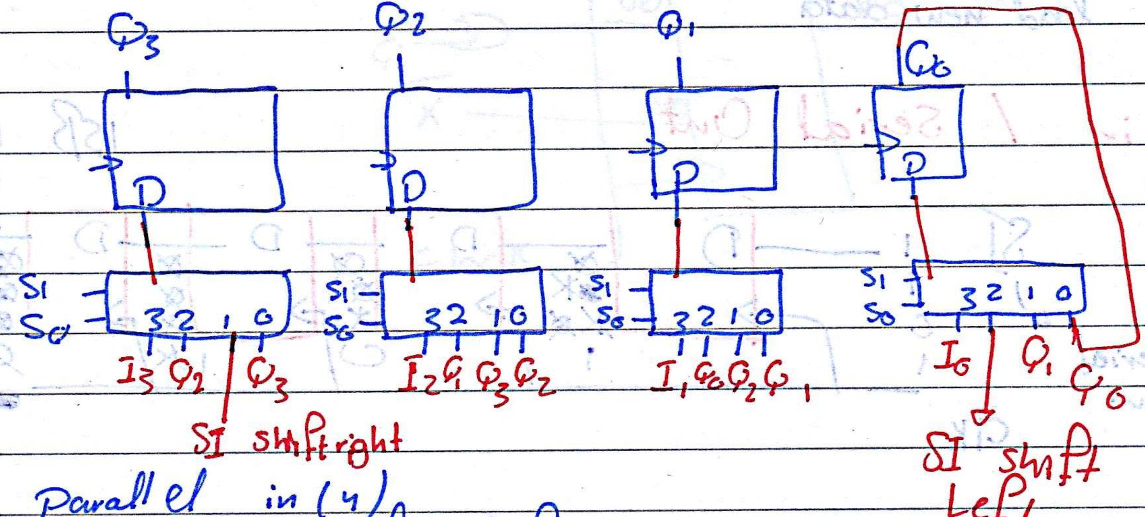


write → 4 clock cycles.
read → 3 Clock cycles



* „Universal shift register„

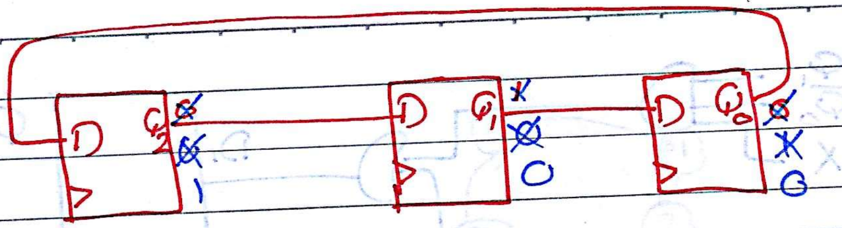
shift	S_1	S_0
1) no change (same)	0	0
2) shift right	0	1
3) Shift Left	1	0
4) parallel Load.	1	1



Parallel in (4)
Serial in shift left
Serial in shift right

Registers

Ex)



After 2 clock cycles find $Q_2 Q_1 Q_2$

= 100

Ex) Designing pattern using D-F.F

Q_1	Q_0	x	$Q_1(t+1)$	$Q_0(t+1)$	D_1	D_0	f
0	0	0	0	0	0	0	0
0	0	1	0	1	0	1	0
0	1	0	1	0	1	0	0
0	1	1	0	1	0	1	0
1	0	0	1	1	1	1	0
1	0	1	0	1	0	1	0
1	1	0	0	0	0	0	0
1	1	1	0	1	0	1	1

$D_1 \rightarrow$

$Q_1 \backslash Q_0 x$	00	01	11	10
0	0	0	0	1
1	1	0	0	0

$$D_1 = Q_1 \overline{Q_0} \overline{x} + \overline{Q_1} Q_0 \overline{x}$$

$D_0 \rightarrow$

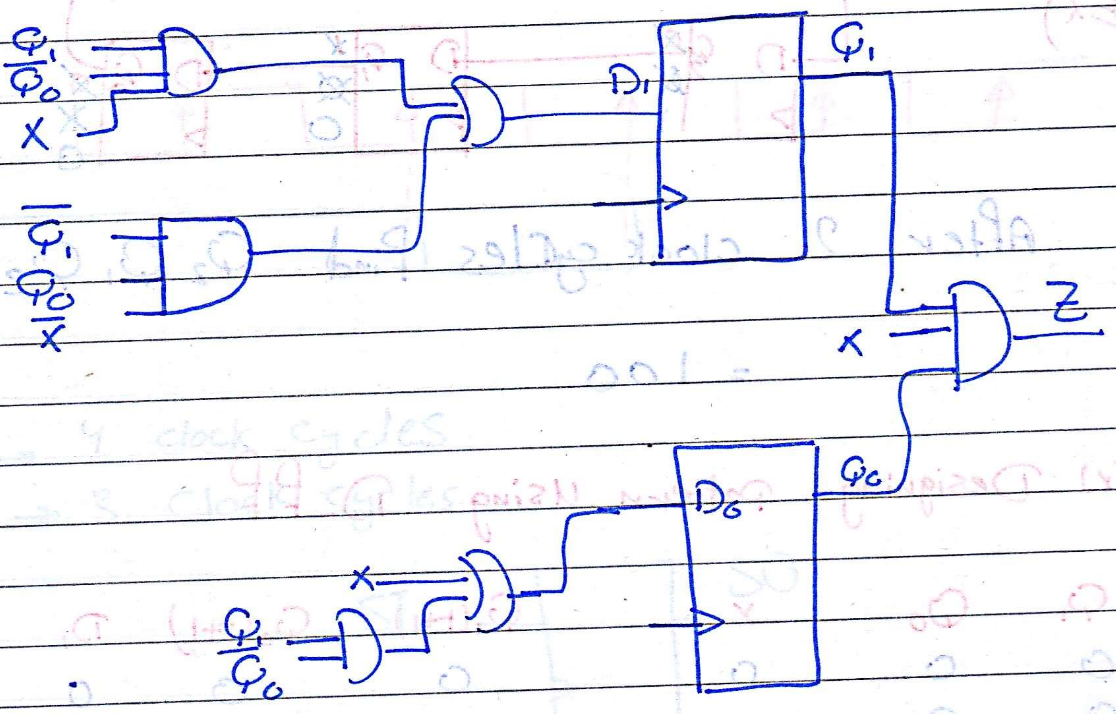
$Q_1 \backslash Q_0 x$	00	01	11	10
0	0	1	1	0
1	1	1	1	0

$$D_0 = x + Q_1 \overline{Q_0}$$

$Z = Q_1 Q_0 Z$

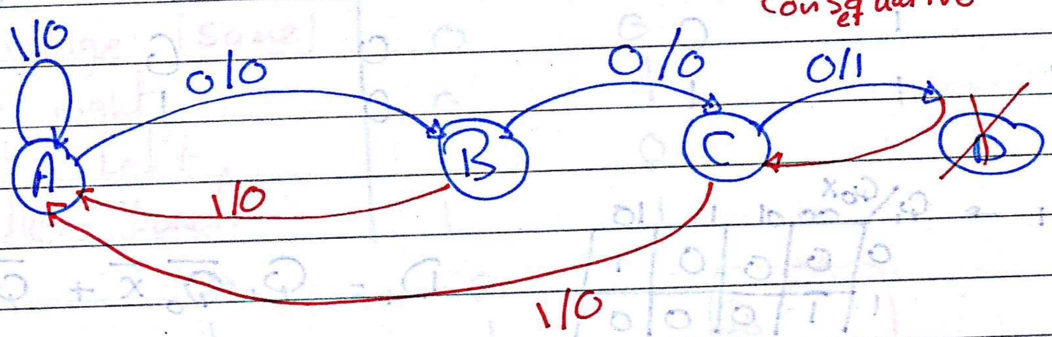
DATE 17.12.2015 Thursday

Class 32



Ex) Design A sequence detector that recognizes the occurence of 3 or More Zero's

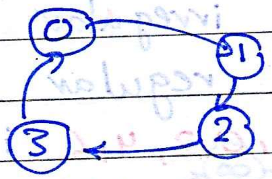
Consequative



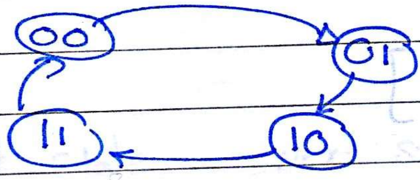
A: I'm recieving 1's
B: "0"
C "00"
D: "000"

"Class 33"

Ex) 0-3



Moore.



Types of Counters:

- A Synchrenous Counters
  - F.F are not Connected to the same Clok
  - → Not in this Course
- Synchrenous Counters
  - regular
    - up
    - down
    - up-down
  - irregular

* up-Counter → initial state 0
final state 2^n-1 → n = # of F.F
step width 1
next state = Current state +1

down-Counter → initial state 2^n-1 → n = # of F.F
final state 0
step width 1
next state = Current state -1

up-down → x → Counter behaviour
0 → up
1 → down

"Class 32"

e.g) 0-4 irregular
0-7 regular
0,2,4,6,0,2,4,6 irregular
0,1,2,3,5,4,6,7,0 irregular

* Modulus_n } → [0, n-1]
Mod_n }

Ex) Mod_6
[0,5] irregular

Ex) Mod_8
[0,7] regular

\- Counter design steps,

1) We need to find # of f.f from the max number

Ex) 0,3,10,0,3,10 --
\# of f.f = 4

Ex) (7-0) # of f.f = 3

2) Determine f.f Type
T, JK

3) Determine of f.f are postive or negative edge

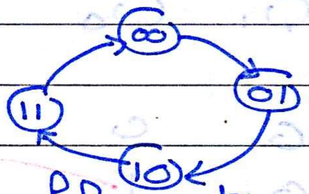
4) Determine the intital State and the final state of the f.f.

DATE 20-12-2015
Sunday

"Class 33"

e.g) 0-3 Counter (00-11)2

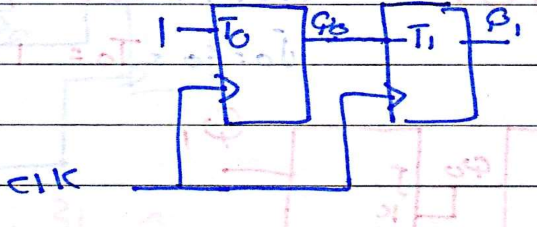
# of F.F = 2



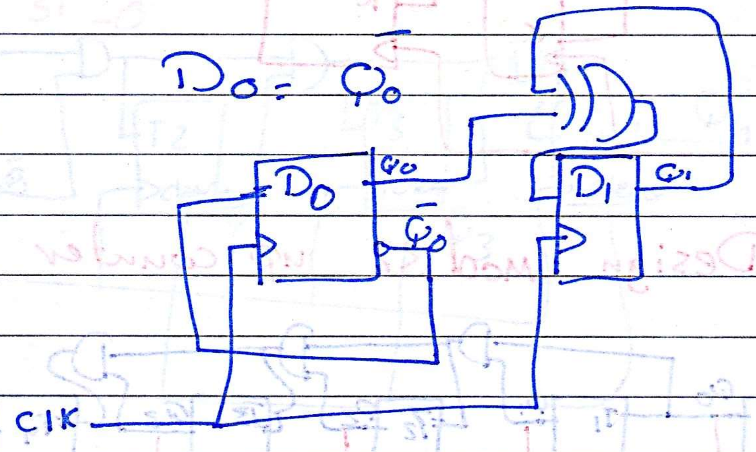
F.F inputs → use Anyone.

Current state		Next state		T_1	T_0	D_1	D_0
Q_1	Q_0	Q_1	Q_0				
0	0	0	1	0	1	0	1
0	1	1	0	1	1	1	0
1	0	1	1	0	1	1	1
1	1	0	0	1	1	0	0

$T_1 = Q_0$ $T_0 = 1$



$D_1 = Q_1 \oplus Q_0$ $D_0 = \bar{Q_0}$



"Class 33"

Ex) 0-7 counter

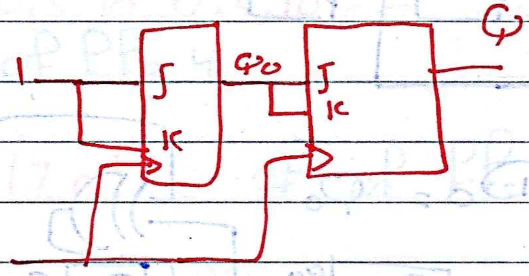
current state			next state					
Q_2	Q_1	Q_0	Q_2	Q_1	Q_0	T_2	T_1	T_0
0	0	0	0	0	1	0	0	1
0	0	1	0	1	0	0	1	1
0	1	0	0	1	1	0	0	1
0	1	1	1	0	0	1	1	1
1	0	0	1	0	1	0	0	1
1	0	1	1	0	1	0	1	1
1	1	0	1	1	1	0	0	1
1	1	1	0	0	0	1	1	1

$T_2 = Q_0 Q_1$

$T_3 = Q_0 Q_1 Q_2$

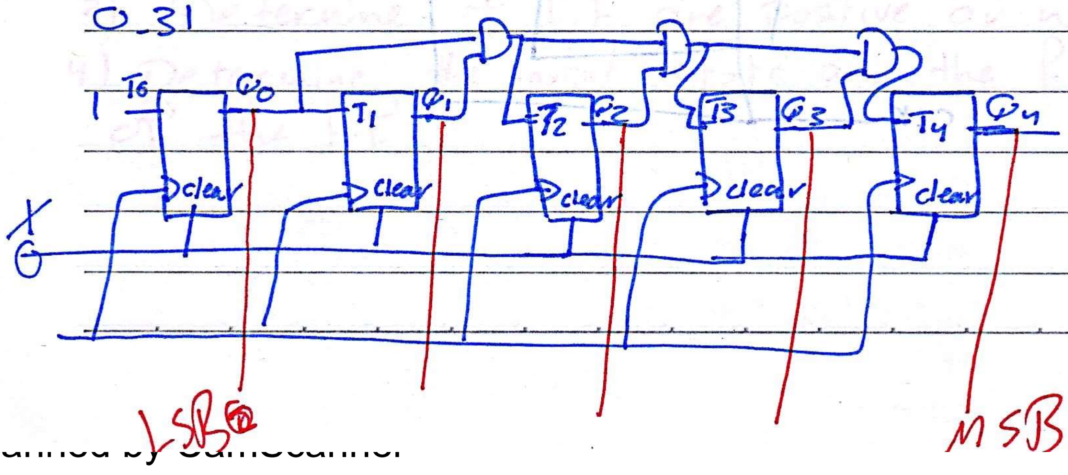
$J_i = K_i = T_i = Q_{i-1} \cdot Q_{i-2} ---- Q_0$

$J_0 = K_0 = T_0 = 1$



Ex) Design mod 32 up counter using T F.F.

0-31



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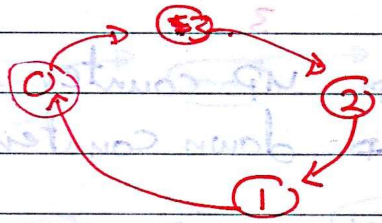
DATE 20-12-2015
Sunday

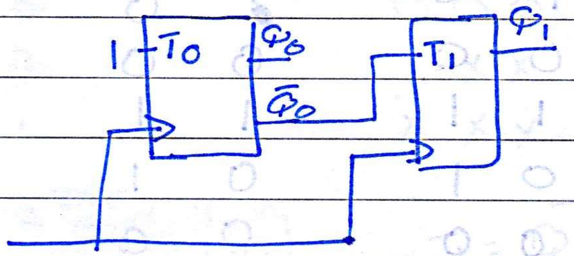
"Class 33"

- Down counter 3-0

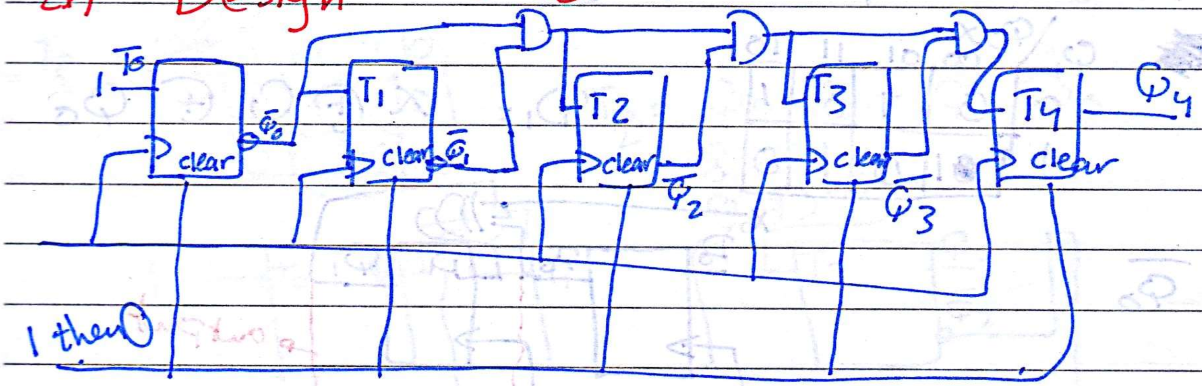


Current state		next state		F.F Inputs	
Q_1	Q_0	Q_1	Q_0	T_1	T_0
0	0	1	1	1	1
0	1	0	0	0	1
1	0	0	1	1	1
1	1	1	0	0	1

$T_0 = 1$ $T_1 = \overline{Q_0}$



Ex) Design 31-0

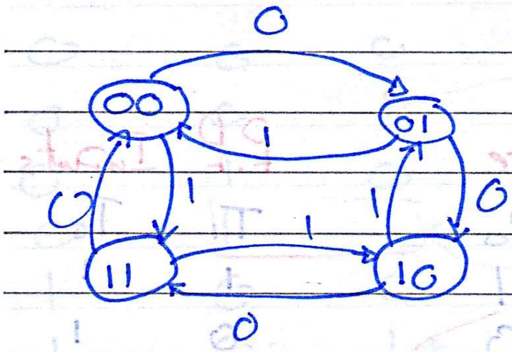


„class 34„

Ex) design up-down count 0-3
3-0

# of F.F = 2

If $x=0 \rightarrow$ up counter
If $x=1 \rightarrow$ down counter.



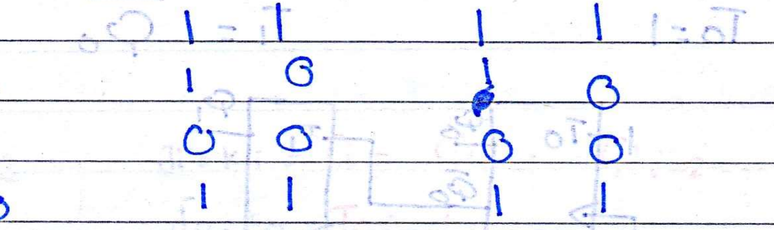
Current state		Inputs	next state		F.F	
Q_1	Q_0	X	Q_1	Q_0	D_1	D_0
0	0	0	0	1	0	1
0	0	1	1	1	1	1
0	1	0	1	0	1	0
0	1	1	0	0	0	0
1	0	0	1	1	1	1
1	0	1	0	1	0	1
1	1	0	0	0	0	0
1	1	1	1	0	1	0

D_1

Q_1 \ Q_0X	00	01	11	10
0	0	1	0	1
1	1	0	1	0

$$D_1 = X \oplus Q_1 \oplus Q_0$$

$$D_0 = \overline{Q_0}$$



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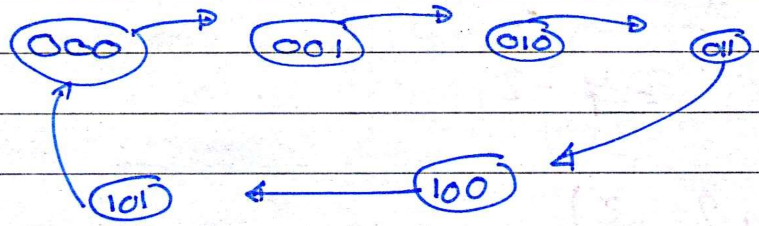
DATE 22-10-2015
Tuesday

Class 34

Irregular →

Ex1) Design Mod_6 counter 0.5



110
111
→ Missing

Current state			Next state			F.F Inputs		
Q_2	Q_1	Q_0	Q_2	Q_1	Q_0	T_2	T_1	T_0
0	0	0	0	0	1	0	0	1
0	0	1	0	1	0	0	1	1
0	1	0	0	1	1	0	0	1
0	1	1	1	0	0	1	1	1
1	0	0	1	0	1	0	0	1
1	0	1	0	0	0	1	0	1
1	1	0	X	X	X	X	X	X
1	1	1	X	X	X	X	X	X

$T_0 = 1$

T_1 →

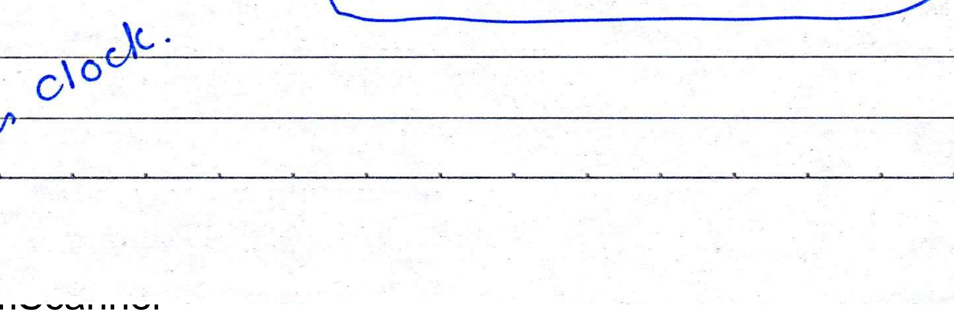
$Q_2 \backslash Q_1Q_0$	00	01	11	10
0	0	1	1	0
1	0	0	x	x

$T_1 = \overline{Q}_2 Q_0$

T_2 →

$Q_2 \backslash Q_1Q_0$	00	01	11	10
0	0	0	1	0
1	0	1	x	x

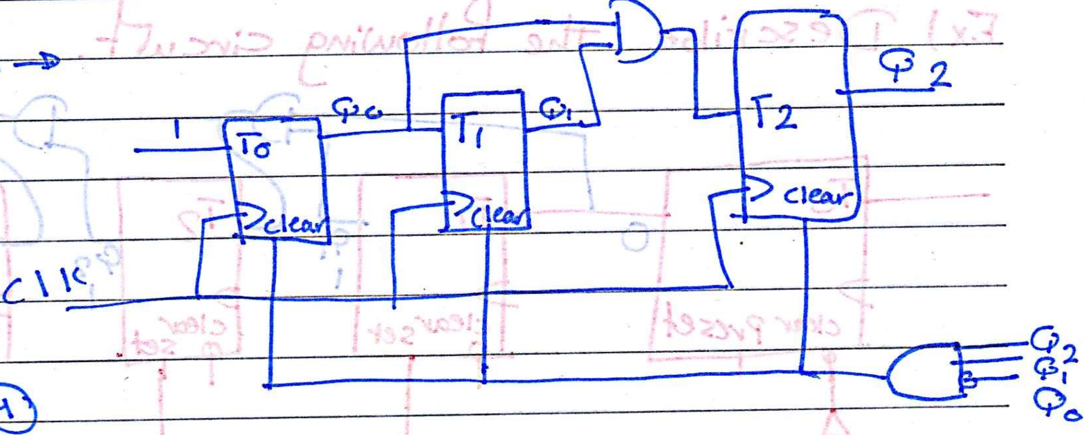
$T_2 = Q_2 Q_0 + Q_1 Q_0$



with clock.

"Class 34"

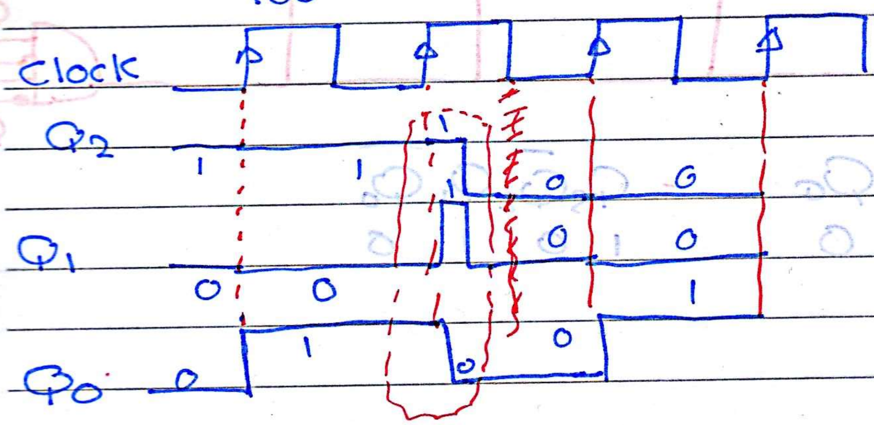
For simplify →



0-7 →

~~6,7~~

Start from ④
100



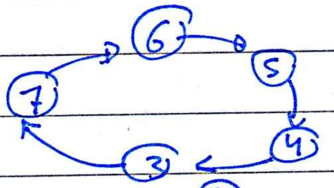
Conditions for simplifing irregular counters:-

① The count must be up or down but not both.

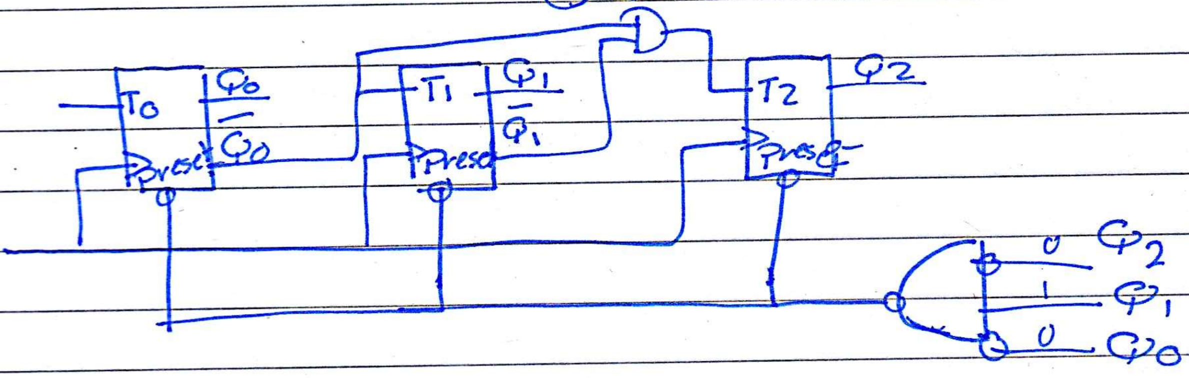
② Stop wdt must be 1

NS = PS+1
= PS-1

Ex) 7-3

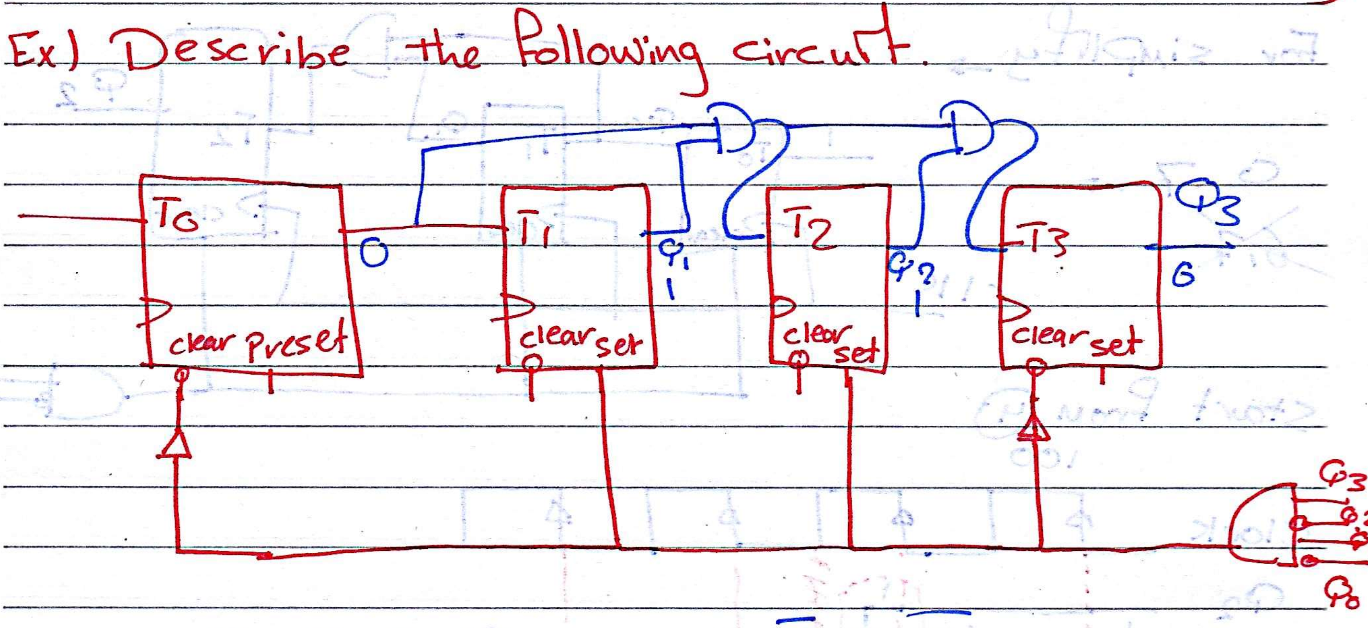


Preset On 2



,class 34,

Ex) Describe the following circuit.



$Q_3 Q_2 Q_1 Q_0 \quad = Q_3 \overline{Q_2} Q_1 \overline{Q_0}$

0 1 1 0   1 0 1 0

[3_9]