NOT ▷○

AND D 乘

OR D 加

XOR ))D ⊕
↳ 不一樣為 1

XNOR ))○ ≡
↳ 一樣為 1

## LAWS

duality： AND/OR 互換 、 1·0 互換

Distributive： $X+YZ=(X+Y)(X+Z)$

DeMorgan's： $(X+Y)'=X'Y'$

$(XY)'=X'+Y'$

Another： $(X+Y)(X'+Z)=XZ+X'Y$

$X\oplus Y=X'Y+XY'$

$X\equiv Y=X'Y'+XY$

Uniting： $XY+XY'=X$

$(X+Y)(X+Y')=X$

Absorption： $X+XY=X$

$X(X+Y)=X$

Elimination： $X+X'Y=X+Y$

$X(X'+Y)=XY$

Consensus： $XY+X'Z+YZ=XY+X'Z$

$(X+Y)(X'+Z)(Y+Z)=(X+Y)(X'+Z)$

## MIN / MAXTERM

SOP： counting 1's

POS： counting 0's (find SOP of F' and DeMorgan's to F)

$X+X'=1$

(m) minterm： 每個 variable 都出現一次的 SOP e.g. $m_0=A'B'C'$

$XX'=0$ (M) maxterm： 同上，但 POS e.g. $M_0=A+B+C$

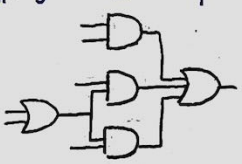
$F=\Sigma m(3,4,5,6,7)=\Pi M(0,1,2)$ / $F'=\Sigma m(0,1,2)=\Pi M(3,4,5,6,7)$

## KMAP

| CD \ AB | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 00 | $m_0$ | $m_4$ | $m_{12}$ | $m_8$ |
| 01 | $m_1$ | $m_5$ | $m_{13}$ | $m_9$ |
| 11 | $m_3$ | $m_7$ | $m_{15}$ | $m_{11}$ |
| 10 | $m_2$ | $m_6$ | $m_{14}$ | $m_{10}$ |

## CIRCUITS

level: 3 2 1



gates: 5 inputs: 11

SOP → AND(2) - OR(1)

POS → OR - AND

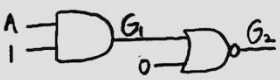
bubbles 往後推

交換 AND - OR

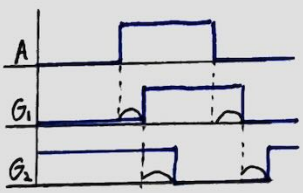
NAND ≡ AND - NOT

NOR ≡ OR - NOT

## TIMING




propagation delay: 20ns




## HAZARD

Static 1-/0- Hazard

output momentarily goes to 0/1 when it should remain a constant 1/0

Dynamic Hazard

output change 3↑ times when changes from 0→1 (1→0)

Remove static 1-/0-

add additional loops for adjacent 1's/0's

Avoid: 不能省略 $XX'X$ 、 $X+X'+\beta$ 、 treat $X$ $X'$ as different variable

分析： static 1-hazard ： 看相鄰的 1 有沒有被 loop

static 0-hazard ： 看 $XX'\alpha$ ， adjacent 0's differ in value of $X$ when $\alpha=1$

dynamic hazard： 看 $XX'\alpha$ ， adjacent 0 and 1 differ in value of $X$ when $\alpha=1$

再看該變化經過的路徑 ≥ 3