ElCoM
ELECTRICAL COMPUTER MECHATRONICS

تقدم لجنة ElCoM الاكاديمية

تلخيص لمادة:

الكترونيات رقمية

للطالبة:

عريب قفيشة

بقلم الطالبة:

قنوت الحيصة

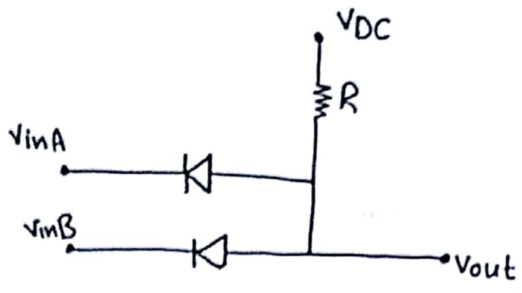
Digital Electronics

First :- "Ch'2' DRL"

DRL cct :

"DRL And gate"

⇓



$$I = \frac{(V_{DC} - V_\gamma) - V_{in}}{R}$$

$$-V_{DC} + V_\gamma + V_{in} = 0$$

$$V_{in} = V_{DC} - V_\gamma$$

*Diode off :

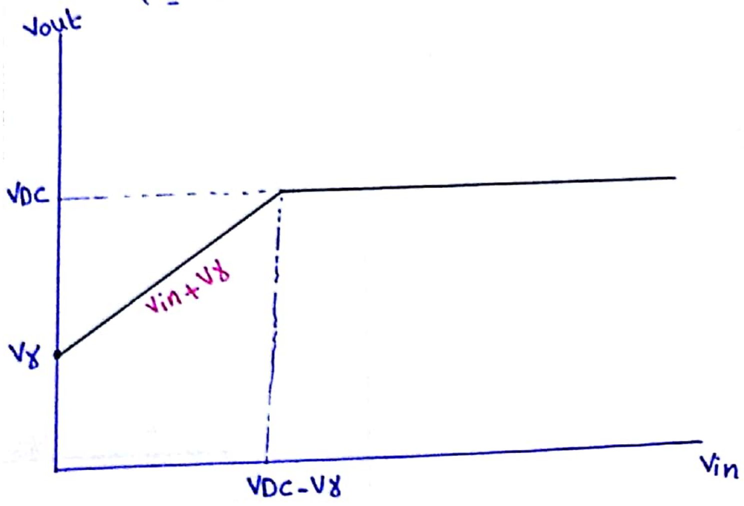
$V_{in} > V_{DC} - V_\gamma$

$I = 0$

*Diode on :

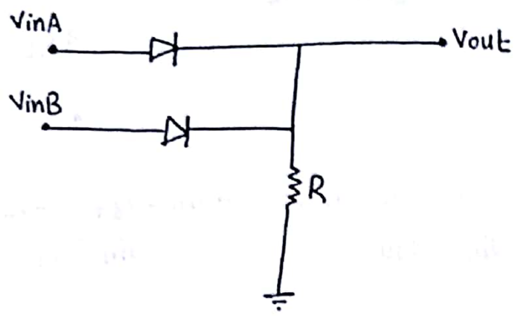
$V_{in} < V_{DC} - V_\gamma$

$I \rightarrow$ (القيمة)



* "DRL oR gate"

⇓



$$-V_{in} + V_\gamma + IR = 0$$

$$I = \frac{V_{in} - V_\gamma}{R}$$

*Diode off :

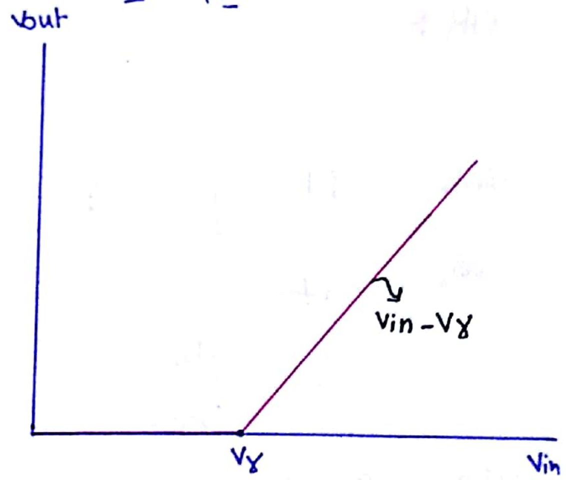
$V_{in} < V_\gamma$

$I = 0$

*Diode on :

$V_{in} > V_\gamma$

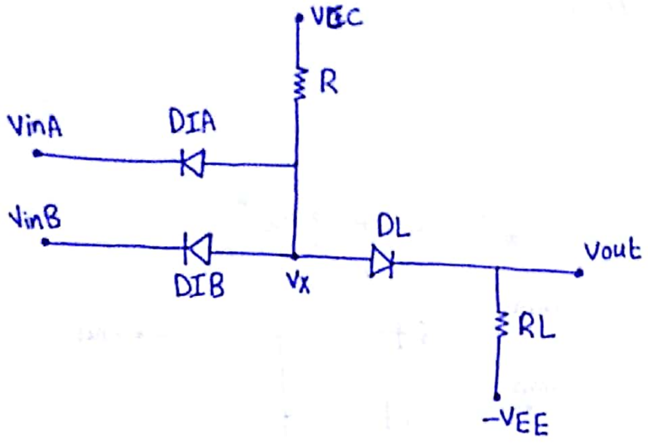
$I \rightarrow$ (القيمة)



$$-V_{out} - V_\gamma + V_{in} = 0$$

$$V_{out} = V_{in} - V_\gamma$$

And



[1] DI-on , DL-on :-

$-V_{in} - V_\gamma + V_\gamma - V_{EE} + RI = 0 \Rightarrow I = \frac{V_{in} + V_{EE}}{R}$

$V_{in} = V_{out}$ $\quad V_{in} = V_{EE}$

[2] DI-on , DL-off :-

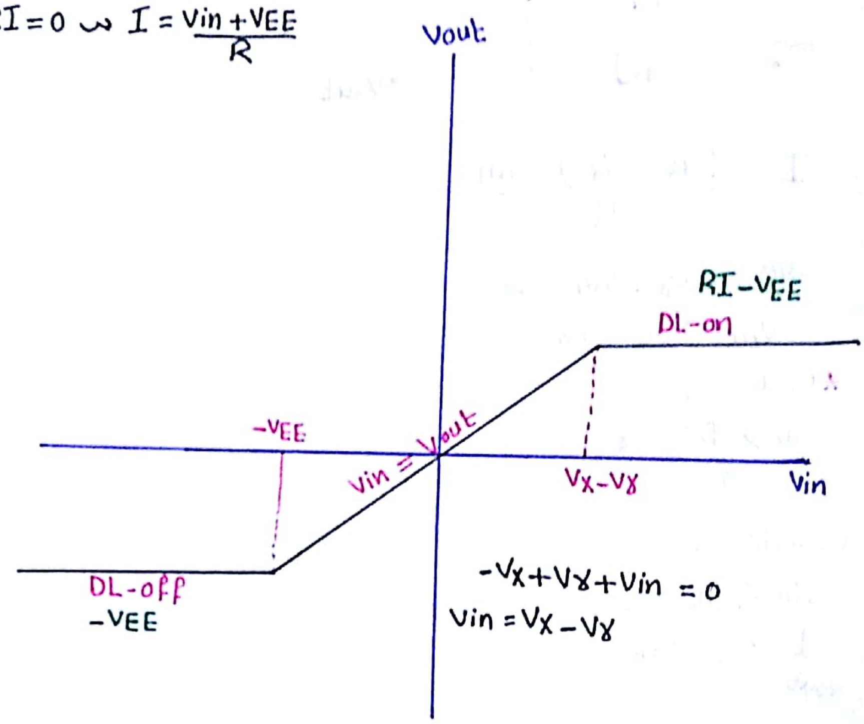
$V_{out} = -V_{EE}$

[3] DI-off , DL-on :-

$-V_{CC} + RI + V_{DL} + I R_L - V_{EE} = 0$

$I = \frac{V_{CC} + V_{EE} - V_\gamma}{R}$

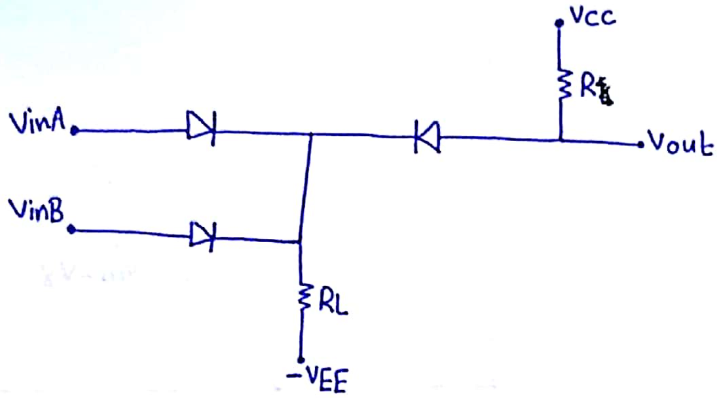
$V_{out} = RI - V_{EE}$



$-V_x + V_\gamma + V_{in} = 0$

$V_{in} = V_x - V_\gamma$

OR :-



[1] DIon , DL-on

$V_{in} = V_{out}$

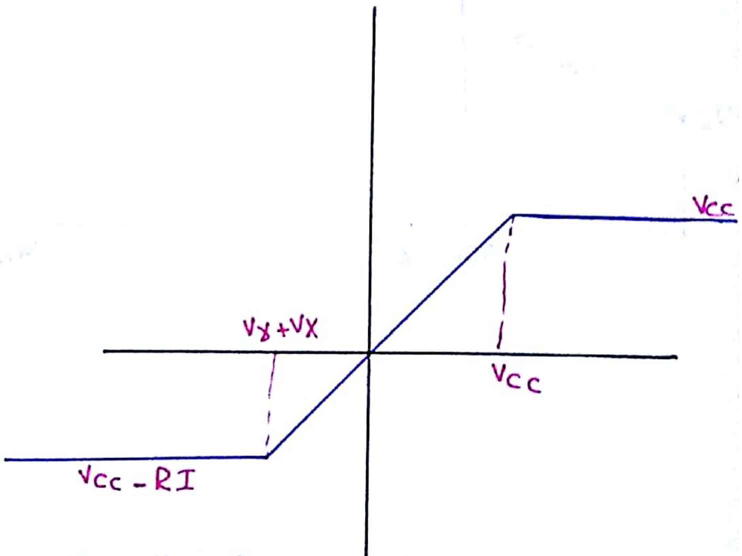
[2] DI-on , DL-off

$V_{out} = V_{CC}$

[3] DI-off , DL-on

$-V_{CC} + (R+R)I + V_\gamma - V_{EE} = 0$

$I = \frac{V_{CC} + V_{EE} - V_\gamma}{R+R}$ $\Rightarrow V_{out} = V_{CC} - RI$



$-V_{CC} + RI + V_\gamma - V_\gamma + V_{in} = 0$

$I = \frac{V_{CC} - V_{in}}{R}$

$-V_{in} + V_\gamma + V_X = 0$

$V_{in} = V_\gamma + V_X$

Ch "4" :-

* Operation modes:

1 Cut off

(B-E), (B-C) → both reverse

$I_B = I_C = I_E = 0$

2 F.A

(B-E) FA (B-C) Reverse

$I_C = \beta I_B$

$I_E = (\beta+1) I_B$

$I_E = I_C + I_B$

3 RA

(B-E) RA (B-C) FA

$I_C = (1+\beta) I_B$

$I_E = \beta I_B$

$V_{BC}(RA) = 0.7$

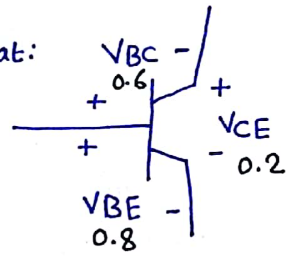
4 Saturation mode:

(B-E) FA (B-C) FA

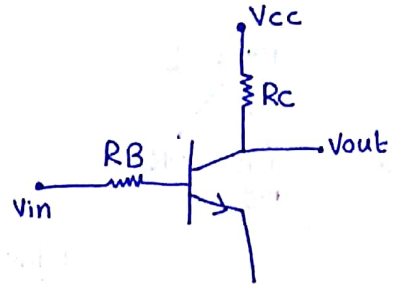
$I_E = I_C + I_B$

$I_E = \sigma \beta_F I_B$

Sat:



*(TTL)



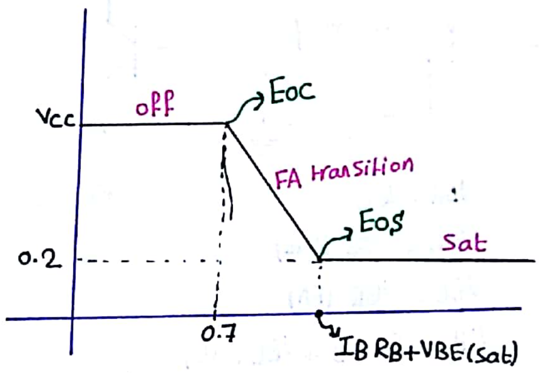
$V_{OL} = V_{CE}(sat)$

$V_{OH} = V_{CC}$

$V_{IL} = V_{BE}(FA)$

$V_{IH} = I_B R_B + V_{BE}(sat)$

$I_B \rightarrow \frac{I_C}{\beta} \rightarrow \frac{V_{CC} - V_{CE}(sat)}{R_C}$



at Eos → $\sigma = 1$

* إذا كانت pnp :-

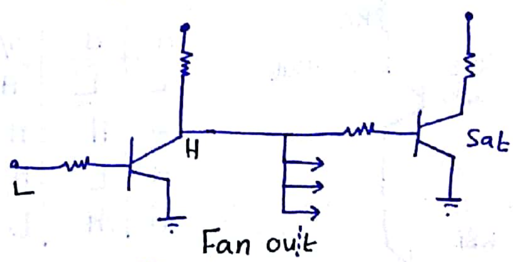
L I/P → Sat

H I/P → off

* $HNM = V_{OH} - V_{IH}$

$LNM = V_{OL} - V_{IL}$

*



$N = \frac{I_{OH}}{I_{IL}}$

دائماً ناخذه للأقل integer

مثل :

4.2 ≃ 4

4.54 ≃ 4

4.7 ≃ 4

Ch"5" RTL

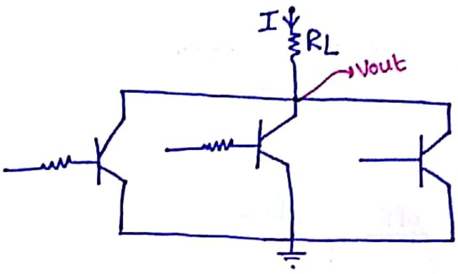
npn

- Series
  - And
  - NAND [inv]
- Parallel
  - NoR [inv]
  - oR

pnp

- Series
  - NoR [inv]
  - oR
- parallel
  - AND
  - NAND [inv]

inv
الـ o/p عند الـ C (C-E)
non-inv
الـ o/p عند الـ E (C-C)



$V_{OH} = V_{CC}$

$V_{OL} = V_{CE}(sat)$

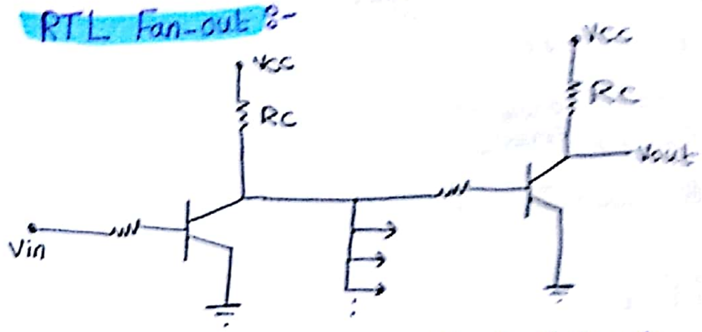
$V_{IL} = V_{BE}\ (FA)$

$V_{IH} = I_B R_B + V_{BE}(sat)$

A	B	o/p
L	L	H
L	H	L
H	L	L
H	H	L

$\overline{A+B}$

RTL Fan-out :-



$N = \frac{I_{OH}}{I_{IH}}$

$-V_{CC} + I_{OH} R_C + V_{OH} = 0$

$I_{OH} = \frac{V_{CC} - V_{OH}}{R_C}$

$-V_{OH} + R_B I_{IH} + V_{BE}(sat) = 0 \Rightarrow I_{IH} = \frac{V_{OH} - V_{BE}(sat)}{R_B}$

$N = \frac{V_{CC} - V_{out}}{V_{out} - V_{BE}(sat)} \cdot \frac{R_B}{R_C}$

$V_{OH} = V_{IH} = I_B R_B + V_{BE}(sat)$

$I_B = \frac{I_C}{\beta}$, $I_C \rightsquigarrow \frac{V_{CC} - V_{BE}(sat)}{R_C}$

$P_{CC}(avg) = \frac{I_{CC}(OH) + I_{CC}(OL)}{2} \cdot V_{CC}$

$I_{CC}(OH) \rightsquigarrow$ without Load لوحده

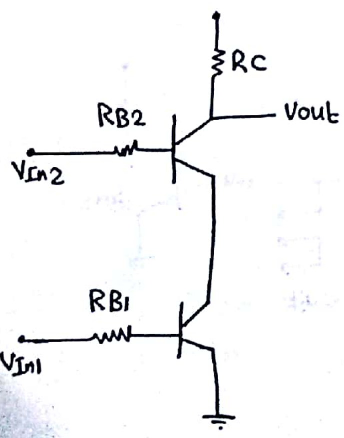
$I_{RC} = I_{CC} = 0$

$I_{CC}(OH) = N I_B = I_{RC}$, $I_{RC} \rightsquigarrow V_{CC} - I_{RC} R_C$, $I_B \rightsquigarrow \frac{V_{out} - V_{BE}(sat)}{R_B}$

$I_{CC}(OH) = I_{RC} = N \left(\frac{V_{CC} - V_{BE}'(sat)}{R_B' + N R_C} \right)$

$I_{CC}(OL) = \frac{V_{CC} - V_{CE}(sat)}{R_C}$

RTL NAND



A	B	o/p
L	L	H
L	H	H
H	L	H
H	H	L

Logic Function $= \overline{AB}$

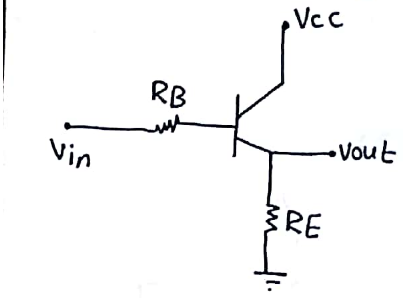
$V_{OH} = V_{CC}$

$V_{OL} = N\ V_{CE}(sat)$

	V_{IL}	V_{IH}
①	$V_{BE}\ (FA)$	$I_B R_B + V_{BE}(sat)$
②	$V_{B_1E_2}(FA) + V_{CE_1}(sat)$	$I_{B_2} R_{B_2} + V_{BE_2}(sat) + V_{CE}(sat)$

Sec 5.6 :

RTL non-inverter



$V_{OH} = V_{CC} - V_{CE(sat)}$

$V_{OL} = 0$

$V_{iL} = V_{BE}(F.A)$

$V_{iH} = I_B R_B + I_E R_E + V_{BE}(F.A)$

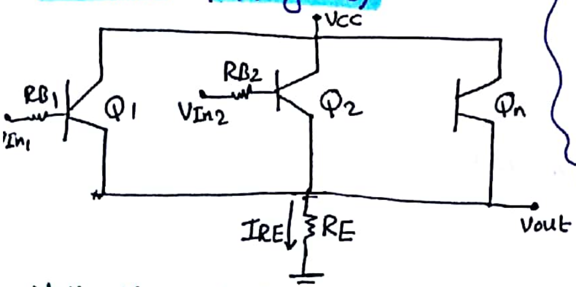
or

$-V_{iH} + I_B R_B + V_{BC}(sat) + V_{CC} = 0$

$V_{iH} = V_{CC} + V_{BC}(sat) + I_B R_B$

$I_B = \dfrac{V_{CC} - V_{CE}(sat)}{(\beta+1) R_E}$

non-inv (OR gate)



$V_{OH} = V_{CC} - V_{CE}(sat)$ $\quad V_{OL} = 0$

$V_{iL} = V_{BE}(F.A)$

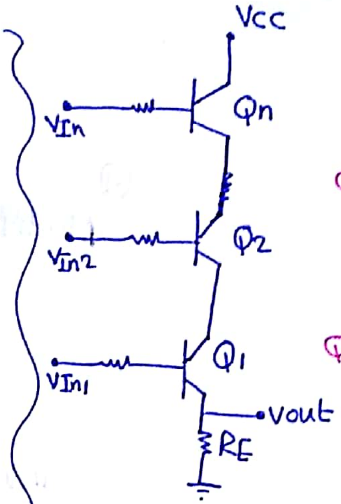
$V_{iH} = V_{CC} + V_{BC}(sat) + I_B R_B$

$I_B = \dfrac{V_{CC} - V_{CE}(sat)}{(\beta+1) R_E}$

$= I_B R_B + I_E R_E + V_{BE}(FA)$

A	B	O/P
L	L	L
L	H	H
H	L	H
H	H	H

(And gate) :-

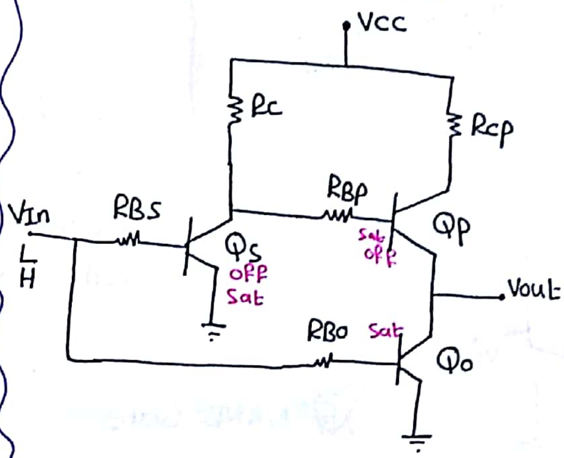


$V_{OH} = V_{CC} - N V_{CE}(sat)$

$V_{OL} = 0$

	V_{iL}	V_{iH}
Q_1	$V_{BE}(F.A)$	$V_{BE}(FA) + I_B R_B + I_E R_E$
Q_2	$V_{BE}(FA) + V_{CE}(sat)$	$V_{BE}(sat) + I_B R_B + I_E R_E + V_{CE}(sat)$

RTL with active pull-up



$Q_o \Rightarrow$ pull-down, sink for the load

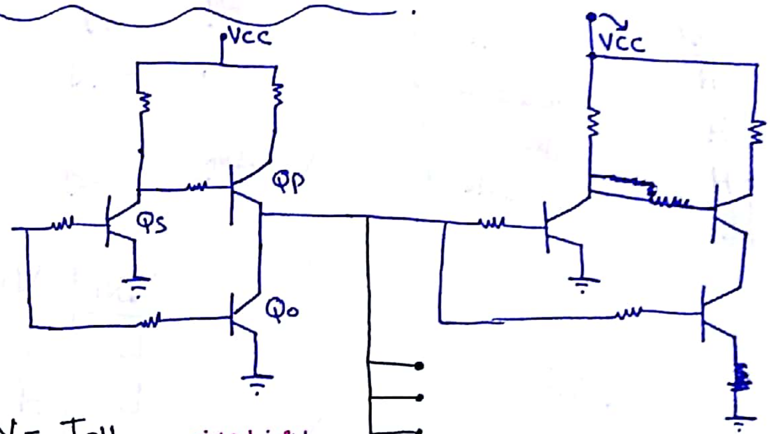
$Q_o, Q_s \rightarrow$ inv

$Q_p \rightarrow$ non-inv

$R_{cp} \simeq 0.1 R_c$

$R_{cp} < R_c$

لأنهم في نفس الـ mode Q_o, Q_s



$N = \dfrac{I_{OH}}{I_{IH}}$ لازم نحط 2 لانه التيار متوزع بينهم

$I_{OH} = N I_{IH} = 2N I_B$

$I_{OH} = I_{EP} \simeq I_{Rcp} = 2N I_B$

$I_{OH} = 2N I_B$

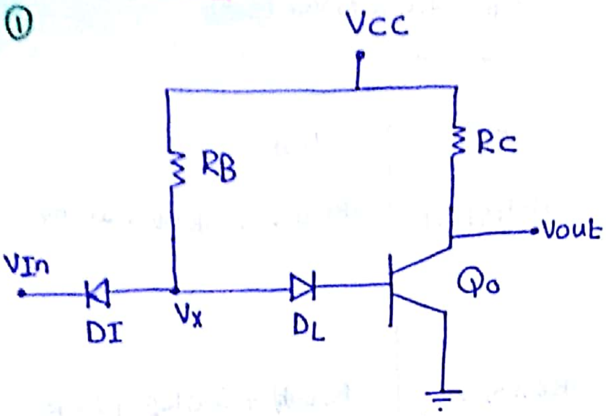
$\dfrac{V_{CC} - V_{CE}(sat) - V_{OH}}{R_{cp}} = 2N \cdot \dfrac{V_{OH} - V_{BE}(sat)}{R_B}$ $\quad$ $R_{Bo} = R_{BS}$

$N = \dfrac{V_{CC} - V_{CE}(sat) - V_{out}}{V_{out} - V_{BE}(sat)} \cdot \dfrac{R_B}{2R_{cp}}$

$V_{out} = V_{iH}$

Ch6 :- DTL

①

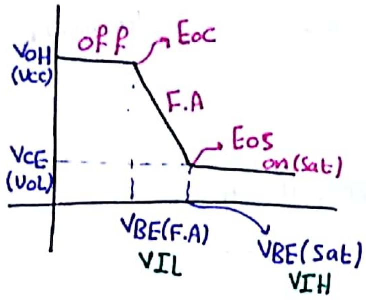


$V_{OL} = V_{CE}(sat)$

$V_{OH} = V_{CC}$

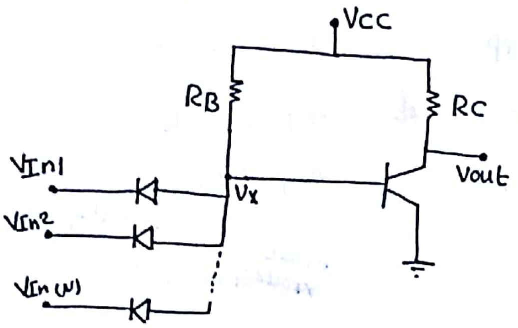
$V_{iL} = V_{BE}(FA)$

$V_{iH} = V_{BE}(sat)$



②

DTL NAND Gate:

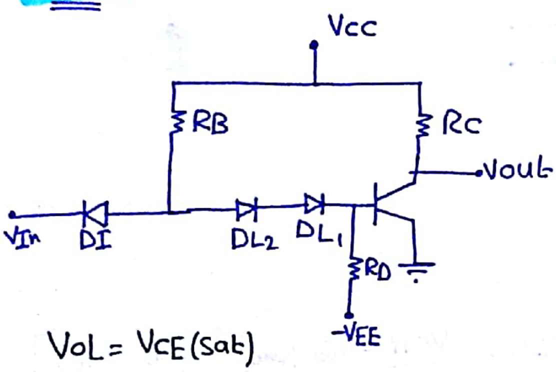


A	B	O/P
0	0	H
0	1	H
1	0	H
1	1	L

اذا I/P Low ح يمنع تشغيله لانه ح يشغل ال diode

③

6.2



$V_{OL} = V_{CE}(sat)$

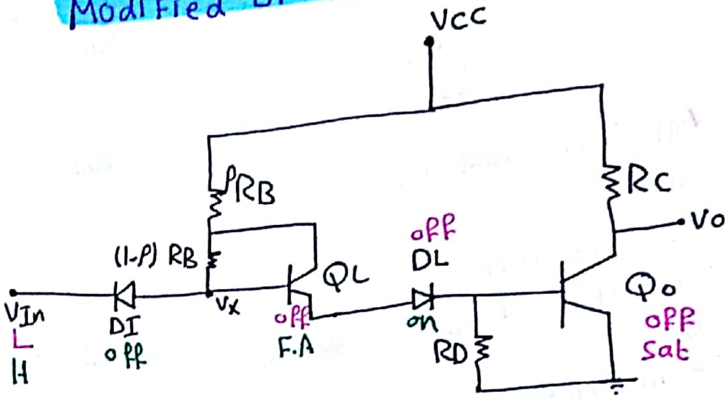
$V_{OH} = V_{CC}$

$V_{iL} = V_{BE}(FA) + V_D(on)$

$V_{IH} = V_{BE}(sat) + V_D(on)$

④

Modified DTL :-



$V_{OH} = V_{CC}$

$V_{OL} = 0$

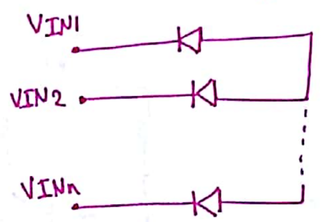
$V_{iL} = 2V_{BE}(FA)$

$V_{IH} = V_{BE}(FA) + V_{BE}(Sat)$

⑤

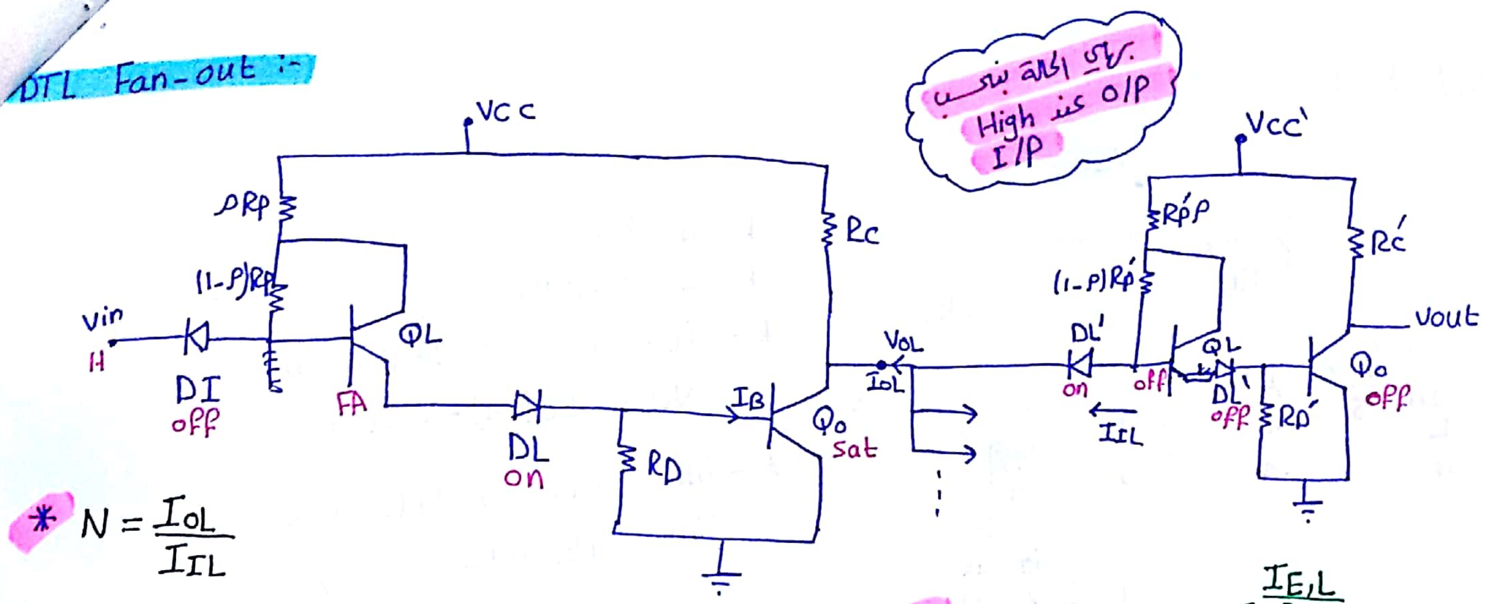
NAND Gate

بنفضل الرمز D



VIN1	VIN2	O/P
L	L	H
L	H	H
H	L	H
H	H	L

DTL Fan-out :-



* $N = \dfrac{I_{OL}}{I_{IL}}$

* $-V_{CC} + R_B I_{IH} + V_\gamma + V_{CE(sat)} = 0$

$I_{IH} = \dfrac{V_{CC} - V_\gamma - V_{CE(sat)}}{R_B}$

* $-V_{CC} + \rho R_B I_E + I_{B,L}(1-\rho) R_B + V_{BE,L(FA)} + V_{DL(on)} + V_{BE,o(sat)} = 0$, where $I_{B,L} = \dfrac{I_{E,L}}{\beta+1}$

* $I_{OL} = I_{C,o} - I_{RC}$

$I_{C,o} \rightarrow 6\beta I_{Bo}$, $\quad I_{RC} \rightarrow \dfrac{V_{CC} - V_{CE(sat)}}{R_C}$

$I_{Bo} = I_{E,L} - I_{RD}$, $\quad I_{RD} = \dfrac{V_{BE(sat)}}{R_D}$

$I_E \rightarrow$ node $\rightarrow I_{B,o}$, $\downarrow I_{RD}$

* $I_{EL} = \dfrac{V_{CC} - V_{BE,L(FA)} - V_{D,L(on)} - V_{BE(sat)}}{\rho R_B + \dfrac{(1-\rho) R_B}{\beta+1}}$ ← صغيرة كثير "نهملها"

$= \dfrac{V_{CC} - V_{BE,L(FA)} - V_{D,L(on)} - V_{BE(sat)}}{\rho R_B}$

* DTL Power Dissipation :

$P_{CC(avg)} = \dfrac{I_{CC(OH)} + I_{CC(OL)}}{2} \cdot V_{CC}$

$I_{CC(OH)} = \cancel{I_{RC}} + I_{\rho RB} = I_{\rho RB}$ ($I_{RC} = 0$; $I_{CC(OH)}$ ← I/P(L))

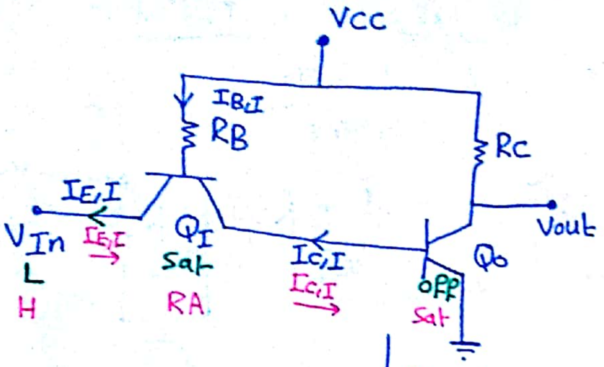
$I_{\rho RB} = \dfrac{V_{CC} - V_\gamma - V_{in(Low)}}{R_B}$

$I_{CC(OL)} = I_{RC} + I_{\rho RB}$ (I/P(H))

$I_{RC} \rightarrow \dfrac{V_{CC} - V_{CE(sat)}}{R_C}$, $\quad I_{\rho RB} \rightarrow = \dfrac{V_{CC} - V_{BE(FA)} - V_{BE(sat)} - V_\gamma}{\rho R_B}$

ممكن نكتبها كاملة انه مع (1-ρ)RB بس هي صغيرة كثير مقارنة فيها ف بنتجاهلها:

Ch7: TTL

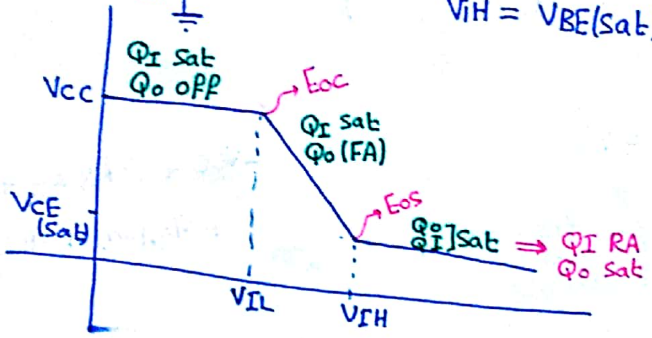


* $V_{OH} = V_{CC}$
* $V_{OL} = V_{CE(sat)}$
* $-V_{IL} - V_{CE(sat)} + V_{BE(FA)} = 0$

$V_{IL} = V_{BE(FA)} - V_{CE(sat)}$

* $-V_{IH} - V_{CE(sat)} + V_{BE(sat)} = 0$

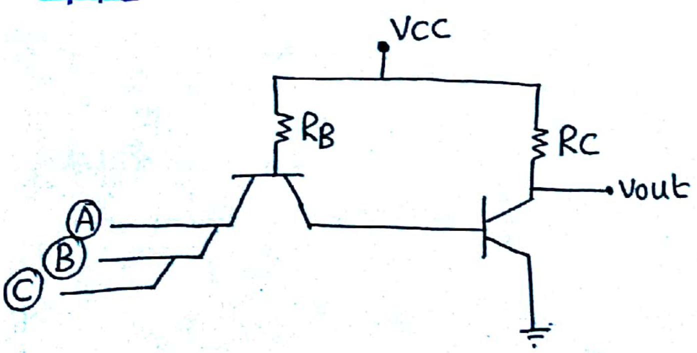
$V_{IH} = V_{BE(sat)} - V_{CE(sat)}$



* Comparison between TTL and DTL

1. D_I, D_L in DTL is replaced by QI
2. TTL has a higher fan-out
3. TTL faster than DTL
4. $I_{TTL} \ggg I_{DTL}$
5. Less propagation delay time

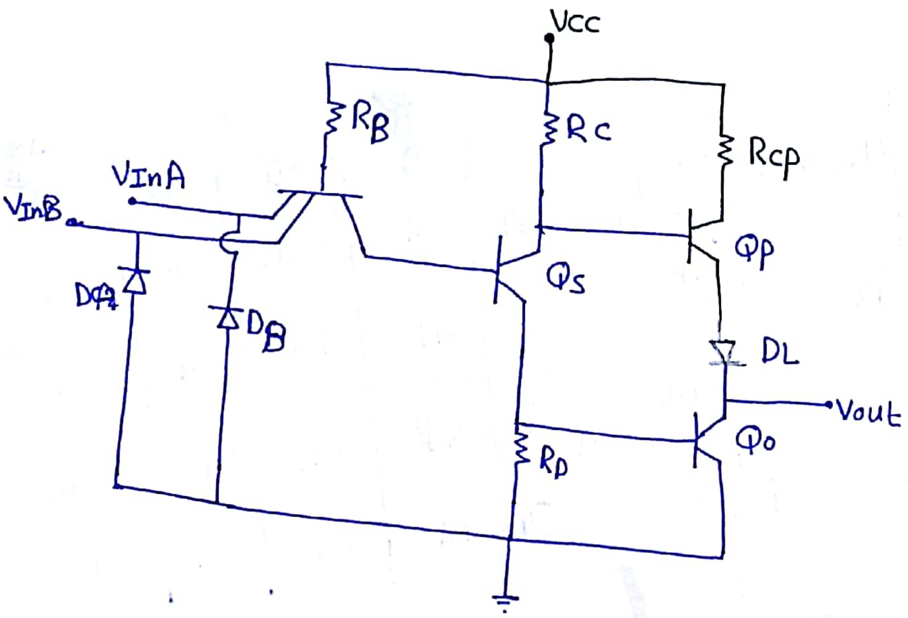
TTL NOR:



A	B	O/P
L	L	H
L	H	L
H	L	L
H	H	L

$= \overline{A+B}$

Standard TTL:



- DA, DB for protection
- Qo pull down
- Qp, Rcp pull up
- Qs : Logic inversion
  driving cct for Qo

$R_c \gg R_{cp}$

$R_{cp} = 0.1 R_c$

Comparison between TTL (basic and Standard)

$I_{standard} > I_{basic}$

R_{cp} < R_c
Standard basic

$\tau_{standard} \ll \tau_{basic}$

عالي

$\tau_{standard} \rightarrow (R_{cp})(c)$

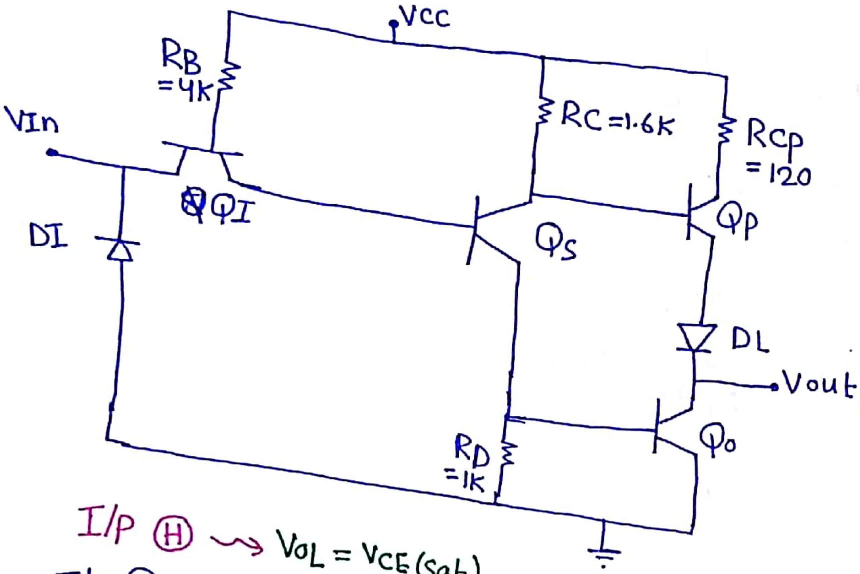
$\tau_{basic} \rightarrow (R_c)(c)$

$$\frac{V_{CC} - V_{CE/p(sat)} - V_\gamma - V_{CE/o(sat)}}{R_{cp}}$$

$$\frac{V_{CC} - V_{CE(sat)}}{R_c}$$

[illegible]

TTL Fan



	① (L)	②	③	④ (H)
QI	Sat	Sat	Sat	RA
Qs	off	FA	FA	Sat
Qo	off	off	FA	Sat
QP	FA	FA	FA	off

I/P (H) ⟶ $V_{OL} = V_{CE(sat)}$

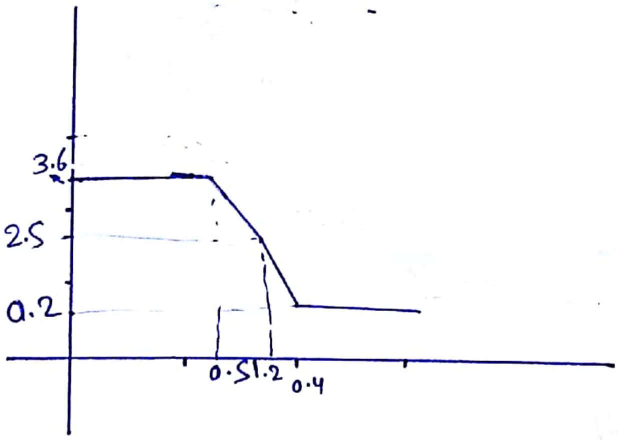
I/P (L) ⟶ $V_{OH} = V_{CC} - V_{BE}(FA) - V_\gamma$
$= 5 - 0.7 - 0.7$
$= 3.6$

* $V_{OB} = V_{cc} - I_C R_C - V_{BE,P} - V_\gamma$
$= 2.5$

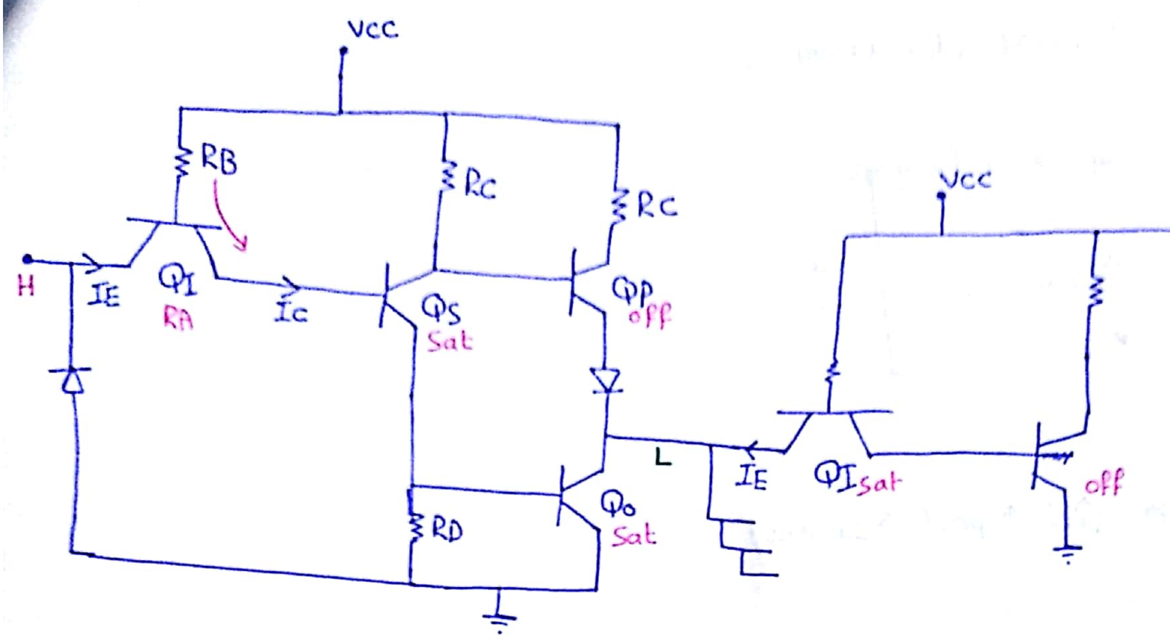
* $V_{iL} = V_{BE}(FA) - V_{CE}(sat)$
$= 0.7 - 0.2$
$= 0.5$

* $V_{iH} = 2V_{BE}(sat) - V_{CE}(sat)$
$= 1.6 - 0.2$
$= 1.4$

* $V_{iB} = 2V_{BE}(FA) - V_{CE}(sat)$
$= 1.4 - 0.2$
$= 1.2$



TTL Fan-out



بشتغل على High I/p

$N = \frac{I_{oL}}{I_{IL}}$

* $I_{IL} = \frac{V_{CC} - V_{BE,o}(sat) - V_{CE,I}(sat)}{R_B}$

* $I_{oL} = 6\beta I_{B,o}$

* $I_{B,o} = I_{E,S} - I_{RD}$

$I_{RD} \rightarrow \frac{V_{BE}(sat)}{R_D}$

$I_{E,S} \rightarrow I_{B,S} + I_{C,S}$

$I_{B,S} = I_{C,I} = (1+\beta) I_{B,I}$

$I_{C,S} = \frac{V_{CC} - V_{CE,S}(sat) - V_{BE,o}(sat)}{R_C}$

$I_{B,I} = \frac{V_{CC} - V_{BC,I} - 2V_{BE}(sat)}{R_B}$

$V_{BC}(RA) = 0.7$

Power Dissipation:

$P_{CC} = \frac{I_{CC}(oH) + I_{CC}(oL)}{2} * V_{CC}$

* $I_{CC}(oH) = I_{RB}(oH) + I_{RC}(oH) + I_{Rcp}(oH)$ (I/p (L)), with $I_{RC}(oH) = 0$, $I_{Rcp}(oH) = 0$

$I_{RB}(oH) = \frac{V_{CC} - V_{BE,I}(sat) - V_{In}(low)}{R_B}$

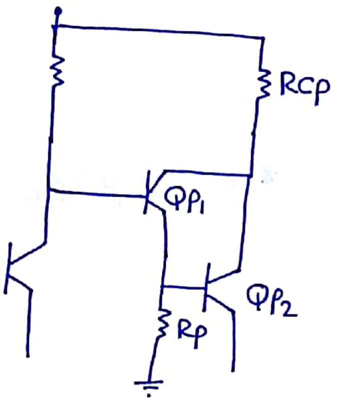
* $I_{CC}(oL) = I_{RB}(oL) + I_{RC}(oL) + I_{Rcp}(oL)$, with $I_{Rcp}(oL) = 0$

$I_{RB}(oL) = \frac{V_{CC} - V_{BC,I}(RA) - 2V_{BE}(sat)}{R_B}$

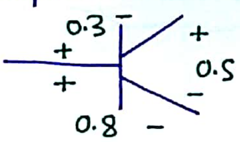
$I_{RC}(oL) = \frac{V_{CC} - V_{CE,o}(sat) - V_{BE,o}(sat)}{R_C}$

	Low power TTL (LTTL)	High speed TTL (HS TTL)	
adv	↓ power	↑ power (dis advantage)	
dis adv	↓speed , ↓ Fan out	↑speed , ↑ current	adv
	↓ current	↑ Fan out	
	↑ τ	↓ τ	

* Darlington pair : (↑N , ↑speed , ↑current)



Chapter 8 : STTL



$V_{SBD} = 0.3V$

to prevent reaching to sat mode we use Schottky diode (SBD)

* operation mode :

[1] off

(B-E) RA (B-C) RA

SBD off]
Q off] Q_{SBD} off

$I_C = I_B = I_E = 0$

[2] FA

(B-E) FA (B-C) RA

SBD off]
Q FA] Q_{SBD} FA

$I_C = \beta I_B$

$I_E = (\beta+1) I_B$

⇒ [3] HARD

(B-E) FA (B-C) FA

SBD on , Q on

$V_{BC} = V_{SBD} = 0.3$

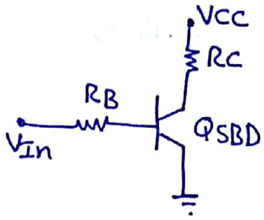
$V_{BE}(hard) = 0.8$

$V_{CE}(hard) = 0.5$

[4] Reverse Schottky (RS)

(B-E) RA (B-C) FA

SBD on] Q_{SBD} (RS)
Q off]



I/P (L) ⇝ Q_{SBD} off $V_{oh} = V_{cc}$

I/P (H) ⇝ Q_{SBD} hard

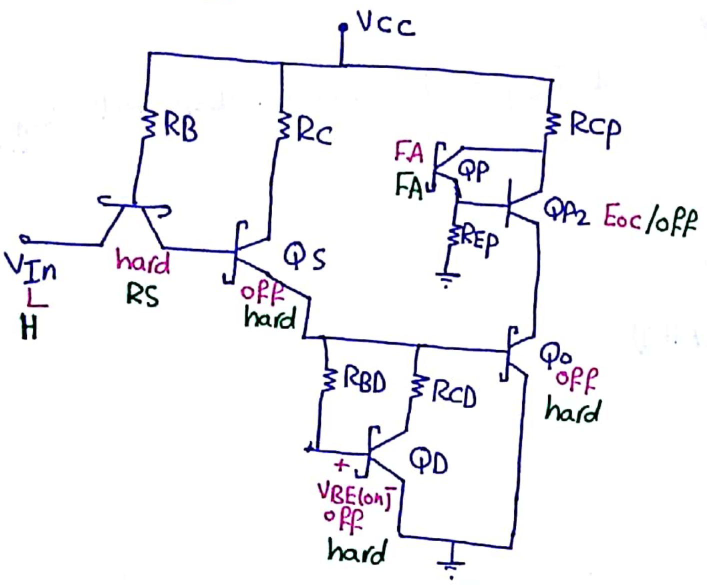
$V_{oL} = V_{CE}(hard) = 0.5$

$V_{iL} = V_{BE}(FA) = 0.7$

$V_{iH} = I_B R_B + V_{BE}(hard)$

$I_B \to \frac{I_C}{\beta} \to \frac{V_{CC} - V_{CE}(sat)}{R_C}$

STTL



* Q_D : pull down , sink for the Load discharge path for Q_o

* Q_o and Q_D work at the same time

* $V_{OH} = V_{CC} - 2V_{BE}(FA)$

* $V_{OL} = V_{CE}(hard) = 0.5$

* $V_{iL} = 2V_{BE}(FA) - V_{CE}(sat)$

* $V_{iH} = 2V_{BE}(hard) - V_{CE}(hard)$

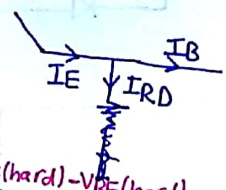
Fan-out :

بنشتغل ع High I/P

$N = \frac{I_{oL}}{I_{IL}}$

$I_{IL} = \frac{V_{CC} - V_{BE,I}(hard) - V_{CE,o}(hard)}{R_B}$

Neglect RBD (too small)



$I_{OH} = \beta I_{B,o}$

$I_{B,o} = I_{E,S} - I_{CD}$

$I_{CD} \to \frac{V_{BE,D}(hard) - V_{CE,D}(hard)}{R_{BD}}$

$IR + V_{CE}(hard) - V_{BE}(hard) = 0$

$I_{E,S} \to I_{B,S} + I_{C,S}$

$I_{C,S} \to \frac{V_{CC} - V_{CE,S}(hard) - V_{BE,o}(hard)}{R_C}$

$I_{B,S} \to \frac{V_{CC} - V_{BC}(RS) - 2V_{BE}(hard)}{R_B}$

Power dissipation:

$I_{CC}(OH) = I_{RB} + I_{RC} + I_{RCP}$ — I/P (L); $I_{RC} \to 0$ (Neglect base current)

$$* \; I_{RB} = \frac{V_{CC} - V_{BE,I}(hard) - V_{In}(Low)}{R_B}$$

$$* \; I_{RCP} = \frac{V_{CC} - V_{BE,P}(FA)}{R_{EP}}$$

$I_{CC}(OL) = I_{RB} + I_{RC} + I_{RCP}$

$$* \; I_{RB} = \frac{V_{CC} - V_{BC}(RS) - 2V_{BE}(hard)}{R_B}$$

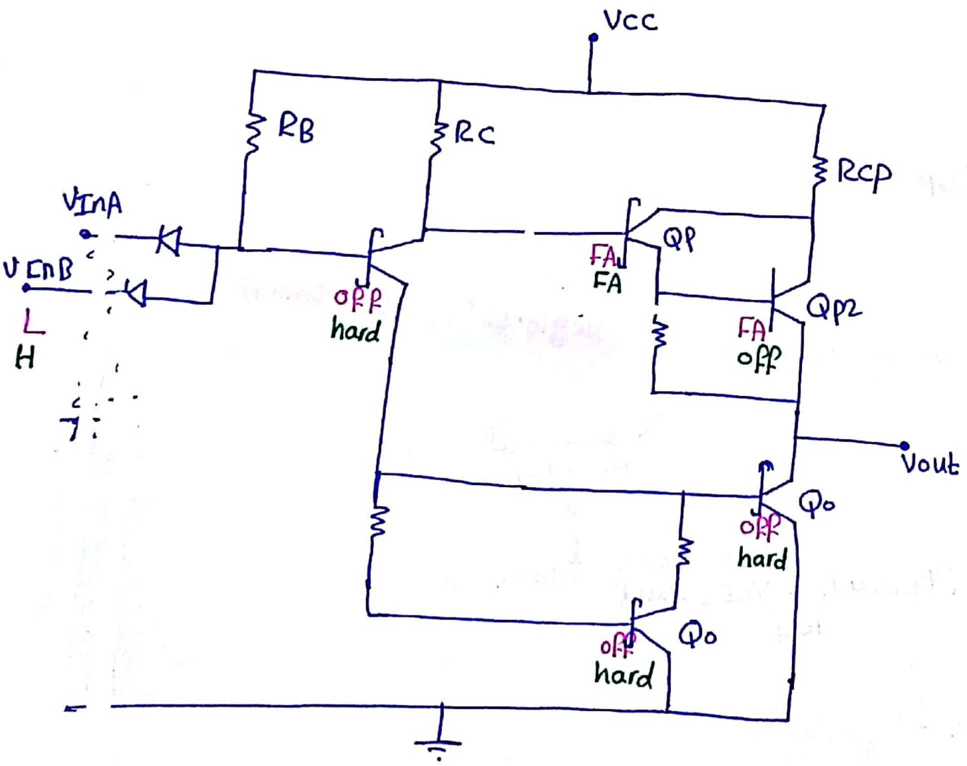
$$* \; I_{RC} = \frac{V_{CC} - V_{CE,S}(hard) - V_{BE,o}(hard)}{R_C}$$

$$* \; I_{RCP} = \frac{V_{CE,S}(hard) + V_{BE,o}(hard) - V_{BE,P}(FA)}{R_{EP}}$$

$-0 - I_R - V_{BE}(FA) + V_{CE}(hard) + V_{BE,o}(hard) = 0$

$$I_{REP} = \frac{V_{CE,S}(hard) + V_{BE,o}(hard) - V_{BE,P}(FA)}{R_{EP}}$$

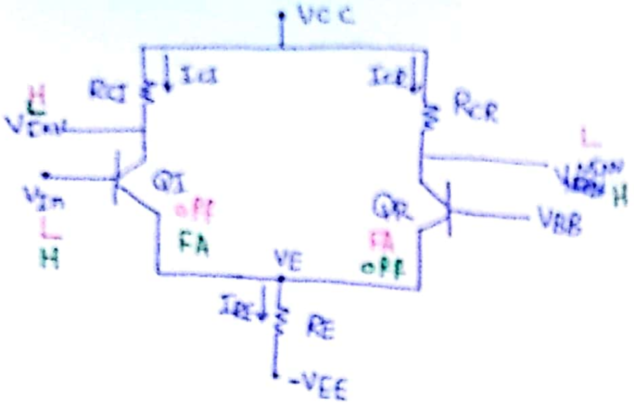
LS TTL:



Replace الـ
Q3 ال
بـ
2 Schottky diode

Second:

Chapter II: (ECL)



* $I_{RE} = \frac{V_E + V_{EE}}{R_E}$

* $V_E = V_{In} - V_{BE,I(ECL)}$ if Q_I on

* $V_E = V_{BB} - V_{BE,R(ECL)}$ if Q_R on

* $V_{Inv} = V_{cc} - I_{CI} R_{CI}$

* $V_{NInv} = V_{cc} - I_{CR} R_{CR}$

$V_{BE}(FA) = V_{BE}(ECL) = 0.75$

---

* I/p (Low)

$V_{In} < V_{BB}$ $\quad Q_I$ (off), Q_R (FA)

$$I_E = \frac{V_{BB} - V_{BE}(ECL) + V_{EE}}{R_E}$$

$I_{CI} = 0$

No voltage drop in R_{CI}.

* I/p (High)

$V_{In} > V_{BB}$ $\quad Q_I$ (FA), Q_R (off)

$$I_E = \frac{V_{in} - V_{BE}(ECL) + V_{EE}}{R_E}$$

$I_{CR} = 0$

---

* الحالة انه عند $V_{in} < V_{BB}$

$Q_I \rightarrow$ off

$V_{BE,I} = V_{In} - V_E$, where $V_E = (V_{BB} - V_{BE,R})$

$= \underbrace{V_{In} - V_{BB}}_{-ve} + V_{BE,R}$

$V_{BE} < V_{BE}(ECL)$

$\rightarrow Q_I$ off

* الحالة انه عند $V_{in} = V_{BB}$

Q_I, Q_R both on

$$I_{CR} = I_{RE} = \frac{V_{BB} - V_{BE,R}(ECL) + V_{EE}}{R_E}$$

$$I_{CI} = I_{RE} = \frac{V_{in} - V_{BE,I}(ECL) + V_{EE}}{R_E}$$

(V_{in} = V_{BB})

$I_{RE} = I_{E,I} + I_{E,R}$

$I_{E,I} = I_{E,R}$

$I_{E,I} = I_{E,R} = \frac{I_{RE}}{2}$

$V_{iH} = V_{BB} + 0.05$

$V_{iL} = V_{BB} - 0.05$

* الحالة انه عند $V_{in} > V_{BB}$

Q_I on

$V_{BE,R} = V_{BB} - V_E$, where $V_E = V_{In} - V_{BE,I}(ECL)$

if $V_{in} > V_{BB} + 0.05$

$V_{BE,R} = V_{BB} - V_{BB} - 0.05 + V_{BE,I}$

$V_{BE,R} < V_{BE,I}(ECL) - 0.05$

$\therefore Q_R$ off

⇒ V_{inv} at V_S

when I/p ↑ , Q_I becomes sat

Q_R remains off

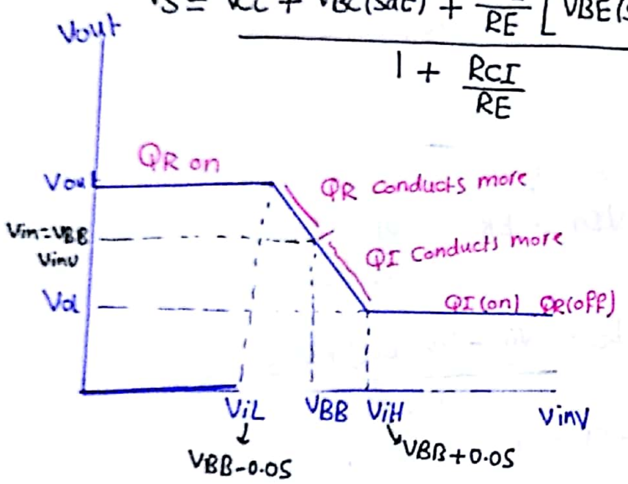
1) $V_{inv} = V_{CC} - I_{CI} R_{CI}$

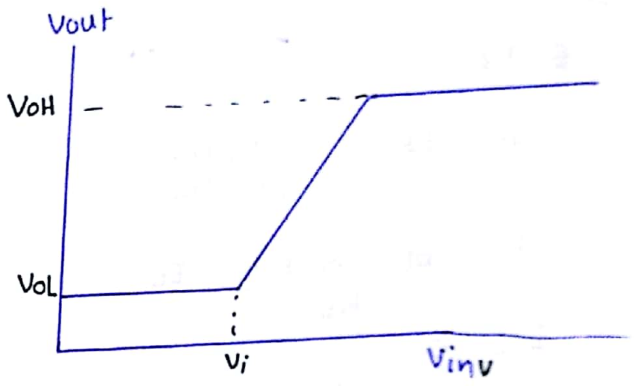
$$I_{CI} = I_{RE} = \frac{V_S - V_{BE,I}(sat) + V_{EE}}{R_E}$$

2) $V_{inv} = V_S - V_{BC}(sat)$

when solving 1 in 2

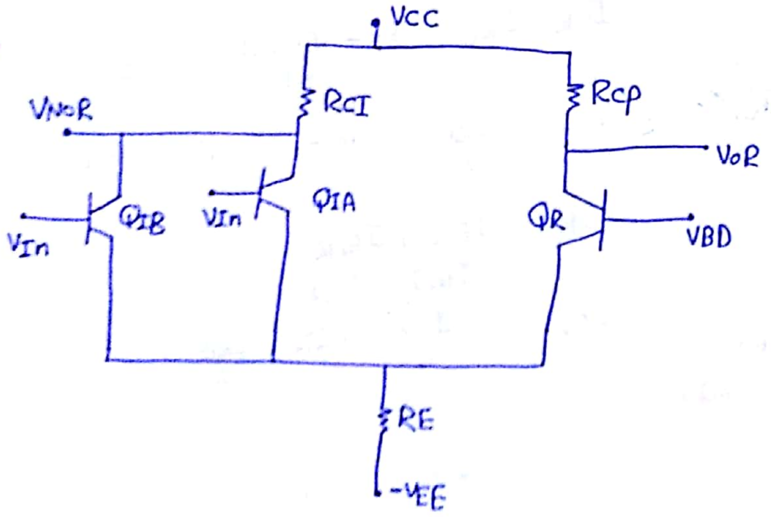
$$V_S = \frac{V_{CC} + V_{BC}(sat) + \frac{R_{CI}}{R_E}\left[V_{BE}(sat) - V_{EE}\right]}{1 + \frac{R_{CI}}{R_E}}$$





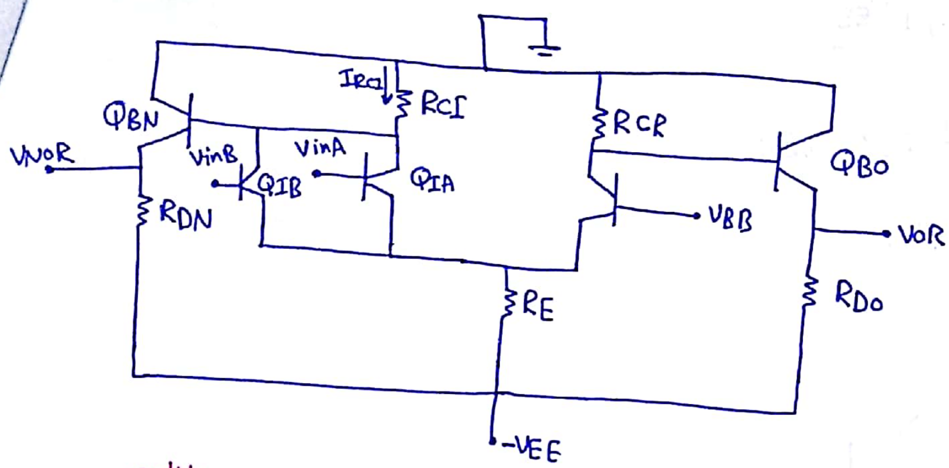
(transition width = 0.1)

$V_{IH} - V_{IL} = 0.1$



A	B	OR	NOR
0	0	1	0
0	1	0	1
1	0	0	1
1	1	0	1

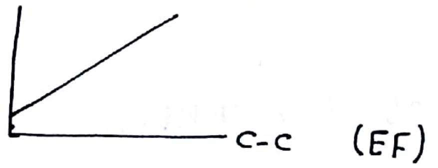
11.5: MECL   OR/NOR gate



Buffers

QBo, QBN always (FA)

cut → Vc > VB



adv:

↑ current at o/p

↑ N (Fan-out)

↑ speed

I/p, o/p swing compatible

dis adv:

↑ power

↑ Switching spikes due to high speed.

---

* R_{DN}, R_{Do} : ① passive pull down cct

② loads for the buffers

$I_{Vin} < I_{BB}$

1) $R_{cI} < R_{cR}$

$I_{Vin} < I_{VBB}$

2) $R_{cI} > R_{cR}$

MECL (NOR)

① $V_{in} < V_{BB}$, Q_I off, Q_R on

الحل يكون هيك بحالة مكنة لتتجاهل Ib

اما اذا مكنة تتجاهل بتصير Ic=Ib=0

$$0 + I_{Rc,I}(R_{c,I}) + V_{BE,RN}(EcL) + V_{NOR} = 0$$

( )

$$V_{OH} = -I_{Rc,I}(R_{c,I}) - V_{BE,Rn}(EcL)$$

$$\boxed{I_{Rc,I} = I_{B,BN}}$$

$$-0 + R_{cI}\, I_{RcI} + V_{BE,Rn}(EcL) + (1+\beta) I_{B,BN} R_{DN} - V_{EE} = 0$$

(I_{RcI} = $I_{B,BN}$)

$$I_{B,BN} = \frac{V_{EE} - V_{BE,Rn}(EcL)}{R_{cI} + R_{DN}(1+\beta)}$$

$V_{iL} = V_{BB} - 0.05$

$V_{iH} = V_{BB} + 0.05$

Fan-o

② $V_{in} > V_{BB}$, Q_I FA , Q_R off

$$I_{RC,I} = I_{RE} = \frac{V_{in} - V_{BE}(EcL) + V_{EE}}{R_E}$$

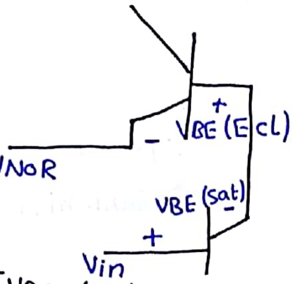
Ignore $I_{B,BN}$ when $I_{CI} > I_{B,BN}$

$$V_{noR} = - I_{RCI} R_{CI} - V_{BE,BN}(EcL)$$

at V_S , $V_{NoR}(V_S)$

$V_{BE}(Sat) \leftarrow V_{BE}(EcL)$ بدل

$-V_{NoR} - V_{BE}(EcL) + V_{BC}(sat) + V_{in} = 0$



③ $V_{NoR} = V_{in} - V_{BE,BN}(EcL) - V_{BC,I}(sat)$

① $I_{RC} = I_{RE} = \frac{V_S - V_{BE}(Sat) + V_{EE}}{R_E}$

② $V_{NoR} = V_{out} = - I_{RCI} R_{CI} - V_{BE,BN}(EcL)$

Solve ② and ③ for V_S

$$V_S = \frac{V_{BC}(sat) + \frac{R_{CI}}{R_E}\left[V_{BE}(sat) - V_{EE}\right]}{1 + \frac{R_{CI}}{R_E}}$$

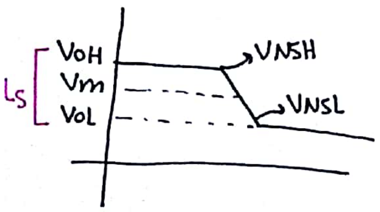
* $V_{NMH} = V_{OH} - V_{IH}$
* $V_{NML} = V_{IL} - V_{OL}$

transition width $= V_{IH} - V_{IL}$

Noise Sensitivity

$V_{HNS} = V_{OH} - V_m$

$V_{LNS} = V_m - V_{OL}$



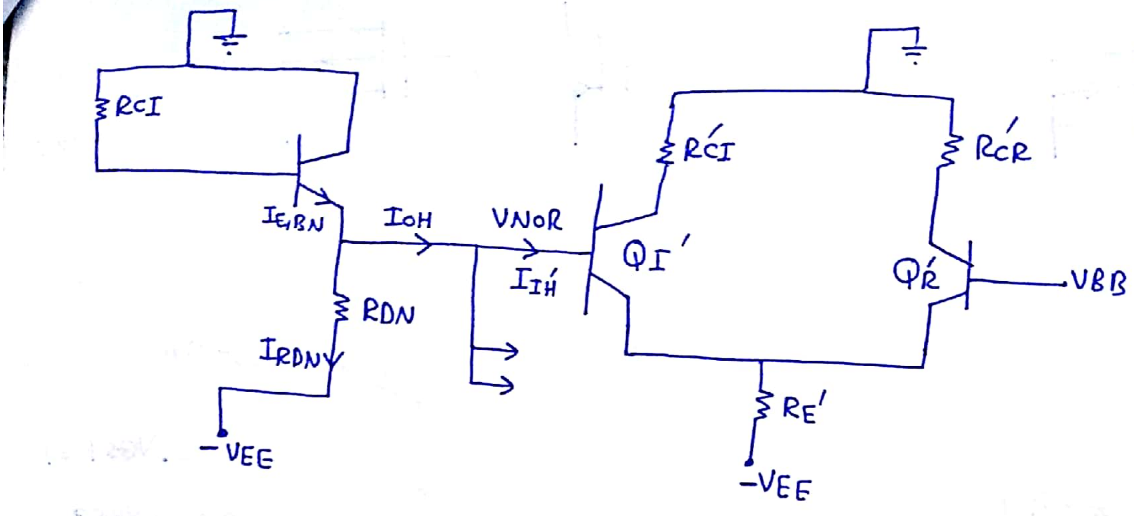
$L_S = V_{OH} - V_{OL}$

Noise immunity

$$V_{NIH} = \frac{V_{NSH}}{L_S}$$

$$V_{NIL} = \frac{V_{NSL}}{L_S}$$

Fan-out MECL(I)



$$N = \frac{I_{OH}}{I_{IH}}$$

$L(I/P) \longrightarrow H\ (O/P)$

$$* \; I_{IH'} = \frac{I_{RE}}{\beta+1} = I_{B,I} = \frac{I_E}{\beta+1}$$

$$* \; I_{RE} = \frac{V_{OH} - V_{BE,I'}(ECL) + V_{EE}'}{R_E'}$$

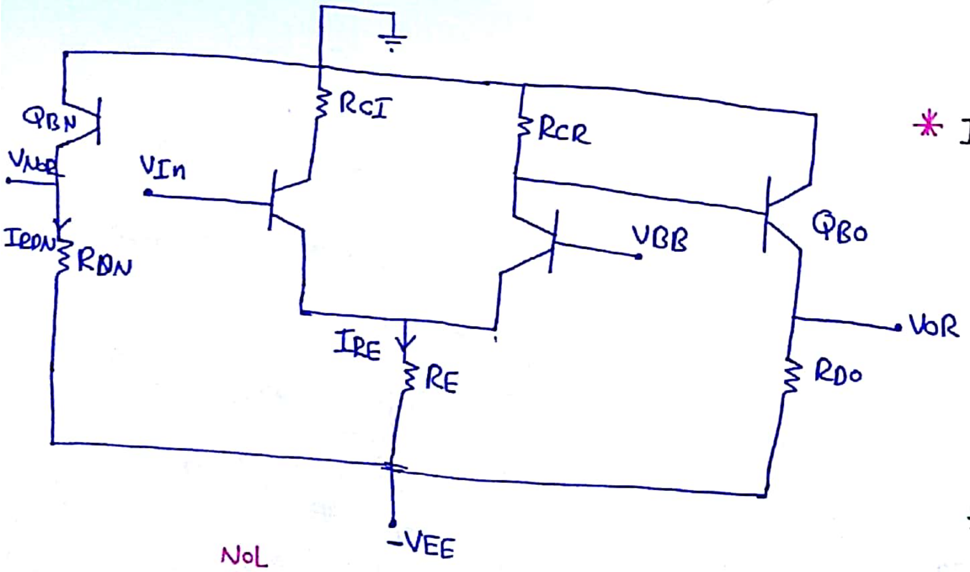
$$* \; I_{OH} = I_{E,BN} - I_{RDN}$$

$$\rightarrow I_{E,BN} = (1+\beta)\, I_{B,BN}$$

$$\rightarrow I_{B,BN} = \frac{0 - V_{BE,BN}(ECL) - V_{OH}}{R_{CI}} (\beta+1)$$

$$I_{RDN} = \frac{V_{OH} + V_{EE}}{R_{DN}}$$

ECL power Dissipation



$$* \; I_{EE}(NOH) = I_{RE}(NOH) + I_{RDN}(NOH) + I_{RDO}(NOH)$$

$$* \; I_{RE} = \frac{V_{BB} - V_{BE,R}(ECL) + V_{EE}}{R_E}$$

$$* \; I_{RDN} = \frac{V_{OH} + V_{EE}}{R_{DN}}$$

$$V_{OH} = -I_{RCI} R_{CI} - V_{BE,BN}(ECL)$$

$$* \; I_{RDO} = \frac{V_{OL} + V_{EE}}{R_{DO}}$$

$$V_{OL} = -I_{RCR} R_{CR} - V_{BE}(ECL)$$

$$* \; I_{EE}(\overset{NOL}{\widehat{OL}}) = I_{RE}(OL) + I_{RDN}(OL) + I_{RDO}(OL)$$

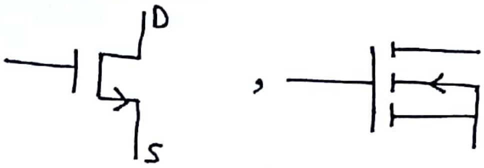
$$I_{RE}(OL) = \frac{V_{in} - V_{BE,I}(ECL) + V_{EE}}{R_E}, \quad I_{RDN}(OL) = \frac{V_{OL} + V_{EE}}{R_{DN}}, \quad I_{RDO}(OL) = \frac{V_{OH} + V_{EE}}{R_{DO}}$$

$$P_{avg(EE)} = V_{EE} \left[\frac{I_{EE}(OH) + I_{EE}(OL)}{2} \right]$$

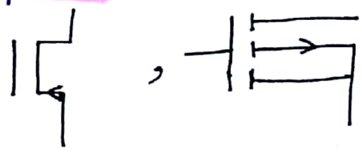
لو حطيت كان عندك Vcc فوق نعمل Super-position ونحسب كل تيار مرة عند VEE ومرة عند Vcc

Chapter 16:

NMOS



PMOS



* NMOS operations:

① $V_{GS} < V_{Tn}$

NMOS off , $I_D = 0$

② $V_{GS} > V_{Tn}$

a) $V_{DS} < V_{DS}(sat)$ → $V_{GS} - V_{TN}$

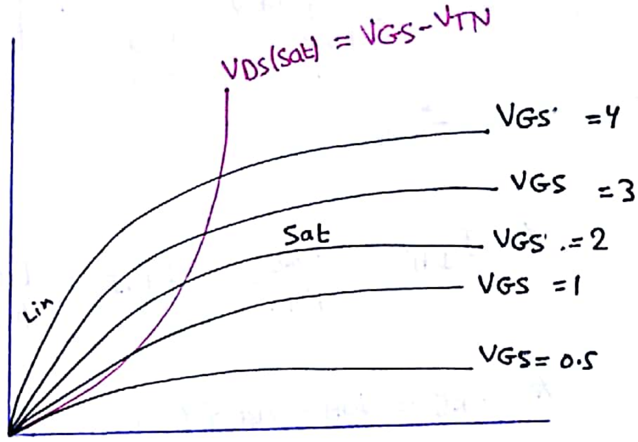
NMOS Linear

$$I_D(Lin) = k_n\left[(V_{GS} - V_{TN})V_{DS} - \frac{V_{DS}^2}{2}\right]$$

b) $V_{DS} > V_{DS}(Sat)$

NMOS Sat

$$I_D(sat) = \frac{k_n}{2}\left[V_{GS} - V_{TN}\right]^2$$



$$* \; k_n = \mu_n C_{ox}' \frac{W}{L} = k_n' \frac{W}{L}$$

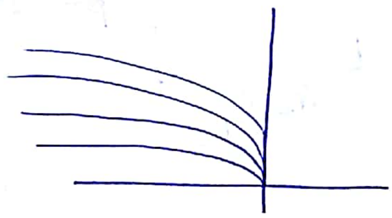
$$* \; C_{ox}' = \frac{\epsilon_{ox}}{t_{ox}}$$

PMOS:

① $V_{SG} < -V_{TP}$

PMOS off

② $V_{SG} > -V_{TP}$

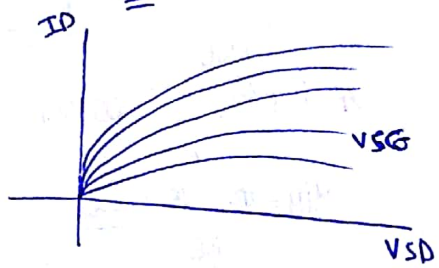


a) $V_{SD} < V_{SD}(sat)$

$$V_{SD}(sat) = V_{SG} + V_{TP}$$

$$I_{DP} = k_p\left[(V_{SG} + V_{TP})V_{SD} - \frac{V_{SD}^2}{2}\right]$$

or



b) $V_{SD} > V_{SD}(Sat)$

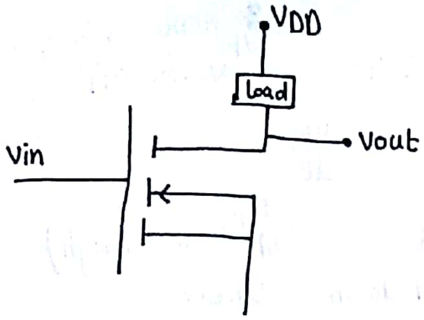
$$I_{DP} = \frac{k_p}{2}\left[V_{SG} + V_{TP}\right]^2$$

PMOS Sat

$$* \; k_p = \mu_p C_{ox}' \left(\frac{W}{L}\right)_p = k_p' \left(\frac{W}{L}\right)_p$$

وحدتها ← $\frac{\mu A}{V^2}$

Chapter 17 :-



* $V_{GS} > V_{TN}$
  NMos Linear

$V_{GS} < V_{TN}$
  NMos off

* نتحكم بـ Id من Rd

To Let $I_D = 0 \longrightarrow R_L \to \infty$
$V_{DS} \simeq 0$

$I_D = 0$ when $V_{DS} = 0$ only

* NMos is used as pull down in active mode

* RDS بتختلف عن R (Load)
(channel)

channel Resistance

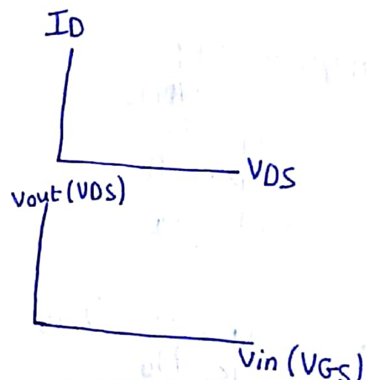
* $R_{DS} = \frac{dV_{DS}}{dI_D}$ if $I_D = I_{D(Lin)}$

$$\frac{1}{R_{DS}} = \frac{dI_D}{dV_{DS}} = k_n \left[V_{GS} - V_{TN} - V_{DS}\right]$$

$$R_{DS} = \frac{1}{k_n\left[V_{GS} - V_{TN} - V_{DS}\right]}$$

$V_{DS} \downarrow$, $R_{DS} \downarrow$, Conductivity $\uparrow$

$V_{DS} = V_{DD} - I_D R_L$ → $I_D = 0$, $V_{DS} = 0$



ونقدر نرسم VDS(sat) عليها
→ $V_{GS} - V_{TN}$

$$P_{DD\,stat} = \frac{I_{DD}(OH) + I_{DD}(OL)}{2} \cdot V_{DD}$$

$$P_{Dyn} = C_L \, f \, V_{DD}$$
(f → Freq)

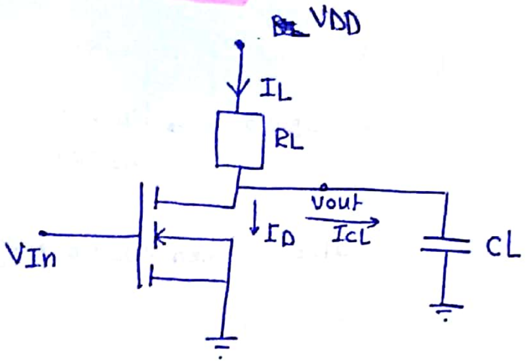
$$P_{total} = P_{stat} + P_{dyn}$$

Freq $\uparrow$, time $\downarrow$, Switching fast

$$I_{dis} \ll I_{charge}$$

$R_{DS} \downarrow$, $V_{DS} \downarrow$, Conductivity $\uparrow$

Fan-out :



* when I/P (Low) (I/P high → Low, NMOS off)

$V_{GS} < V_{TN}$

$I_L = I_{cL} = C_L \frac{dV_c}{dt}$

* when I/P (high) (I/P Low → high)

NMos pull down , Linear

$I_{dis} = -I_{cL}$

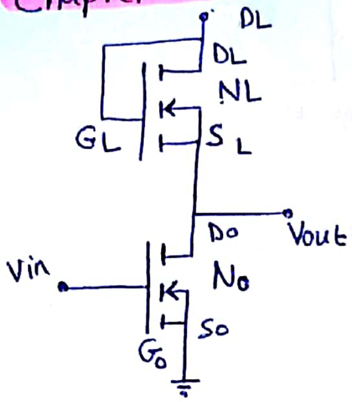
$= -C_L \frac{dV_c}{dt} = -(I_L - I_D)$

$I_{cL} = I_L - I_D$

$I_{cL} = C_L \frac{dV}{dt}$

$I_{dis} = -C_L \frac{dV}{dt}$

Chapter 19 :



NL ⇒ Load
No ⇒ MosFET

* $V_{DS,L} = V_{GS,L}$ because G_o, GL are Connected

* $V_{DSL(Sat)} = V_{GSL} - V_{TL}$
V_{DSL}

$V_{DSL} > V_{DSL(Sat)}$ NMos Sat

$I_{DL} = I_{Do}$

* $V_{out} = V_{DSo} = V_{DD} - V_{DS,L}$

$V_{DS,L} = V_{DD} - V_{DSo} = V_{GS,L}$

* **VoH** if $V_{in} = V_{GS,o} < V_{TN}$

No is off

$I_{D,o} = I_{D,L} = 0$

$V_{DS,o} = V_{DD} - V_{DS,L}$ (V_{GSL})

$V_{DS,L} = V_{GS,L} = V_{T,L}$

$V_{DS,o} = V_{OH} = V_{DD} - V_T$

NL → Sat

* **VoL** $V_{in} \geq V_{To}$ (high)

Vout at Vm $V_{DS,o} \geq V_{DS,o(Sat)}$

NL, No both Sat

$I_{DL(Sat)} - I_{Do(Sat)}$

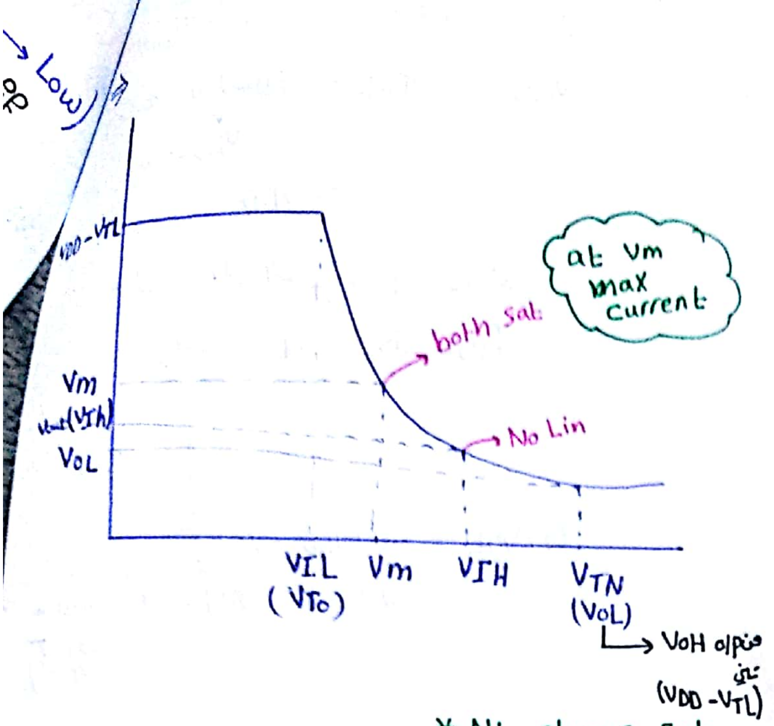
① $\frac{K_L}{2}\left[V_{GS,L} - V_{T,L}\right]^2 = \frac{K_o}{2}\left[V_{GS,o} - V_{To}\right]^2$

② $V_{GS,L} = V_{DS,L} = V_{DD} - V_{out}$

③ $V_{GS,o} = V_{IN}$

② and ③ in ①

$V_{out} = -\sqrt{\frac{K_o}{K_L}}\, V_{IN} + V_{To}\sqrt{\frac{K_o}{K_L}} + V_{DD} - V_{TL}$



* NL always sat

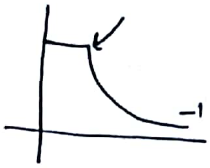
o/p drops with slope $-\sqrt{\frac{K_o}{K_L}}$

the Larger the $-\sqrt{\frac{K_o}{K_L}}$, the steeper the transition

* at midpoint $V_{In} = V_{out} = V_m$ (Both sat)

$\hookrightarrow V_m + \sqrt{\frac{K_o}{K_L}}\, V_m = V_{DD} - V_{TL} + V_{To}\sqrt{\frac{K_o}{K_L}}$

$$V_M = \frac{V_{To}\sqrt{\frac{K_o}{K_L}} + V_{DD} - V_{TL}}{1 + \sqrt{\frac{K_o}{K_L}}}$$



*
لإيجاد VoL نقوم بـ

$N_L(Sat) = N_o(Lin)$

$I_{DL}(Sat) = I_{Do}(Lin)$

$$\frac{K_L}{2}(V_{GS,L} - V_{TL})^2 = K_o\left[(V_{GS_o} - V_{To})V_{DS,o} - \frac{V_{DS,o}^2}{2}\right]$$

$V_{GS,L} \to V_{DS,L} = V_{DD} - V_{out}$; $V_{GS_o} \to V_{IN} = V_{DD} - V_{TL}$; $V_{DS,o} \to V_{out}$

$$V_{oL} = \frac{K_L (V_{DD} - V_{T,L})^2}{2K_L (V_{DD} - V_{T,L}) + 2K_o (V_{DD} - V_{T,L} - V_{T,o})}$$

$$\boxed{V_{I,L} = V_{T,o}}$$

* V_{IH} لايجاد $V_o(V_{IH})$ و

Slope of $V_{IH} = \frac{dv_{out}}{dv_{IN}} = -1$

1) $I_{DL}(sat) = \frac{K_L}{2}(V_{GS,L} - V_{TL})^2$

$= \frac{K_L}{2}(V_{DD} - V_{out} - V_{TL})^2$

2) $dI_d(V_{out}) = \frac{dI_d}{dV_{out}} \, dv_{out}$

3) $\frac{dI_d}{dV_{out}} = -K_L(V_{DD} - V_{out} - V_{TL})$

4) $I_D(Lin) = K_o\left[(V_{GS} - V_{TN})V_{DS} - \frac{V_{DS}^2}{2}\right]$ ($V_{GS} \to V_{in}$, $V_{DS} \to V_{out}$)

5) $dI_{D_o} = \frac{dI_{D_o}}{dv_{in}} dv_{in} + \frac{dI_{D_o}}{dv_{out}} dv_{out}$.

6) $K_o V_{out}$

7) $K_o(V_{IN} - V_{To} - V_{out})$

Linear = Sat نساوي مشتقات ال

$dI_{DL}(Sat) = dI_{Do}(Lin)$

$\frac{dI_{DL}}{dV_{out}} dv_{out} = \frac{dI_{Do}}{dV_{in}} dv_{in} + \frac{dI_{Do}}{dV_{out}} dv_{out}$

$dv_{out}\left(\frac{dI_{DL}}{dv_{out}} - \frac{dI_{Do}}{dv_{out}}\right) = \frac{dI_{Do}}{dv_{in}} dv_{in}$

$\frac{dv_{out}}{dv_{in}} = \frac{\frac{dI_{Do}}{dv_{in}}}{\left(\frac{dI_{DL}}{dv_{out}} - \frac{dI_{Do}}{dv_{out}}\right)} = -1$ ---(8)

3, 6, 7 in 8 بنعوض

$V_{out}(V_{IH}) = \frac{K_o(V_{IN} - V_{To}) + K_L(V_{DD} - V_{T,L})}{2K_o + K_L}$ ($V_{IN} \to V_{IH}$)

* $V_{in}(V_{inH}) = V_{T,o} + \frac{2(V_{DD} - V_{TL})}{\sqrt{\frac{3K_o}{K_L}} + 1}$

→ at $I_D = 0$

$V_{DS,o} = V_{DD} - V_{DS,L}$

$V_{GS,L} = V_{DSL} = V_{TL}$

$I_{DL} = I_{Do} = 0$

$V_{DS,o} = V_{DD} - V_{TL} = V_{OH}$

* at $V_{DS} = 0$

$V_{GS,L} = V_{DSL} = V_{DD} - V_{out} = 0$ ($V_{DS,o} = 0$)

$= V_{DD}$

* لاستخراج القيم من الحركة نرجع

$I_{D,o}(Lin) = I_{D,L}(Sat)$

الملخص:

① $V_{OL} = \frac{K_L(V_{DD} - V_{T,L})^2}{2K_L(V_{DD} - V_{T,L}) + 2K_o(V_{DD} - V_{T,o} - V_{T,L})}$

② $V_{OH} = V_{DD} - V_{T,L}$

③ $V_{IL} = V_{GS,o}$

④ $V_{IH} = V_{T,o} + \frac{2(V_{DD} - V_{T,L})}{\sqrt{\frac{3K_o}{K_L}} + 1}$

⑤ $V_m = \frac{V_{DD} - V_{T,L} + \sqrt{\frac{K_o}{K_L}} V_{T,o}}{1 + \sqrt{\frac{K_o}{K_L}}}$

⑥ $V_{out}(V_{IH}) = \frac{K_L(V_{DD} - V_{T,L}) + K_o(V_{IH} - V_{T,o})}{2K_o + K_L}$

Power dissipation:

$P_{total} = P_{stat} + P_{dyn}$

$P_{dyn} = \mathcal{V} C_L V_{DD}^2$

$P_{stat} = V_{DD} - \frac{I_{DD}(OL) + I_{DD}(OH)}{2}$

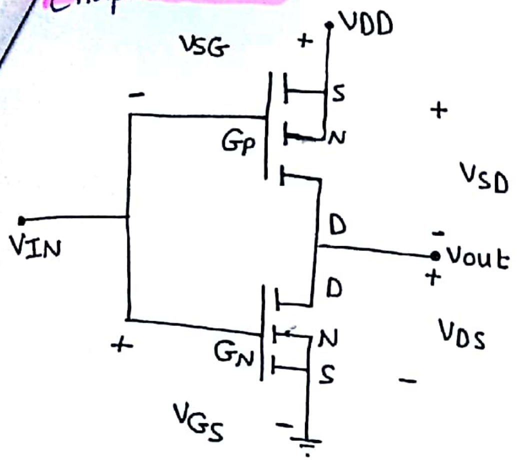
* $I_{DD}(OH)$ I/P (L)

$I_{DL}(sat) = I_{Do}(off) = 0$

* $I_{DD}(OL)$ I/P high

$I_{Do}(Lin) = I_{DL}(Sat)$

Chapter 23:



Vin	Gp	GN
L	Lin	off
H	off	Lin

* I/p (Low) , VoH

$0 > V_{TP}$

$V_{in} = 0$, $V_{GS} = 0 < V_{TN} \rightarrow N_o$ (off)

$V_{SG} = V_{DD} - V_{IN} = V_{DD}$ (V_{IN} = 0)

V_{SG} , $V_{DD} > -V_{TP} \rightarrow P_o$ (Lin)

$V_{SD}(sat) = V_{SG} + V_{TP}$

$V_{SD}(sat) = V_{DD} + V_{TP}$

$V_{SD} < V_{SD}(sat)$
(Lin)

$I_{DN}(off) = I_{DP}(Lin)$

$I_D = 0$ only when $V_{SD} = 0$

$\rightarrow V_{DS} = V_{DD} - V_{SD} = V_{DD} = V_{OH}$

$V_{OH} = V_{DD}$

$V_{OH} \rightarrow V_{IL} \rightarrow N_o$ off $\rightarrow I_{DP}, I_{DN} = 0 \rightarrow V_{DS} = 0$

$V_{DS} = V_{DD} - V_{out}$ (V_{DS} = 0)

$V_{out} = V_{DD}$

$V_{OH} = V_{DD}$

* I/p (high) , $V_{in} = V_{DD}$

N_o , Lin	P_o , off
$V_{GS} = V_{DD}$	$V_{SG} = V_{DD} - V_{in} = V_{DD} - V_{in} = 0$
$V_{DD} > V_{IN}$	$0 < -V_{TP}$ off

$I_{DN}(Lin) = I_{DP}(off)$

$* I_{DN}$ is 0 when $V_{DS} = 0$

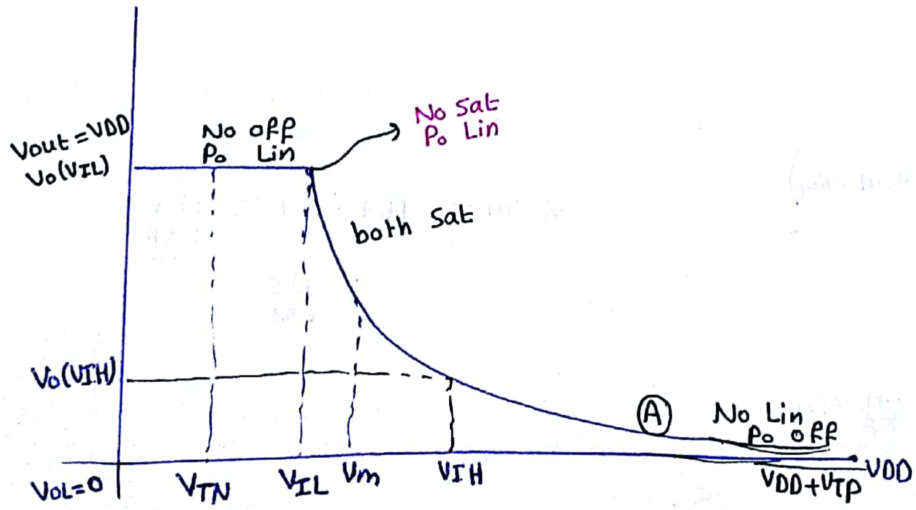
$V_{OL} = 0$

$V_{OL} \rightarrow V_{IH} \rightarrow P_o$ off

$I_D = 0 \rightarrow V_{DS} = 0$

$V_{out} = V_{DS} = 0$

$V_{OL} = 0$



⇒ at (A)

when P_o turns off

$V_{SG} = V_{DD} - V_{IN}$

For P_o to be on

$V_{SG} > -V_{TP}$

$V_{DD} - V_{IN} > -V_{TP}$

$-(-V_{in} > -V_{TP} - V_{DD})$

$V_{in} < V_{TP} + V_{DD}$

عكسها

$\left[\begin{array}{l} V_{SG} < -V_{TP} \\ V_{in} > V_{DD} + V_{TP} \end{array}\right.$

off تكون P_o ح

---

to find V_{IL}

P_o Lin , No Sat

$I_{DP_o}(Lin) = I_{DN_o}(Sat)$

$$K_p\left[(\underset{V_{DD}-V_{in}}{V_{SG}} + V_{TP})\underset{V_{DD}-V_{out}}{V_{SD}} - \frac{V_{SD}^2}{2}\right] = \frac{K_n}{2} * \left[(\underset{V_{in}}{V_{GS}} - V_{TN})^2 \right]$$

$dI_{DN} = dI_{DP}$

$$\frac{dI_{DN}}{dv_{in}} dv_{in} = \frac{dI_{DP}}{dv_{in}} dv_{in} + \frac{dI_{DP}}{dv_{out}} dv_{out}$$

$$V_{in} - V_{GS,o} = K_p \underset{V_{DD}-V_{out}}{V_{SD,P}} + K_p(\underset{V_{DD}-V_{in}}{V_{SG,P}} + V_{TP}) - K_p(\underset{V_{DD}-V_{in}}{V_{SG}} + V_{TP}) - V_{out}$$

$$V_{IL} = \frac{2V_{out}(V_{IL}) - V_{DD} + V_{TP} + \frac{K_n}{K_p}V_{TN}}{1 + \frac{K_n}{K_p}}$$

$V_{OL} = 0$

* $V_{OH} = V_{DD}$, $V_{OL} = 0$

* $$V_{iH} = \frac{V_{DD} + V_{TP} + \frac{K_n}{K_p}(V_{TN} + 2V_{out}(V_{iL}))}{1 + \frac{K_n}{K_p}}$$

* $$V_m = \frac{V_{DD} + V_{TP} + V_{IN}\sqrt{\frac{K_n}{K_p}}}{1 + \sqrt{\frac{K_n}{K_p}}}$$

* $$V_{iL} = \frac{2V_{out}(V_{iL}) - V_{DD} + V_{TP} + \frac{K_n}{K_p}V_{TN}}{1 + \frac{K_n}{K_p}}$$

⇒ * mid point $V_{in} = V_{out} = V_m$

$$I_{DN}(Sat) = I_{DP}(Sat)$$

$$\frac{k_n}{2}(V_m - V_{TN})^2 = \frac{k_p}{2}\left[\frac{V_{SG,P}}{V_{DD}-V_m} + V_{TP}\right]^2$$

$$\frac{k_n}{2}(\overset{V_{GS}}{V_m} - V_{TN})^2 = \frac{k_p}{2}\left[V_{DD} - V_m + V_{TP}\right]^2$$

$$V_m = \frac{V_{DD} + V_{TP} + V_{TN}\sqrt{\frac{k_n}{k_p}}}{1 + \sqrt{\frac{k_n}{k_p}}}$$

V_{IH} , P_o Sat , I_D Lin

نساوي المشتقات

$$\frac{dV_{out}}{dV_{in}} = -1$$

$$V_I = \frac{V_{DD} + V_{TP} + \frac{k_n}{k_p}(V_{TN} + 2V_{out})}{1 + \frac{k_n}{k_p}}$$

$$NM_{H} = V_{OH} - V_{IH}$$

$$NM_L = V_{IL} - V_{OL}$$

* Symmetric VTC

$$V_m - V_{IL} = V_{IH} - V_m$$

$$k_o = k_p$$

$$\frac{W_p}{L_p} \simeq 2.5\,\frac{W_n}{L_n}$$

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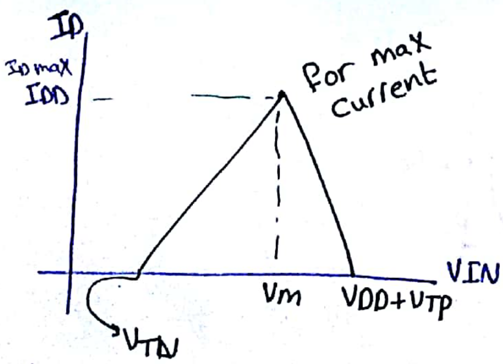
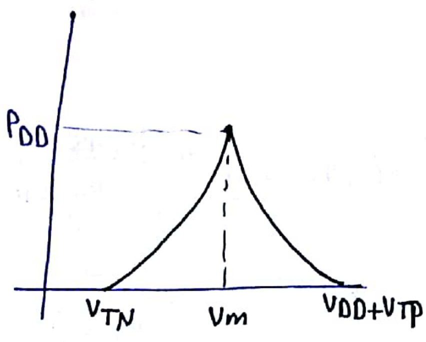
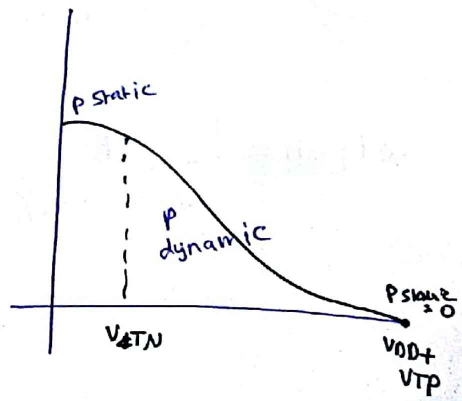
* **Power Dissipation:**

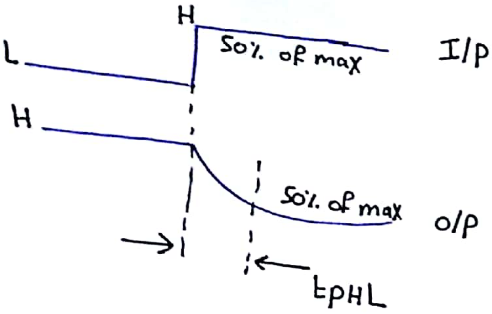
Static power = 0 , dynamic power = $C_L\, V\, V_{DD}^2$



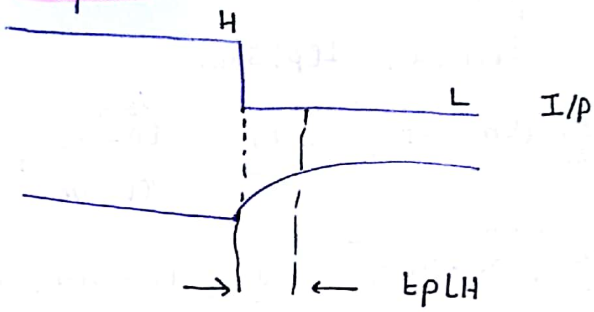




⇒ **tpHL**



* **tpLH**



* $k_n = k_p = \mu_n C_{ox} \frac{W_n}{L_n}$

- Single cap of Load -

$$C_{IN} = (W_n L_N + W_p L_p) C_{ox}'$$

$$\frac{W_p}{L_p} = 2.5 \frac{W_N}{L_N}$$

* total cap of Load Fan-out $= \frac{C_L}{C_{in}}$

$$\frac{C_L}{k_n} = \frac{F C_{in}}{k} = \frac{F C_{in}}{\mu_n C_{ox}' \frac{W_n}{L_n}}$$

assume $L_p = L_N \longrightarrow W_p = 2.5\, W_n$

$$C_{in} = (W_n L_N + 2.5\, W_n L_N) C_{ox}$$

$$= 3.5\, W_n L_n C_{ox}$$

$$\frac{C_L}{k_n} = \frac{F(3.5\, W_n L_n C_{ox})}{C_{ox}' \frac{W_n}{L_n} \mu} = \frac{3.5\, F L_n^2}{\mu_n} \quad \text{---④}$$

tpHL ---③

$$F = \frac{\mu_n}{3.5\, L_n^2} \cdot \frac{C_L}{k_n}$$

* $F = \dfrac{\mu_n \, t_{p(max)}}{3.5\, L_n^2 \left[\dfrac{2V_{TN}}{(V_{DD}-V_{TN})^2} + \dfrac{1}{V_{DD}-V_{TN}} \ln\left(\dfrac{1.5V_{DD}-2V_{TN}}{0.5\, V_{DD}}\right)\right]}$ (Length → L_n)

* $t_{pHL} = \left[\dfrac{2V_{TN}}{k_n (V_{DD}-V_{TN})^2} + \dfrac{1}{k_n (V_{DD}-V_{TN})} \ln\left(\dfrac{1.5\, V_{DD}-2V_{TN}}{0.5\, V_{DD}}\right)\right] C_L$

* $t_{pLH} = \left[\dfrac{-2V_{TP}}{k_p (V_{DD}+V_{TP})^2} + \dfrac{1}{k_p (V_{DD}+V_{TP})} \ln\left(\dfrac{1.5V_{DD}+2V_{TP}}{0.5\, V_{DD}}\right)\right] C_L$

$\Rightarrow k_n = k_n' \dfrac{w_n}{L_{min}} C_{ox}$

$\dfrac{w_n}{L_{min}} = \dfrac{k_N}{k_{N'}}$

$w_n = L_{min} \dfrac{k_N}{k_{N'}}$

$w_p = w_N \dfrac{k_n'}{k_p'}$

مهم

$\dfrac{w_p}{w_n} = \dfrac{k_n'}{k_p'}$

* لازم ادري Length, size, max C_L

1) $t = \ldots\ldots$ (C_L)

2) $C_{in} = (W_nL_n + W_pL_p) C_{ox}$

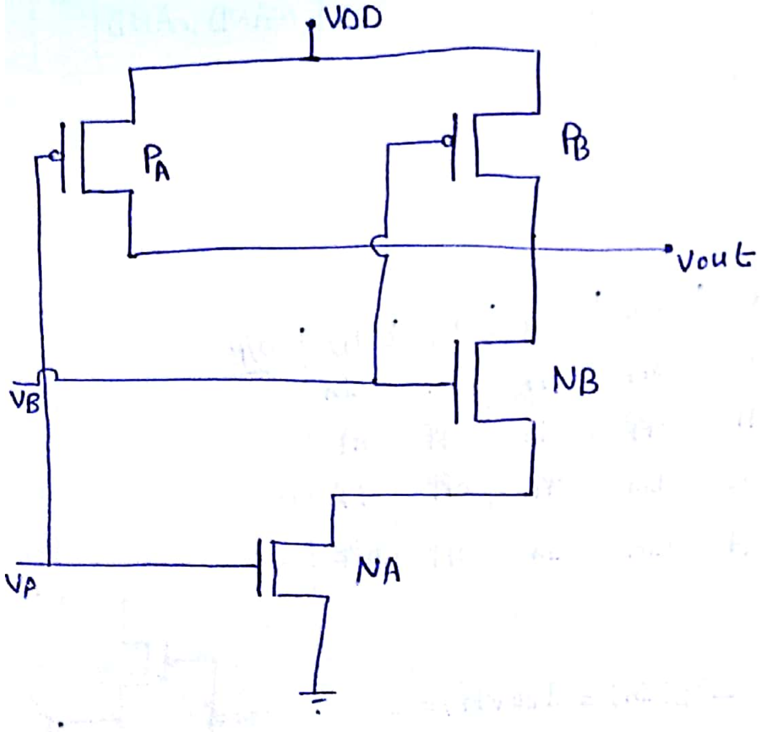
3) $\dfrac{W_p}{L_p} = 2.5 \dfrac{W_n}{L_n}$

* $F = \dfrac{C_L}{C_{in}}$ → نحسب للنتيجة

* Vtp و VTN ونأخذ الاقل لانو عدد ال gate .يكون اقل يعني ما ح يشتغل اذا اخذنا الاكبر

Final

Chapter 24:



V_A	V_B	NA	NB	PA	PB	O/P
L	L	off	off	Lin	Lin	H
L	H	off	off	Lin	off	H
H	L	off	off	off	Lin	H
H	H	Lin	Lin	off	off	L

* اول حالة L,L

$I_{DPA} + I_{DPB} = I_{DN(A,B)}(\text{off})$

$2 I_D(\text{Lin}) = 0$

$I = 0 \longrightarrow V_{SD} = 0$

$V_{out} = V_{DD} - \cancel{V_{SD}}^{\,0} = V_{DD}$

* حالة H,L

$I_{DP_B}(\text{Lin}) = I_{DN}(\text{off}) = 0$,

$V_{SD} = 0$

$V_{out} = V_{DD}$

⇒

* For symmetry (AND, NAND)

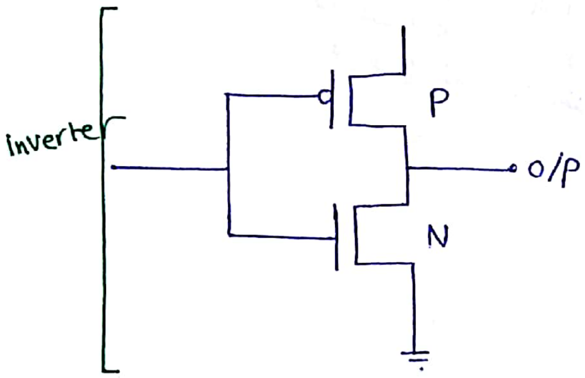
For i I/p CMOS

i $\frac{W_p}{L_p} = 2.5 \frac{W_n}{L_n}$

in this case, For 2 I/p CMOS gate

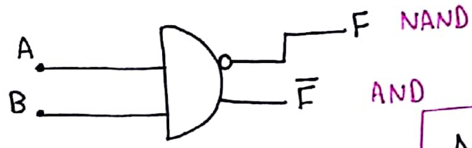
$2\frac{W_p}{L_p} = 2.5 \frac{W_n}{L_n}$

* لتحويلها من NAND لـ AND نشبك inverter



N→pull down → NAND, AND

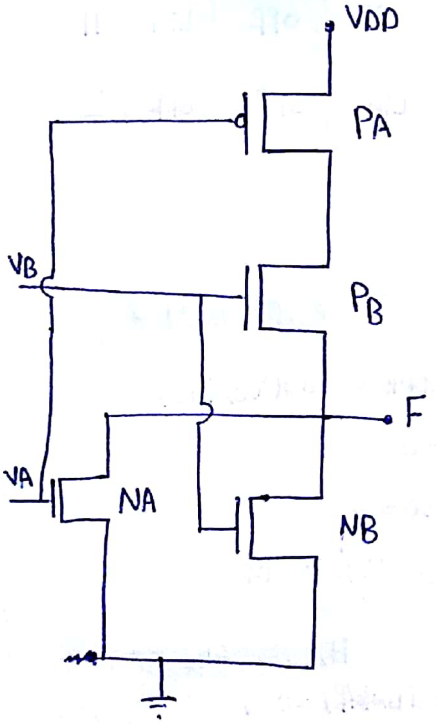
P→pull up



AND	NAND
0	1
0	1
0	1
1	0

N_{series} , $P_{parallel}$
[NAND , AND]

NOR / OR



VA	VB	NA	NB	PA	PB
L	L	off	off	Lin	Lin
L	H	off	Lin	off	off
H	L	Lin	off	off	off
H	H	Lin	Lin	off	off

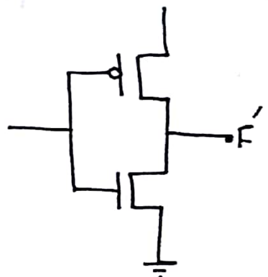
$2I_D(Lin) = I_{Dp}(off) = 0$

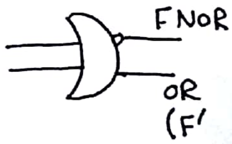
$V_{oL} = 0 = V_{DS}$

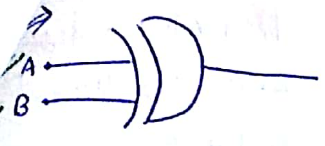
* For symmetry (OR, NOR)

$\frac{W_p}{L_p} = i\ (2.5) \frac{W_n}{L_n}$

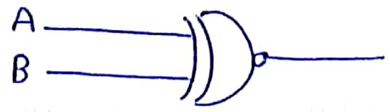
$N_{parallel}$, P_{series}
⇒ [NOR, OR]





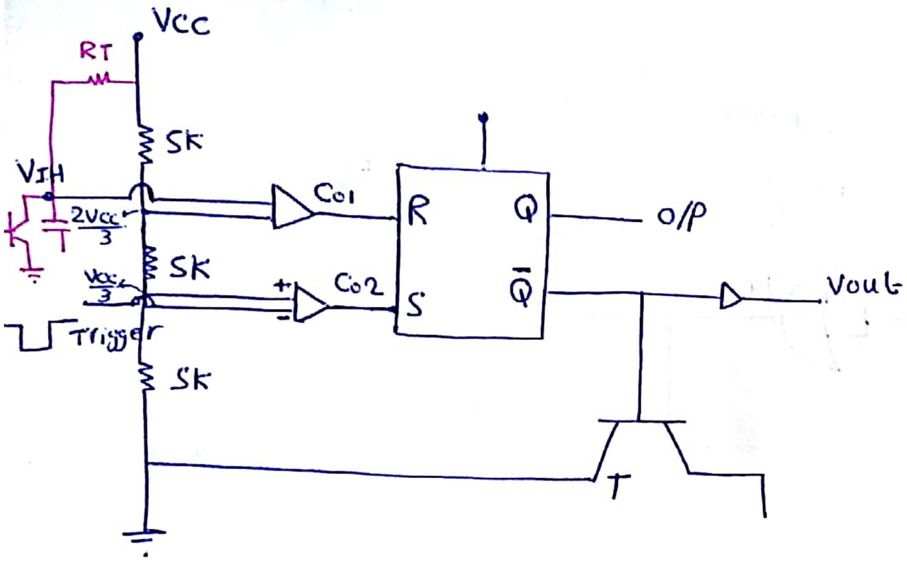


$= A\bar{B} + B\bar{A}$
$A \oplus B$
XoR



XoR
$\bar{A}\,\bar{B} + AB$ $\quad \overline{A \oplus B}$
متشابهات ا، مختلفات 0

* 555 timer:



① $V_{th} \geq \frac{2}{3} V_{cc} \longrightarrow$ Co1 H → Reset $Q=0$, $\bar{Q}=1$

Trigger(H) $V_{th} < \frac{2}{3} V_{cc} \longrightarrow$ Co1 L → Reset $Q=0$, $\bar{Q}=1$, $T_{sat} \rightarrow V_c = 0$

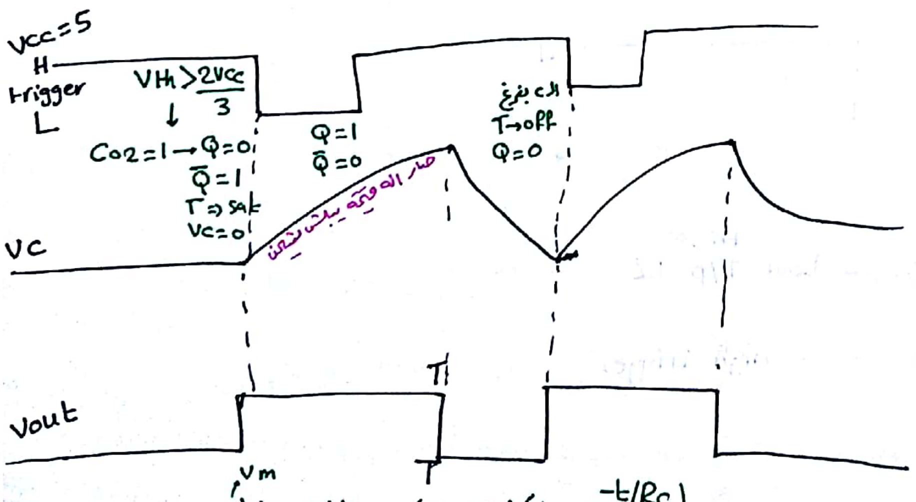
ال Low trigger بأثر فقط على Co2

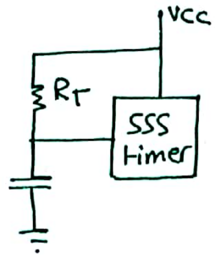
② Trigger L

Co2 = 0 ← هون ال L على السالب يعني Trigger $> \frac{Vcc}{3}$

Set = 1 و $Q=1$, $\bar{Q}=0$ $\quad T_{off}$

$V_c \longrightarrow$ charging





لا تشبك

$V_c = V_t + (V_i - V_t)(1 - e^{-t/RC})$

$\frac{2Vcc}{3} = 3.3$

$t_p = 1.1\ RC$

* اذا مابدنا نستخدم $\frac{2Vcc}{3}$ بتحكم بدالها Controller اله قيمة ودايما تأخذ آخر قيمة
$V_{controller} = V_{threshold}$
اذا اعطينا للController قيمة

Concept of
1. nonretriggable
2. re triggable
3. Astable
4. mono Stable
5. Bi stable

⇒ Multivibrators:

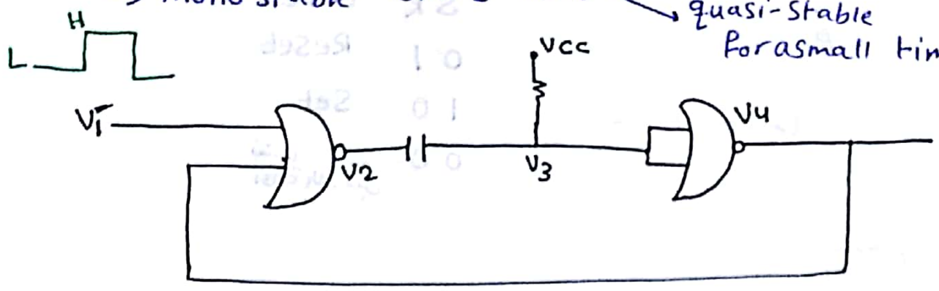
$\tau = t_2 - t_1$

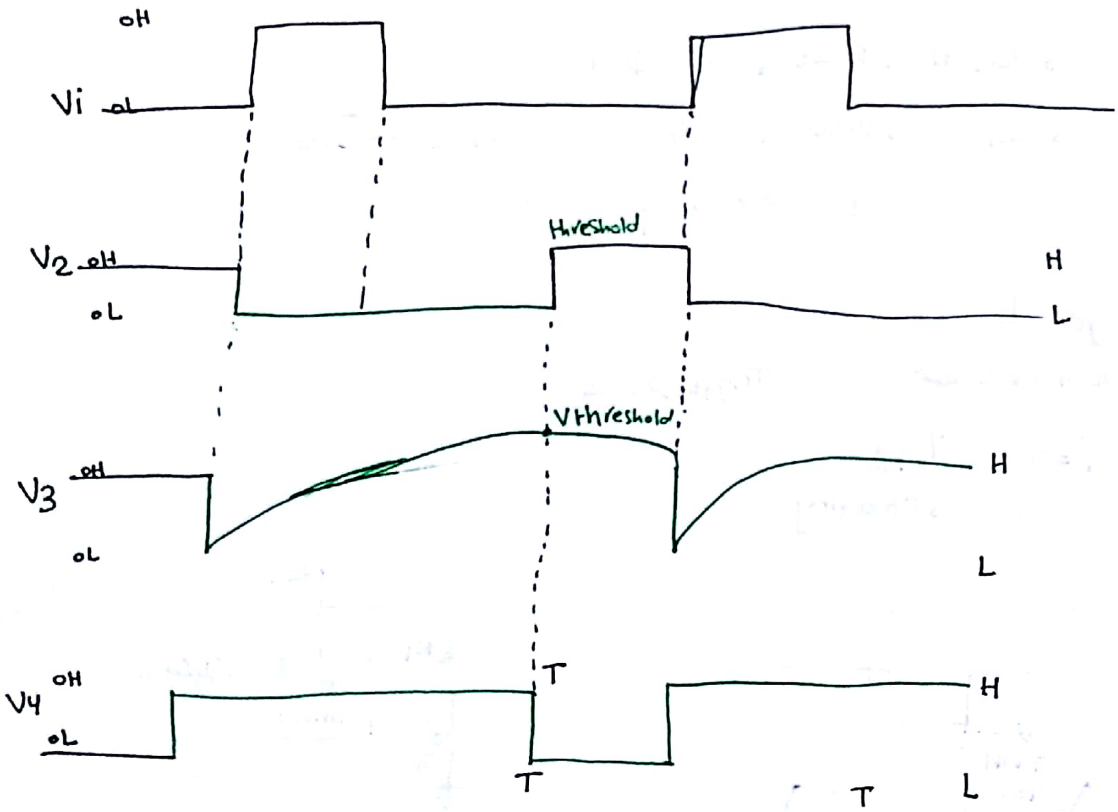
$T = Rc \ln 2 = 0.7\,Rc$

$V_{th} = V_C = V_i + (V_f - V_i)(1 - e^{-t/\frac{Rc}{\tau}})$ — $V_i \to 0$, $V_f \to V_{DD}$, $V_i \to 0$; $T = 0.7RC$

* $V_{th} = \frac{V_{DD}}{2}$

→ mono Stable CMOS cct
- stable
- quasi-stable for a small time → resume to (stable)

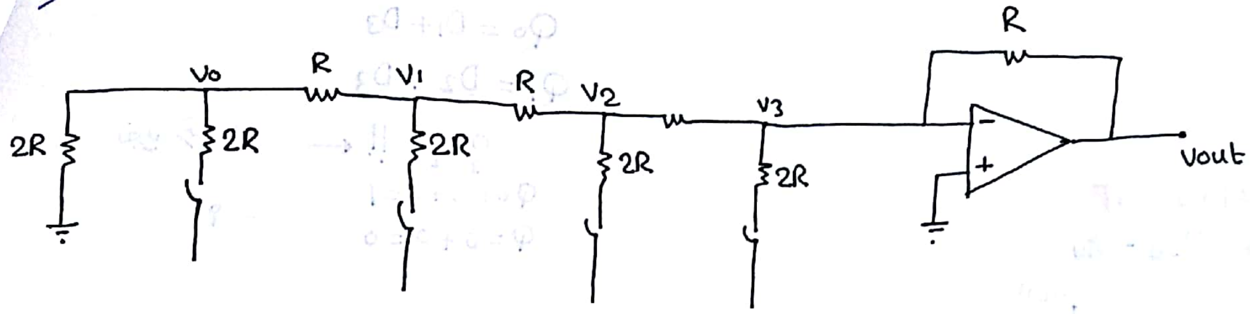




Vc = 0 Low o/p ← Low I/p trigger

Vc = ع يتغير high o/p ← high trigger

D-A Converter



$$V_{out} = \frac{-V_{ref}}{2}\left(\frac{D_{N-1}}{2^0} + \frac{D_{N-2}}{2} + \cdots + \frac{D_1}{2^{N-2}} + \frac{D_0}{2^{N-1}}\right)$$

$$V_{out} = \frac{-n}{2^N} V_{ref}$$

$$V_{ref} = \frac{\#\ of\ Levels}{\#\ of\ Counts} \cdot \underbrace{V_{out}}_{V_{o\,max}}$$

$$Res = \frac{V_{ref}}{2^N - 1} \quad , \quad Acc = \frac{Res}{V_{ref}} = \frac{1}{2^N - 1}$$

A-D Converter

$$Res = \frac{V_{ref}}{N+1}$$

(N+1 ← عدد comparator)

$$Acc = \frac{Res}{V_{ref}}$$

$$V_{ref,m} = \frac{m}{n+1} V_{ref} < V < \frac{m+1}{n+1} V_{ref}$$

(m ← عدد الـD اللي عندهم 1 ارشغالين)

حسب ←
- اذا المعطى رسمة وفيها R في المقام = عدد الـ R
- اذا المعطى دون رسمة، فقط عدد comp في المقام N+1 (← عدد الcomp)

* كل اللي تحت اي رقم اللي عندو (1) اللي بهاي الحالة هو 5 نعتبرهم X، وكل اللي فوقو نعتبرهم (1)

لما اكتب مثلاً الرقم وعندي 8-3 encoder (101)

$$Q_0 = D_1 + D_3 + D_5 + D_7$$
$$= X + X + 1 + 0 = 1$$

$$Q_1 = D_2 + D_3 + D_6 + D_7$$
$$X + X + 0 + 0 = 0$$

$$Q_2 = D_4 + D_5 + D_6 + D_7$$
$$X + 1 + 0 + 0 = 1$$

$$= 101$$

تسميات

dig o/p of Comp = dig I/p of encoder

= binary # prior to encoder

حسب الـ encoder 8-3 / 4-2 (بكون اما 8 او 4)

dig encoder o/p → بكون 2 او 3

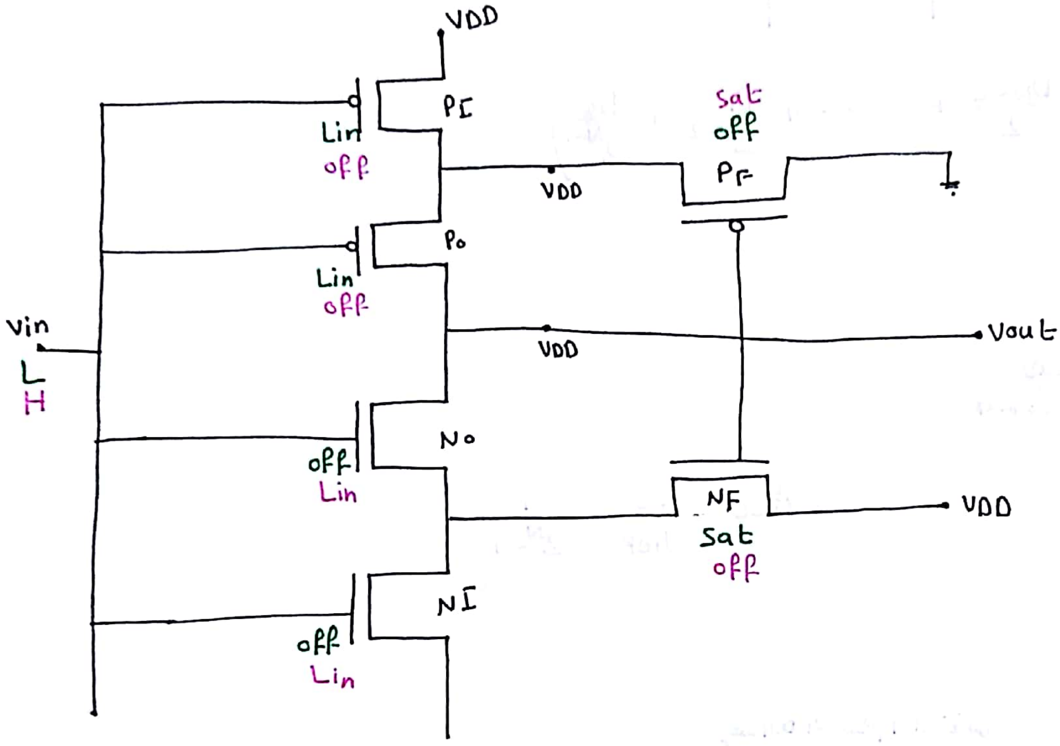
* مثل EX الدفتر انه طلعنا قيمة m وطلعت مثلاً 1 ⟵ dig o/p = 00000001 و N=8

لو مثلاً 4 ⟵

7	6	5	4	3	2	1	0
0	0	0	0	1	1	1	1

26. CMOS ST

Hysteresis = $V_{ID} - V_{IU}$



$V_{OH} = V_{DD}$

$V_{OL} = 0 \longrightarrow I = 0 \longrightarrow V_{SD} = 0$

* $V_{iL} = V_{IU} = \dfrac{\sqrt{\frac{K_{PI}}{K_{PF}}}\,(V_{DD} + V_{TP})}{1 + \sqrt{\frac{K_{PI}}{K_{PF}}}}$

$I_{DP_I}(sat) = I_{DP_F}(sat)$

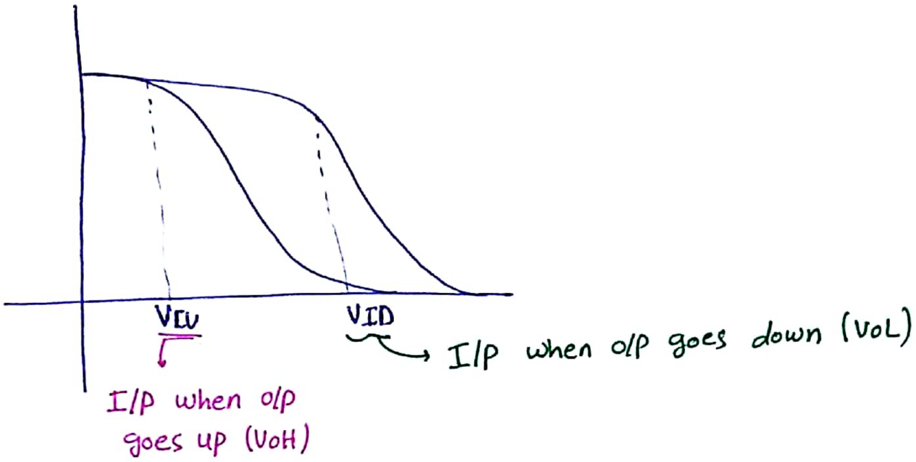
$\frac{K_{PI}}{2}\left[(V_{SG,PI} + V_{TP})^2\right] = \frac{K_{PF}}{2}\left[(V_{SG,PF} + V_{TP})^2\right]$

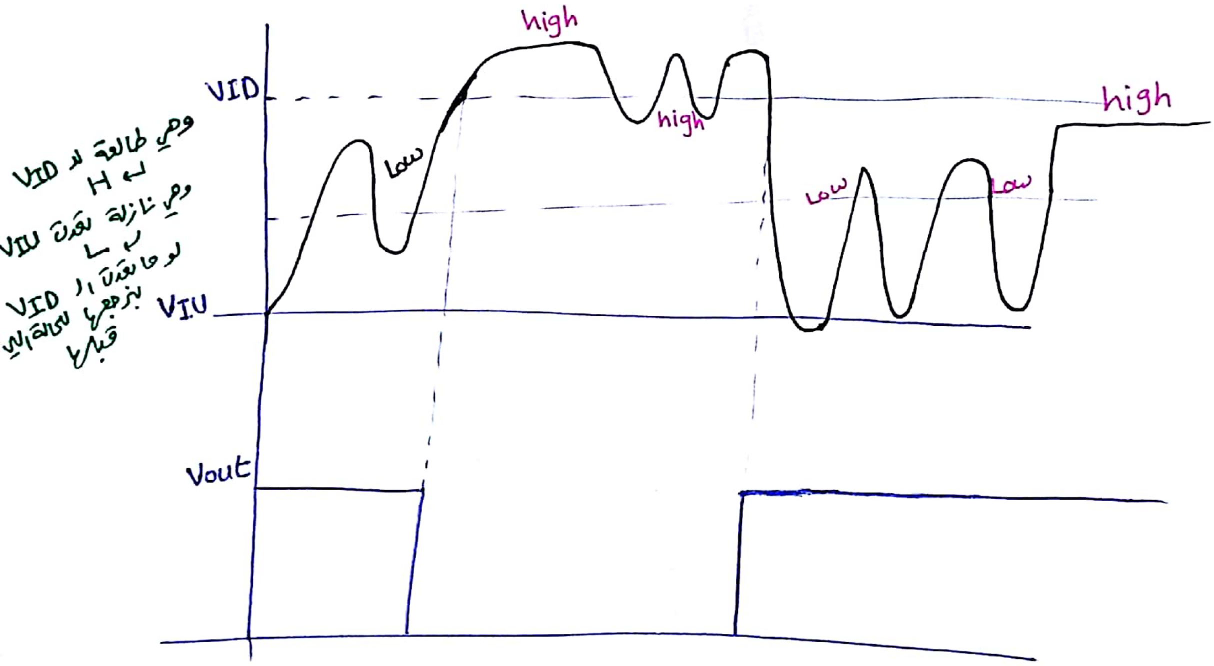
$V_{SG,PI} = V_{DD} - V_{in}$

$V_m = \frac{V_{DD}}{2}$

* $V_{iH} = V_{ID} = \dfrac{V_{DD} + \sqrt{\frac{K_{NI}}{K_{NF}}}\,V_{TN}}{1 + \sqrt{\frac{K_{NI}}{K_{NF}}}}$

$I_{D,NI}(sat) = I_{D,NF}(sat)$


VIU
VID
I/P when o/p goes down (VoL)
I/P when o/p goes up (VoH)


high
VID
high
high
low
low
Low
VIU
Vout
وهي طالعة لـ VID
H ←
وهي نازلة تعدت VIU
L ←
لو ما تعدت ال VID
بترجع للحالة اللي
قبلها