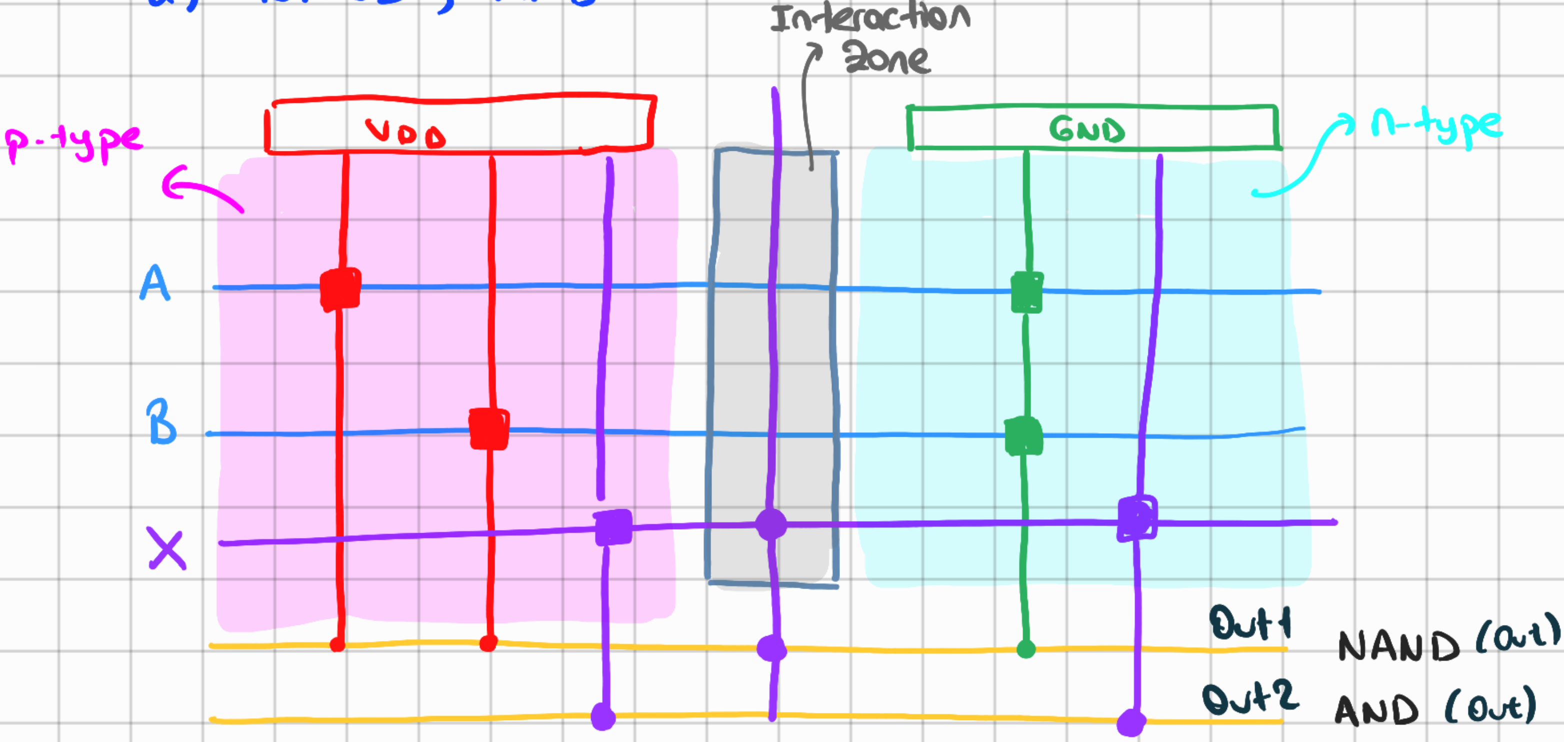
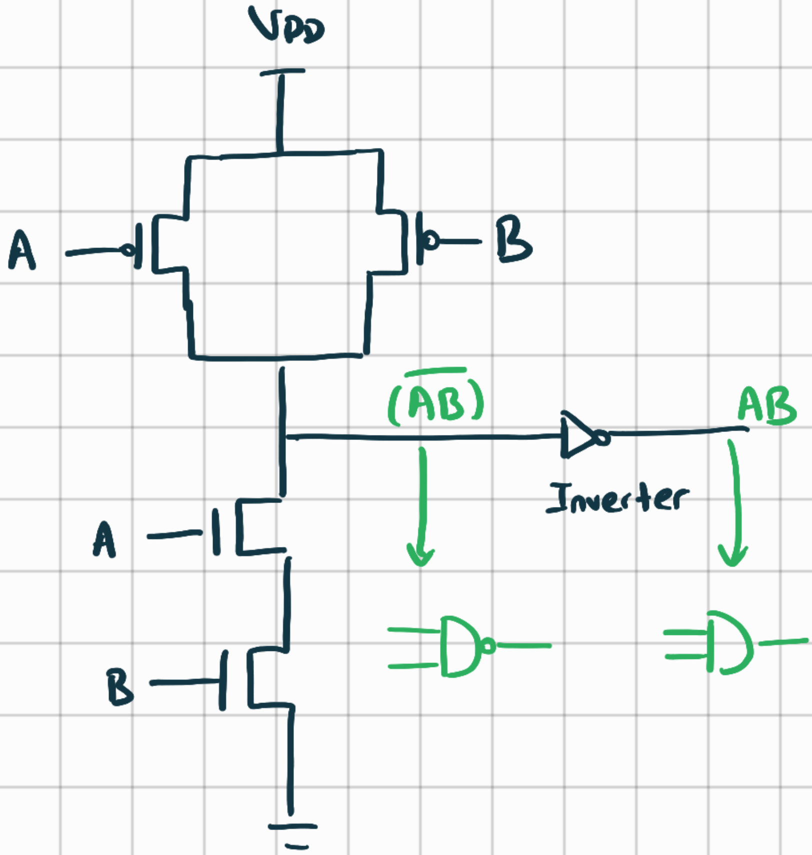
Zeynepnur Şahinel

MICRO-435 HW9

Question 1 Array Circuits with Molecular Transistors

a) NAND , AND





· explain current flow depending on input conditions

· Verify the truth table.

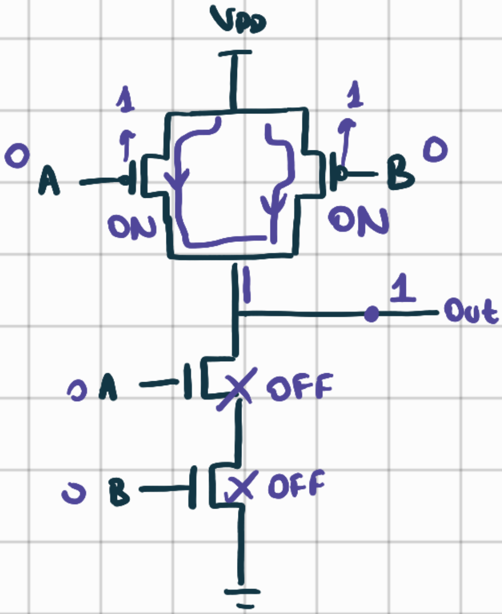
· Discuss where problems could arise

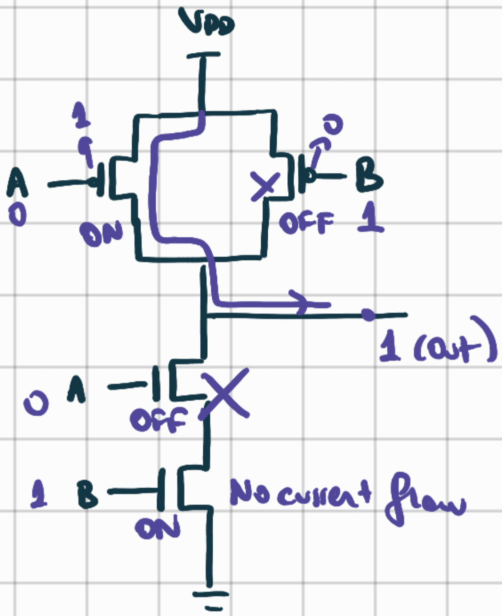
(Out1) (Out2)

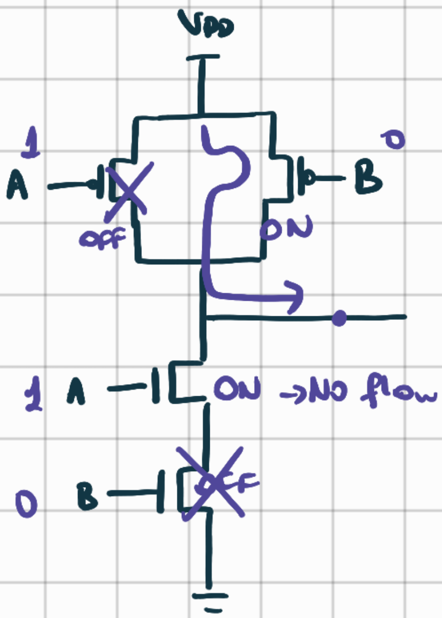
Truth Table NAND & AND

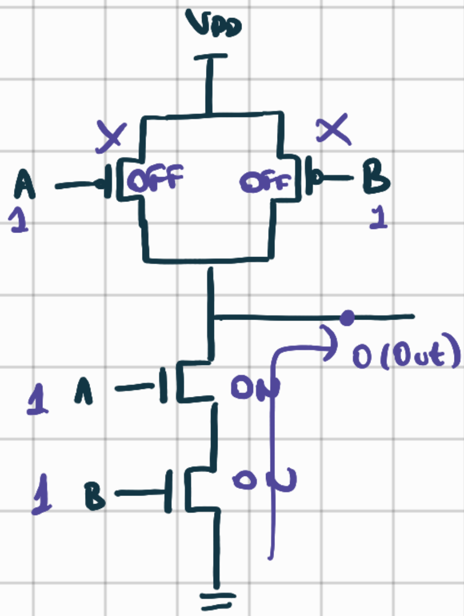
Invert

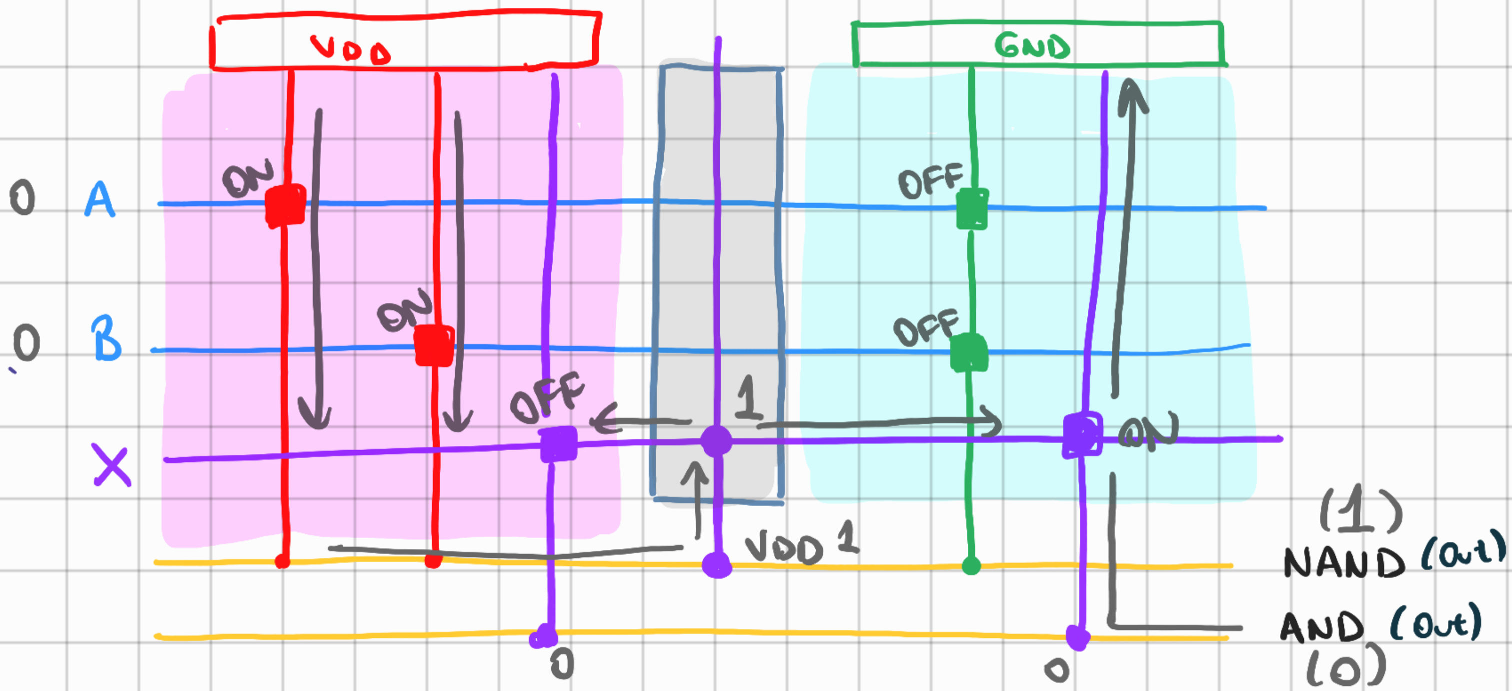
A	B	Out1	Out2
0	0	1	0
0	1	1	0
1	0	1	0
1	1	0	1



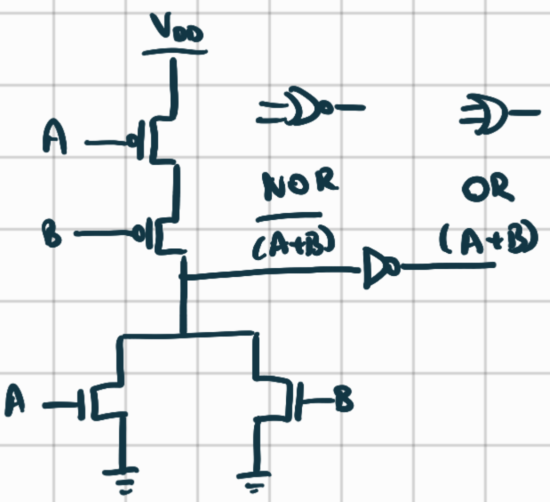


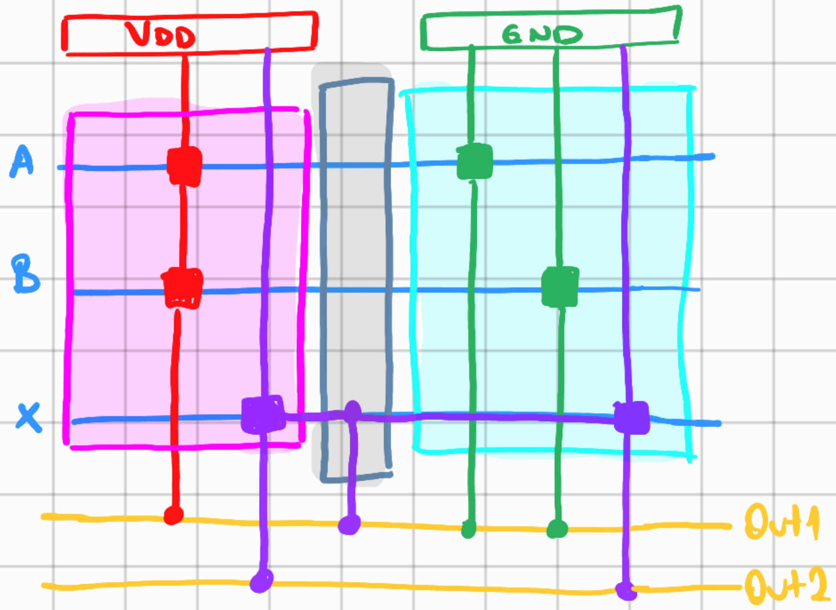






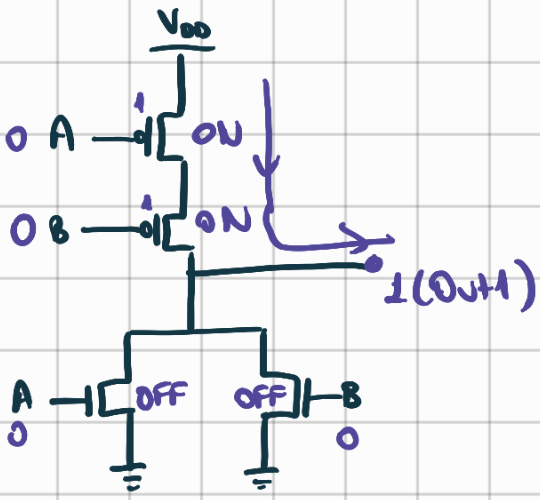
b) NOR , OR

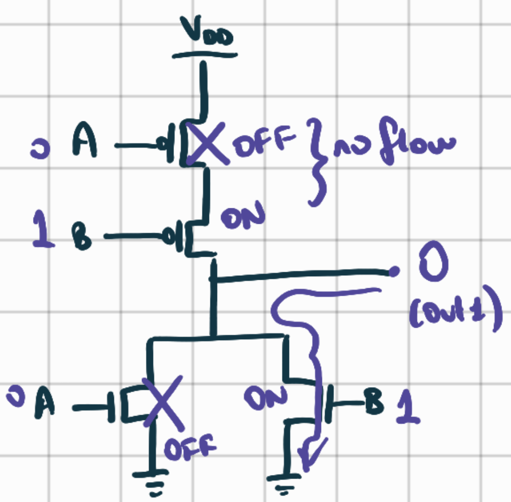


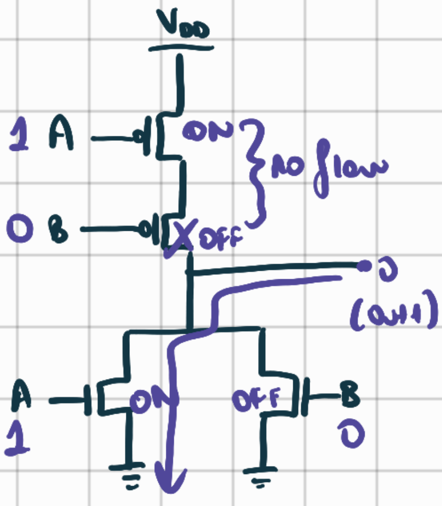


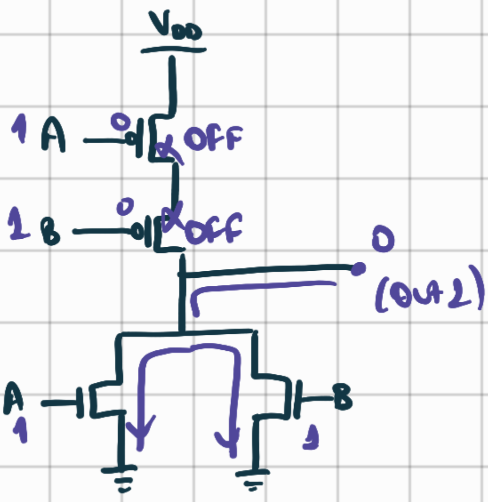
Truth Table for NOR & OR

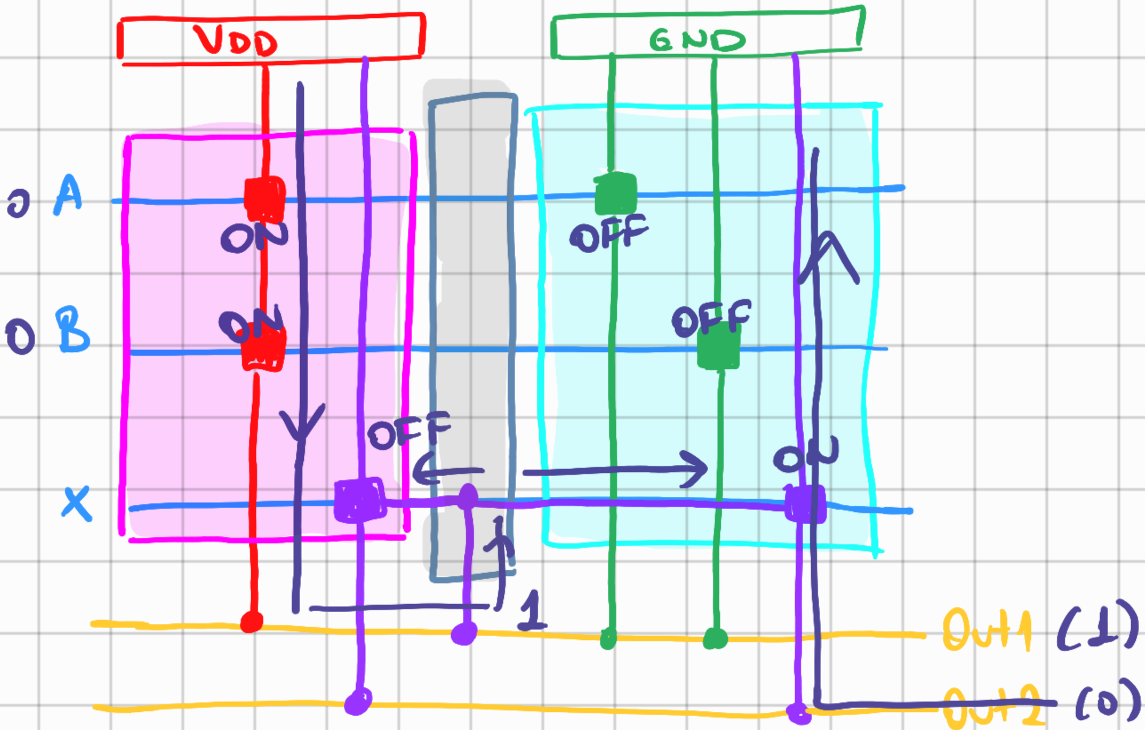
A	B	(NOR) Out1	(OR) Out2
0	0	1	0
0	1	0	1
1	0	0	1
1	1	0	1





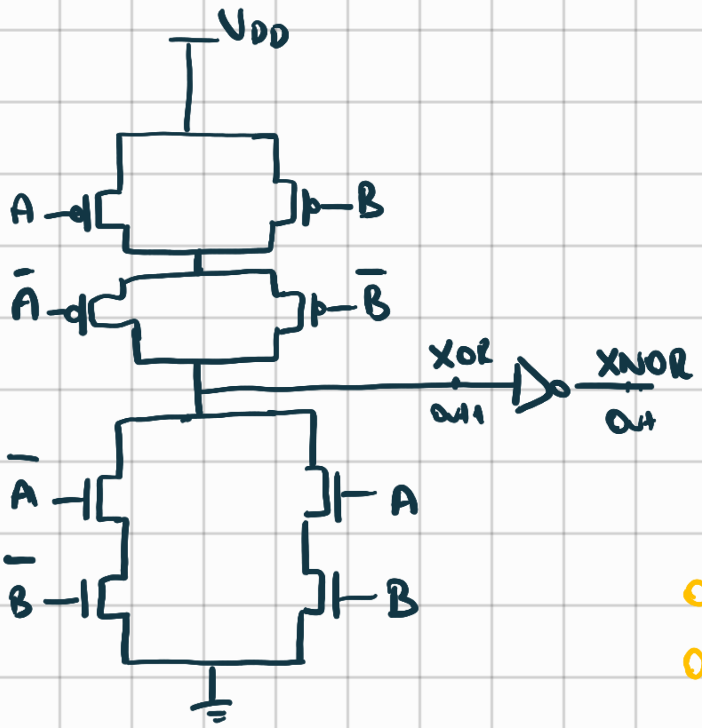


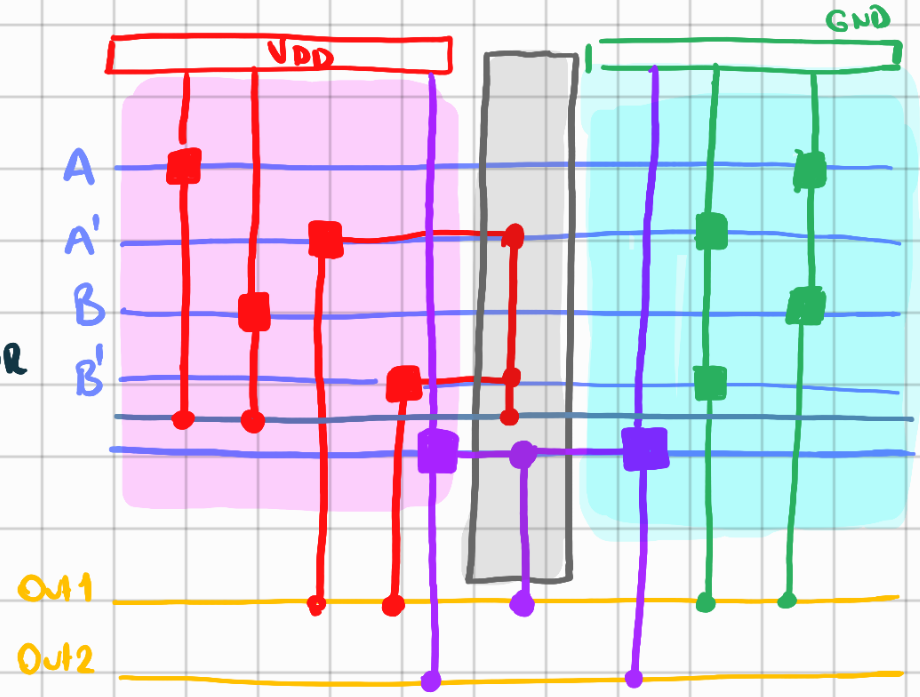




c) XOR, XNOR

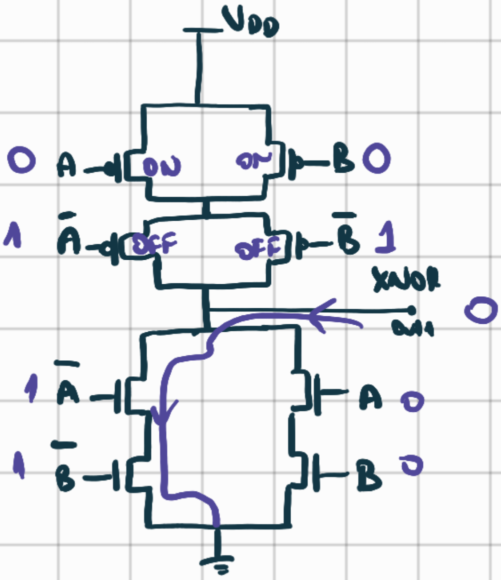
$$XOR = A\bar{B} + \bar{A}B \quad , XNOR = \bar{A}\bar{B} + AB$$

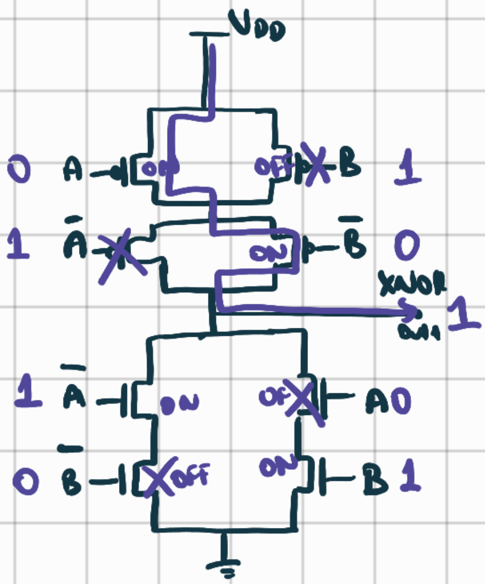


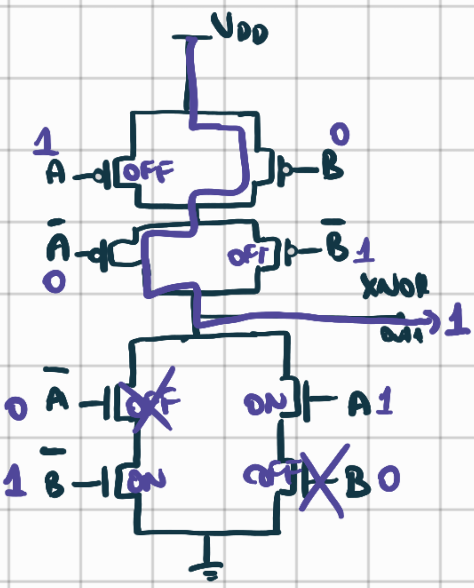


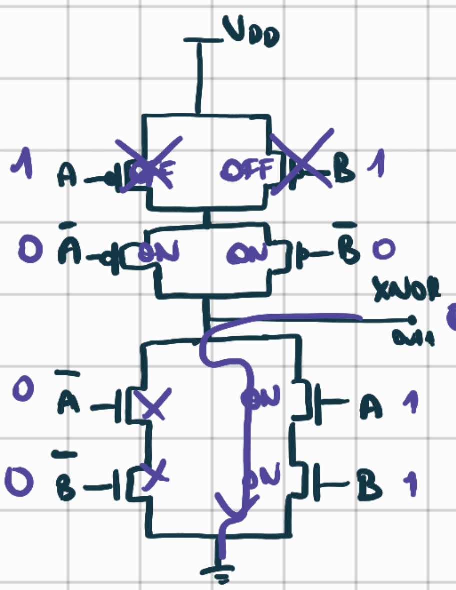
Truth Table for XOR XNOR

A	B	XOR Out1	XNOR Out2
0	0	0	1
0	1	1	0
1	0	1	0
1	1	0	1



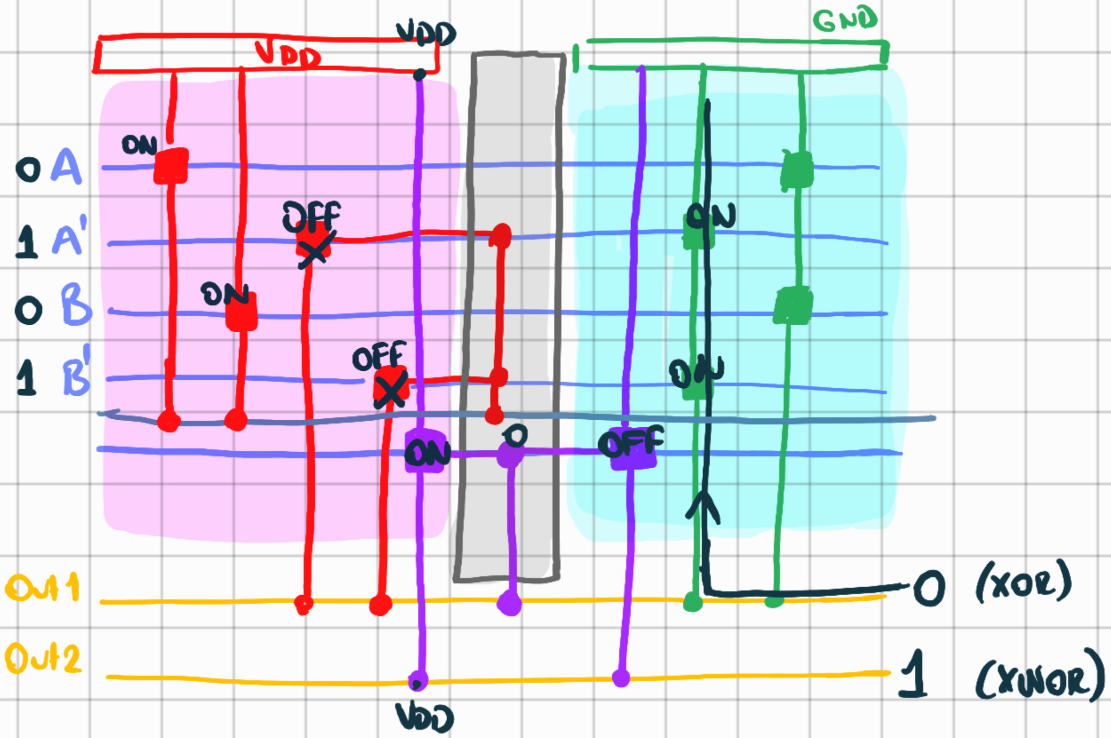






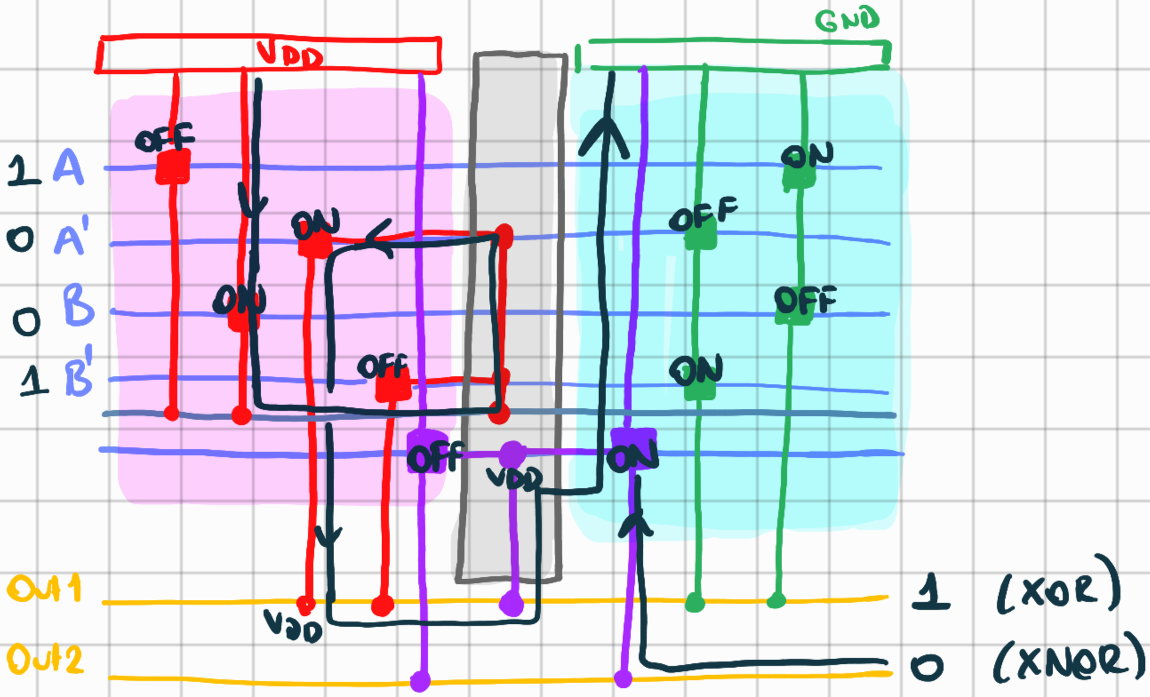
Case 1

A = B = 0

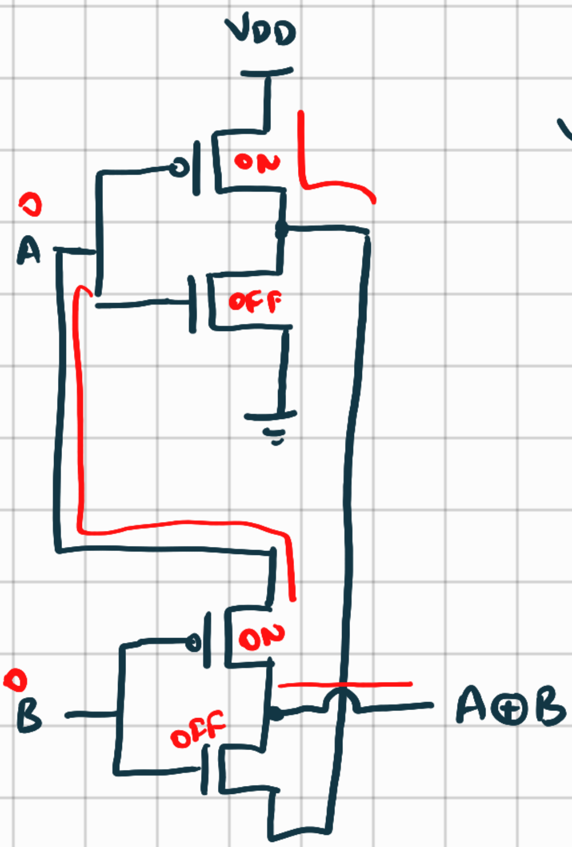


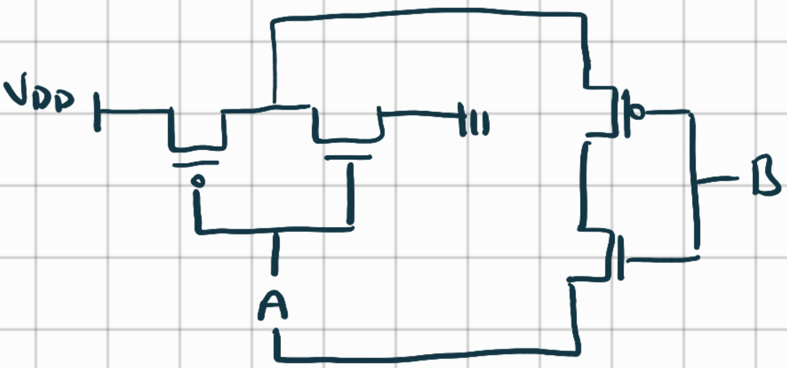
case 2

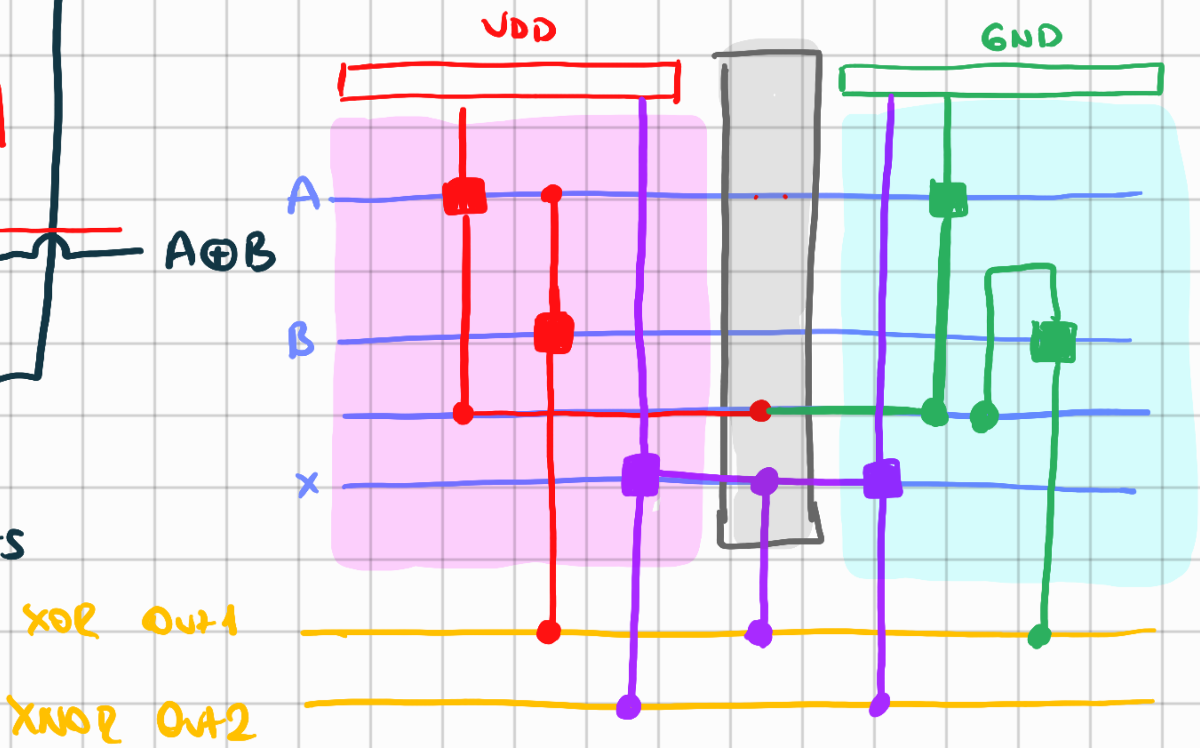
A = 1
B = 0



More Basic Design



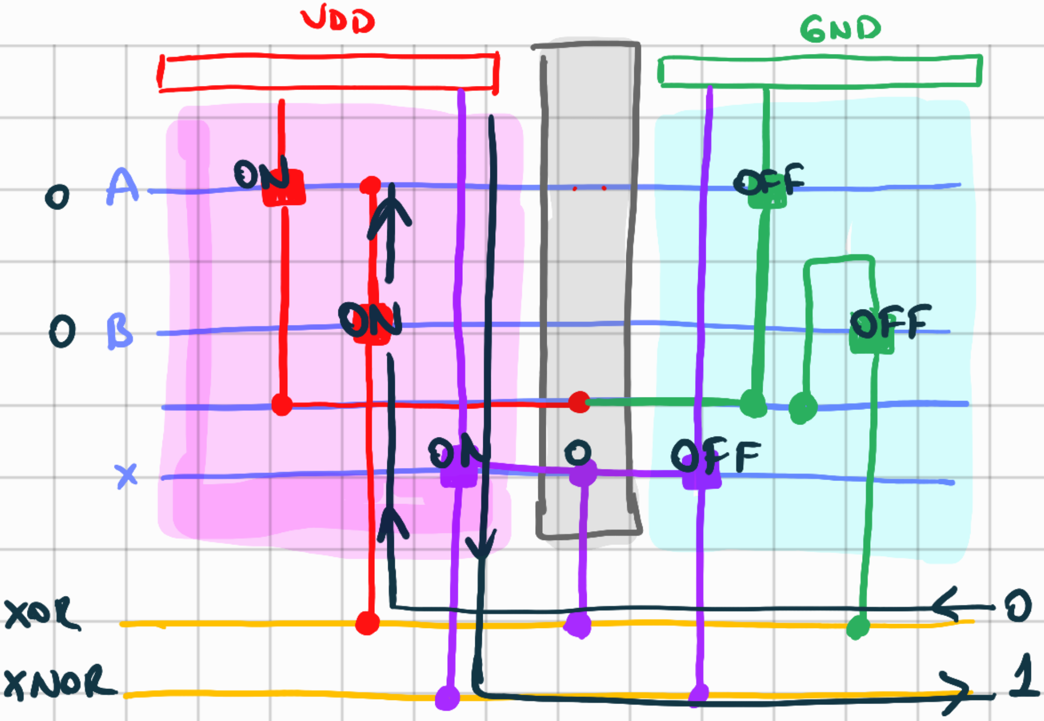




* less transistors
* less input connection

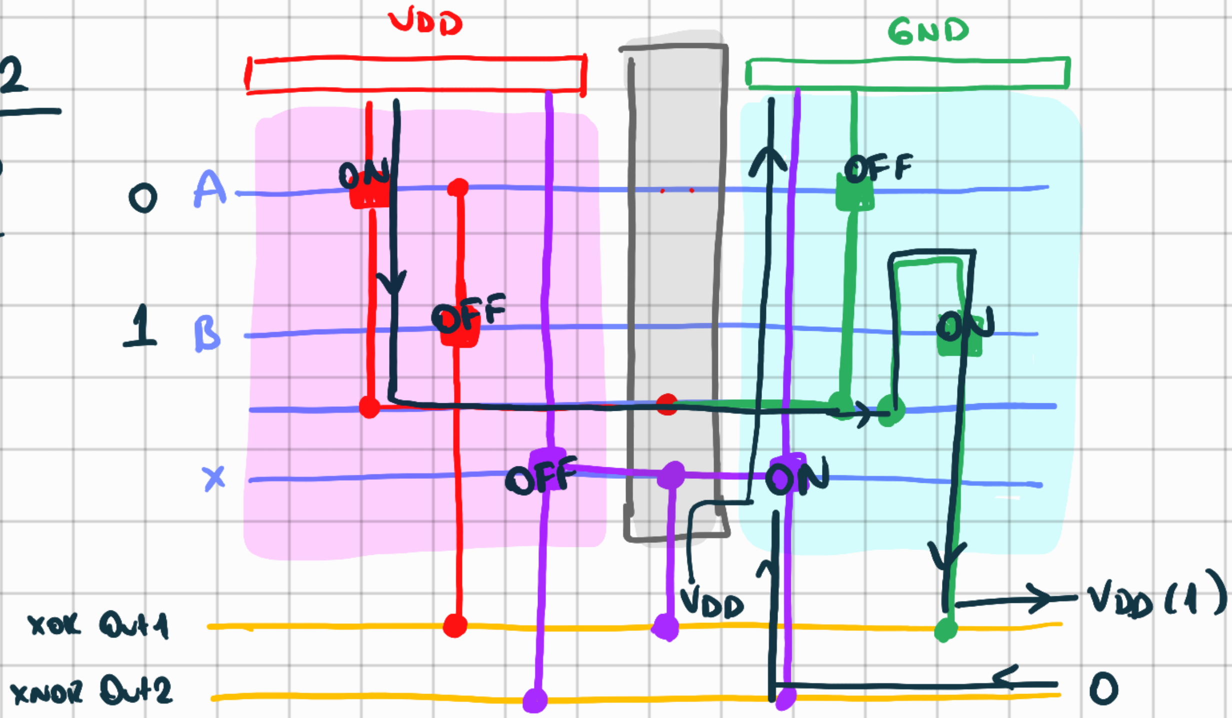
Case 1

A = 0
B = 0

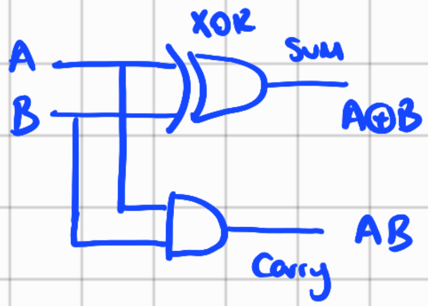


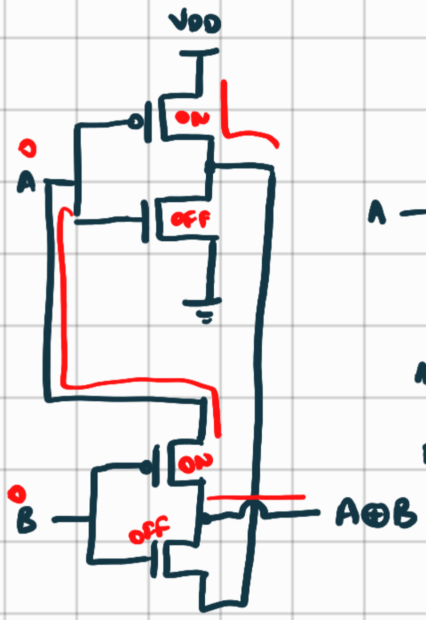
Case 2

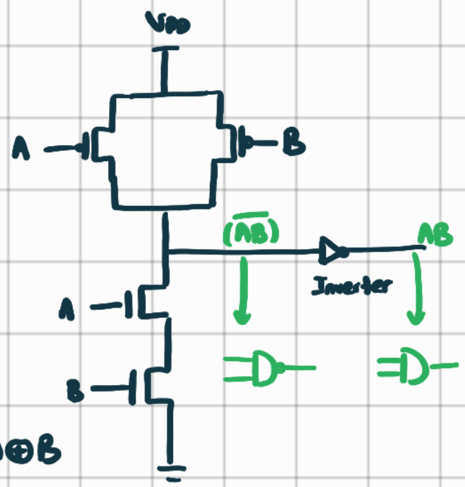
A = 0
B = 1

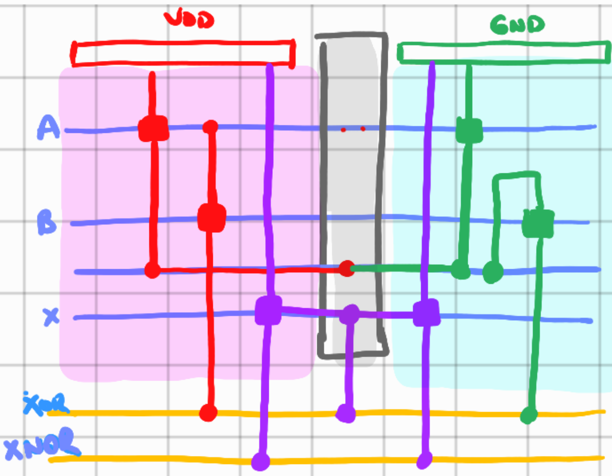


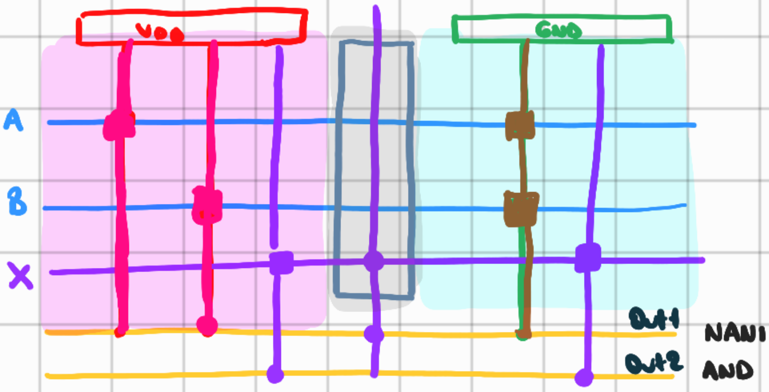
D) Half adder

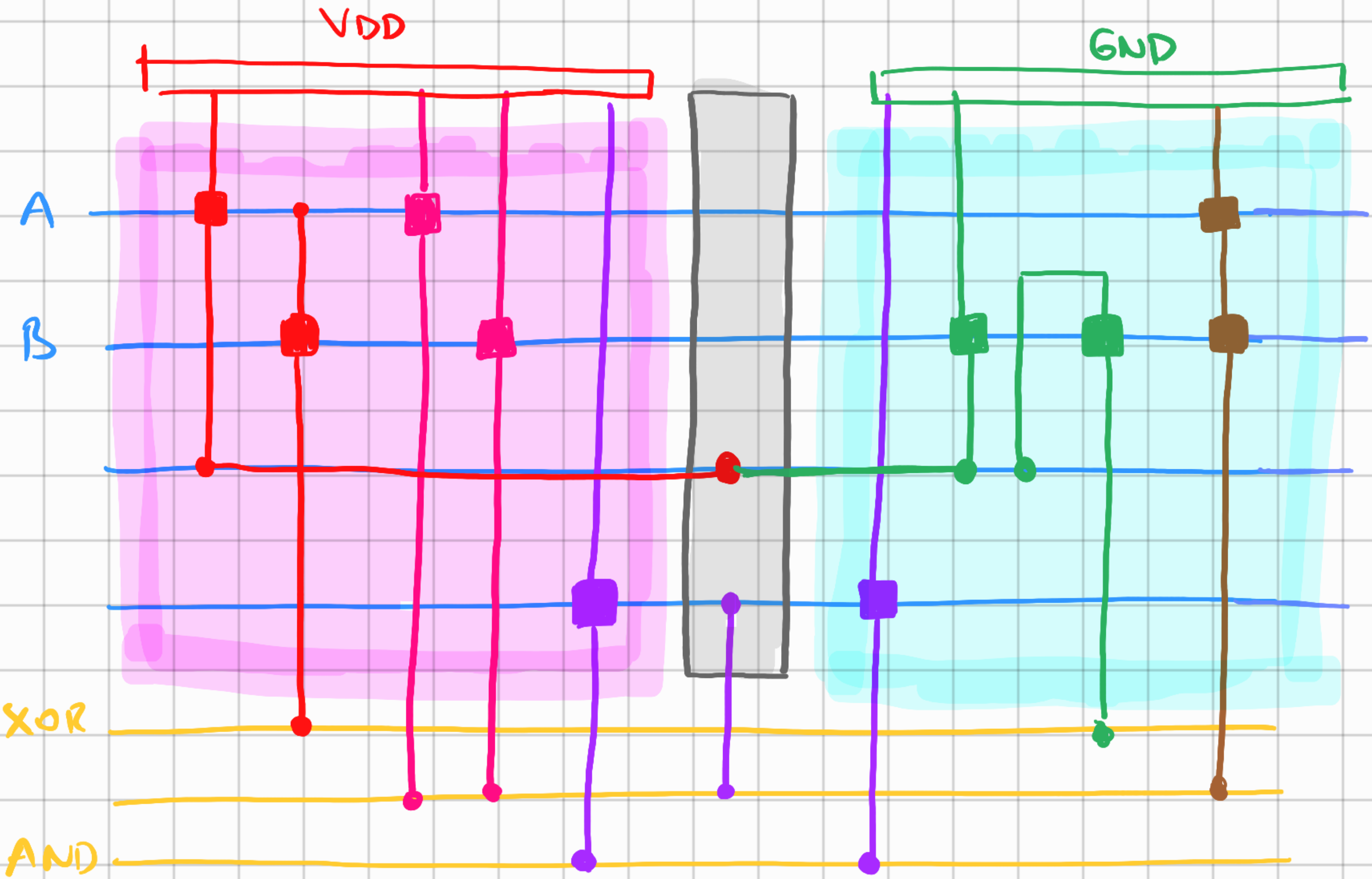






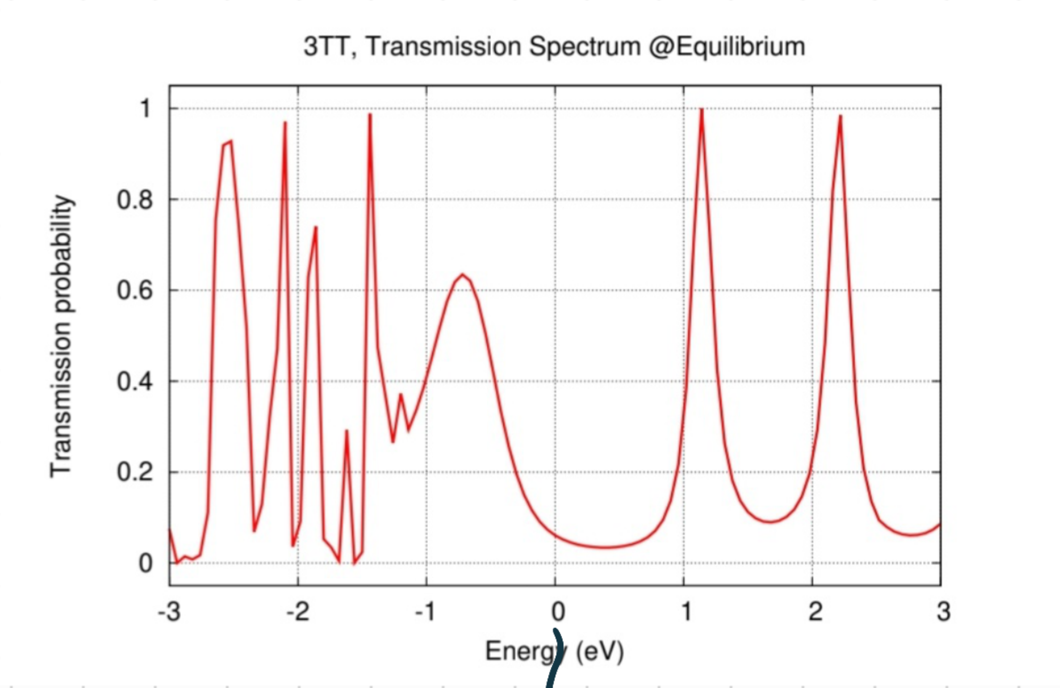

VDD
GND
A
B
X
XOR
XNOR


VDD
GND
A
B
X
Out1
NAND
Out2
AND


VDD
GND
A
B
XOR
AND

Focus 1

Question 3 An initial analysis of 3TT Molecule



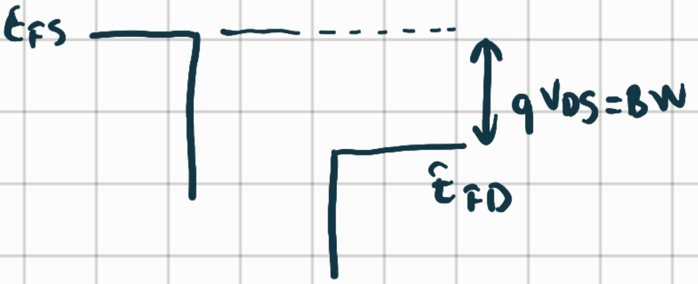
E_{FDOT}

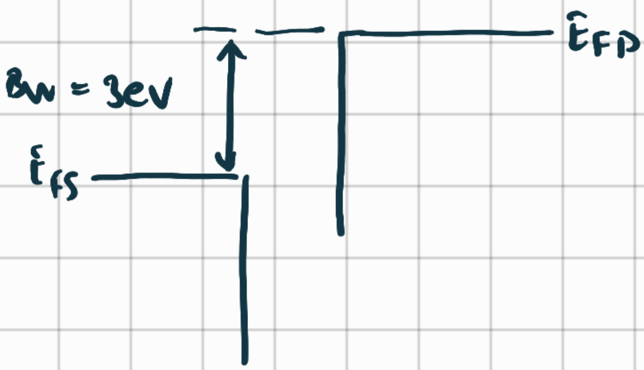
Focus 1 - Q1)

$$BW = E_{FS} - E_{FD} = qV_{DS}$$

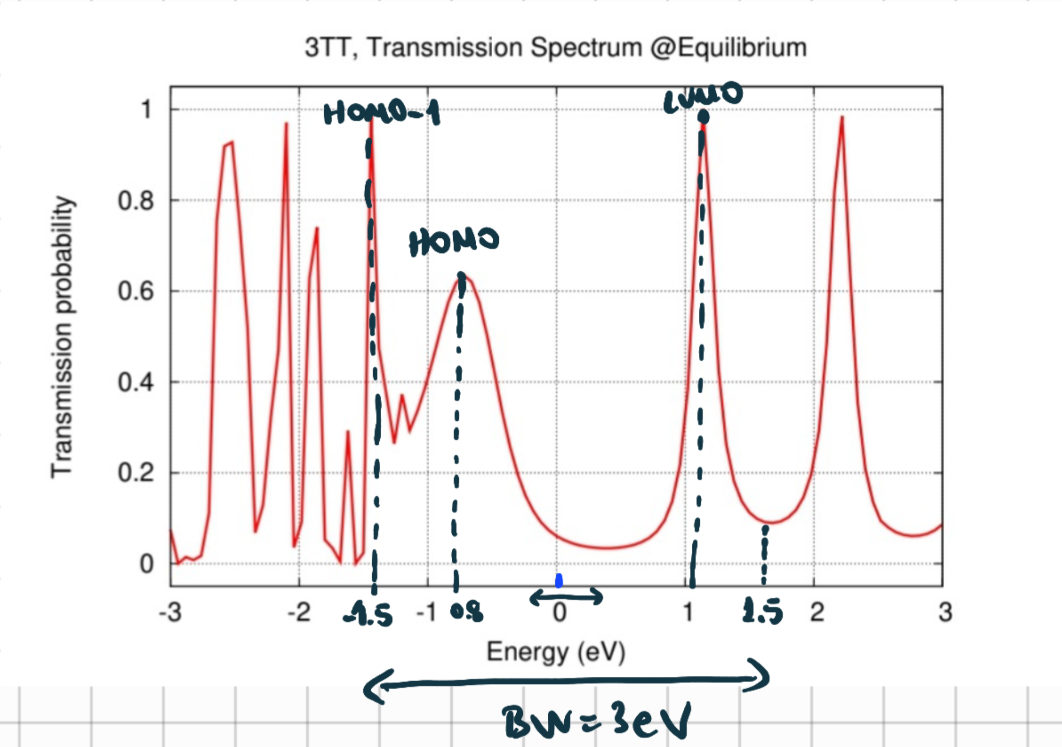
for $V_{DS} = [-3V, +3V]$

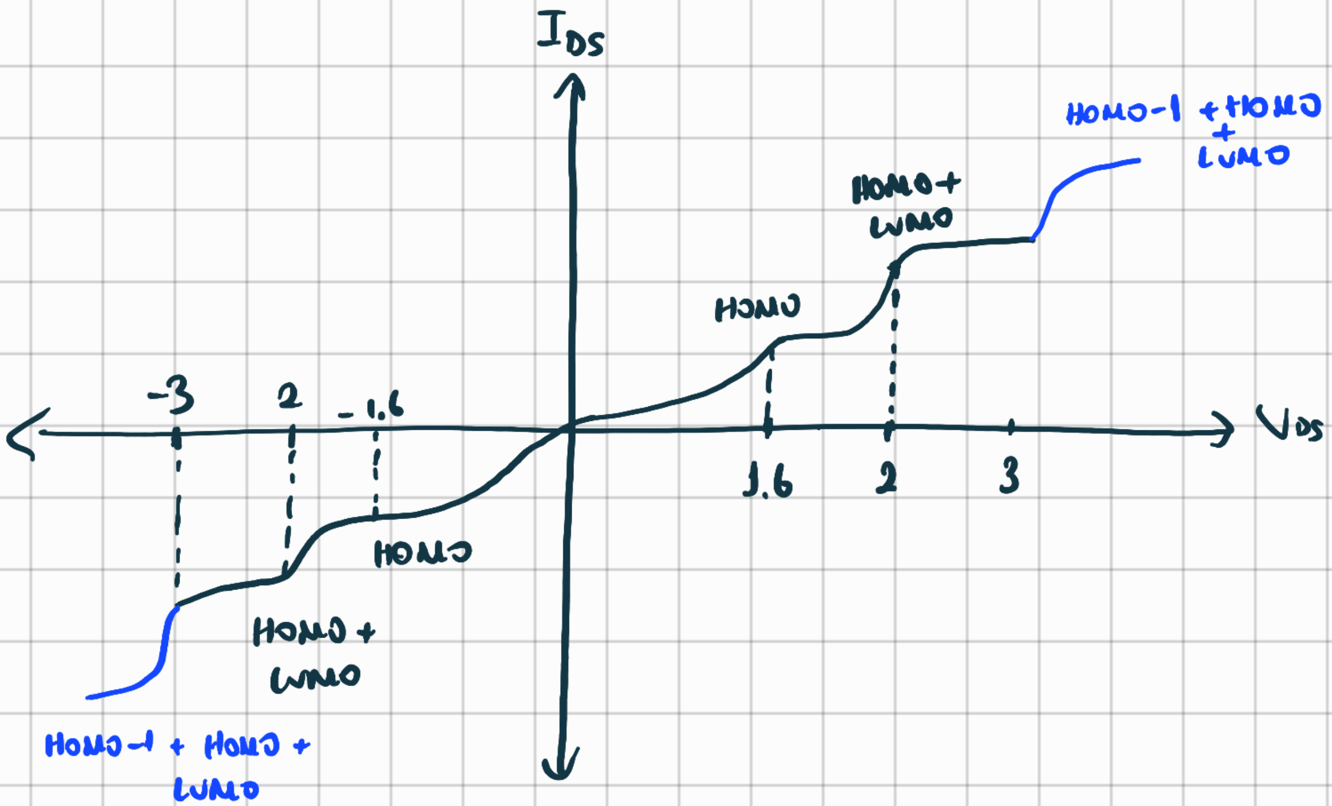
the maximum width of $BW = 3eV$ when $V_{DS} = +3V$ or $V_{DS} = -3V$.





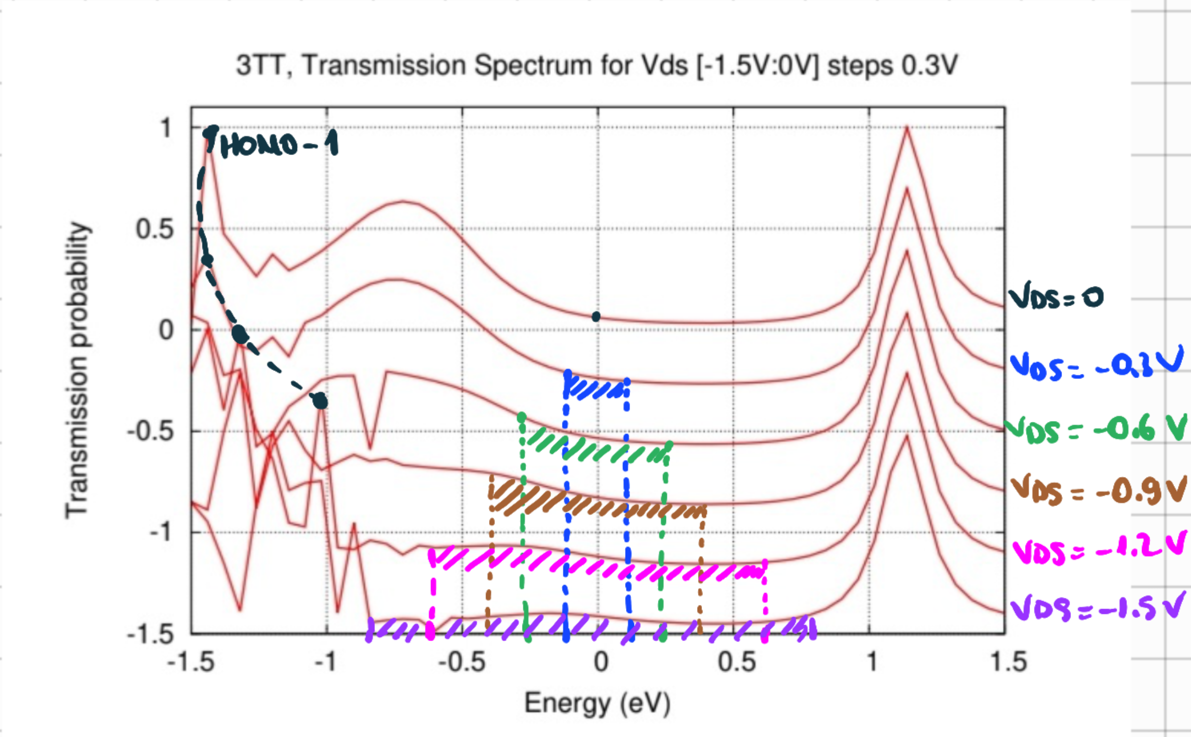
Focus1 Q2





Here we assumed, TS (transmission spectrum is fixed)

Focus 1 Q3

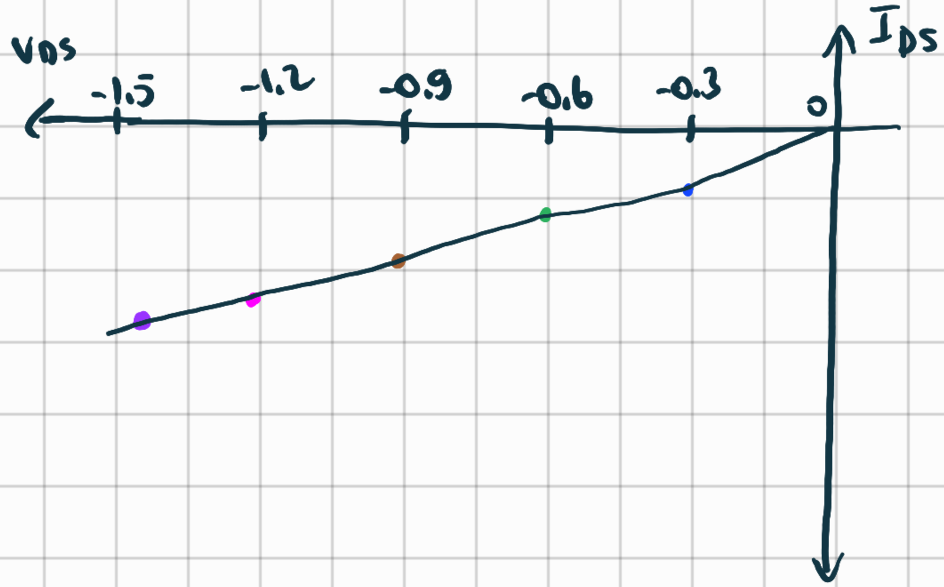


$$U_{VDS} = -q \frac{C_D}{C_{ES}} V_{DS}$$

$V_{DS} < 0$ $\quad U_{DS} > 0$ shifts higher energies

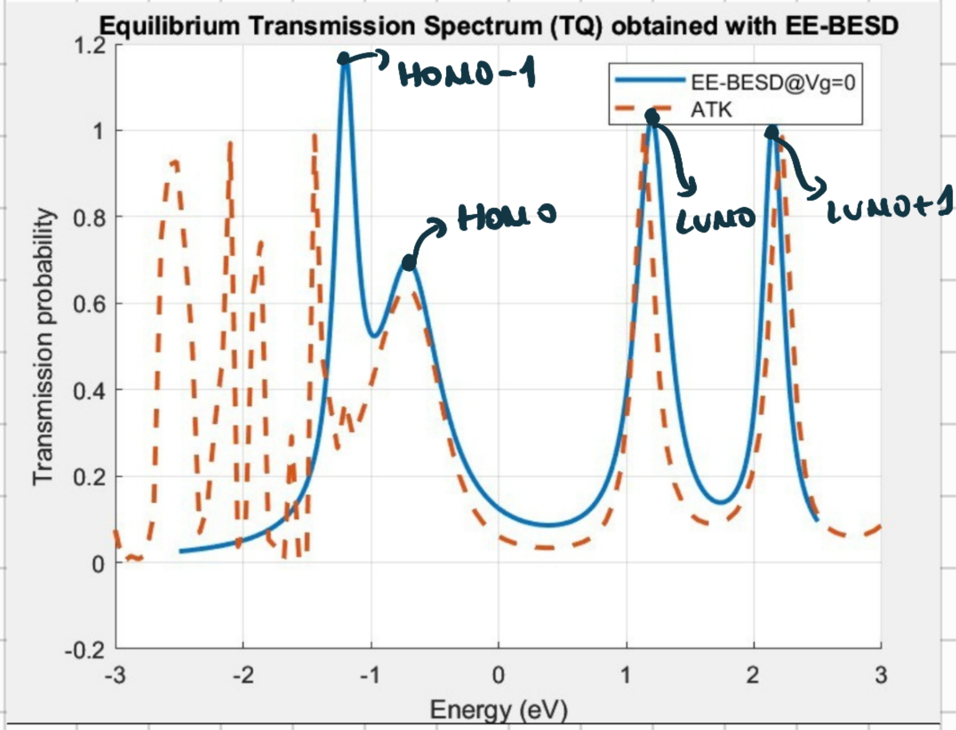
Spectra shifted towards higher energies. And HOMO-1 also participates to conduction.

Focus 1 Q4



Focus 1 Q5

$E0 = [-0.7 \quad -1.2 \quad 1.2 \quad 2.15] \rightarrow$ energ levels



Focus 1 Q6

Parameters:

q = 1 e^- charge (Coulombs)

h = Planck constant (Js)

$\hbar$ = Reduced planck constant (Js)

m = e^- mass (kg)

eps0 = Vacuum permittivity (F/m)

G_0 = conductance (?) ($m^2 kg/s^2 K$)

k = Boltzman constant

T = temperature (°C)

$kT = k(T+273)/q$ eV

$U_F = 0$ Fermi energy level of DOT

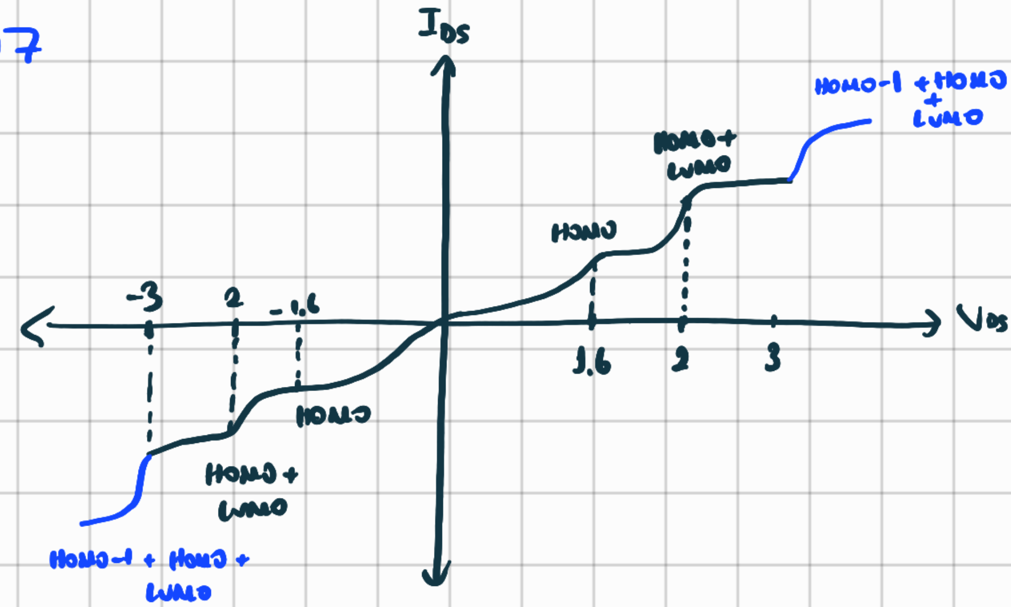
ϵ_0 = energ levels [HOMO-1, HOMO, LUMO, LUMO + 1]

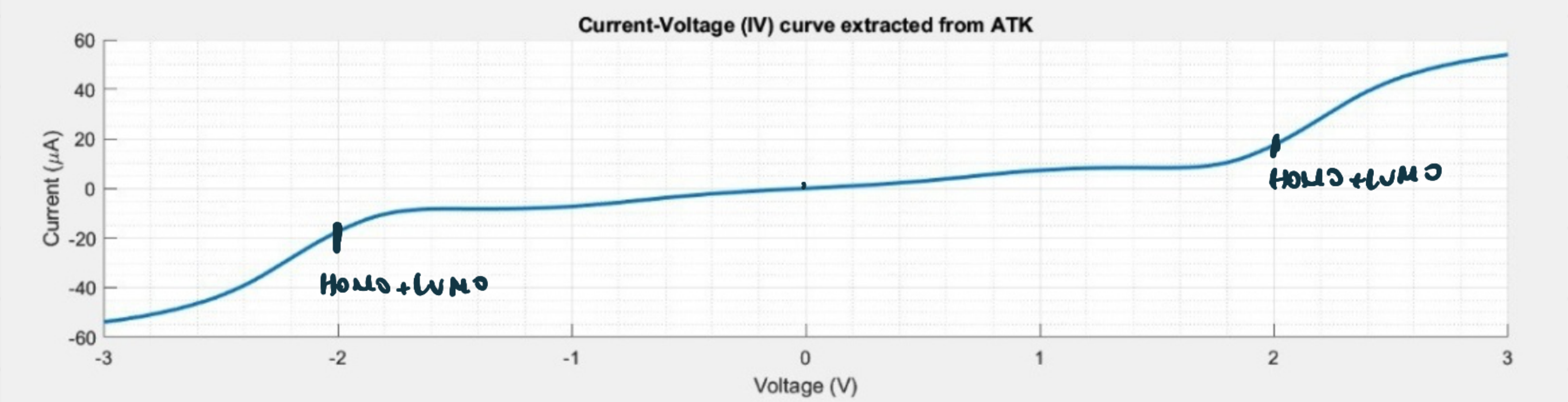
γ_1 = coupling factor between source electrode and molecule

γ_2 = coupling factor between drain and molecule

$\gamma = \gamma_1 + \gamma_2$ = total coupling factor ?

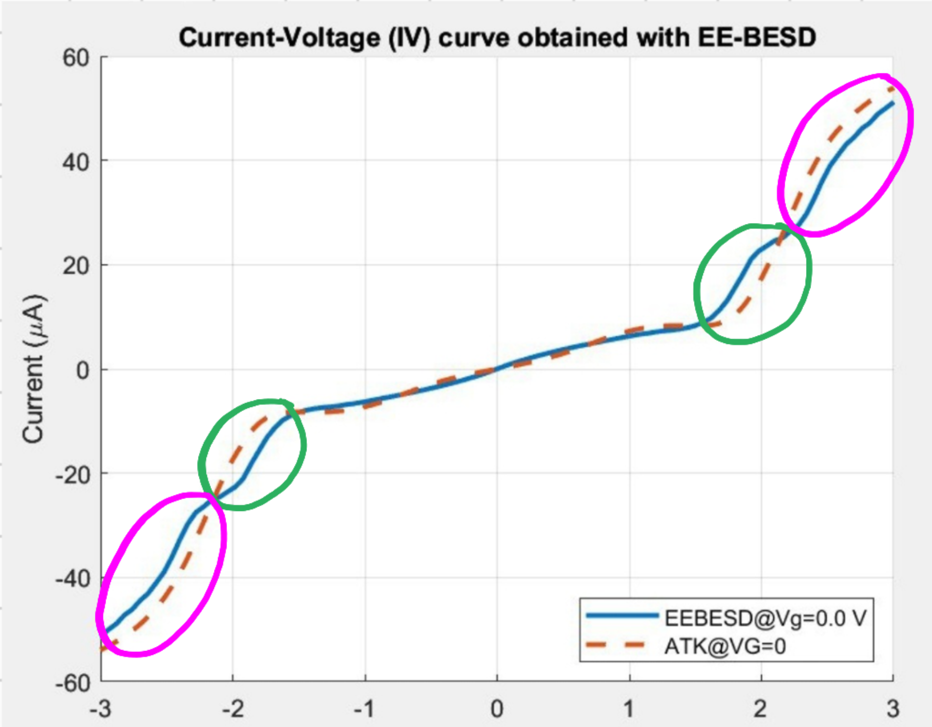
Focus 1 Q7



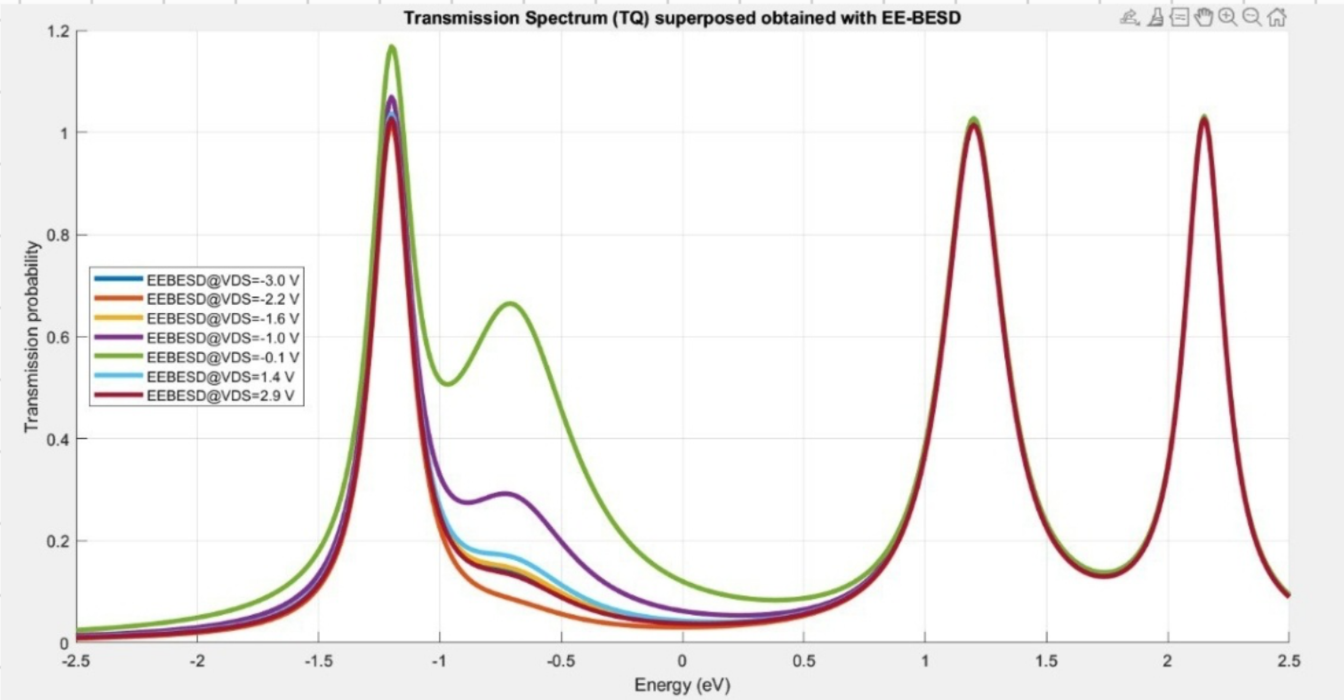


They look similar.

Focus 1 Q8

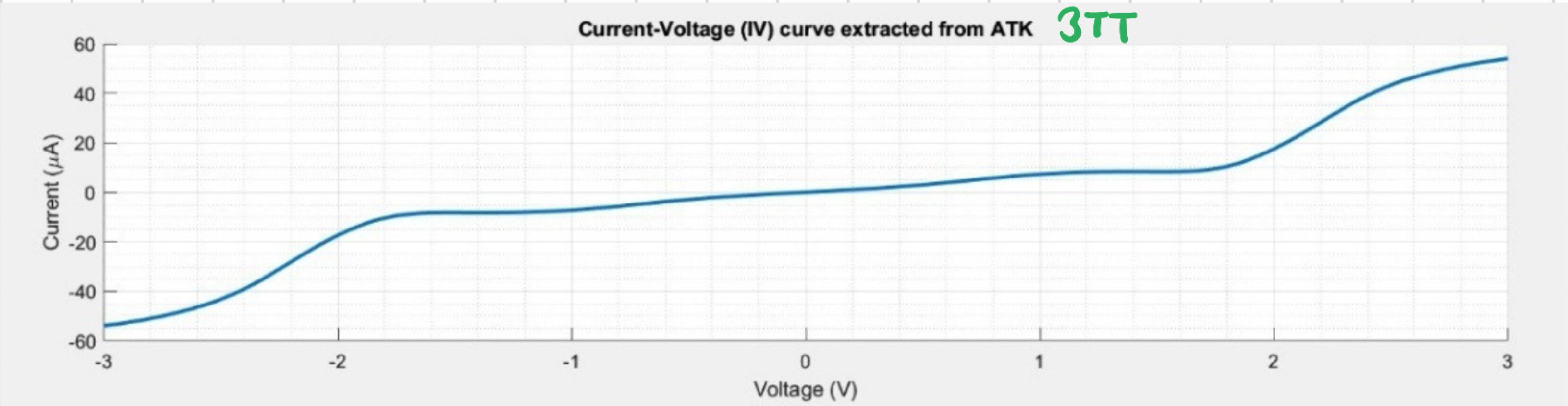


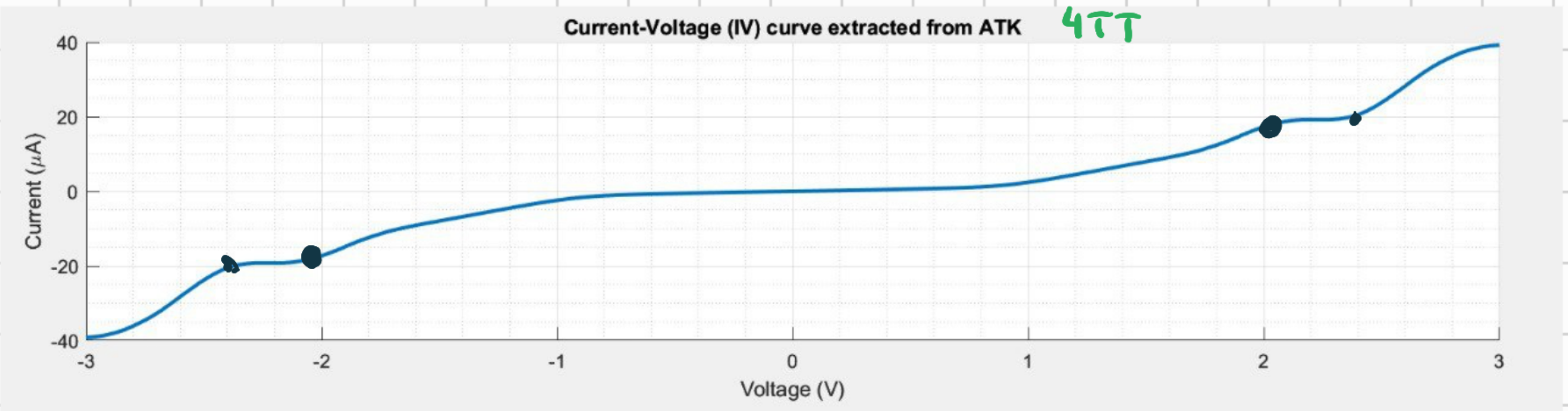
Focus 1 Q9



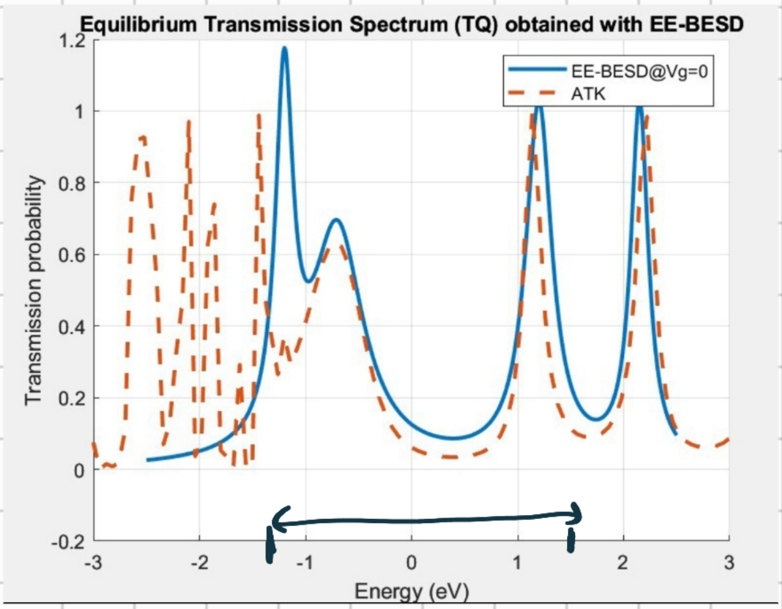
There's a considerable difference between EEBESD & ATK in peak variations. For EEBESD, lower energy levels than HOMO-1 are not present.

Focus 2 Q10



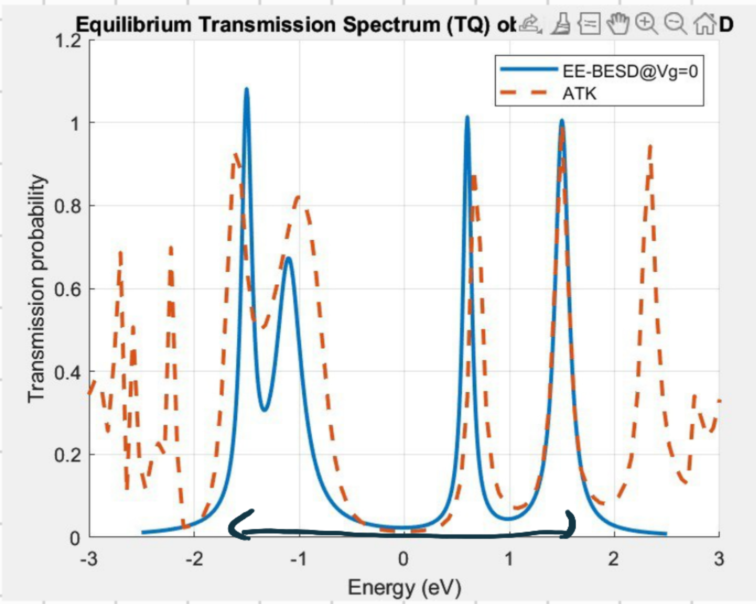


For 3TT case, current is larger than 4TT.



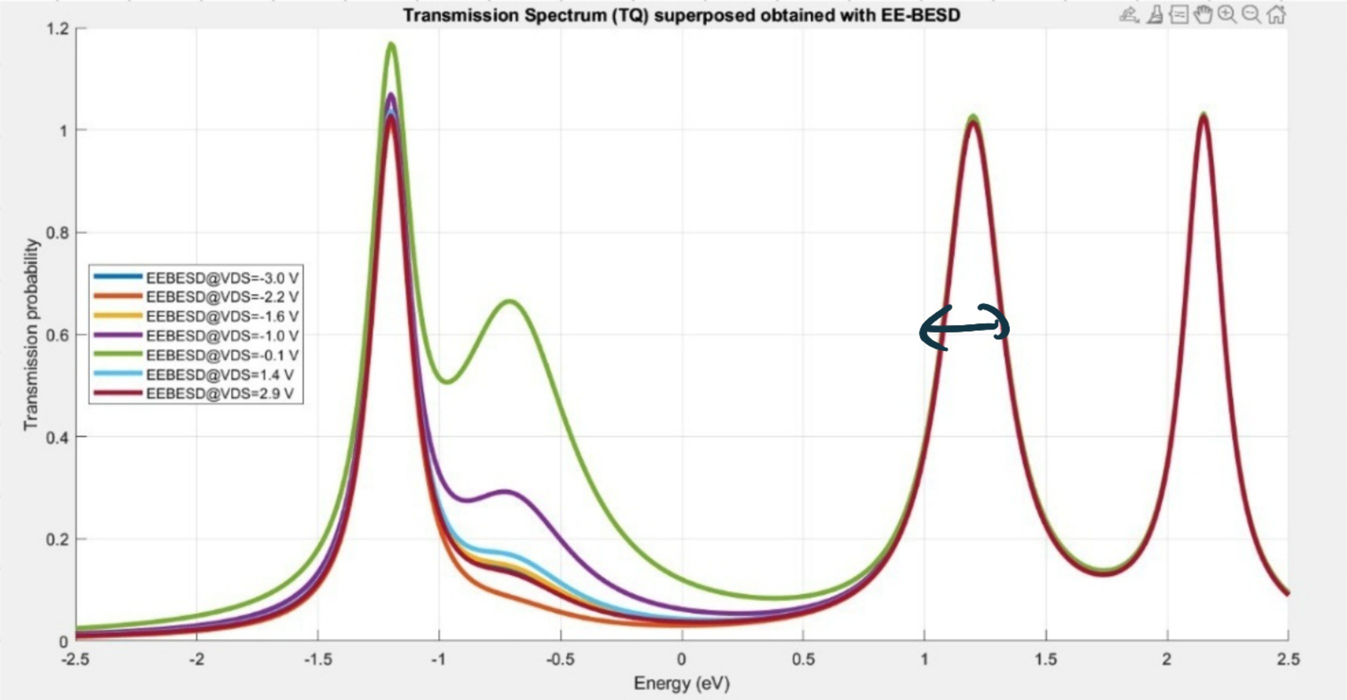
3TT

3peaks

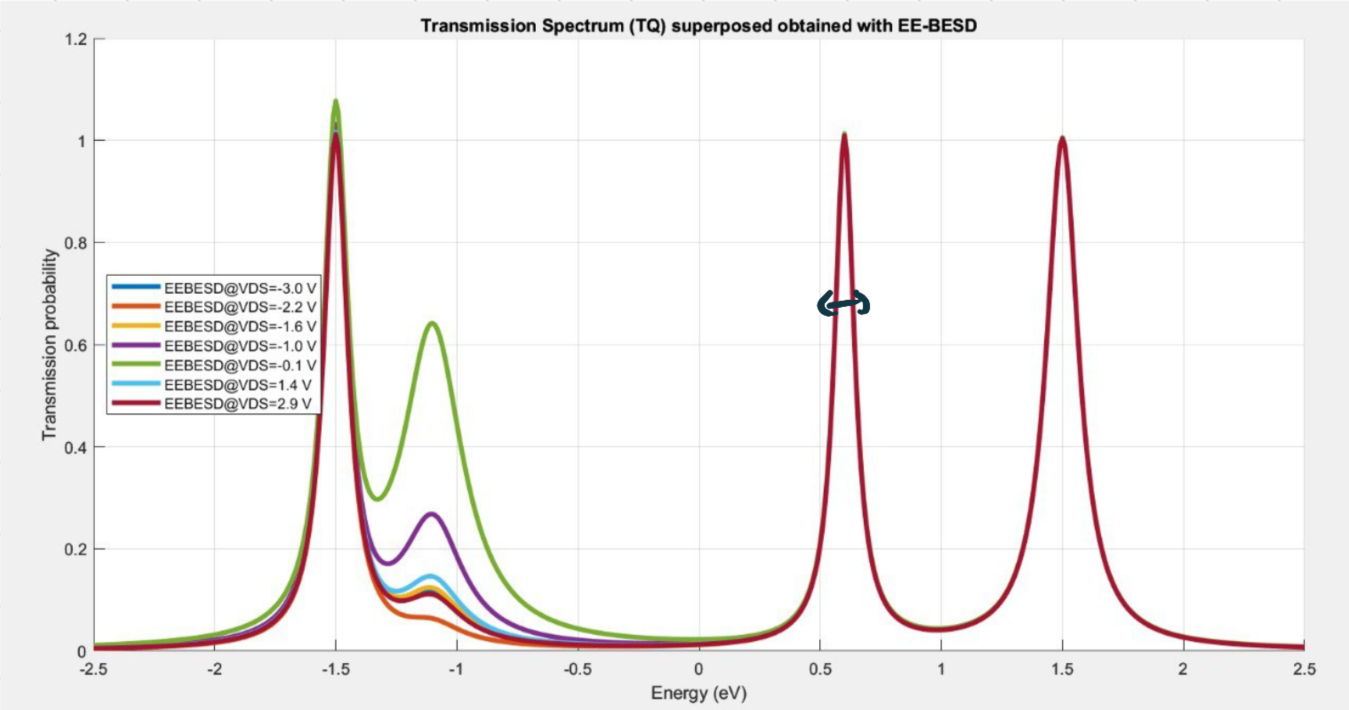


4TT

4peaks



3TT



4TT

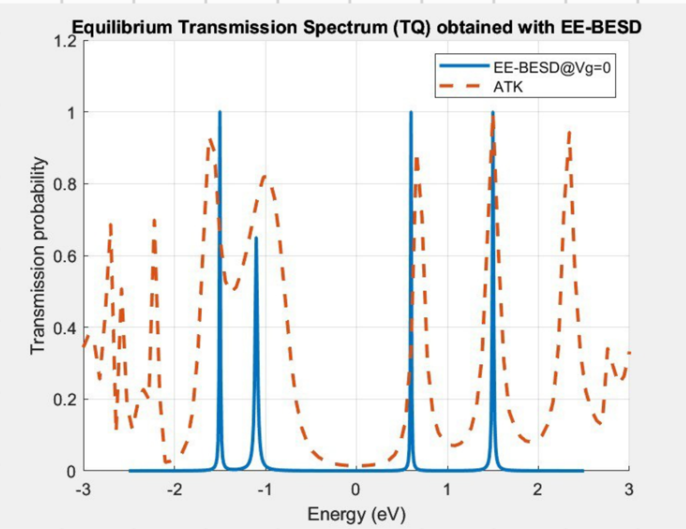
For 4TT, broadening is reduced; thus, narrow peaks occur and these factor decreases I_{DS}. Even though more peaks and reduction in HLG occur.

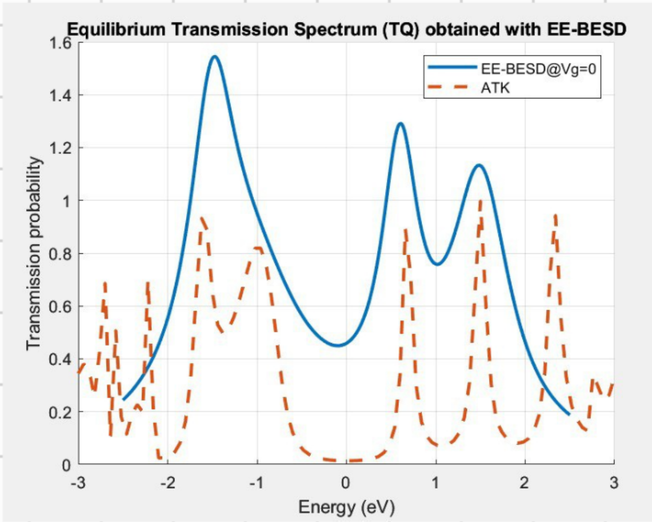
Focus2 Q4

Expectations:

Decreasing coupling factor yields weaker bonding; therefore, narrow peaks are expected. (broadening decreases). Thus, smaller current values are expected.

Increasing coupling factor yields stronger bonding ⇒ Increased broadening ⟶ wider peaks ⟶ Increase in current





$\gamma = 0.01$

$\gamma = 0.5$