INTEGRATED CIRCUITS 1

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Design a 65 nm single ended common source amplifier with the following specs:

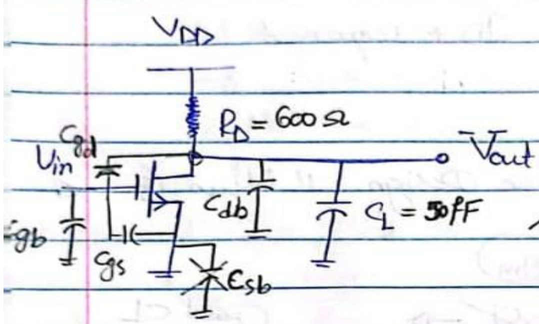
VDD → 1.2 V

DC GAIN → 6 dB

Pdc <= 1.2 mW

CL → 50 fF

Design Question using
The 65 nm technology



specs:

$V_{DD} = 1.2\ V$

DC gain = 6 dB

BW ≥ 10 GHz

$P_{DC} \leq 1.2$ mW

$C_L = 50$ fF

we take I_D to be $\boxed{1\,mA}$

degrees of freedom
- → $V_{SB} = 0$ ⇒ determined by topology
- → $V_{GS} = 516$ mV
- → $V_{DS} = 0.6$ V
- → W
- → L = 150 nm

we have 3 constraints and 4 degrees of freedom

$$gain = -g_m\,(R_D \parallel r_o) \longrightarrow 1$$

we have one pole at Vout and another one at Vin → far away

$$BW \simeq \omega_{P_{out}}$$

$$BW = \frac{1}{2\pi\,(R_D \parallel r_o)\left[C_{db} + C_L + \left(1 - \frac{1}{A}\right) C_{gd}\right]}$$

let $V_{DS} = \frac{V_{DD}}{2} = 0.6V \therefore V_{RD} = \frac{V_{DD}}{2}$

$\therefore$ for $I_D = 1\,mA \quad \therefore R_D = \frac{0.6\,V}{1\,mA} = 600\,\Omega$

First iteration:

$GBW = 1.9952 \times 10^{10}$

$\therefore GBW = \frac{g_m}{2\pi C_L} \Rightarrow$ assume That $C_L >> C_{db} + (1-\frac{1}{A})C_{gd}$

$\therefore 2\times10^{10} = \frac{g_m}{2\pi \times 50\times10^{-15}}$

$\therefore g_m = 6.28\times10^{-3}\ S$

Let $g_m = 9\times10^{-3}\ S$

$\therefore \frac{g_m}{I_D} = 6.28 \Rightarrow$ let for Margin $\frac{g_m}{I_D} = 9$

$\frac{g_m}{I_D} = \frac{2}{V^*} \quad \therefore \boxed{V^* = 0.22\ V}$

from The gain ; $A_v = g_m (R_D // r_o)$

$\therefore A_v = g_m(R_D // r_o) > 1.9952$

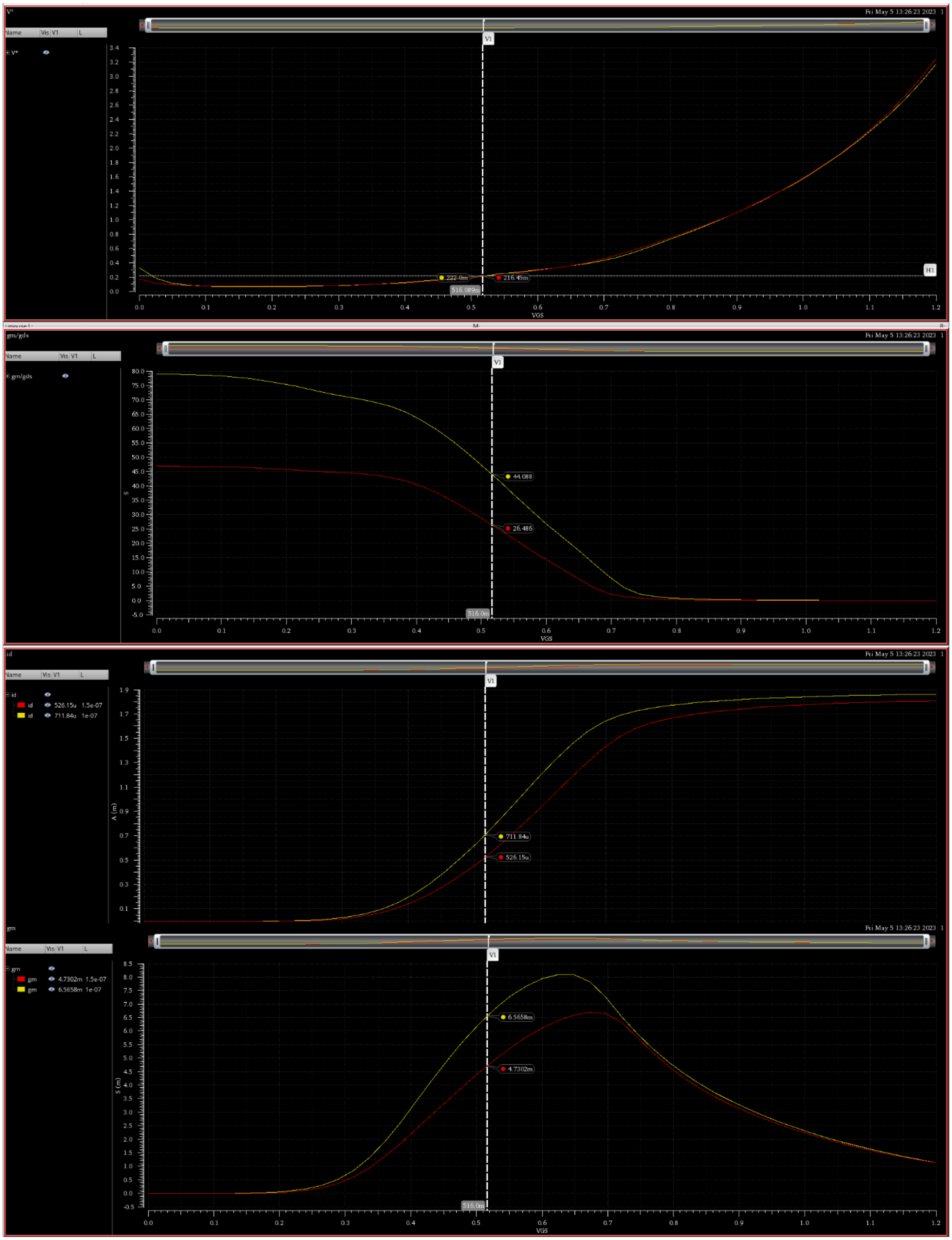
$\therefore \frac{1}{\frac{1}{R_D} + g_{ds}} > 317.7$

$\frac{1}{R_D} + g_{ds} < \frac{1}{317.7}$

$\boxed{g_{ds} \leqslant 1.48\times10^{-3}}$

$\boxed{\frac{g_m}{g_{ds}} \geqslant 6}$

Here we applied a comparison between the 150 nm and 100 nm to see which of them would fit :



with $W = 10\ u$

from The graphs we will choose $L = 150\ um$

we found That $V_{GS} = 516\ mv$

and $I_{DQ} = 711.84\ u$

$g_{mQ} = 6.5658\ ms$

Then

W	ID
10 u	711.84 u
?	1000u

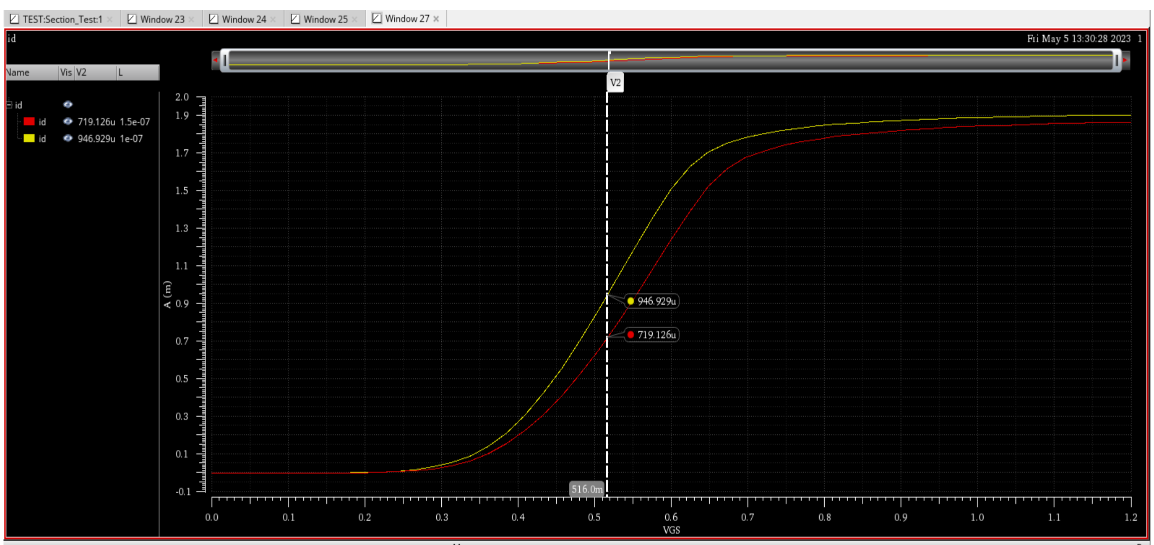
$\therefore\ \boxed{W = 14.048\ um}$

We got $I_D = 946.929\ u$

Band width = 4.939 G

We will decrease L to 120 um to see

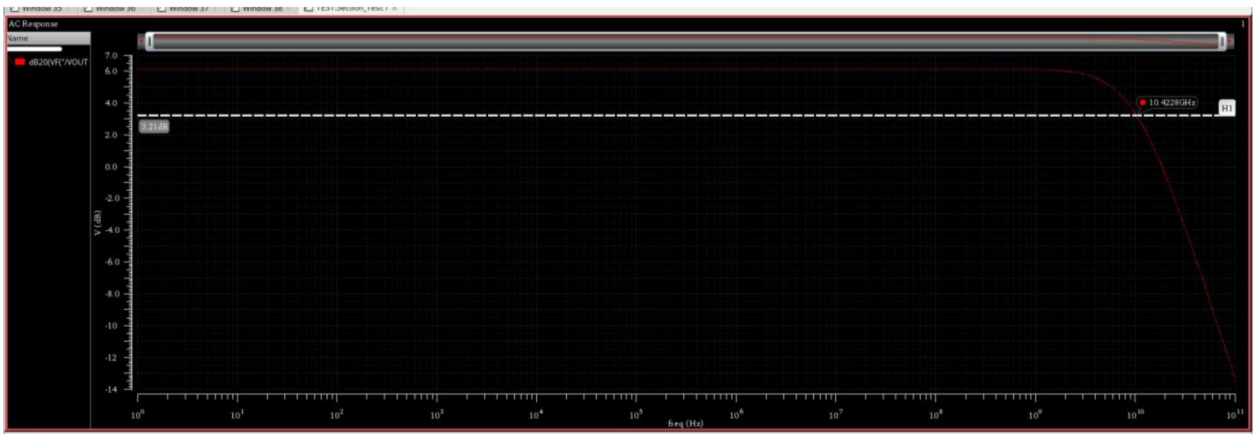
R_D: we can decrease R_D to increase The Bandwidth

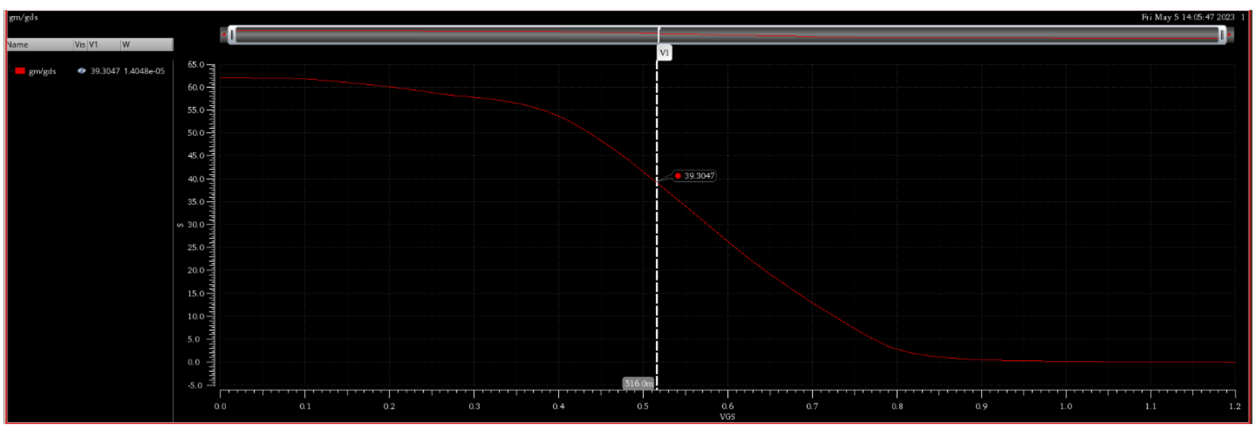


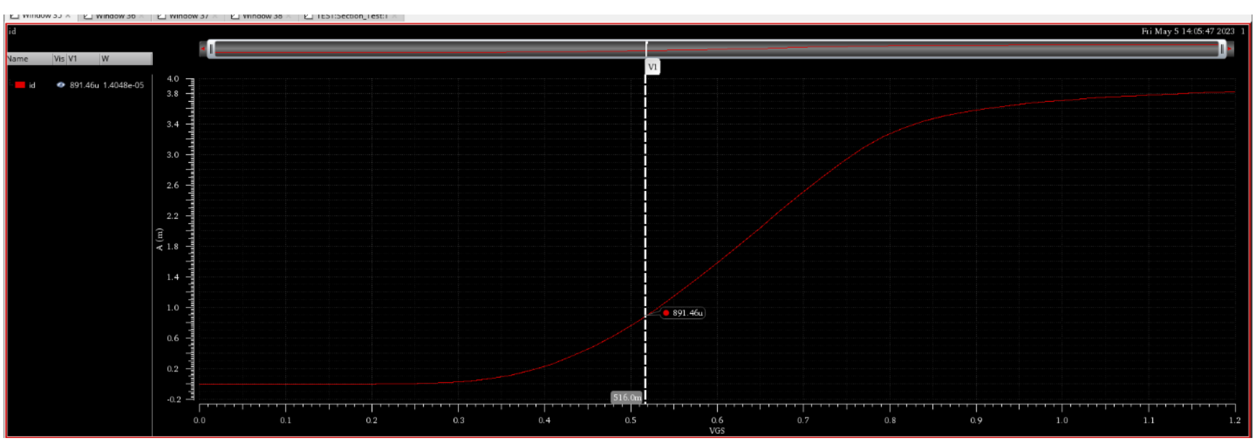
put $R_D = 400\ \Omega$ $\longrightarrow$ BW = 7.359 G
while other factors
still hold the specs

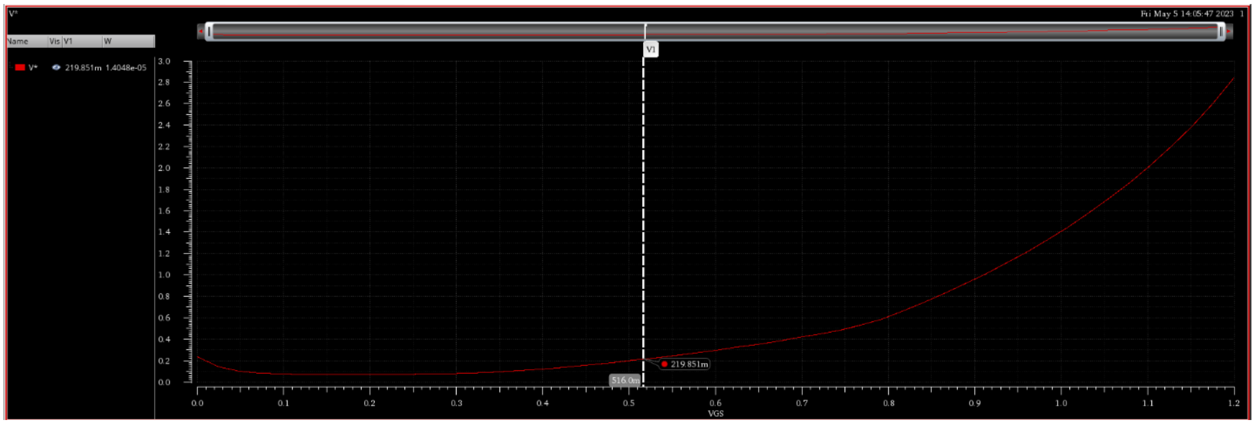
put $R_D = 300\ \Omega$ $\longrightarrow$ BW = 9.607 G

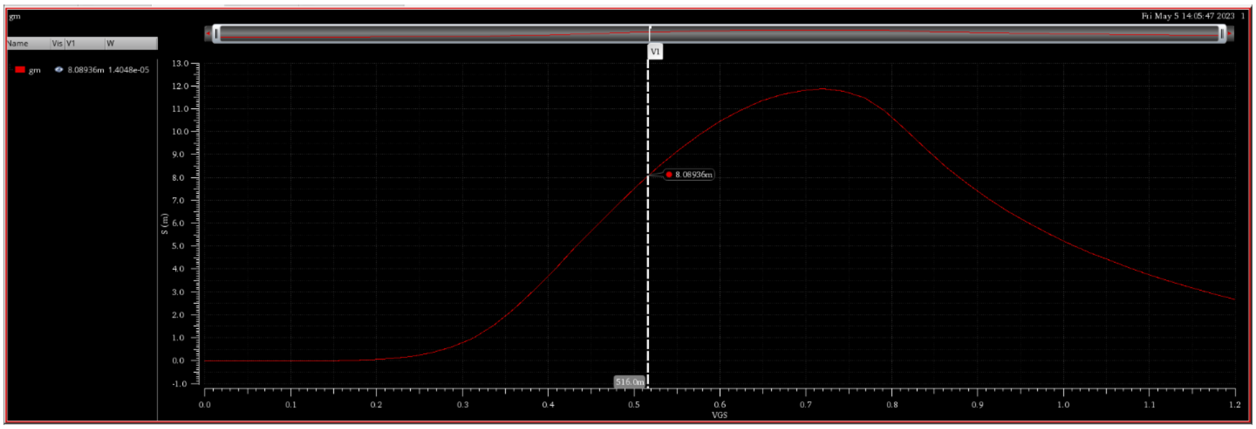
put $R_D = 275\ \Omega$ $\longrightarrow$ BW = 10.43 G
while other factors
are intact

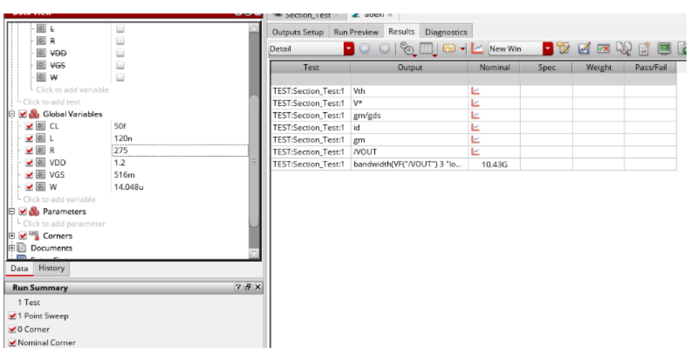


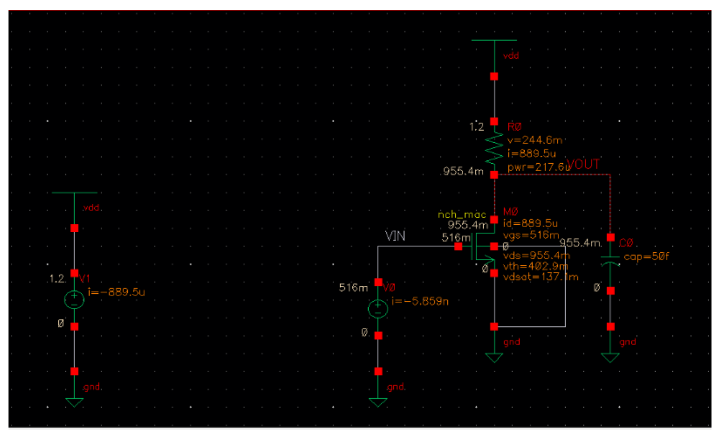












Specs desired	Specs achieved
Dc gain = 6 dB	6.21 dB
BW ≥ 10 GHz	10.43 GHZ
$I_{DC} \leq 1$ mA	0.8895 mA

$V_{SB} = 0$

$V_{GS} = 516$ mv

$V_{DS} = 955.4$ mv

$W = 14.048$ um

$L = 120$ nm