LAB 02 Common Source Amplifier

We would like to design a resistive loaded CS amp meets the specifications below.

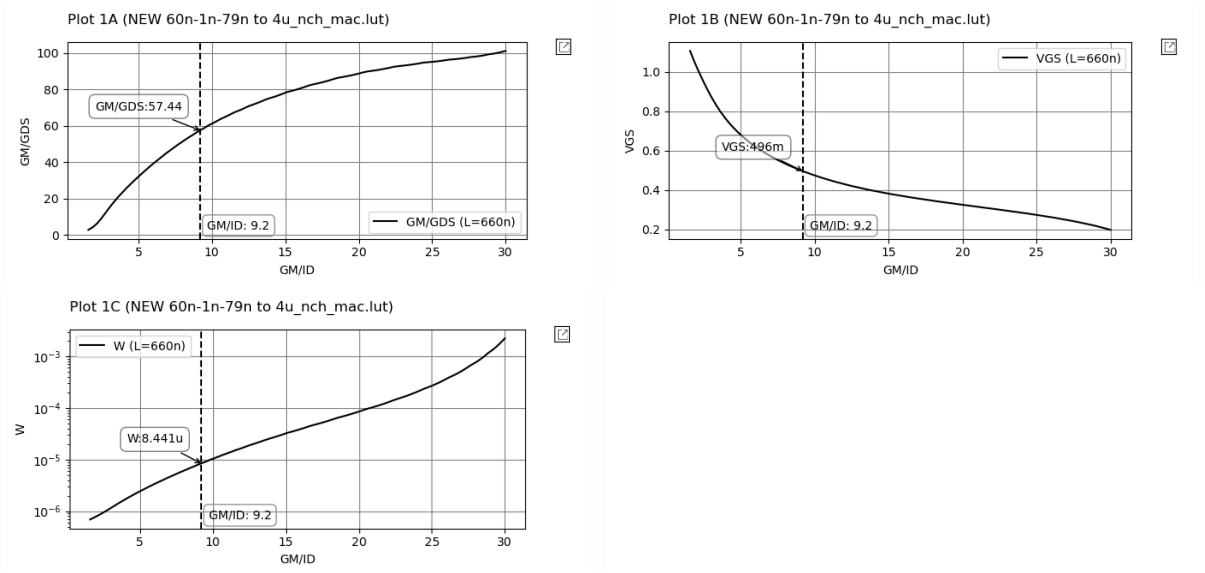
Spec.	
DC Gain	$5 = 14\ \text{dB}$
Current Consumption	$\leq 100\ \text{uA}$

1 | Assume $V_{out} = 0.6 \rightarrow$ maximum output swing $\rightarrow R_D = \frac{1.2-0.6}{100\ u} = 6000\ \Omega$

2 | Assume $R_{out} = 5454\ \Omega \rightarrow\ R_{out} = \frac{R_D.r_o}{R_D+r_o} = 5454 \rightarrow r_o \geq 59934\ \Omega$

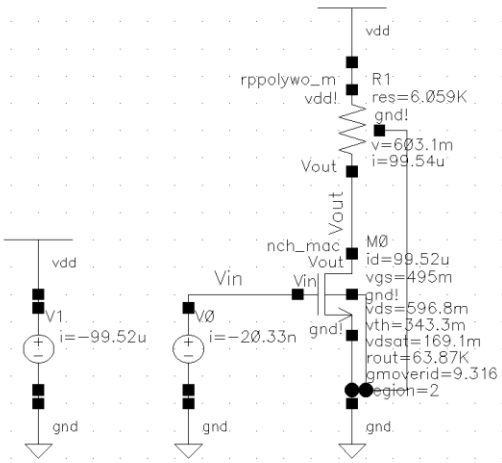
3 | $A_v = g_m R_{out} = 5 \rightarrow g_m = 917\ \text{uS} \rightarrow \frac{g_m}{I_D} = 9.2$

4 | $\frac{g_m}{g_{ds}} \geq 55$



1 | DC OP

1. Creat Test bench and Run DC OP



2. Compare ro and RD. Is the assumption of ignoring ro justified in this case? Do you expect the error to remain the same if we use min L?

   ro >> RD = 10 RD, the ignorance assumption is valid

   If we use min L, ro will be reduced and error due to ignorance will increase

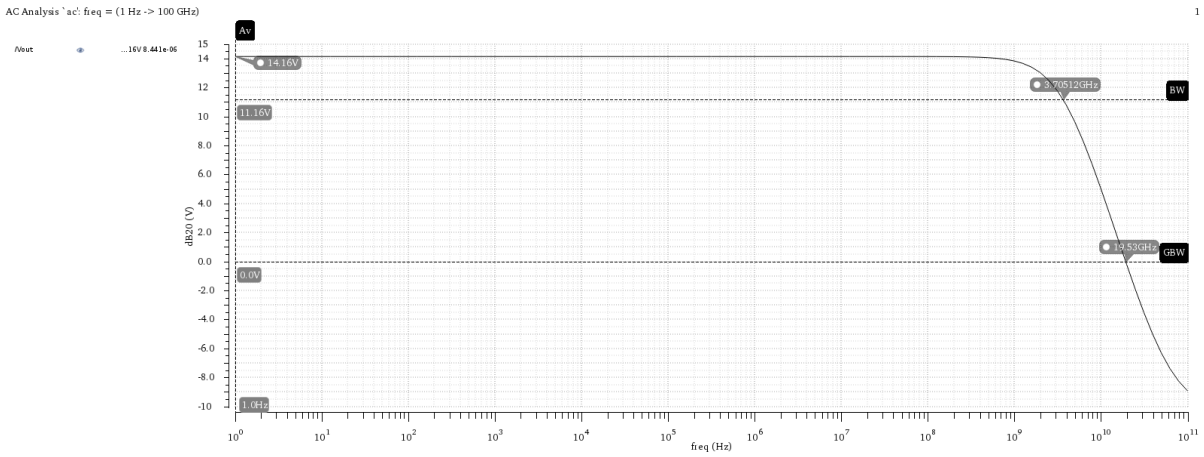
3. Calculate the intrinsic gain of the transistor.

$$\text{intrinsic gain} = g_m r_o = 59.22 = 35.45\ \text{dB}$$

4. Calculate the amplifier gain analytically. What is the relation (≪,<,≈,>,≫) between the amplifier gain and the intrinsic gain?

$$A_v = g_m R_{out} = 5.13 \ll g_m r_o$$

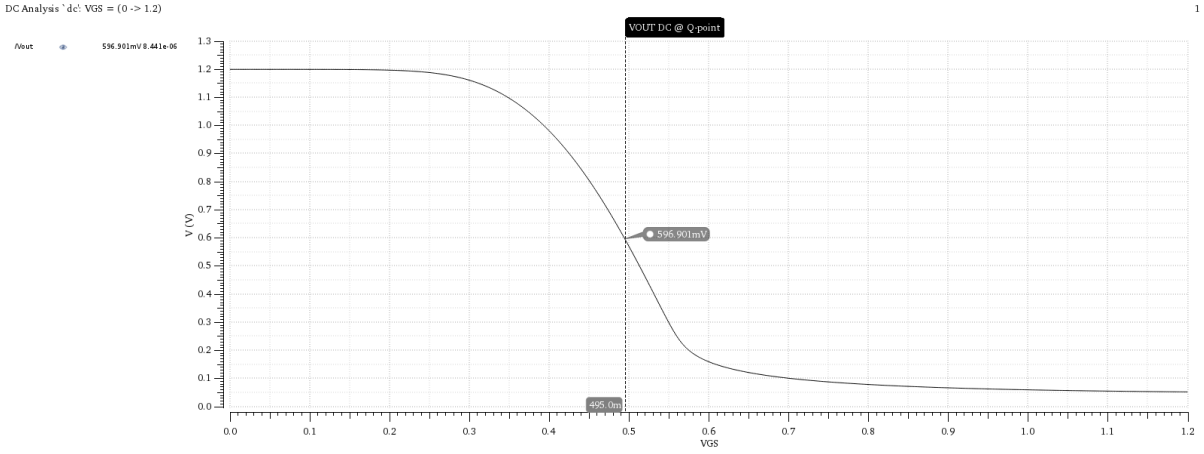
5. Create a new simulation configuration and run AC analysis. Report the gain vs frequency. Annotate the DC gain and make sure it meets the spec.



2 | Gain Non-Linearity

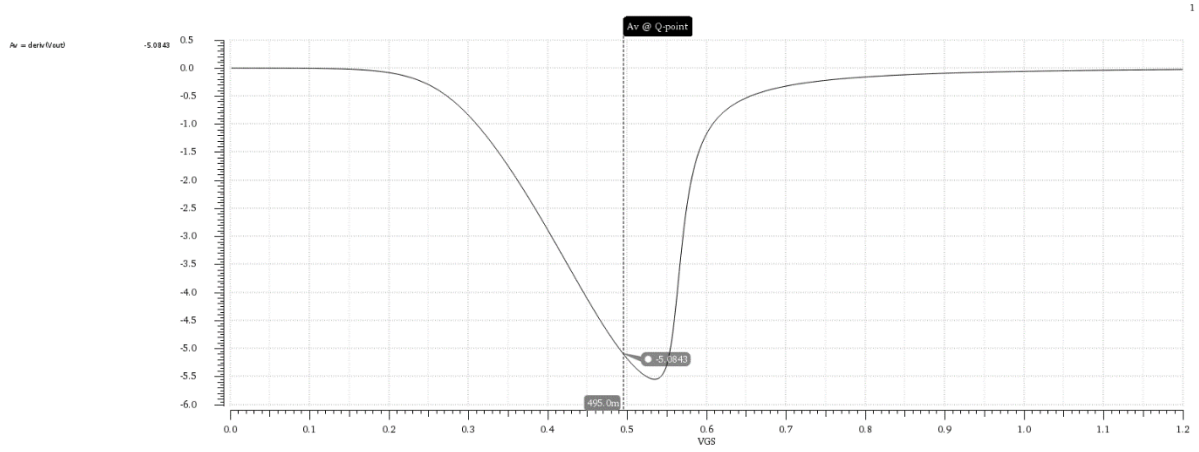
1. Create a new simulation configuration. Perform a DC sweep for the input voltage from 0 to VDD with 2mV step
2. Report VOUT vs VIN. Is the relation linear? Why?

   No, $V_{out} = V_{DD} - I_D R_D$, and ID is a function of Vin (VGS)



3. Calculate the derivative of VOUT using calculator. Plot the derivative vs VIN. The derivative is itself the small signal gain. Is the gain linear (independent of the input)? Why?

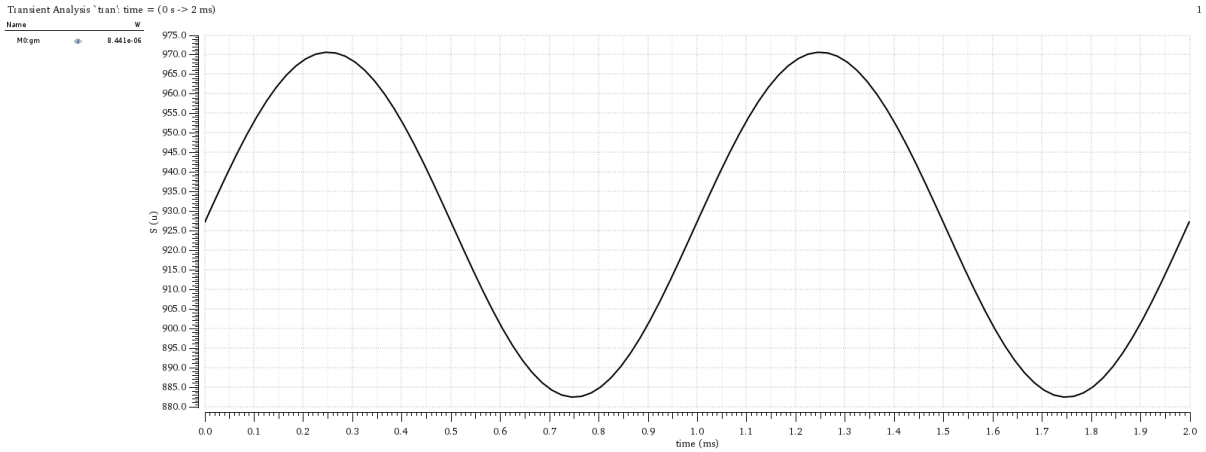
   No, gain $= A_v = g_m R_D$ and $g_m = \mu C_{ox} \frac{W}{L}(V_{in} - V_{th})$



4. Set the properties of the voltage source to apply a transient stimulus (sine wave of 1kHz frequency and 10mV amplitude superimposed on the DC input voltage).

5. Create a new simulation configuration. Run transient simulation for 2ms. Plot gm vs time. Does gm vary with the input signal? What does that mean?

   Yes, meaning the amplifier is not linear and the gain varies with the input



6. Is this amplifier linear? Comment.

   No, the output changes with the changing in the input