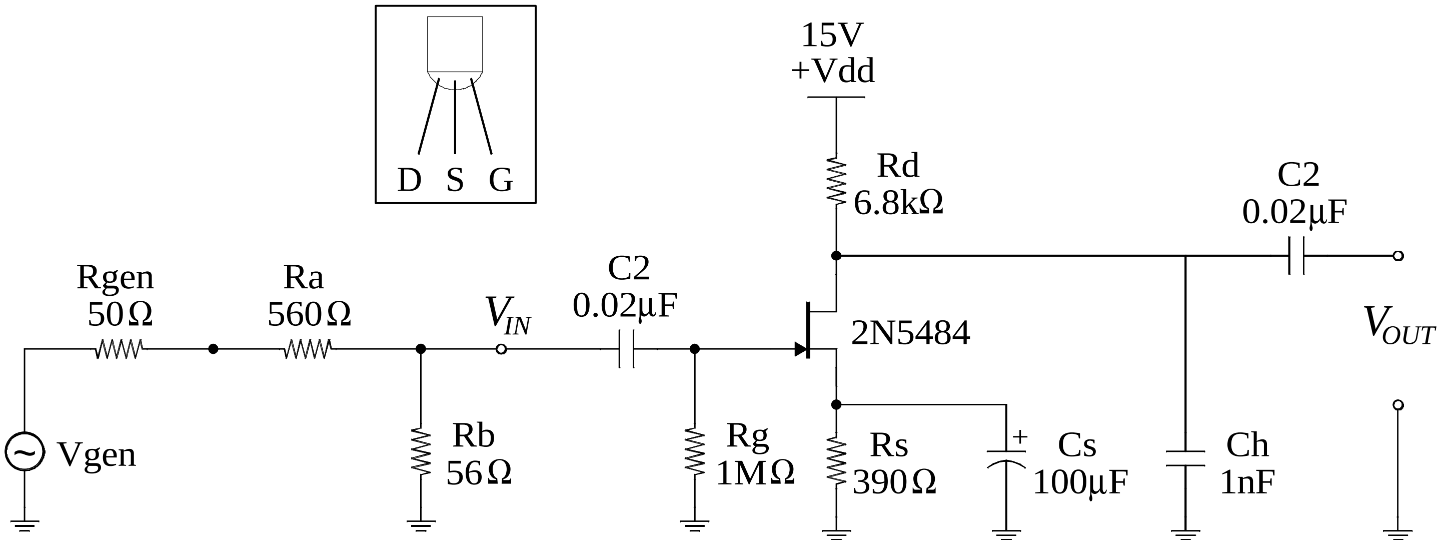
FET EXPERIMENT

Lab 1 Notes – EE 321K



Given for the prep:

Drain current when in saturation: $I_{DSS} = 2.5\ \text{mA}$

Pinch-off voltage: $V_P = -1\ \text{V}$

Gate current: $I_G = 0\ \text{mA}$

Slope of output characteristic in saturation $Y_{OS} = 0\ \Omega^{-1}$

TRANSFER CHARACTERISTIC

The relationship between the drain current and the gate-to-source voltage with the FET in saturation.

$$\boxed{I_D = I_{DSS}\left(1 - \frac{V_{GS}}{V_P}\right)^2}$$

DC LOAD LINE

The relationship between the drain current and the gate-to-source voltage with the gate at ground potential.

$$\boxed{I_D = -\frac{1}{R_S}V_{GS}}$$

V_{GSQ}, I_{DQ} Q POINT

The DC operating point of the FET, found at the intersection of the above two functions; the point at (V_{GSQ}, I_{DQ}).

SATURATION REGION

The FET is in the saturation region when $V_{DS} > |V_P|$.

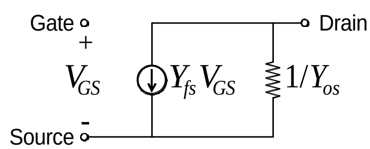
V_{GSQ} DRAIN-TO-SOURCE OPERATING VOLTAGE

The drain-to-source voltage present when the FET is operating at the Q-point.

$$V_{DSQ} = V_{DQ} - V_{SQ} = \left(V_{DD} - I_{DQ}R_d\right) - I_{DQ}R_s$$

Y_{fs} TRANSCONDUCTANCE

The transconductance of the FET model is the rate of change of the drain current in response to a change in the gate-to-source voltage, or the slope of the transfer characteristic curve at the Q-point.



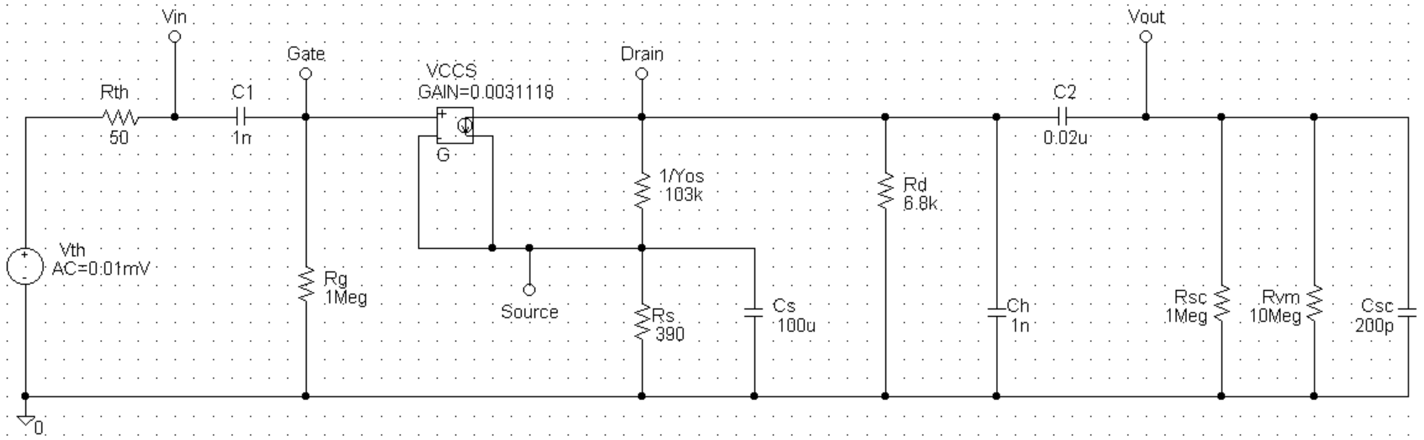
$$\boxed{Y_{fsQ} = g_m = \left|\frac{\partial I_D}{\partial V_{GS}}\right|}$$

Y_{os} OUTPUT TRANSCONDUCTANCE

The output transconductance of the FET model is the rate of change of the drain current as a function the drain-to-source voltage, or the slope of the output characteristic at the Q-point.

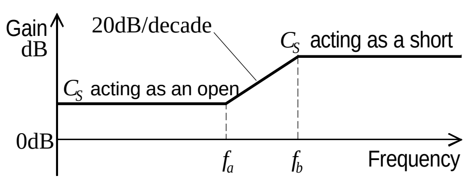
$$\boxed{Y_{os} = \frac{1}{r_o} = \left|\frac{\partial I_D}{\partial V_{DS}}\right|}$$

PSPICE MODEL Lab1withCs.sch



FREQUENCY CORNERS DUE TO C_S

The capacitor C_S produces two frequency corners f_a and f_b with a 20dB/decade slope in between.



At f_a, the reactance of C_S is equal to R_S.

$$f_a = \frac{1}{2\pi C_S R_S}$$

$$f_b = f_a\left(1+Y_{fs}R_S\right) = \frac{1}{\underbrace{2\pi C_S\left[R_S \,||\left(1/Y_{fs}\right)\right]}_{\text{by "looking" into the circuit from Cs}}}$$

FREQUENCY CORNER DUE TO C_1

The capacitor C_1 produces a low frequency corner.

$$f_{L1} = \frac{1}{2\pi C_1\left(R_{th}+R_g\right)}$$

FREQUENCY CORNER DUE TO C_2

The capacitor C_2 produces a low frequency corner.

$$f_{L2} = \frac{1}{2\pi C_2\left[R_d + \left(R_{VM} \,||\, R_{SC}\right)\right]}$$

FREQUENCY CORNER DUE TO C_h and C_{sc}

The capacitor C_h and the capacitance due to cables and instruments C_{sc} produce a high frequency corner.

$$f_H = \frac{1}{2\pi\left(C_h + C_{sc}\right)\left(R_d \,||\, R_{VM} \,||\, R_{SC}\right)}$$

DISTORTION ANALYSIS

Given an input sinewave of 0.12V peak.

$$V_{GS} = V_{GSQ} + 0.12\sin\omega t$$

What is the percent second harmonic distortion?. Using the transfer function:

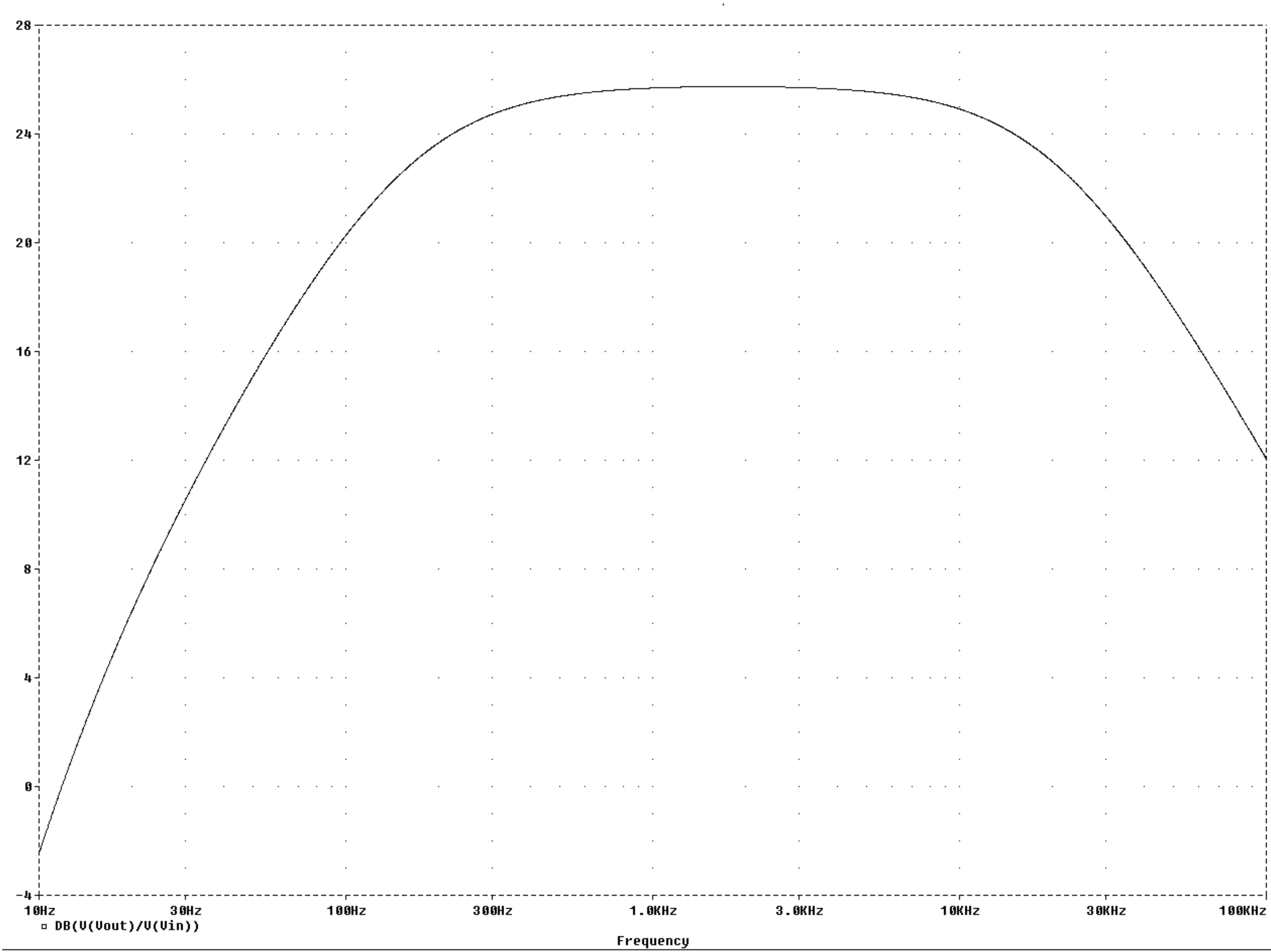
$$I_D = I_{DSS}\underbrace{\left(1-V_{GS}/V_P\right)^2}_{\text{Only this term needs to be evaluated.}}$$

Evaluate:

$$\left(1-\frac{V_{GSQ}+0.12\sin\omega t}{V_P}\right)^2 = \left(1-\frac{-0.38+0.12\sin\omega t}{-1}\right)^2$$

$$= \left(0.62+0.12\sin\omega t\right)^2 = \left(0.0144\sin^2\omega t + 0.148\sin\omega t + 0.3844\right)$$

Taking the coefficients from the first and second harmonic: $\%\ 2^{\text{nd}}\text{ harmonic} = \frac{0.0144}{0.1488}\times 100 = 9.6774\%$


28
24
20
16
12
8
4
0
-4
10Hz
30Hz
100Hz
300Hz
1.0KHz
3.0KHz
10KHz
30KHz
100KHz
DB(V(Vout)/V(Vin))
Frequency