

Fall-2021 UM-SJTU JI Ve311 Homework #7

Instructor: Dr. Chang-Ching Tu

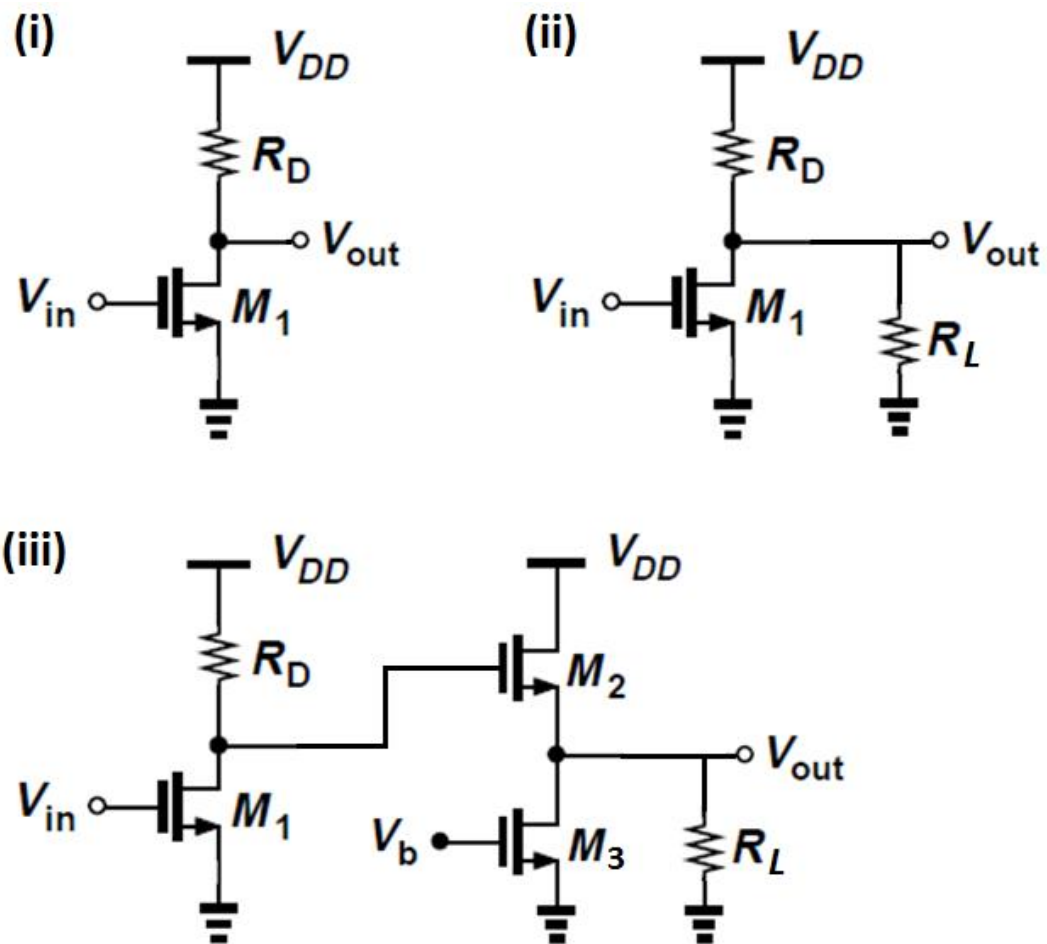
Due: 10:40 am, December 1, 2021 (Wednesday)

Note:

- (1) Please use A4 size papers.
- (2) Please use the SPICE model in page 3 for simulation and calculation.

1. [Common-Source with Resistive Load + Source Follower]

- (a) [50%] Assume $\lambda = 0$ and $\gamma = 0$. For $V_{DD} = 5$ V, $V_{IN} = 1$ V, $V_b = 1$ V, $(W_{drawn}/L_{drawn})_1 = 50 \mu\text{m} / 2 \mu\text{m}$, $(W_{drawn}/L_{drawn})_2 = (W_{drawn}/L_{drawn})_3 = 20 \mu\text{m} / 2 \mu\text{m}$, $R_D = 10 \text{ k}\Omega$ and $R_L = 2 \text{ k}\Omega$, what is the voltage gain A_v for each circuit below? Does the voltage gain drop significantly after adding a small resistive load (R_L) and then recover after adding a source follower (M_2 and M_3) as a buffer?
- (b) [25%] For each circuit below, using the design and biasing condition in (a), plot V_{out} and A_v as a function of V_{in} (from 0 V to 5 V) in Pspice. Compare the hand-calculation results in (a) with the simulation results here.
- (c) [25%] For circuit (iii), using the design and biasing conditions in (a), plot V_{out} as a function of time (from 0 to 0.1 second) in Pspice, when $V_{in} = 1 + A \times \sin(2\pi 100t)$ (V) and $A = 0.01$ V, 0.1 V and 1 V. What do you observe when the amplitude increases?



NMOS Model

LEVEL = 1	VTO = 0.7	GAMMA = 0.45	PHI = 0.9
NSUB = 9e+14	LD = 0.08e-6	UO = 350	LAMBDA = 0.1
TOX = 9e-9	PB = 0.9	CJ = 0.56e-3	CJSW = 0.35e-11
MJ = 0.45	MJSW = 0.2	CGDO = 0.4e-9	JS = 1.0e-8

PMOS Model

LEVEL = 1	VTO = -0.8	GAMMA = 0.4	PHI = 0.8
NSUB = 5e+14	LD = 0.09e-6	UO = 100	LAMBDA = 0.2
TOX = 9e-9	PB = 0.9	CJ = 0.94e-3	CJSW = 0.32e-11
MJ = 0.5	MJSW = 0.3	CGDO = 0.3e-9	JS = 0.5e-8

VTO: threshold voltage with zero V_{SB} (unit: V)

GAMMA: body effect coefficient (unit: $V^{1/2}$)

PHI: $2\Phi_F$ (unit: V)

TOX: gate oxide thickness (unit: m)

NSUB: substrate doping (unit: cm^{-3})

LD: source/drain side diffusion (unit: m)

UO: channel mobility (unit: $\text{cm}^2/\text{V/s}$)

LAMBDA: channel-length modulation coefficient (unit: V^{-1})

CJ: source/drain bottom-plate junction capacitance per unit area (unit: F/m^2)

CJSW: source/drain sidewall junction capacitance per unit length (unit: F/m)

PB: source/drain junction built-in potential (unit: V)

MJ: exponent in CJ equation (unitless)

MJSW: exponent in CJSW equation (unitless)

CGDO: gate-drain overlap capacitance per unit width (unit: F/m)

CGSO: gate-source overlap capacitance per unit width (unit: F/m)

JS: source/drain leakage current per unit area (unit: A/m^2)

Vacuum permittivity (ϵ_0) = 8.85×10^{-12} (F / m)

Silicon oxide dielectric constant (ϵ_r) = 3.9