Fall-2020 UM-SJTU JI Ve311 Homework #8

Instructor: Dr. Chang-Ching Tu

Due: 11:59 am, November 18, 2020 (Wednesday)

Note:

(1) Please use A4 size papers.

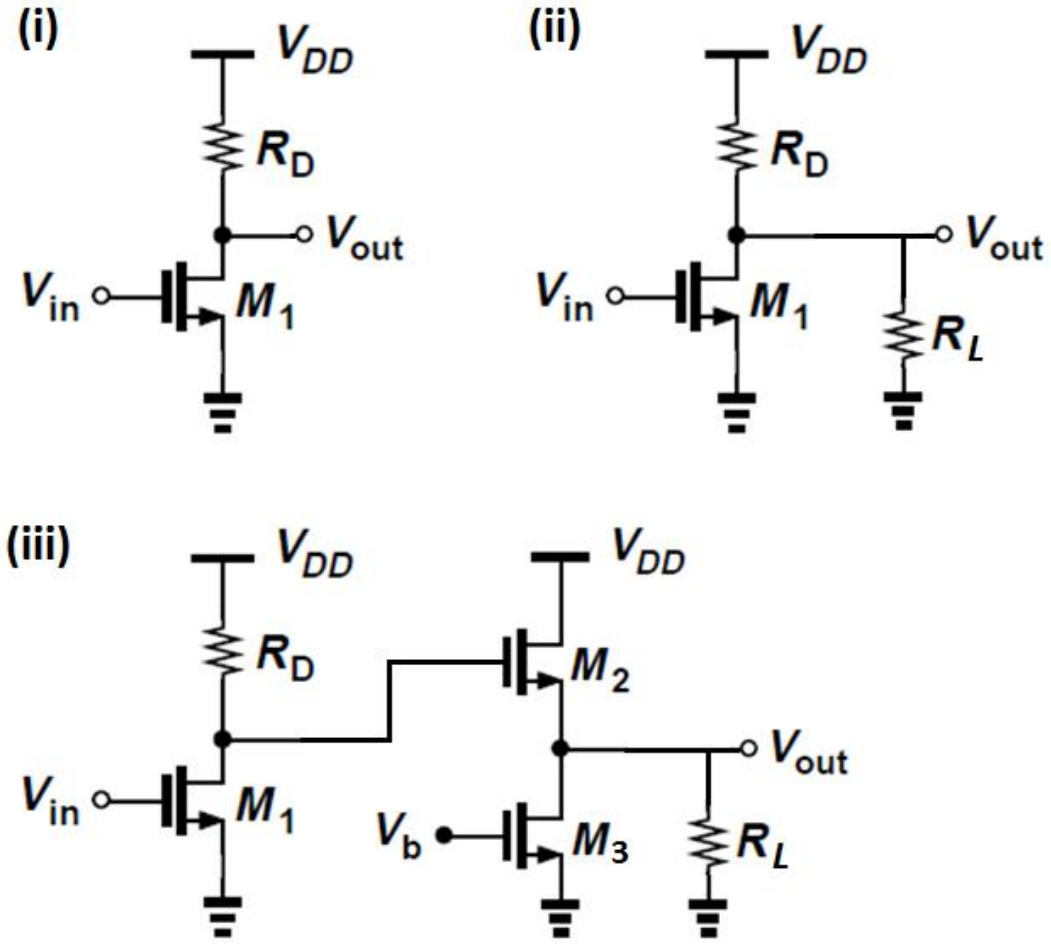
(2) Please use the SPICE model in page 3 for simulation and calculation.

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 μm / 2 μm, $(W_{drawn}/L_{drawn})_2 = (W_{drawn}/L_{drawn})_3$ = 20 μm / 2 μm, R_D = 10 kΩ and R_L = 2 kΩ, 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?


(i)
V_{DD}
R_D
V_{out}
V_{in}
M_1
(ii)
V_{DD}
R_D
V_{out}
V_{in}
M_1
R_L
(iii)
V_{DD}
V_{DD}
R_D
M_2
V_{out}
V_{in}
M_1
V_b
M_3
R_L

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: $cm^2/V/s$)
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_o) $= 8.85 \times 10^{-12}$ (F / m)
Silicon oxide dielectric constant (ϵ_r) $= 3.9$