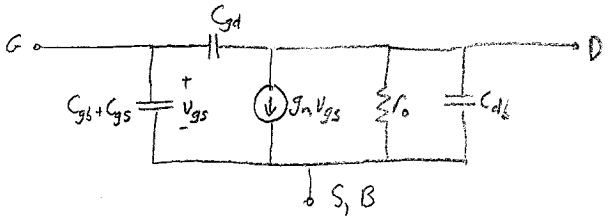
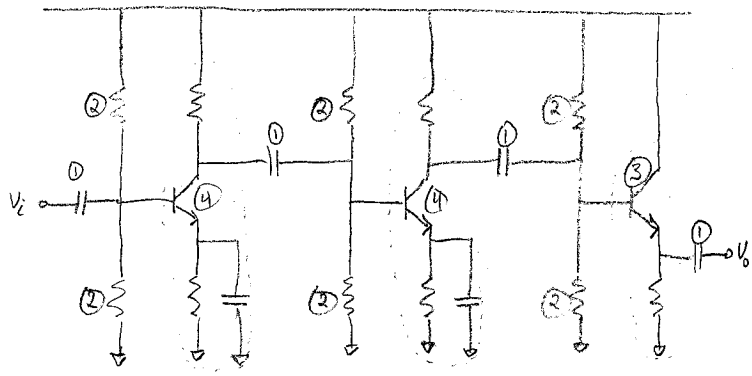
EE 140 Homework #1 Fall 2009

1)



C_{sb} is omitted because charge can flow freely between the source and bulk. If there can be no storage of charge, then there is no charge storage element (capacitor).

2ai)



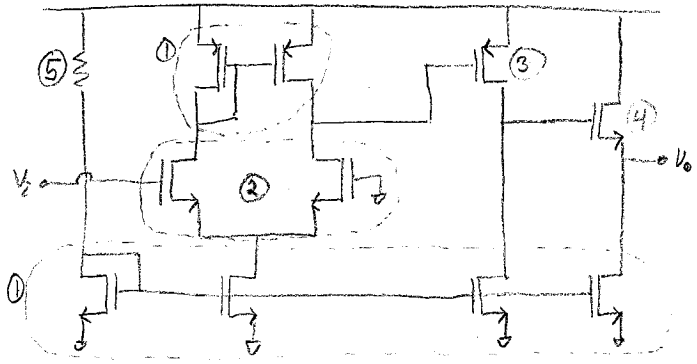
① AC coupling between stages

② DC biasing resistors (voltage divider)

③ Resistively loaded emitter follower (common collector)

④ Resistively loaded common emitter with low-frequency degeneration (HPF).

2aii)



① Current mirror

② Differential pair with single-ended input and output

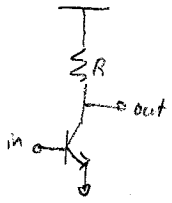
③ Common source gain stage

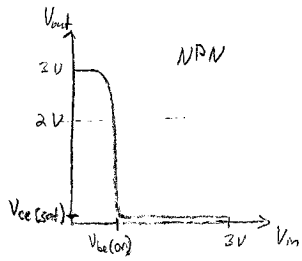
④ Source follower output stage (common drain)

⑤ "current source" resistor

2b) 3.1 contains only 3 BJTs, but has 11 resistors and 6 capacitors. 3.2 is designed with many more transistors, but uses MOS technology and contains only one passive element. 3.1 is better in the case that we are using discrete components, where transistors are expensive and passives are cheap. The opposite is true in integrated circuits; MOSFETs are cheap and passives are expensive, making 3.2 a better choice for monolithic fabrication.

3)



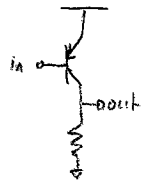


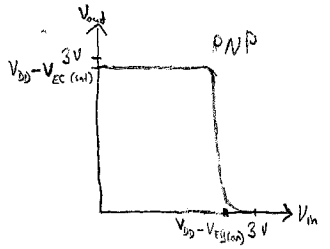
To calculate the gain at 2V, we need the derivative at this point. Alternatively,

$A_v = G_m R_o, \quad G_m = g_m = \frac{I_c}{V_T} = \frac{V_{cc} - V_{out}}{R V_T}$

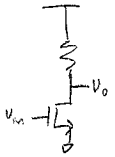
$R_o \approx R \Rightarrow A_v \approx \frac{V_{cc} - V_{out}}{V_T} = 38.5$

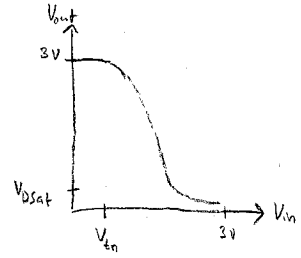
Note: This is only true at room temperature, because $V_T = kT/q$.





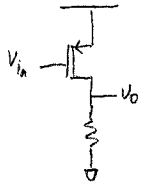
The slope of BJTs is steeper than that of MOSFETs.

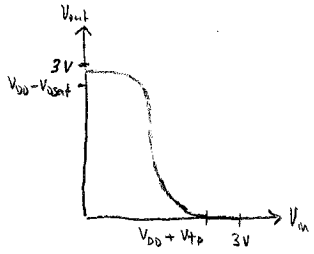




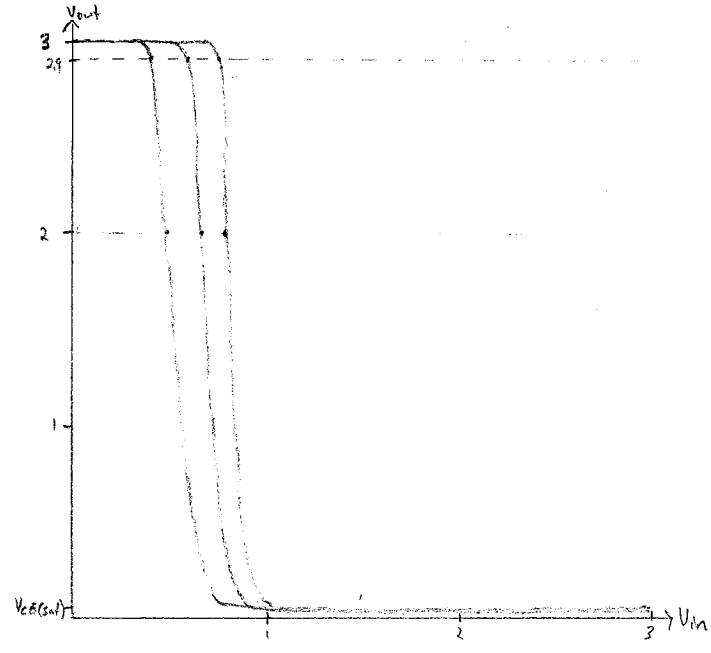
N devices: V_{out} never reaches bottom rail

P devices: V_{out} never reaches top rail





4)



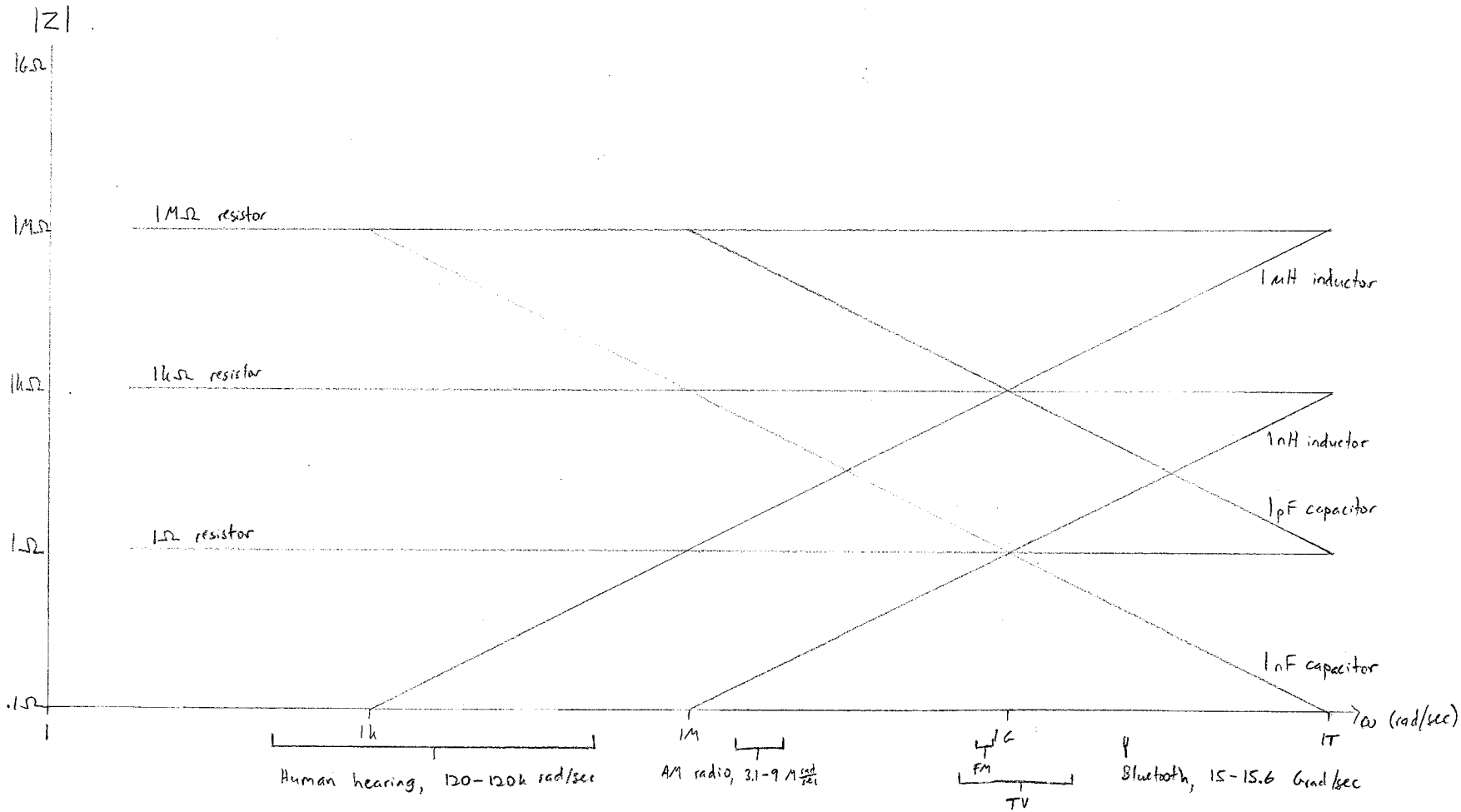
From $V_{BE(on)}$ vs. I_c plot on page 3,

2.9 V output ⇒ 100 mA current
2.0 V output ⇒ 1 mA current

	2.9V 100mA	2.0 V 1mA
$V_{BE(on)}$		
-40°C	740 mV	790 mV
25°C	600 mV	660 mV
125°C	400 mV	470 mV

$V_{CE(sat)}$ increases very slightly with temperature (not clearly shown)

5)



6)

FM radio: 550-680 M rad/sec

broadcast TV: 340-506 M rad/sec