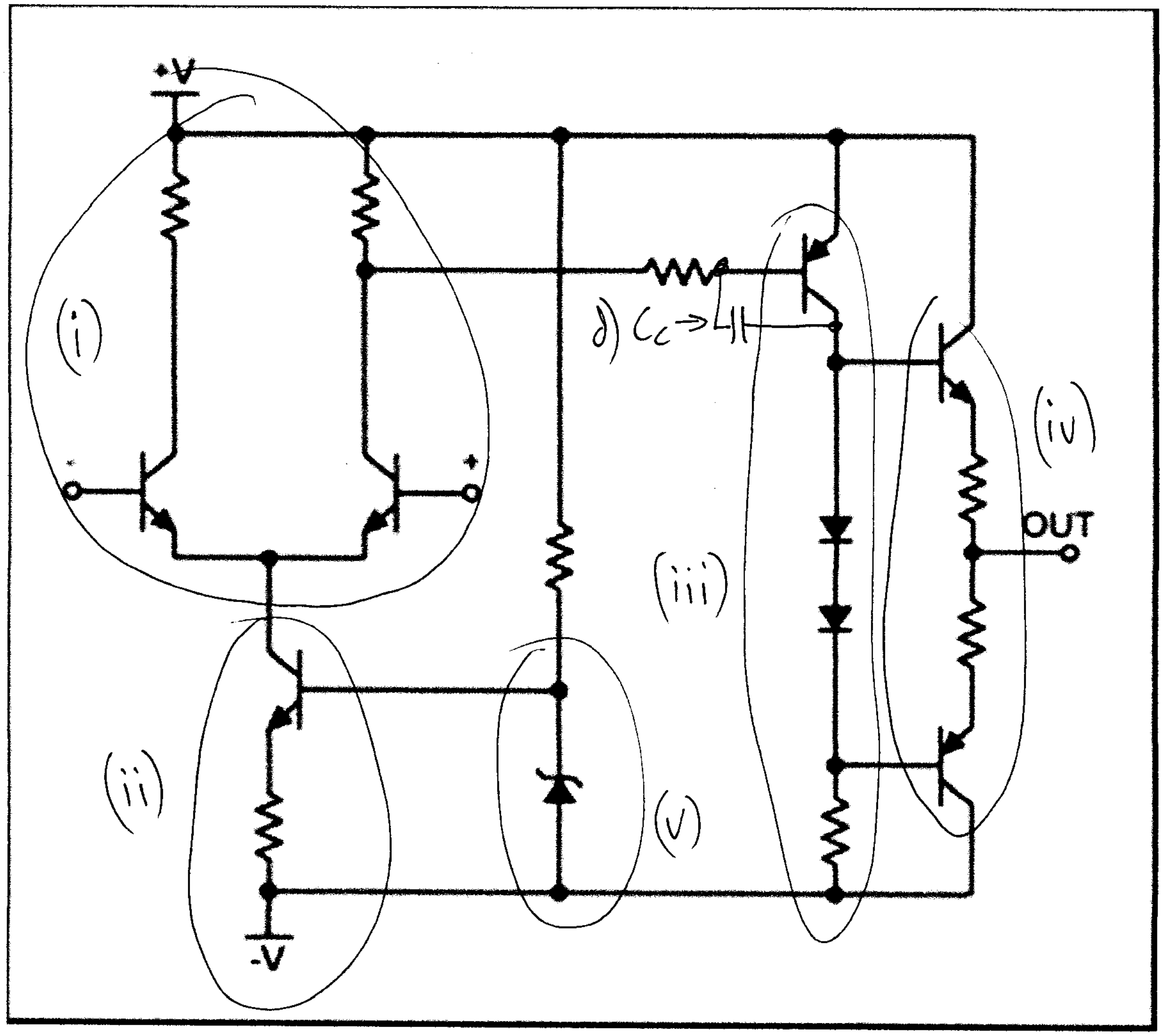
EE140 HW 6 Solutions

1) a)



b) The resistor limits the current in that branch.

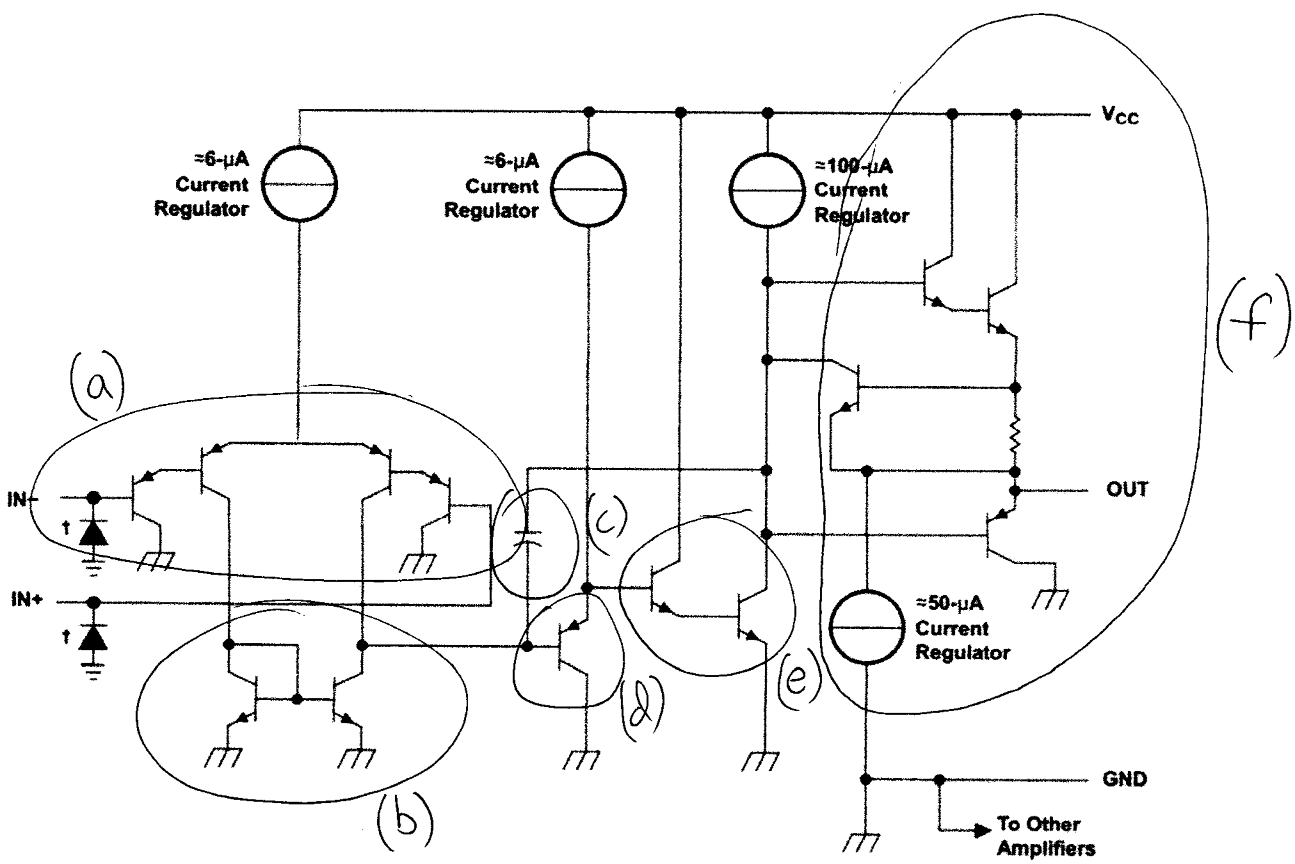
c) Itail = (3.5V - 0.7V – V-) / 1 kohm = 2.8 mA (assuming V- = 0V)

The Zener voltage is relatively constant regardless of supply variation so Itail is mostly independent of the supply voltage.

d) See above.

#1) 9 pts total
a) 5 pts, 1 for identifying each block
b) 1 pt
c) 2 pts, 1 for tail current, 1 for supply variation comment
d) 1 pt

2)



#2) 6 pts total
1 pt each for identifying each block

3)

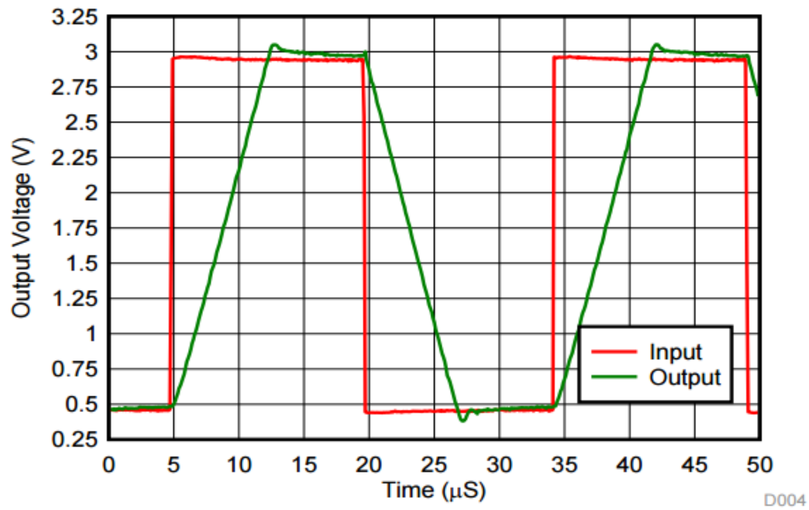


Figure 4. Voltage Follower Large Signal Response (50 pF)

a) The rising slew rate is 1.75V/5us = 350 kV/s and the falling is 2V/5us = 400 kV/s.

b) The smallest of all the source/sink values in the table is 1mA, which leads to dV/dt = I/C = 1mA/50pF = 20 MV/s. This number is much larger than the slew rate in Fig 4 so the output stage is not the limiting factor.

c) The slew rate must then be due to the compensation capacitor, which on both rising and falling edges has a current limit of 6uA due to the 6uA diff pair current source. C = I / (dv/dt). Taking the average of the rise/fall slew rates, C = 6 uA / (375000 V/s) = 16 pF.

#3) 6 pts total
a) 2 pts, 1 each for rising and falling slew rates
b) 2 pts, 1 for finding output current limit, 1 for saying it is not output slew limited
c) 2 pts, 1 for tail current as limiting factor, 1 for calculating Cc

4)

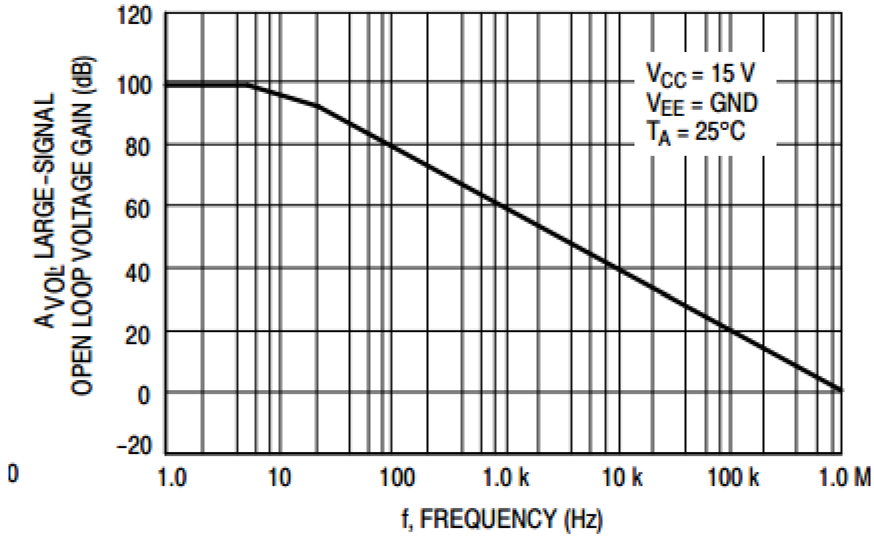


Figure 6. Open Loop Frequency

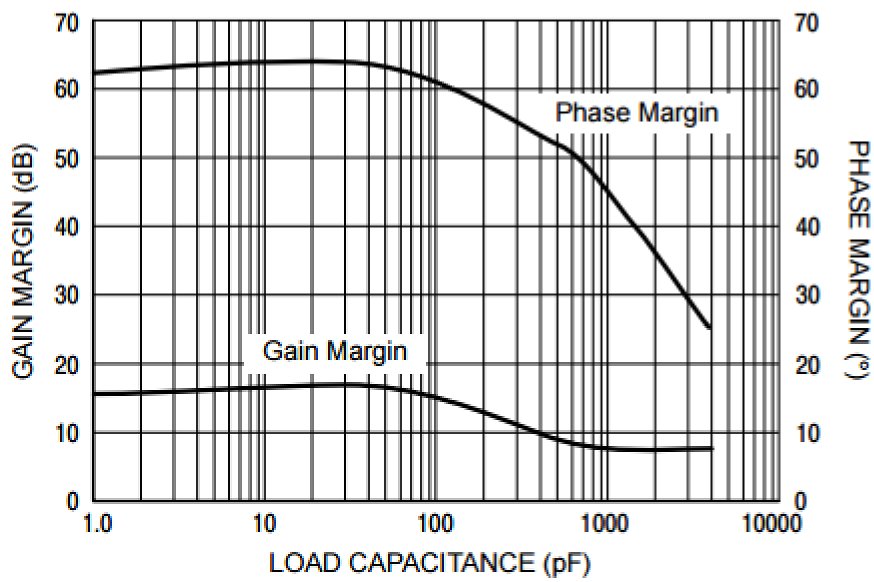
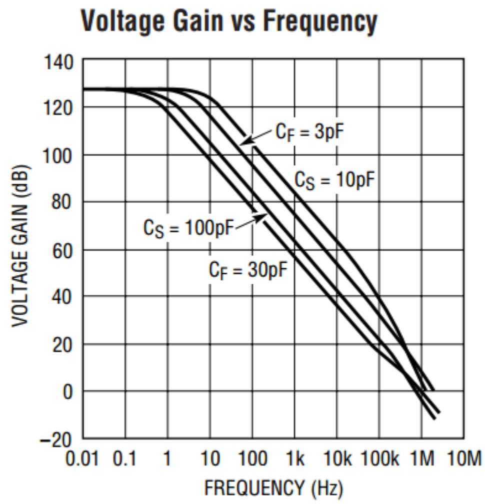


Figure 4. Gain and Phase Margin

a) Av0 = 100,000 V/V, fp1 = 5 Hz, fu = 1 MHz
b) The phase margin is 45 degrees for CL = 1000pF, so P2 must be at the unity gain frequency, fp2 = 1MHz.

#4) 5 pts total
a) 3 pts, 1 each Avo, fp1, fu
b) 2 pts, 1 for saying PM=45, 1 for saying wp2=wu

5)

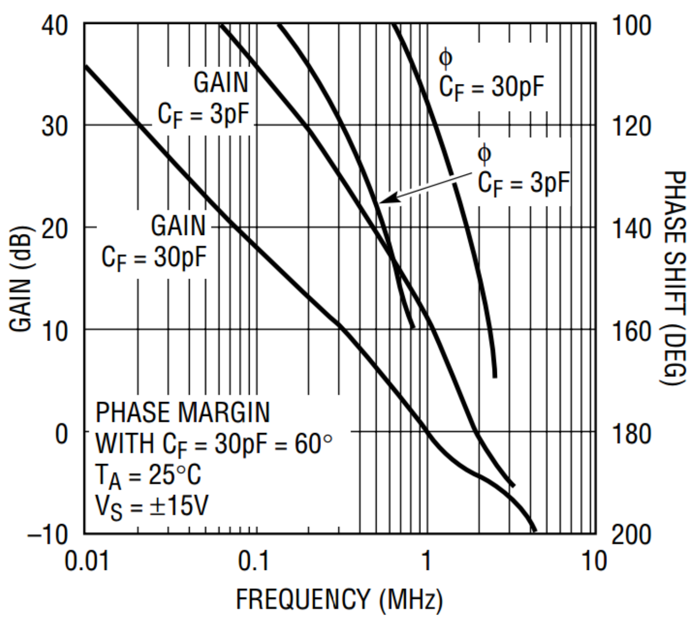


a)

i. Gain at 0.1Hz is about 3e6. f = 0.001, so closed loop gain error is -1/Af = -1/3000.

ii. Cs=10pF puts the pole at about 5 Hz, while Cf = 30pF puts the pole at about 0.2 Hz.

b)



For PM=60deg,

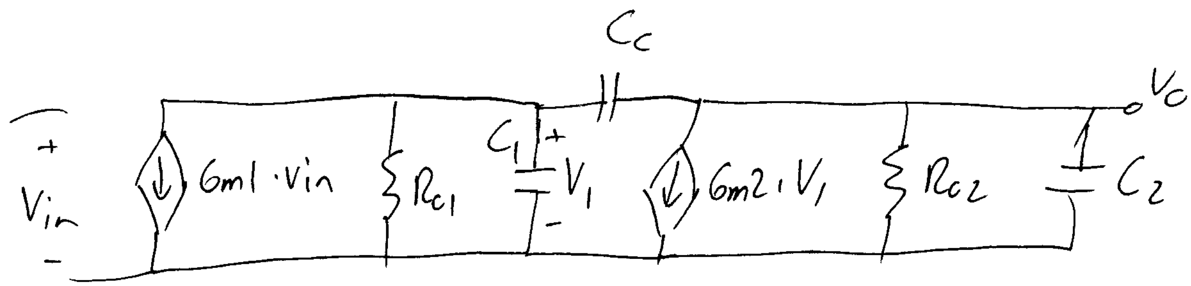
CF=3pF, the minimum gain is 26dB @ 300kHz (feedback factor of 0.05).

CF=30pF, the minimum gain is 0dB @ 1MHz (feedback factor of 1, it is unity gain stable).

#5) 7 pts total
a) 3 pts, 1 for gain error, 1 each for the two poles in (ii)
b) 4 pts, 1 for min gain and 1 for bandwidth, for both values of CF

(6)

a)



b)

$$\frac{V_{out}}{V_{in}}(s) = \frac{(C_c s - Gm2) R_{o2}}{R_{o1} R_{o2} \xi s^2 + R_{o1}\left((1 + Gm2 R_{o2}) C_c + C_1\right) + R_{o2}(C_c + C_2) s + 1}$$

where $\xi = C_1 C_c + C_1 C_2 + C_c C_2$

c) i)

$$\omega_{p2} = \frac{1}{\omega_{p1}} \cdot \frac{1}{R_{o1} R_{o2}(C_1 C_c + C_1 C_2 + C_c C_2)}$$

ii) $$\omega_{p1} = \frac{1}{R_{o1} Gm2 R_{o2} C_c}$$

$$\omega_{p2} = \frac{Gm2\, C_c}{C_1 C_c + C_1 C_2 + C_c C_2}$$

iii) For $PM \geq 45°$, $\omega_{p2} \geq \omega_u = \frac{Gm1}{C_c}$

$$\frac{Gm2}{Gm1} \cdot \frac{C_c^2}{C_1 C_c + C_1 C_2 + C_c C_2} \geq 1$$

#6) 7 pts total
a) 2 pts for correctly redrawing
b) 2 pts
c) 3 pts, 1 for each subpart

#7) 5 pts total (EE240 only)
a) 2 pts
b) 3 pts