Exam 1
C. DiMarzio, Northeastern University
EECE2412, Fall 2024
9 Oct 2024

Student Name: _____

1 Short–Answer Questions

Pick one answer for each problem.

a: The voltage difference between the inverting and non–inverting inputs of an operational amplifier is always zero.

☐ True ☒ False

b: The bandwidth of an amplifier circuit using an op–amp is

☐ infinite.
☐ in the spec sheet for the op–amp.
☐ equal to the bandwidth of the Open–Loop op–amp.
☒ equal to the gain–bandwidth product of the op–amp divided by the gain of the circuit.

c: For proper operation of an amplifier circuit using an op–amp, the feedback must be to the inverting input.

☒ True ☐ False

d: The bandwidth of an amplifier circuit consisting of two cascaded amplifiers is...

☐ equal to the bandwidth of the amplifier stage with the larger bandwidth.
☒ less than that of the amplifier stage with the minimum bandwidth
☐ determined by the gain–bandwidth product.

e: Adding donor impurities to silicon will...

- [x] increase the number of free electrons and decrease the number of holes.
- [ ] increase the number of holes and decrease the number of free electrons.
- [ ] increase the number of holes and free electrons.
- [ ] decrease the number of holes and free electrons.

f: Which of the following is true of intrinsic silicon in an applied electric field?

- [ ] The hole current is equal to the electron current.
- [ ] The drift current is equal to the diffusion current.
- [x] The number of holes is equal to the number of free electrons.
- [ ] The holes and free electrons move in the same direction.

g: In a diode not connected to any circuit, the drift current is equal to the diffusion current but in the opposite direction.

- [x] True
- [ ] False

h: When light is incident on a photodiode, it produces an extra forward current.

- [ ] True
- [x] False

i: Power supply ripple is reduced by a filter capacitor. The ripple ...

☒ is lower for a full–wave rectifier than a half–wave one, if the circuits are otherwise the same.
☐ increases if the capacitance of the filter capacitor is increased.
☐ is higher if the AC frequency is higher.

j: There is a limit to how many stages of diode logic may be cascaded.

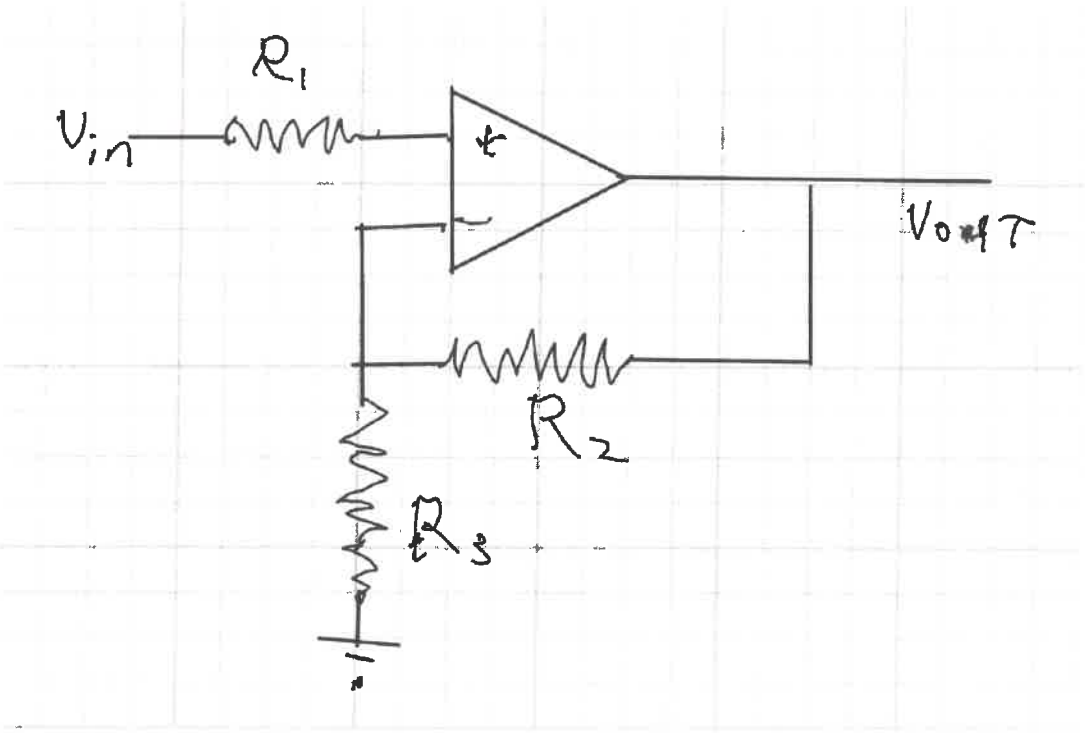
☒ True ☐ False

k: Zener diodes...
☑ Can be used in series with their Zener voltages adding.
☐ Are normally used with forward bias.
☐ Are described by the Shockley Equation.

l: A reverse–biased diode will respond faster to changes in the circuit than a zero–biased or forward–biased one.

☒ True ☐ False

2 Amplifiers



The figure shows a circuit using an op–amp. In the circuit, $R_1 = 2\,\text{k}\Omega$, $R_2 = 10\,\text{k}\Omega$, and $R_3 = 1\,\text{k}\Omega$. The op–amp has an open loop voltage gain of 120 dB and an open–loop bandwidth of 10 Hz. The power supply voltages are ± 10 Volts.

a. What is the function of this amplifier?

Non-Inverting Amp

b. What is the voltage gain?

11

$V_+ = V_{in}$

$V_- = V_+$

$V_{in} = V_{out} \frac{R_3}{R_2 + R_3}$

$\frac{V_{out}}{V_{in}} = \frac{R_2 + R_3}{R_3} = 11$

c. Answer part b in decibels.

20.8 dB

d. What is the input resistance?

∞ $\quad i_+ = 0$

e. What is the bandwidth of the circuit?

910 kHz

$GBP = 10^6 * 10\,Hz$

$f_0 = \frac{GBP}{11}$

f. What is the maximum input that will not suffer distortion at the output?

0.91 Volts

$\frac{10V}{11}$

g. If the input is $v_{in} = 2\,\text{Volts} + 0.1\,\text{Volts} \times \cos \omega t$, what is the output?

+10 volts

3 Semiconductors

The intrinsic carrier concentration of silicon is $1.5 \times 10^{10}\,/\mathrm{cm}^3$. The mobility of electrons is $\mu_n = 1350\,\mathrm{cm}^2/\mathrm{V/s}$ and that of holes is $\mu_p = 480\,\mathrm{cm}^2/\mathrm{V/s}$. The silicon is doped with a donor at a concentration of $N_D = 6 \times 10^{10}\,/\mathrm{cm}^3$. A field of 1kv/cm is applied.

a. What is the concentration of electrons?

$6.35 \times 10^{10}\,/\mathrm{cm}^3$

b. What is the concentration of holes?

$3.59 \times 10^{9}\,/\mathrm{cm}^3$

c. What is the current density due to electrons?

$1.37 \times 10^{-2}\,\mathrm{A}$

d. What is the current density due to holes?

270 μA

zero

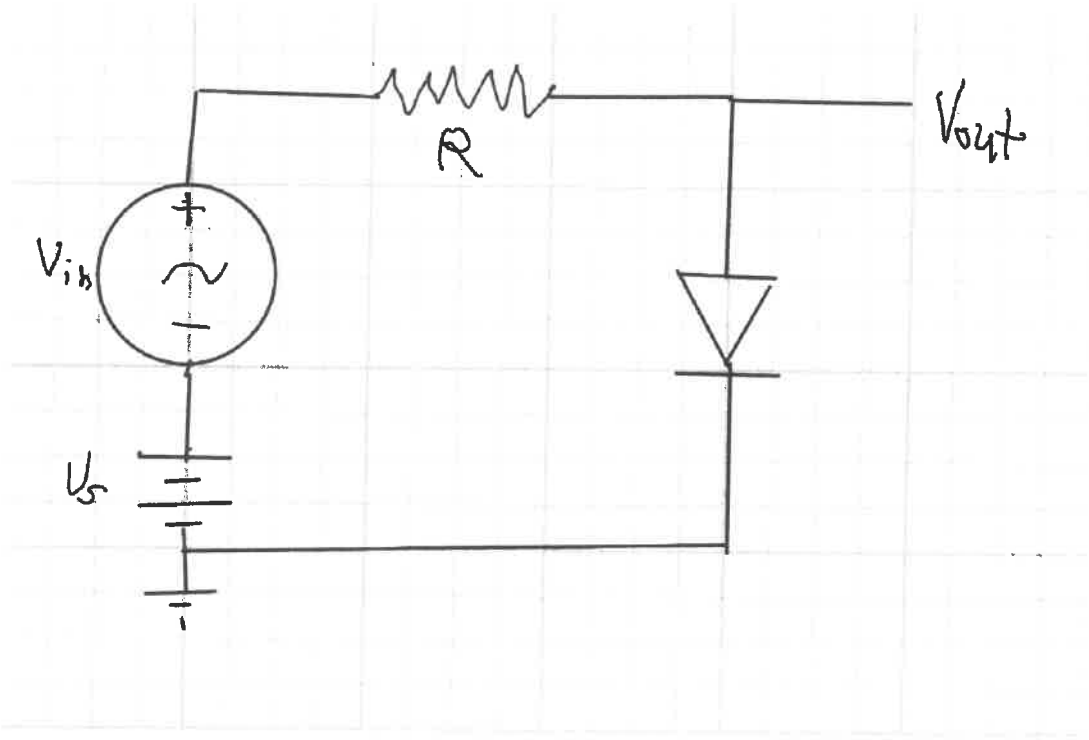
$N_D + p = N_A + n$

$p\,n = n_i^2$

$(n - N_D)\,n - n_i^2 = 0$

$J_? = e\,\mu_? \,?\, E$

4 Diode Circuits



Consider the diode circuit in the figure. The DC voltage is $V_S = 10$ Volts, and $R_1 = 2\,\text{k}\Omega$. The AC voltage is $v_{in} = 0.5$ Volts zero–to–peak.

a. Estimate the DC current through the diode. mV

4.65 mA

$I_D = (V_s - 0.7V)/R$

b. What is the effective resistance of the diode, r_d for the AC circuit?

5.4 Ω

$r_d = V_t / I_D$

c. What is the AC current, zero–to–peak?

934 A $\quad i = \frac{V_{in}}{R}$

d. Now we measure the actual voltage to be 0.63 Volts across the diode. What is the actual current?

0.0489 A $\quad I_D = (V_S - 0.63V)/R$

e. In part c, what is the saturation current, I_s of the diode?

5.3×10^{-24} A $\quad e^{0.63/V_T} = \frac{I_S}{I_D} + 1$ (from d.)