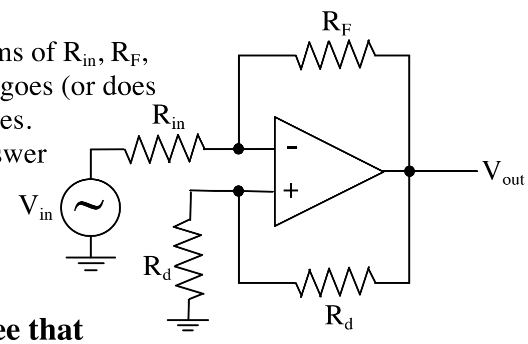
PHY2250- HW 9 – Op Amps - Answers.

1. (1 point) What is "slew-rate distortion" and when does it occur? (Some of you saw this in lab.) Feel free to refer to your text.

Slew rate distorion is when the amp is trying to a produce a slope which is too high, higher than the rate of change the op-amp can support. (The higher the amplitude and/or frequency of the output, the more likely this is to occur.) Thus it will produce a lower slope, which may result in having a sine wave turned into a triangle wave.

2. (2 points) Look through the textbook chapter on op-amps, and write the names of as many different types of circuits/amplifiers/signal-processors built from op-amps as you can. (Hint: Look at the figures!)

3. Regarding the schematic of the op-amp circuit to the right…
a) Find V_+ and V_-, the voltages at the + and - inputs, respectively, in terms of R_{in}, R_F, V_{in} and V_{out}. Hint: assume you *know* V_{out}, think about where the current goes (or does *not* go), and thus what *simple circuit* each "channel" of the op-amp makes.
b) If the R_F feedback loop functions so as to force $V_+ = V_-$, use your answer to part (b) to compute the gain of the amplifier (in terms of R_{in} and R_F).
c) Is this amplifier inverting or non-inverting?



Answer:

3. a) Treating each current path as a "voltage divider," we see that

$$V_+ = V_{out}\frac{R_d}{2R_d} = \boxed{\frac{V_{out}}{2}},$$

$$V_- = \boxed{V_{in} + (V_{out} - V_{in})\frac{R_{in}}{R_{in}+R_F}}.$$

In greater detail: If we say the current flows from V_{in} to V_{out}, we can follow the voltage changes as follows:

$$V_{in} - IR_{in} - IR_F = V_{out},$$

from which we find the current

$$I = \frac{V_{in} - V_{out}}{R_T},$$

where $R_T = R_{in} + R_F$. (Note: The choice of direction of current flow is arbitrary; we could just as easily reverse the direction and the sign of current.) The voltage V_- is found by either following the voltage changes "down" from V_{in} or "up" from V_{out}:

$$V_- = V_{in} - IR_{in} \quad \text{(also } = V_{out} + IR_F\text{)}.$$

…Substituting in for I yields the full expression for V_-.

b) Setting $V_+ = V_-$, we find

$$\frac{V_{out}}{2} = V_{in} + (V_{out} - V_{in})\frac{R_{in}}{R_T}.$$

Collecting like terms gives

$$V_{out}\left(\frac{1}{2} - \frac{R_{in}}{R_T}\right) = V_{in}\left(1 - \frac{R_{in}}{R_T}\right),$$

from which we find the total gain

$$G = \frac{V_{out}}{V_{in}} = \frac{\left(1 - \frac{R_{in}}{R_T}\right)}{\left(\frac{1}{2} - \frac{R_{in}}{R_T}\right)} = \frac{\left(\frac{R_F}{R_T}\right)}{\left(\frac{1}{2} - \frac{R_{in}}{R_T}\right)} = \frac{R_F}{\frac{1}{2}(R_F - R_{in})} = \boxed{\frac{2}{1 - R_{in}/R_F}}.$$

c) Looking at the expression for gain *G*, we see that…

for $R_{in} < R_F$, the gain is *positive* and the amp is *non-inverting*, but…
for $R_{in} > R_F$ the gain is *negative* and the amp is *inverting*.
The case of $R_{in} = R_F$ produces a gain which is *indeterminate*.

4. Problem 33-28

They are in phase. The amp shown is a non-inverting amplifier.

5. Problem 33-39
See answers in back of text

6. Problem 33-50

Since $V_- = V_+$, and $V_+ = 0V$,
$Vout = I_{in} R$.

- **a. (.002 A)(1000 Ω) = 2 V**
- **b. 3 V**
- **c. 10 V**