EECS 210 Fall 00
Homework #7
Due(in class) Friday 10/27/00

(The numbered problems are from your textbook).

1. Problem 5.20

Also repeat this problem when the power supply voltage is increased to $\pm$15 V.

2. Problem 5.29

3. Problem 5.30

4. Problem 5.34

5. Problem 5.40 (Do not assume an ideal Op-Amp)

6. Lab Homework Problem(Assigned by A. Ganago)

Background Information

The output voltage of an amplifier, as well as its output power can be limited by several parameters. An intense output signal will be clipped if any of these parameters is exceeded. We discussed in detail the so-called voltage clipping: if the output signal amplitude $V_{out,\,max}$ gets close to the supply voltage V_{cc} the signal will be clipped.

In the following problems we consider the so-called current clipping. The output current I_{out} through a load resistor is limited by the internal circuitry of the op amp chip. The output voltage of an amplifier with load resistor R_L equals $I_{out} \cdot R_L$. Thus the output voltage cannot exceed the product of the maximal output current and the load resistor. If the expected output voltage $V_{out} = Gain \cdot V_{in}$ exceeds the $I_{out} \cdot R_L$ product for the maximal output current it simply means that the expected voltage will not be reached. In other words, clipping will occur due to current limitations.

For example consider an op amp chip that can deliver only I_{out} = 5 mA. If you choose a load resistor R = 100 Ω, then the maximal $I_{out} \cdot R_L$ = 500 mV. It means that any signal whose peak amplitude exceeds 500 mV will be clipped, even though this amplitude is much smaller than V_{cc}. This is a clear example of current clipping. On the other hand, if you choose a load resistor R = 10 kΩ for the same amplifier then the maximal product $I_{out} \cdot R_L$ equals 5 mA · 10 kΩ = 50 V. It means that output signals will be clipped due to current limitations if their peak amplitude exceeds 50 V. However, most likely the voltage clipping conditions, that is $V_{out,\,max}$ gets close to the supply voltage V_{cc}, will be

reached at much lower signal amplitudes. In this case output signals will not suffer from current clipping.

Problem Part (a)

In Lab 3 you worked with an audio amplifier based on LM 380 chip with a load resistor of 8 Ω (equal to the resistance of many speakers). The chip specifications are listed on p. 43 – 45 of Laboratory Manual. Its maximal output current $\boldsymbol{I}_{\boldsymbol{out}}$ discussed above equals Short Circuit Current and Peak Current listed on p. 44. Use a conservative estimate and assume that a signal whose peak-to-peak amplitude reaches ($\boldsymbol{V}_{\boldsymbol{cc}}$ – 4 Volts) can be clipped.

Consider an amplifier based on LM 380, which is connected to a speaker with 8 Ω resistance. Determine whether the output signals can suffer from current clipping if the voltage from the power supply equals $\boldsymbol{V}_{\boldsymbol{cc}} = 10$ V. Assuming sinusoidal input, calculate maximum average power delivered to the load when signals are NOT clipped. Repeat for $\boldsymbol{V}_{\boldsymbol{cc}} = 22$ V. Now consider the same amplifier that feeds two speakers connected in parallel. The resistance of each speaker is again 8 Ω. Decide which of the four possible combinations (i.e., Vcc=10 V or 22 V and R_L = 8 Ω or 4 Ω) of load resistance and supply voltages ensures highest average power delivered to the load. Check whether the power limits of LM 380 are exceeded (see Package Dissipation14-Pin DIP on p. 44 of Laboratory Manual). Can we achieve higher output power by connecting two speakers to this amplifier when V_{cc} = either 10 V or 22 V?

Problem Part (b)

In Lab experiments 4 – 6 you will use LM 747, an op amp whose parameters are identical to those of LM 741 described on p. 53 – 57 of Laboratory Manual. The maximum output current $\boldsymbol{I}_{\boldsymbol{out}}$ discussed above equals Output Short Circuit Current listed on p. 57. In your estimates use the typical value listed in the table. Since both positive and negative voltages are applied to this chip, clipping may occur "on both sides" – when a large positive signal approaches $+\boldsymbol{V}_{\boldsymbol{cc}} = +12$ V or when a large negative signal approaches – $\boldsymbol{V}_{\boldsymbol{cc}} = -12$ V. For simplicity, assume that the signal is symmetric. Use a conservative estimate assuming that if peak amplitude of a signal exceeds ($|\boldsymbol{V}_{\boldsymbol{cc}}|$ – 2 Volts) then the signal may be clipped. The two chips LM 474 and LM 380 that you use in the lab are different. Using the manufacturers' specs, you can compare their performance in particular applications.

Consider an audio system that uses LM 741 in its output stage loaded with an 8 Ω speaker. Use typical values of the output short circuit current listed in the manufacturer's specification sheets on p. 55 – 57 of Laboratory Manual. Assuming sinusoidal input signals determine the maximum average power that can be delivered to the load. Compare the usefulness of LM 741 and LM 380 as an output amplifier (thus high power is needed) of an audio system.