EXPERIMENT #1
AUDIO MONITOR

INTRODUCTION:

The last stage in many communications systems is an *audio amplifier* of some type. An audio amplifier provides both voltage and current gain for signals from the *detector* stage so that a loudspeaker may be driven. The amplifier you'll be constructing in this experiment will let you hear audio-frequency signals at many points within a system, and can be used as a valuable troubleshooting tool. It is suggested that you build it in permanent form.

The active circuitry (resistors, diodes, and transistors) of this amplifier is contained entirely on a single IC (Integrated Circuit) chip. Before the invention of ICs, even simple audio amplifiers required dozens of individual components and took up a great deal of space. Today's IC technology is what enables *miniaturization*. Miniaturized electronics allows us to build all sorts of neat "gadgets" such as hand-held portable telephones, pagers, personal digital assistants (PDAs), and the like.

In this experiment, the following will be accomplished:

- You will build an audio amplifier using the LM386 provided in the lab kit.
- You'll get additional experience in the use of the signal generator and oscilloscope.
- You will measure the performance of the LM386, and learn how to measure audio power amplifier output characteristics.

CIRCUIT ANALYSIS:

Figure 1 is the audio amplifier circuit. The LM386 IC audio amplifier chip does all the work!

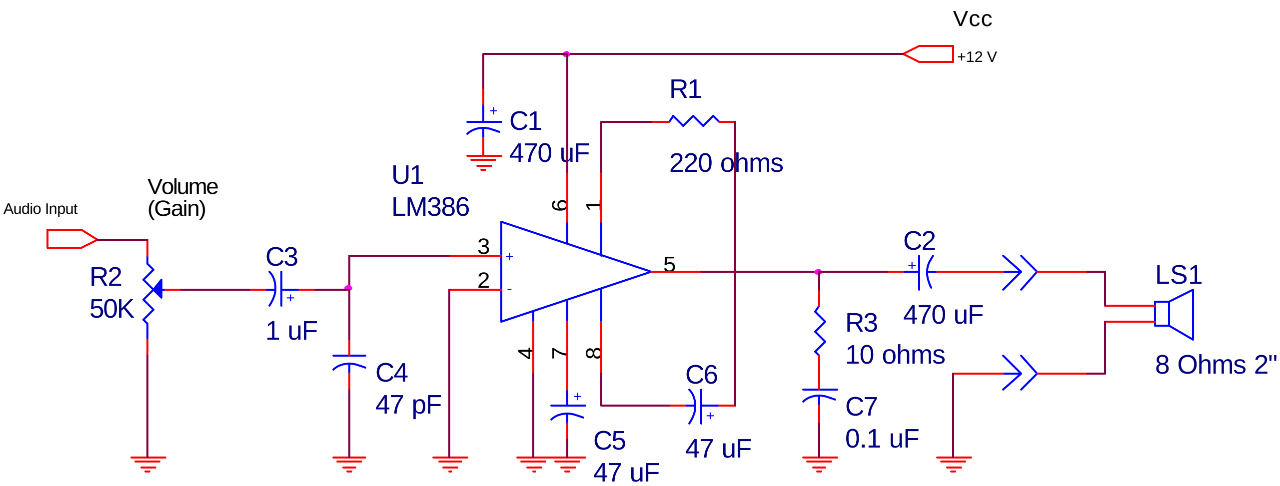


Figure 1: Audio Monitor Using the LM386

Input signals are applied to the amplifier at the *audio input* connection. The audio signal flows down into potentiometer R2, which functions as a variable voltage divider. The percentage of AC input signal that leaves R2 is controlled by the position of R2's wiper (the arrow). When the wiper is all the way down at ground, *no* signal leaves R2 and the "volume" is at minimum. Sliding the wiper of R2 upwards (clockwise rotation of the physical potentiometer) increases the percentage of signal that can escape R2, which in turn increases the effective gain and "volume" of the audio circuit.

The AC signal passes through capacitor C3 after leaving R2. C3 is a *DC block*. It allows AC (information) to pass through to the audio amplifier, but prevents DC from passing, which might disturb the DC bias on pin 3 of U1, the LM386. C4 is an *RF bypass* capacitor. It is effectively an open-circuit at audio frequencies, but a *short* at radio frequencies. (Recall that the reactance of a capacitor decreases as frequency increases). Its purpose is to short any stray RF at the amplifier input to ground *before* it can get into the amplifier IC. We don't want to hear local radio stations, CBers, or any other unintended signals coming out of our circuit!

The input signal is finally applied to pin 3 of U1. U1 is a special "power operational amplifier." It is built in a manner similar to a regular op-amp, but has internal negative feedback already in place, and also has an extra stage to boost the current for driving a loudspeaker. In other words, U1 provides both voltage and current gain -- U1 is a *power amplifier*. U1 does all the real work in this circuit! R1 and C6 set the *voltage gain* of U1, C1 and C5 are *filters* for the power supply, and C2 is a *DC block* for the output circuit. (Because the LM386 uses a push-pull output circuit, the DC voltage on pin 5 is about one-half of *Vcc*. Applying 6 Volts to a speaker wouldn't be very healthy for the speaker!)

LABORATORY PROCEDURE:

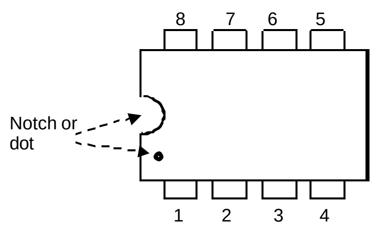
Name _______________ Sign-off _________

1. Build the circuit of Figure 1. Note the following:

   C1, C2, C3, C5, and C6 are *electrolytic* capacitors. These parts are polarized and must be installed the correct way! (The longer lead is the (+) or positive lead. Observe the polarity markings.)

   C4 is a *ceramic disc* capacitor. It is most likely marked "47", "47J", "47 pF", or "470." Putting the wrong capacitor in this place can make your circuit inoperative!

   Observe the pinout of U1 carefully. It is in an 8-pin DIP (dual inline package) and the pin numbers read like this:



   TIP: It is best to <u>solder</u> two hookup wires to the speaker before connecting it into the circuit.

2. Connect the following test equipment to the circuit:

   SIGNAL GENERATOR: Connect to the *audio input* terminal of the circuit (top of potentiometer R2). Connect the generator "hot" (RED) lead to the *audio input* and the generator ground lead (BLACK) to the circuit ground.

   DUAL TRACE OSCILLOSCOPE: Connect *channel 1* to the *audio input*. Connect *channel 2* to the *audio output* of the circuit (Negative side of capacitor C2). Connect all ground (BLACK) leads to the circuit ground.

3. Apply power to the circuit and set the test equipment as follows:

   SIGNAL GENERATOR: Frequency 1 KHz, waveshape sine, output voltage 50 mVpp (you may need to observe the waveform on the scope to set the output voltage).

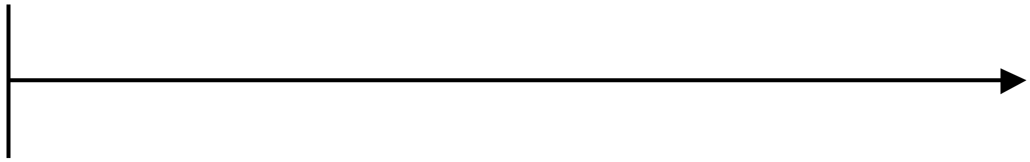
   OSCILLOSCOPE: Timebase 200 µS/division ; Channel 1, AC coupling, 10 mV/division; Channel 2, AC coupling, 1 V/division.

4. On the audio monitor circuit, adjust potentiometer R2 for maximum volume. This should be at full clockwise rotation of the control.

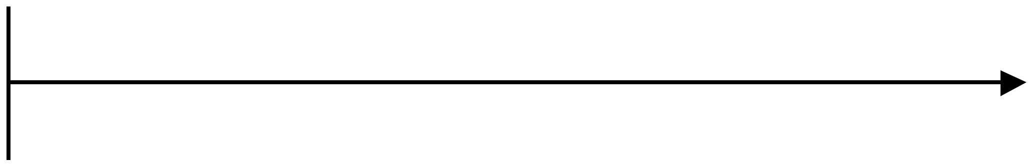
5. You should now hear the 1 KHz tone from the signal generator playing through the loudspeaker. If it gets to be too annoying, just disconnect the speaker and replace it with an 8 to 10 Ohm fixed resistor!

6. Record the input and output waveforms below. Accurately record all important voltage and time dimensions for each waveform.

AUDIO INPUT



AUDIO OUTPUT



7. What is the *voltage gain* of the circuit according to the data you collected in step 6?

TIP: Voltage gain is measured in Volts/Volt (V/V) and is calculated by:

$A_v = \frac{V_{out}}{V_{in}}$ Where V_{out} and V_{in} are the AUDIO OUTPUT and AUDIO INPUT signals of this circuit.

When you measure V_{out} and V_{in}, remember that they must be in the same dimensions (Vpk, Vpp, Vrms, etc).

Show your calculation:

Voltage Gain (V/V): ________________

8. What is the *voltage gain* of the circuit in *decibels?*

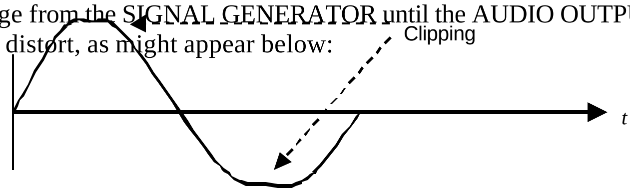
TIP: The formula for calculating voltage decibels is: $dB = 20\log(A_v)$

Show your calculation:

Voltage Gain (dB): ________________

9. Let's measure the *maximum undistorted output power* of this amplifier. (You may want to replace the loudspeaker with an 8 to 10 Ohm fixed resistor in this step!)

a) Increase the voltage from the SIGNAL GENERATOR until the AUDIO OUTPUT signal begins to "clip" or distort, as might appear below:



b) Back down the input voltage from the SIGNAL GENERATOR until the output signal cleans up again.

c) Record the peak-to-peak voltage at the AUDIO OUTPUT. This is the *maximum undistorted audio output signal voltage*:

Maximum audio output signal voltage ____________ Vpp

d) Convert the signal voltage into RMS for power calculation.

Recall that: $V_{rms} = \frac{Vpp}{2\sqrt{2}} \approx \frac{Vpp}{2.82}$

Maximum audio output signal voltage ____________ Vrms

e) Calculate the *power* being delivered to the loudspeaker by Ohm's law.

Write the equation for power (given Voltage and Resistance) here: _______________________

The RMS voltage you calculated in (d), and the resistance of the loudspeaker is about 8 Ohms.

Show your calculation for maximum output power.

Maximum undistorted output power: _____________ (Include appropriate units)

10. Get a sign off for your working circuit. You may want to save this circuit for later use, if you have a spare breadboard.

Troubleshooting Hints

Most troubles with the *audio monitor* circuit can be traced to wiring errors or power supply troubles. In case of trouble, try the following:

1. Perform a careful visual inspection of the circuit, comparing it to the schematic diagram. Make sure each component value matches what is called for on the schematic diagram.

2. Check the DC voltage at the following locations:

Circuit Location	DC voltage reading and tolerance	Comments
U1 pin 6	12 V +/- 0.5 V	*Vcc* power supply for the power operational amplifier IC
U1 pin 4	0 V (Ground)	*Ground* terminal of LM386
U1 pin 5	6 V +/- 1 V	The potential of 6V represents a centered DC operating point for the amplifier circuit. This is determined internally within U1. If this voltage is out of range, make sure C2 is installed in the correct direction, and that nothing except C2 is connected to U1 pin 5.
U1 pin 2	0 V (Ground)	Inverting input terminal.
U1 pin 3	0 V to 0.1 V	Non-inverting input terminal. If the voltage is greater than the limit, check for a wiring error on pin 3.

3. Check the AC voltages in the order listed at the following locations, using an oscilloscope. The test points are listed in order of signal flow, from input to output.

Circuit Location	AC signal reading	Comments
Top of R2	50 mV pp @ 1 KHz	Input signal from SIGNAL GENERATOR
U1 pin 3	50 mV pp @ 1 KHz	Depends on input signal level. R2 must be set for maximum volume. This is the input to the amplifier chip.
U1 Pin 5	At least 6 Vpp @ 1 KHz	Output signal of amplifier circuit. Depends on input signal level and setting of R2.

QUESTIONS

1. What component in the circuit of Figure 1 contains the active amplifier circuitry?

____

2. What is the function of potentiometer R2? Explain how R2 performs its function.

____

____

____

3. What two points must be measured to determine the voltage gain of an amplifier?

1. ____

2. ____

4. Explain how to measure the maximum undistorted output power of an amplifier.

____

____

____

____

5. What else have you learned in this lab?

____

____

____

____

____

____