

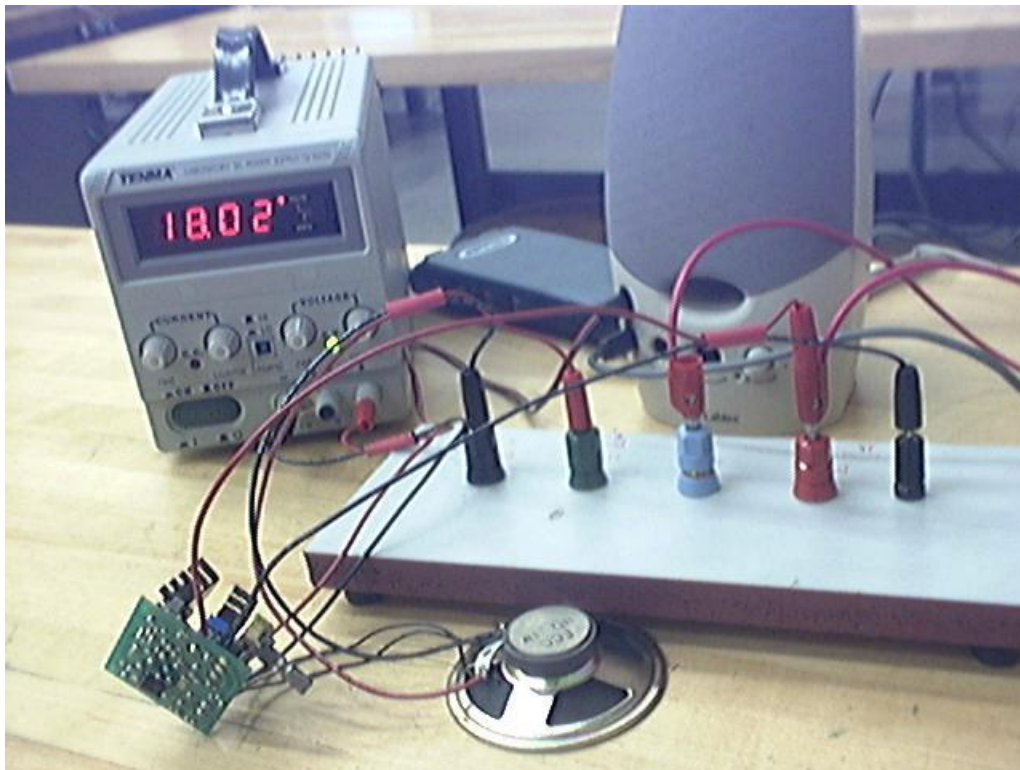
## FREQUENCY RESPONSE OF AN AUDIO AMPLIFIER

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The objectives of this experiment are:

- To understand the concept of HI-FI audio equipment
- To generate a frequency response curve for an audio amplifier
- To thoroughly bore you

**APPARATUS:** Audio Amplifier (Circuit Chip), Computer with FFTSCOPE software, Speaker, Power supply, Interconnecting Cables

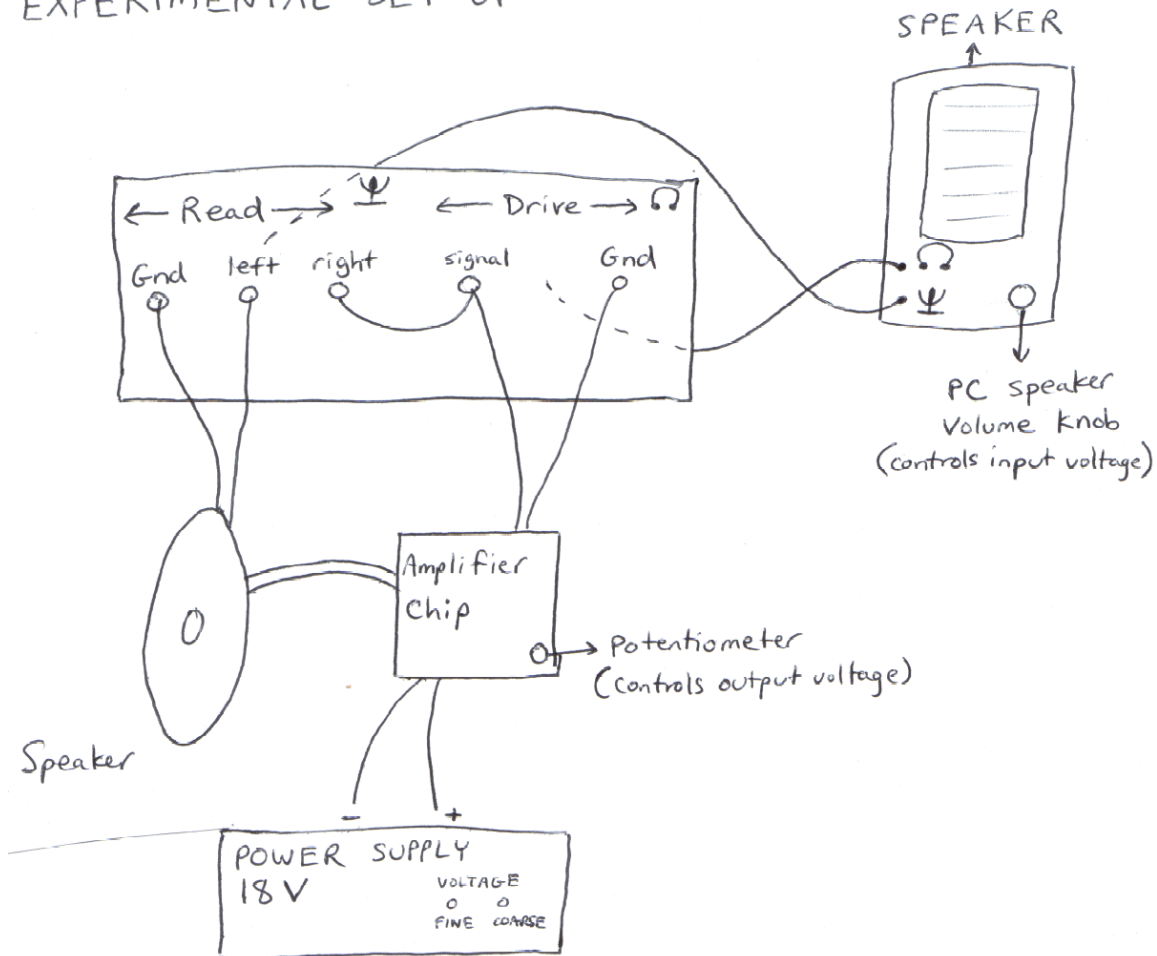


A good high fidelity amplifier will have frequency specifications flat to within  $\pm 1$  dB from 20 Hz to 20 kHz at a specified power. Under the best conditions the human ear can barely detect a 1 dB change in sound level, and only a very young child can hear frequencies as high as 20 kHz. So an amplifier this good probably won't introduce any audible distortion of its own into your sound system. On the other hand, a 1 dB change in amplifier output voltage corresponds to about a 12% change in voltage

which is easily measured with an oscilloscope. In this experiment you will study the frequency response of an inexpensive audio amplifier and obtain a response curve.

The equipment should already be set up and all connections should be in place. The general premise of the set-up is that an AC comes into the "Drive" side of the wooden board. The jack labeled "Gnd" is just a ground to prevent damage to the equipment or the people handling it. The "Signal" input splits with one branch connecting to the amplifier chip, and the other to the jack labeled "right" on the "Read" side of the wooden board. Therefore the input signal is being fed back into the computer to be read directly, and is also going through the amplifier. After the current passes through the chip and gets amplified, it passes through the speaker which emits sound. The wiring from the speaker then continues to the "Read" side and connects to the "Gnd" and "left" jacks, returning to the PC speaker to be read as output voltage by the FFTSCOPE software. The diagram below indicates the connections between the various components of the system.

EXPERIMENTAL SET-UP



The amplifier chip itself is kit 48 from DIY Electronics. It is made up of resistors, capacitors, transistors, and other electronic components (see kitsrus.com for details if you are interested). The chip is pictured below.



## PROCEDURE

**A. CAUTION:** Initially, keep the volume of the sound very low by setting both the PC speaker volume and potentiometer (metal knob on chip) at a low level. Place your hand near the chip (but do not touch) periodically to determine whether the chip is becoming too hot. If so, turn down the PC speaker volume and/or blow on the chip to cool it.

Turn on the power supply by pressing the green on/off button and, using the Voltage Fine knob, set it to approximately 18 V. Only use the Coarse knob if the Fine knob doesn't bring you close enough to 18 V. The chip should say "18 V DC" which indicates that this is the appropriate voltage. Switch the black "ON/OFF" switch on the circuit board to "ON". Using the computer, open the folder "course folder" on the desktop, then open the

“301” folder within. Double click the icon titled “linein.gmx”. This will tell the sound card in the computer from which jack the information is coming in, and thus how to properly interpret the raw data.

Open the FFTSCOPE software in the “course software” folder on the desktop. Set the function generator to Sine. Press the “GO/STOP” button and, if you see only one trace, the “Stereo/Mono” button. There should be two traces visible now, a red one and a blue one. The units of the red trace are on the left and those of the blue trace on the right. The units are in mV, but the values may not be meaningful in anything more than a relative way (i.e. you can compare the traces, and the values at different driving frequencies, but the numbers may not give the actual voltage due to absence of calibration). The L and R values at bottom will give the values at the position of the cursor. The L trace should be red and the R trace blue. If not, push the button with the red and blue arrows curled in a circle (it is to the right of the Stereo/Mono button).

The PC volume knob will control the voltage input to the amplifier, whereas the potentiometer knob will control the voltage output by the amplifier. Both traces will respond to adjusting the PC volume knob, while only the L (red) trace will respond to adjusting the potentiometer level. Remember to keep the volume low as you experiment with the set-up.

**B.** Usually manufacturers of audio equipment give the frequency response of an amplifier in dB relative to its response at a particular frequency. Use 1 kHz as the reference frequency. With the function generator on Sine set the Frequency to 1 kHz and check that the input level (trace R, blue) is 20 mV. Watch the L trace (red) which displays the amplifier output voltage and **slowly increase** the amplifier volume until the output level reaches about 100 mV. Going to “view” in the drop down menu at the top of FFTSCOPE and selecting “view peak-to-peak amplitude” will tell you twice the amplitude of the left trace, succeeded by the right trace.

**C.** Measure the amplifier output voltage (trace L, red) at each of the frequencies from 20 to 16,000 Hz as indicated in the table below. Since the input voltage (i.e. the voltage provided by the function generator) can drop at higher frequencies, before recording your data check that the input voltage (trace R, blue) is within a few mV of 20. Readjust the PC volume level if necessary to insure a 20 mV input signal. Watch the red trace and note the output level. Record the input and output voltage in columns 2 and 3 in the table below using “view peak-to-peak amplitude” as above. Be careful not to change the potentiometer control while recording your data. If you accidentally change it, start over.

**D.** To calculate the response in dB, use the equation:

$$\text{Response (dB)} = 20 \log [V_{\text{output}} / 0.1]$$

Use the data in column 3 for the Output and record your Response in column 4. This procedure converts the voltage output to a decibel response relative to 0 dB at 1 kHz. This is (as noted above) because manufacturers give the frequency response of an amplifier in dB relative to its response at a particular frequency. We decided to use 1 kHz

as our reference frequency, where the amplifier's output voltage was adjusted to give 0.1 V. You can easily see that for this frequency  $20 \log[0.1/0.1] = 20 \log[1] = 0 = \text{Response (dB)}$ .

**E.** Make a plot of the Response (dB) versus Frequency (Hz) with Graphical Analysis software. Connect your data with a smooth hand drawn or computer generated curve. Include your data table and clearly label your graph.

**F.** Now to do things the simple way (which is how it is done in real life). Using FFTSCOPE switch to FFT mode by pressing the "FFT/OSC." button. Set the Function Generator to "White noise", and press the green button with the downward red arrow to turn FFT averaging on. You can turn averaging off when the curves are smooth (i.e. noise has died out) by clicking the button again, or by pressing the space bar. The red trace (L/R ratio) will give you the frequency response curve which you meticulously assembled above (here with hardly any effort). The blue trace you may ignore. Go to File in drop down menu and print the screen.

## FREQUENCY RESPONSE OF AN AUDIO AMPLIFIER

### LAB REPORT FORM

**NAME:** \_\_\_\_\_ **DATE:** \_\_\_\_\_

**PARTNERS:** \_\_\_\_\_

Frequency (Hz)	Input (V)	Output (V)	Response (dB)
20			
50			
100			
500			
1 k			
5 k			
10 k			
16 k			

**Please attach graph for part E. and screen shot for part F.**

**Question 1:** What is the range of frequencies (highest and lowest) for which the amplifier's response is constant within 3 dB? This is called the 3 dB frequency response of the amplifier and is often quoted by the manufacturer.

**Question 2:** Does this amplifier qualify as high fidelity equipment? Explain.

**Question 3:** Within the range of frequencies typically encountered in music is the frequency response flat? Is this desirable for audio experience? How would the response observed affect the aural effect of recorded music?