

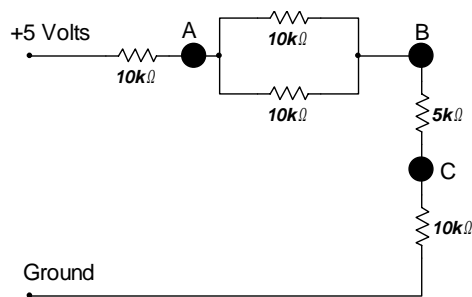
2/22/2006 SOLUTIONS

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
22.071/6.071 Introduction to Electronics, Signals and Measurement
Spring 2006

Lab4. Protoboarding Techniques. Sampling and Aliasing.

Experiment 1.

For this exercise you will build the following circuit on the protoboard. Connect the +5 Volts and Ground as indicated and then measure the signal at the points indicated by A, B and C.



The goal of the exercise is to become more familiar with the prototyping board and how it is wired. The guidelines to follow are:

1. Make sure the system power is off while you are building your circuits.
2. Establish power traces and test them. For example if you will be building a circuit that needs +5V and ground then first establish the +5V as one of the red traces and the ground as the adjacent blue by connecting them to the power supply. Test the actual value of the voltage at the power traces with the multimeter or the oscilloscope.
3. Turn the system back off and start building your circuit.
4. Keep your wires short and do not run wires over components
5. Build your circuit in sections and test each section before proceeding.

First measure the Voltages at A, B and C and record the values below. Next change the input voltage from +5V to -15 V. Assume that the system you have just constructed is linear, what do you expect the voltages at A, B and C to be and why?

Do your measurements agree with your expectations?

Input Voltage	+5V	-15V
Voltage at A	3.3v	-10v
Voltage at B	2.5v	-7.5v
Voltage at C	1.67v	-5v

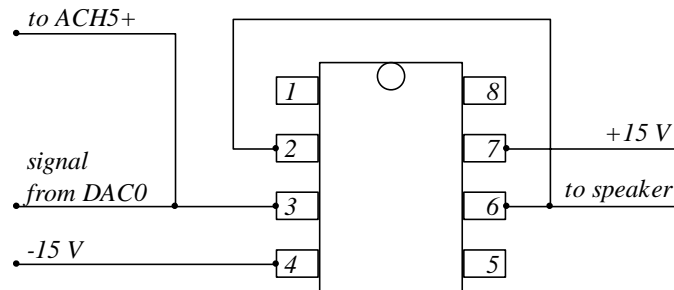
Experiment 2.

Building a device to power a speaker.

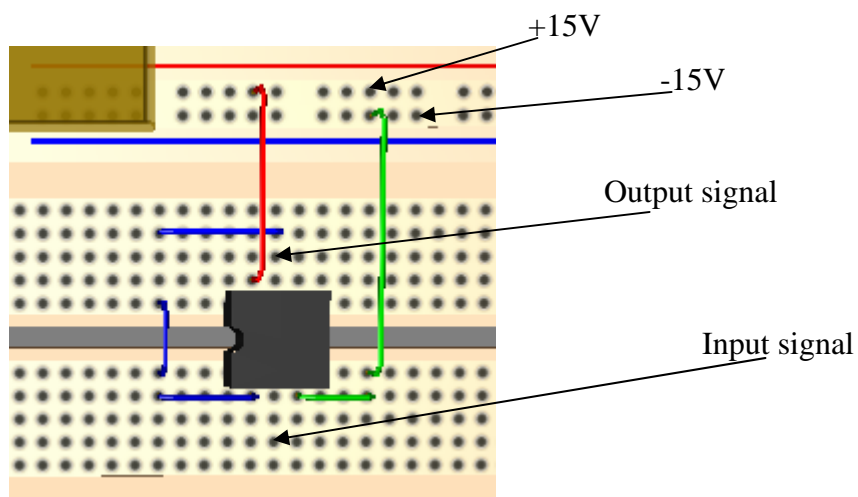
In the following experiments we will need to send a signal to our speaker from the computer. For our speaker to work properly, we must provide to it more current than the computer can output. We will build a device called a buffer that will sit between the output of the computer and the speaker. This device will provide the necessary power to the speaker but without affecting the signal that comes from the computer output. We will thus have the opportunity to see and hear the exact form of the original signal. In any event this is going to help us further understand how to build circuits on the protoboard.

The circuit we are going to build is based on a device called the operational amplifier. We will learn a lot more about this very useful device later on. For now we will just use it without consideration of its properties and operational characteristics.

The schematic of the circuit is



Place the device as indicated in the schematic below and make the connections shown.



Test your circuit by connecting the power as indicated and use a 1 kHz sine wave with an amplitude of 5 Volts as the input signal.

View the output with your scope and test to make sure that everything works.

Now you have built a very useful device that can be used for various experiments. Save it.

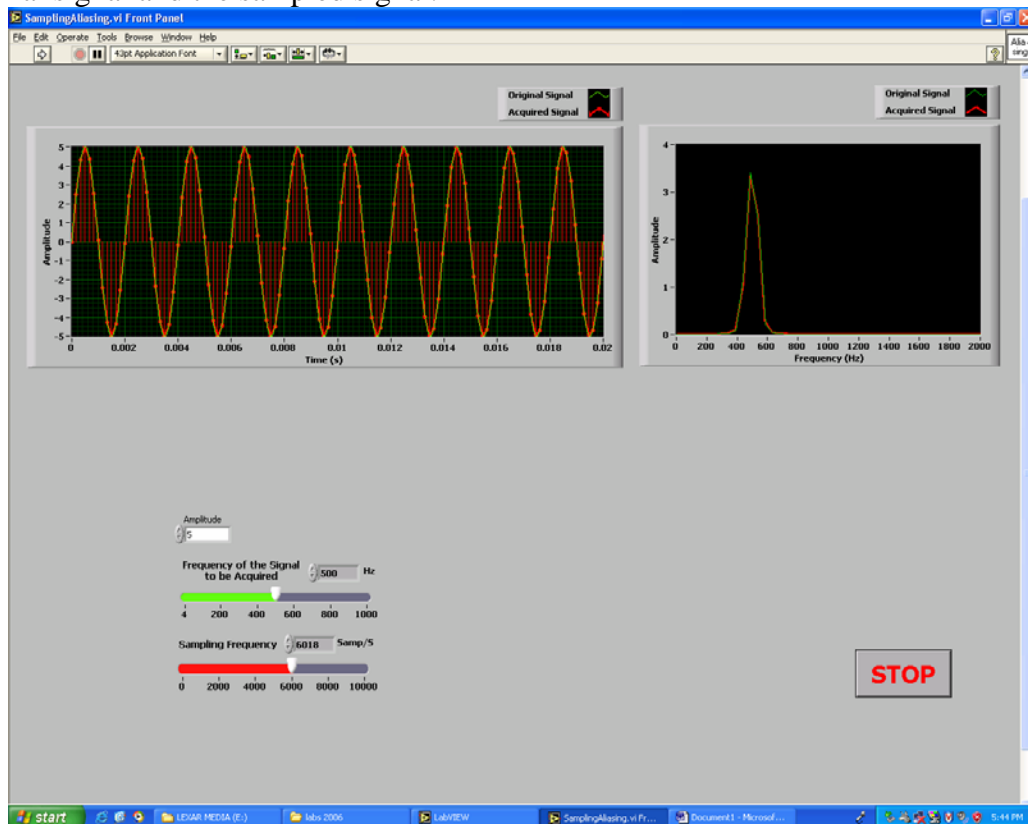
Experiment 3. Sampling a signal

Here we will investigate sampling and the phenomenon of aliasing.

In class we learned that in order to be able to reproduce a signal from a sample the sampling frequency has to be greater than twice the bandwidth of the signal under investigation.

With this experiment we will investigate the sampling process in a visual way. The first instrument to use is called **SamplingAliasing** and may be downloaded from your class web site. Run the instrument and investigate the results as you change the signal frequency and the sampling rate.

The green trace represents the original signal and the red dots indicate the sampled values. On the right side of your instrument interface you see the Fourier transform of the original signal and the sampled signal.



Construct a signal with a frequency of 500 Hz. Now change the sampling frequency and observe the results.

What happens when the sampling frequency is 1000 Hz?

The observed frequency = signal frequency.

What do you observe when the sampling frequency is less than 1000 Hz?

The frequency of the reconstructed wave fluctuates; aliasing occurs.

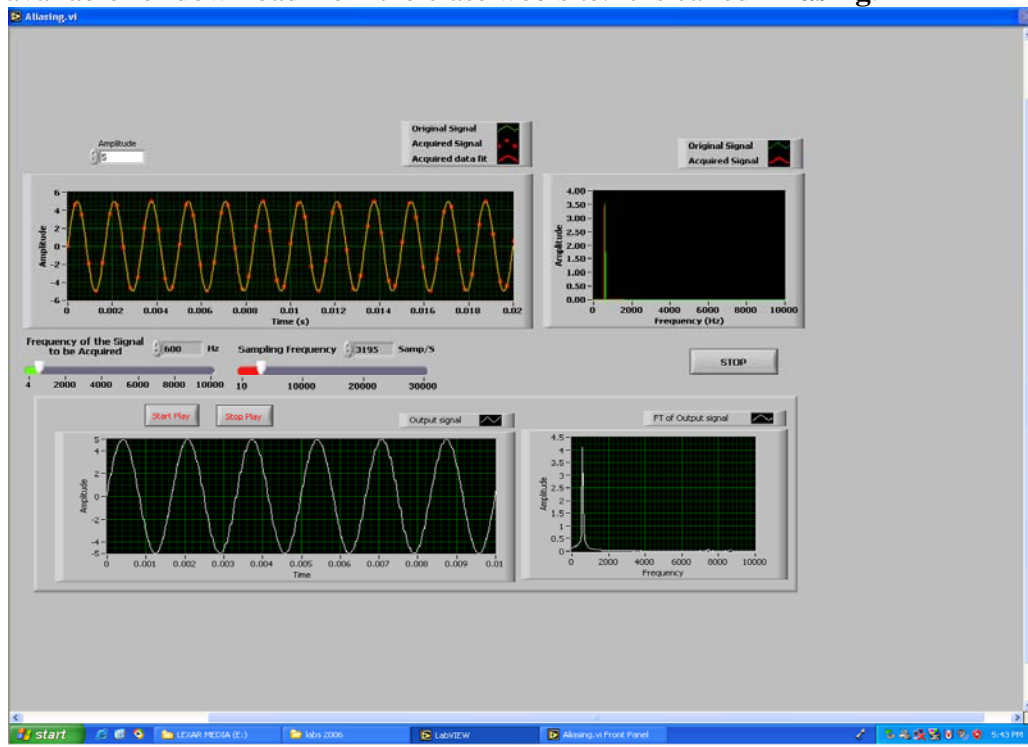
What do you observe when the sampling frequency is > 1000 Hz ?

Same as 1000Hz.

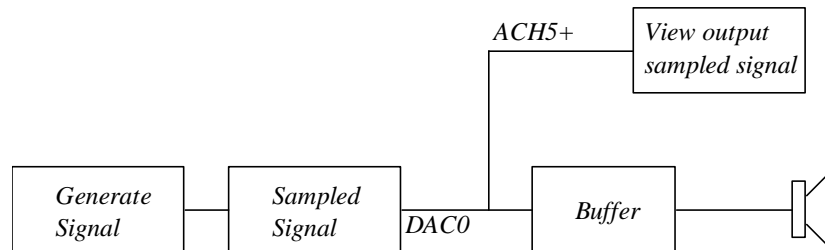
What do you observe when the sampling frequency is 1000 Hz ?

The observed frequency approaches the signal frequency for frequencies > 1000Hz..

Let's now continue with the sampling problem by using yet another instrument which is also available for download from the class web site. It is called **Aliasing**.



The system diagram of the instrument is shown below.



The output from the computer comes at DAC0. Connect the output signal to ACH5+. The sampled output signal appears in the lower graphs of the instrument. Notice you have to use the Start Play and Stop Play buttons in order to hear the results of your sampling selection.

Run the instrument and observe the phenomenon of aliasing. i.e what happens when sampling frequency is less than twice the signal frequency.

The observed frequency is less than the signal frequency and fluctuates.

Select a signal frequency of 800 Hz. Listen to the sampled signal with the highest possible sampling rate. Now decrease the sampling rate until you begin to notice a difference in the sound. What is the sampling rate below which you begin to notice a change in the signal pitch. *1600Hz.*