Guitar pickup and motor speed measurement

In this lab you will build a guitar pick-up which you will use to record the signal from a very fancy plywood “guitar”. The same device will help you figure out how fast a motor is spinning. The sensor you will make is called a variable reluctance sensor. We will explain how the sensor works at the beginning of class, you may also consult Wikipedia. You will also learn to analyze data in the frequency domain.

You need to start by building your own sensor. Take about 14 feet of the 30 gauge enamel wire, one small rare earth magnet, and 2 clear plastic disks. Using super glue (and some lab gloves), glue the plastic disks to the magnet as shown in Figure 1. You can use steel on your desk as a clamp; place a drop of super glue on the plastic, place the magnet on and put the assembly on the metal so the magnet squeezes into the plastic, repeat for the other disk. The super glue should dry in seconds and this process should be very quick. Wear some nitrile gloves so you don’t get superglue on your hands. Take a bolt and attach to the magnet assembly to give you something to hold on to; then neatly wrap the enamel wire around the magnet (inside the plastic) as shown in Figure 1. You should have about 75 turns of the wire. Leave leads of about 1 foot.

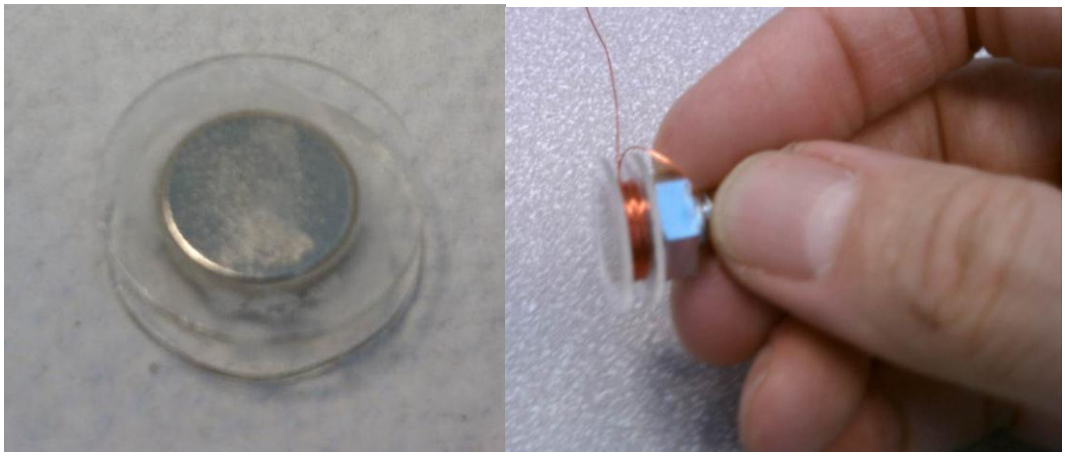

Figure 1: Making your own guitar pickup.

Once you have the wire wrapped, you will need to solder some short hook-up wires to your sensor so you can plug it into the breadboard. The solder will melt the enamel to make electrical contact. If you don’t know how to solder, we can show you in class.

Now build the first part of the circuit in Figure 2, comprised of the AD623 with the 1 K feedback resistor (what is the gain of the amplifier?). Send the output of the amplifier to the DAQ analog channel 0. Place your guitar pick-up under the wire of one of the “guitars”. Use double sticky tape to hold the pick-up in place as shown in Figure 3.

Pluck the guitar and run your program. You should see about a 1 V signal corresponding to the vibration of the guitar string.

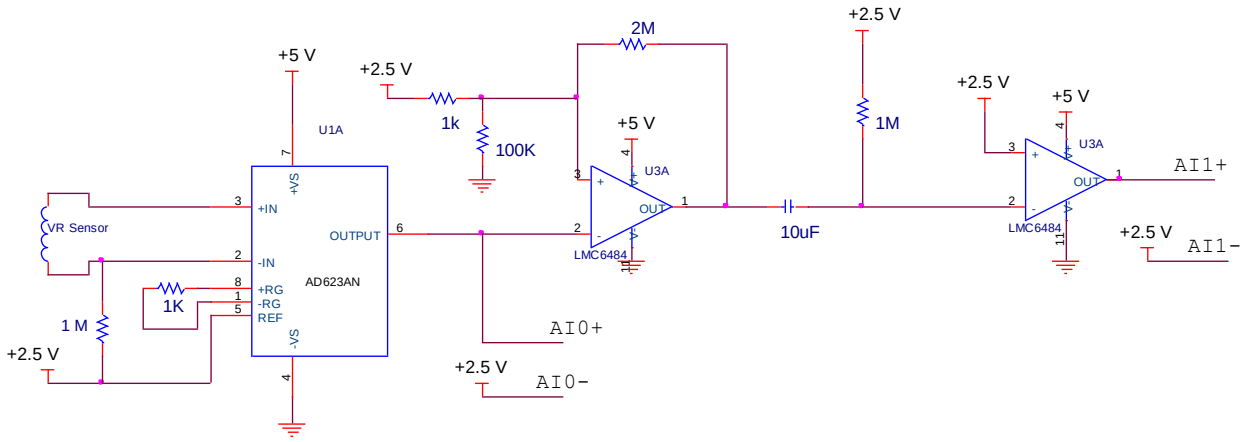

Figure 2: Circuit schematic for both parts of the lab.

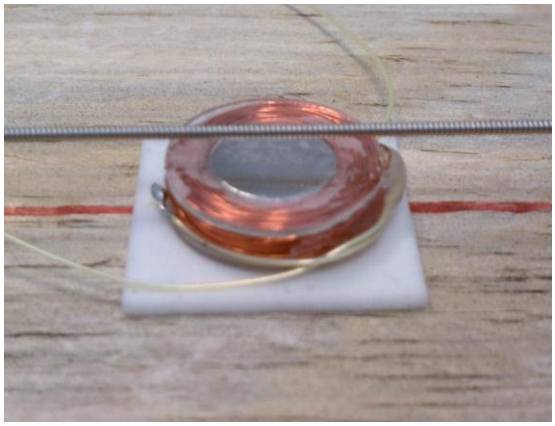

Figure 3: Placement of guitar pickup.

You will need to modify the program we gave you to incorporate a "real time" frequency display. You should modify the program to show the signal in the time domain and in the frequency domain. You need to fill in the blank function on the MATLAB script we give you to start with to compute the power spectrum using MATLAB's FFT algorithm. An example of what your program output may look like is shown in Figure 4; in this example the circuit was just hooked up to wire acting as an antenna for 60 Hz noise.

You should experiment with plucking the guitar in different places and at different strengths. You should see several modes excited which decay at different rates. If you pluck at different locations you might see different modes excited. If you or one of your peers has a good musical ear, you could try tuning the guitar to a specific note and then compare to measurement. You could try recording and playing the sound back through your computer's sound card as a kind of amplifier.

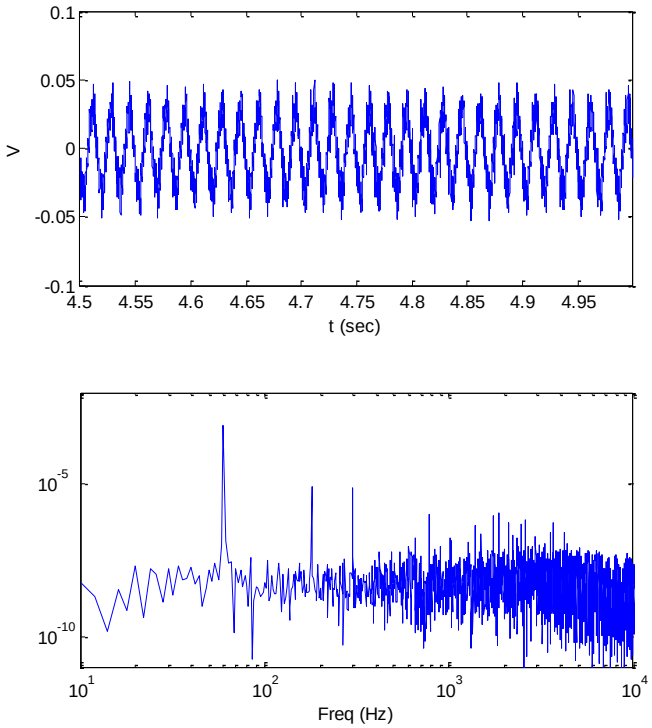

Figure 4: Sample output from MATLAB program you should write. Display the signal in the time and frequency domain. In this example, the input is a wire acting as an antenna which is picking up 60 Hz electrical noise.

Once you have this aspect of the circuit working, you will need to build the rest of the circuit shown in Figure 2. The remainder of the circuit will be used for counting. We will have some metal bolts attached to some lego wheels. You should run the wheel with a 9V battery. As the wheel spins, bring the sensor close to the wheel. On the analog input channel 0, you should see a little positive-negative "blips" as the bolts spin by. The rest of the circuit converts this blip into a fixed width pulse which you can use to count how many times per second that a bolt comes by. You will need to figure out and explain how the rest of the circuit works. If you are unsure, you can add additional analog input channels to measure what is happening at each stage. Note that the first op-amp is wired with positive feedback, thus the assumptions that the input voltages are equal is no long true.

Modify your program to display the speed that the motor is spinning from the pulses which come from the circuit.

In your lab report, provide some data from the guitar experiment and the motor experiment. From the guitar string experiment provide some data showing the different modes being excited when you pluck the string. Provide some sample data in the frequency domain. Provide your function which computes the power spectrum. For the motor experiment, provide some sample data and a brief explanation of how the circuit works. If you have trouble figuring out the op-amp with positive feedback, the circuit is called a Schmitt Trigger and you can look it up. What is the function of the RC part of the circuit? What is the difference between the output of the whole circuit and the Schmitt Trigger?