A05.01 SkeeterSat Calibrations
LaACES Student Ballooning Course
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Materials:

Student(s) should have the following materials, equipment, and supplies:

1. SAFETY GLASSES or GOOGLES
2. Assembled SkeeterSat
3. A digital multimeter (DMM) capable of measuring voltage, current, and resistance
4. 9-volt alkaline battery
5. Beakers
6. Hot-Plate
7. Freezer or bag of ice
8. Thermometer

The laboratory should also be equipped with the following:

1. Flat work tables sufficient to seat all students with plenty of work space
2. One or more computers with sound card and microphone, and Spectrogram software installed.

Using *SkeeterSat* as a Temperature Sensor

You can utilize the SkeeterSat as a temperature sensor. The pitch of the beep is dependent on the temperature of the thermistor. When the temperature rises, the resistance will decrease, and the pitch will go up. If the temperature decreases, the resistance will increase, and the pitch will go down.

Due to this relationship, it is possible to use the SkeeterSat as a temperature sensor by recording the audio frequencies emitted by the SkeeterSat and correlating the audio frequency to temperature. To make a reliable measurement, the pitch frequency should be recorded at multiple temperatures. This can be accomplished by submerging the thermistor into water that has been cooled or heated to a specific temperature.

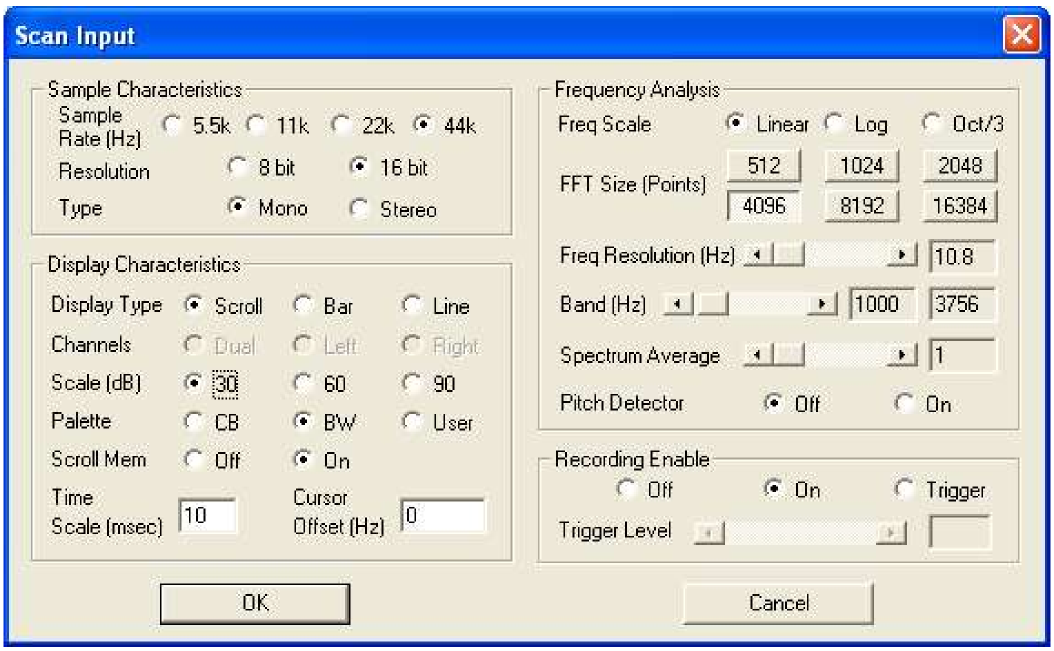
The audio emitted by the SkeeterSat is a combination of multiple frequencies being emitted at the same time. These frequencies are harmonics – repeating signals that are multiples of a base or fundamental frequency. You can calculate the fundamentat frequency by measuring the difference between adjacent harmonics. To get an accurate measurement of the temperature, the resonant frequency is required.

SpectroGram Operation

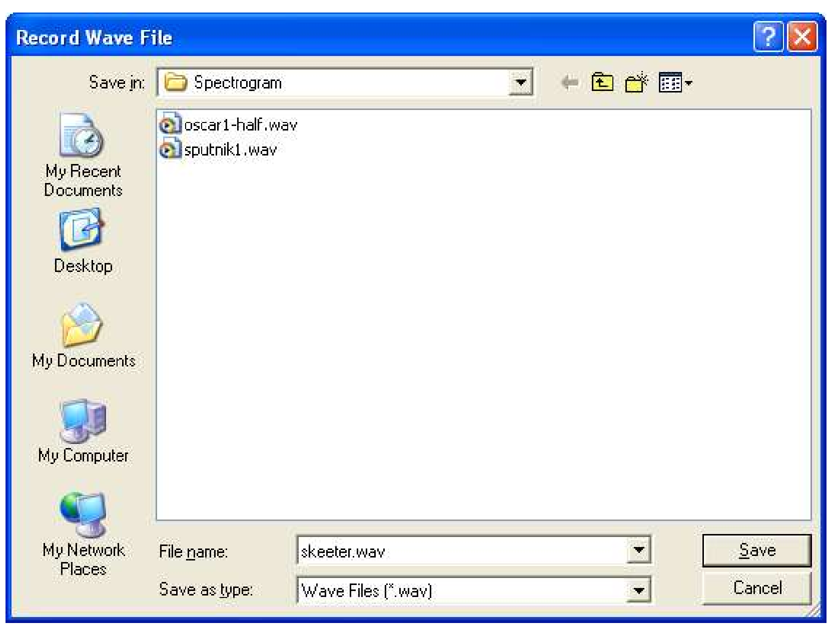
While you can just listen to *SkeeterSat* beeping happily, some means of reducing the beeps to numerical data is needed if this simple telemetry system is to have meaning. The *Sperctrogram* program provides that tool.

On a flash drive or other storage device provided by LaACES you will find a folder called *Spectrogram*. Copy the files from the *Spectrogram* folder to your computers hard drive. No installation process is needed, you can just launch the application <*gram.exe*> Be sure you have a microphone connected to your computer's soundcard input, and that the microphone recording input is enabled, with its volume slider set about halfway to maximum. Place the microphone close to *SkeeterSat's* speaker.

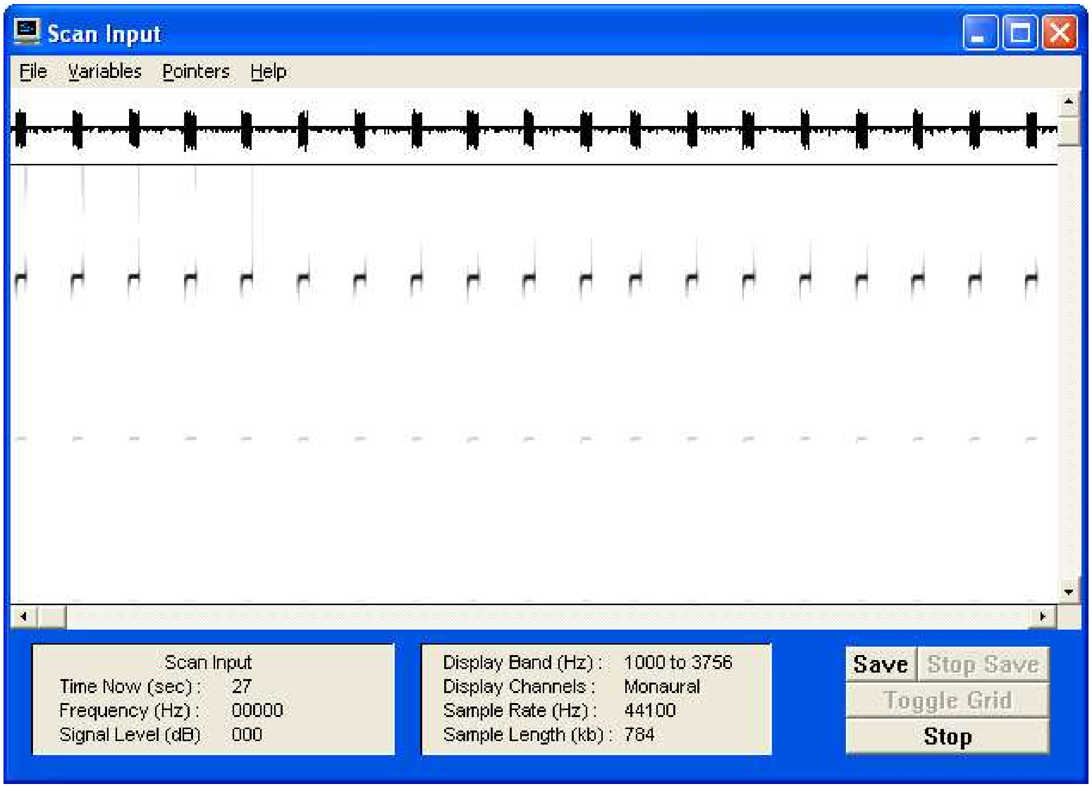
The first thing you will encounter is a setup screen like the one pictured. For now, just click the appropriate button to make your setup the same as the one shown.



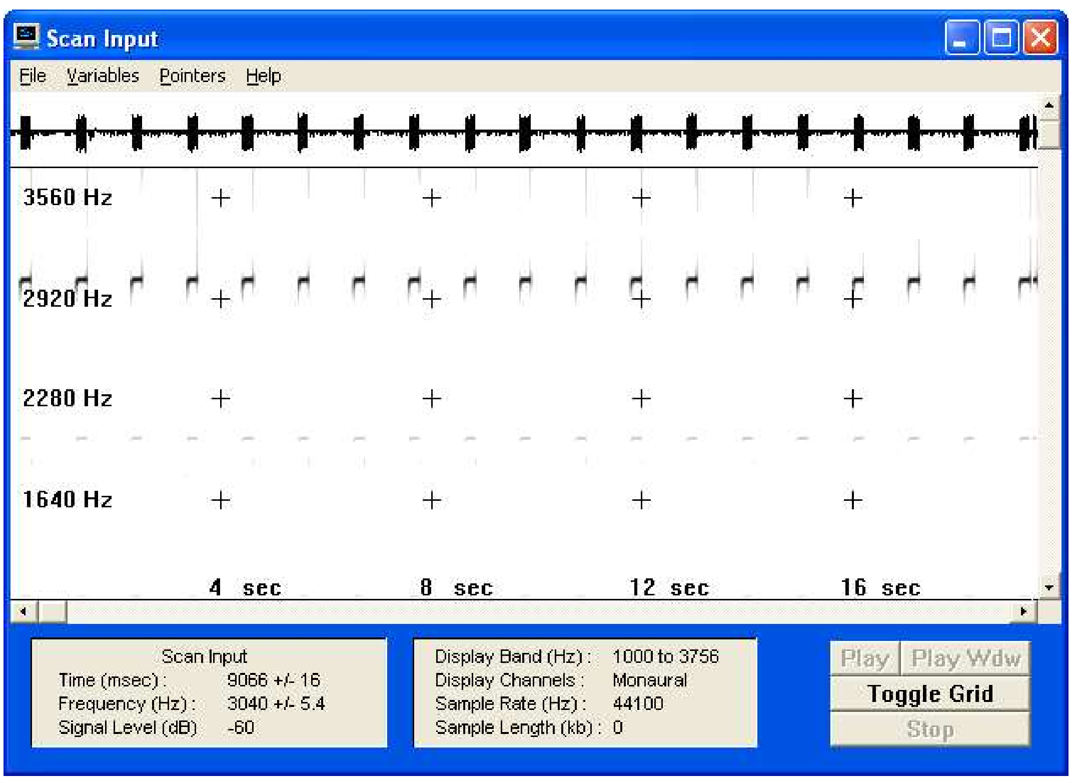
When you click <*OK*> you will be prompted for a filename to be used to save a wav file. Enter a name of your choosing and click <*SAVE*>



A pattern similar to the one pictured next should begin scrolling across your screen.



Click <*STOP*> then wait a few seconds for the program to respond.
Now click <*TOGGLE GRID*> and you should see the following display.



As you move the cursor around the screen notice how the box in the lower left shows you the time, frequency, and amplitude of the recorded signal. This is the tool you need to make meaningful measurements with *SkeeterSat*. *Spectrogram* has many other features and capabilities. Spend some time reading through the HELP file within the program.

SkeeterSat Calibration

Now that you know how to record the audio frequencies, you can begin to calibrate the SkeeterSat. You will need at least one beaker of water, a thermometer, a hot plate, and ice or a freezer. Ensure that your thermistor has been water-proofed by either coating it in liquid electrical tape or protecting it in a plastic bag. Submerge the thermistor into the water. Measure the temperature of the water in the beaker at room temperature and record the audio frequencies emitted.

When you recorded the audio frequencies, calculate the fundamental frequency by subtracting each harmonic from the neighboring harmonic. The difference between each harmonic is equal to the fundamental frequency. Repeat this calculation with multiple harmonics and record its results.

Next, put ice into the beaker and wait for the water to cool. When the water has cooled, submerge the thermistor into the water, measure the water's temperature, and record the audio frequencies. Notice the space between harmonics has decreased. This means the fundamental frequency has also decreased. Calculate the fundamental frequency and record its results.

Finally, put the beaker on the hot plate and wait for the water to heat. When the water has heated, submerge the thermistor into the water, measure the water's temperature, and record the audio frequencies. Notice the space between harmonics has increased. This means the fundamental frequency has also increased. Calculate the fundamental frequency and record its results.

Repeat this process with multiple temperatures, heating and cooling the water as needed. More accurate calibrations can be made by including a larger data set with appropriate analysis.

Next, plot the fundamental frequency as a function of temperature. Include each data point recorded and analyze the trend. Is the relationship linear? Are there any irregularities to the data? What can you determine about the characteristics of the thermistor from this data? What are some limitations of using the SkeeterSat as a temperature sensor?