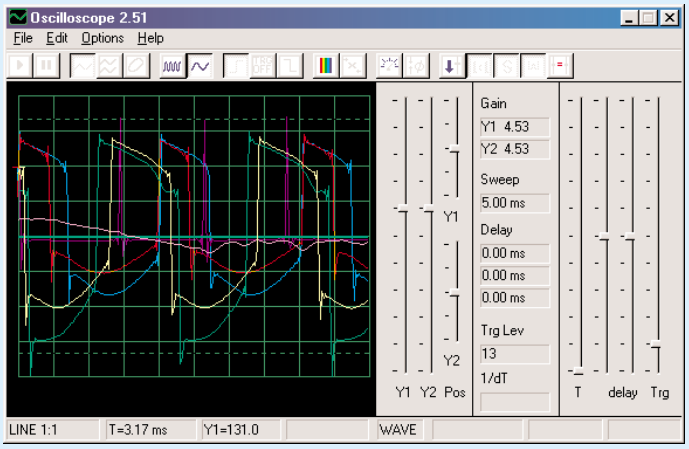
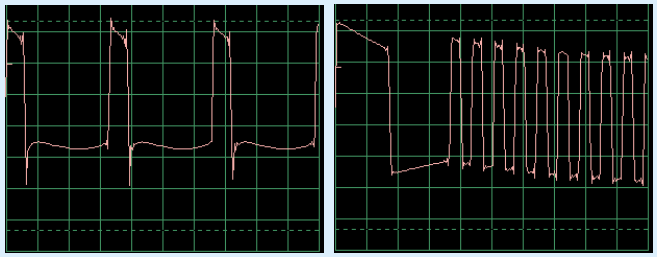
CI-22
BASIC ELECTRONIC EXPERIMENTS
with computer interface

Experiments PC1-PC8

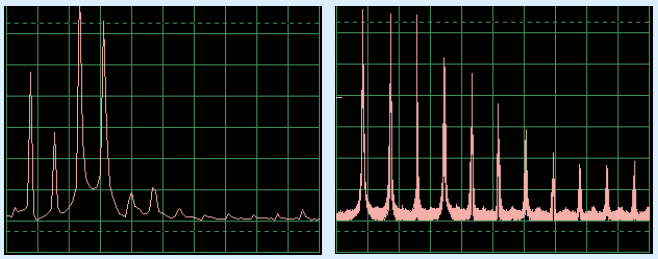
Sample Controls Display



See these Oscilloscope Signals



See these Spectrum Analyzer Signals



Instruction Manual

Elenco Electronics, Inc.

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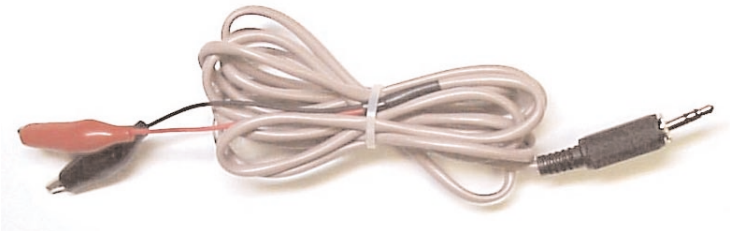
Looking at Electronic Signals using the WINSCOPE Software:

Electronics engineers use specialized test equipment to “see” electronic signals and make performance measurements. They use an oscilloscope to look at the waveform of the signal in time and use a spectrum analyzer to look at its frequency content. This equipment is specialized and usually very expensive.

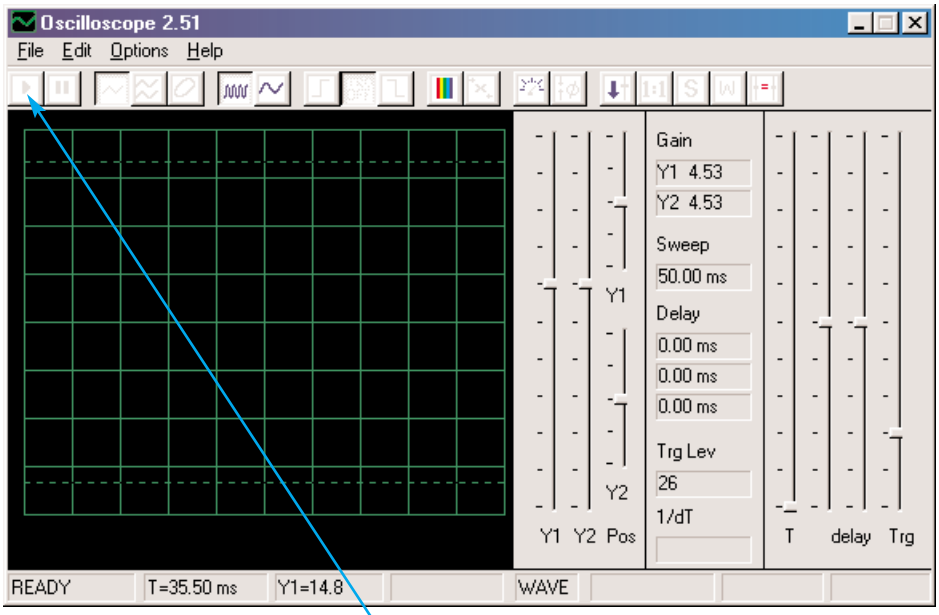
The Winscope software simulates this equipment using your personal computer. The **PC-interface cable** can be connected across any 2 points in your circuit to look at the signal.



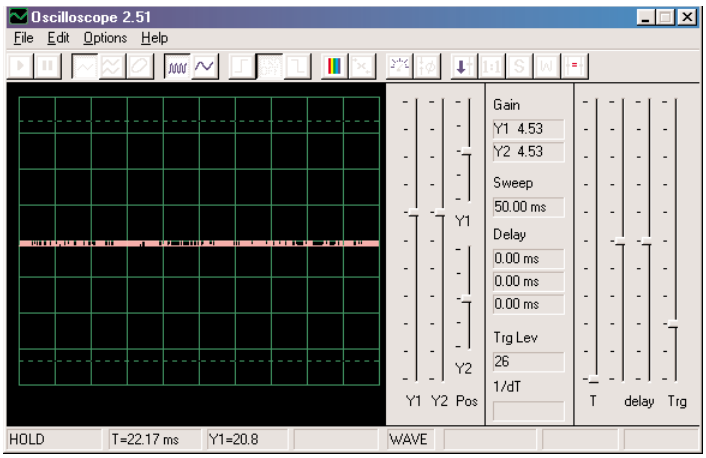
WARNING:

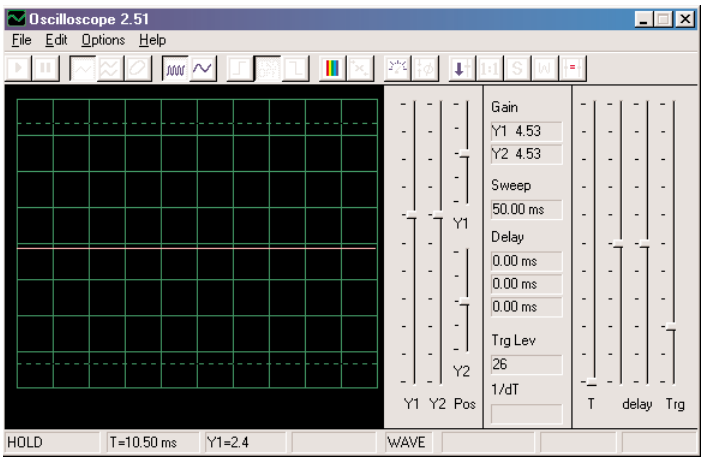
SHOCK HAZARD - **NEVER** connect the probe to AC power or a wall electricity outlet for any reason since serious injury or damage may result.

It is usually connected to the output of a circuit, as in the circuits shown for the CI-22. Connect the plug end of the probe to the microphone input on the back of your personal computer. Run the Winscope application (from the CI-22 menu). It will come up in Hold mode looking like this:



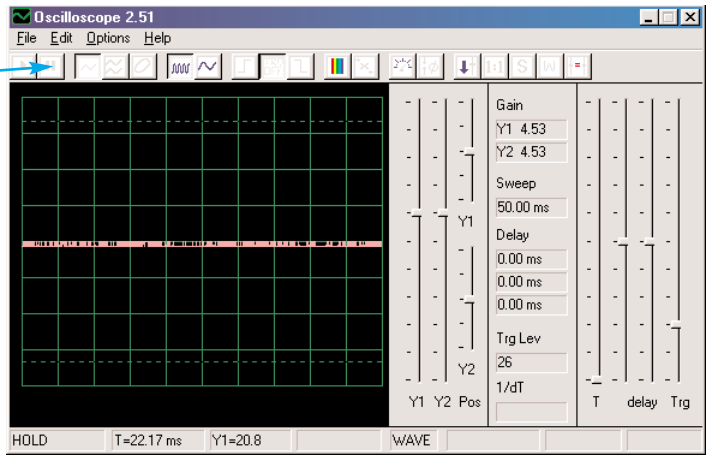
Click on the On-Line button to turn it on. You should now get one of the following 2 pictures, depending on whether your microphone input is properly turned on:





If you get the picture on the right then your microphone input is not properly turned on, go to the "Turning On Your Microphone Input" to turn it on. There may also be other sound card controls on your computer that you need to set, when your input is properly configured then you will get a picture like the left one above. Touch the red and black "alligator" clips on the PC-interface cable to each other and you should see the random pattern on the winscope screen change as you do so. You are now ready to proceed with the first CI-22 experiment or you may investigate the Winscope software on your own.

You may freeze a waveform on the screen by clicking on the Hold mode button (just to the right of the On-Line button).



WARNING: Do not "save setup" in Winscope. Many of the buttons on Winscope control features that this manual will not be using. If you accidentally place the Winscope software into an unknown mode, you may always close and restart Winscope. Doing so will reset all settings to those described in this booklet unless you have done a "save setup".

PROJECT PC1 SHOWS HOW TO USE THE MAIN FUNCTIONS OF WINSCOPE SO DO IT FIRST!

NOTES:

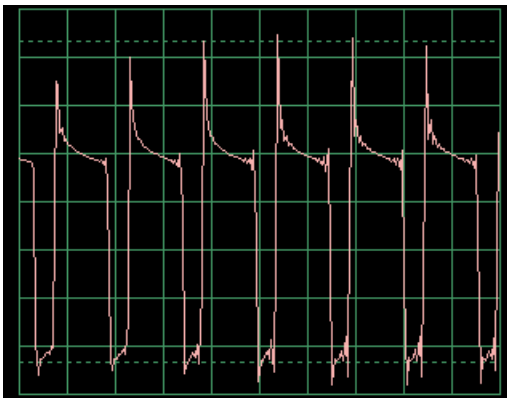
1. It is recommended that you disable or turn down the volume to the speakers on your computer. CI-22's use of the microphone input port will also channel the same signal to the speakers, and the result is often very annoying.

2. It is recommended that you be familiar with the PK-101 parts and assembly methods before building any of the circuits in this manual.

IMPORTANT NOTE: The designs for the microphone input port vary throughout the computer industry. Hence you may get waveforms different from those shown in your manual even though the circuit is actually performing the same way. Here are some types of differences:

A. The gain of your microphone input may be significantly different from that indicated on pages 8-10 (and similarly for the other circuits). Page 6 describes how to turn on the microphone input and adjust its volume to about 40% of max, you may want to adjust this volume higher or lower so that your results better match those shown. Note that having the volume set too high may "clip off" the top or bottom portion of a waveform.

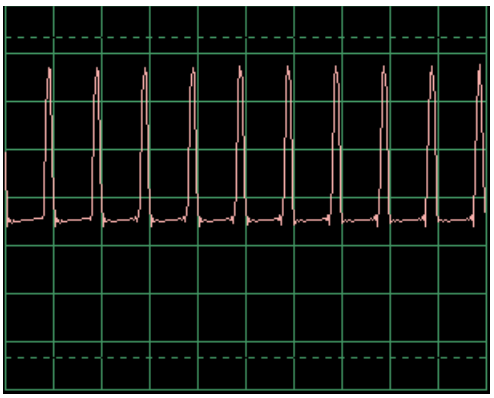
B. The oscilloscope waveforms shown on your display may appear upside down ("inverted") from those shown throughout this document. For example the waveform shown on the top of page 9 would look like this:



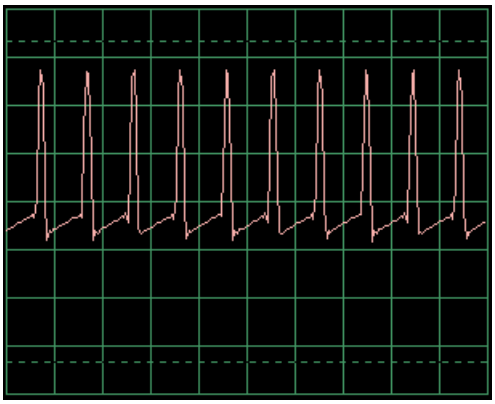
If this is the case then swap the connections of the red and black clips of the Winscope probe in all circuits.

C. The shape of waveforms may appear distorted for some circuits, due to protection circuitry that acts as a filter. For example:

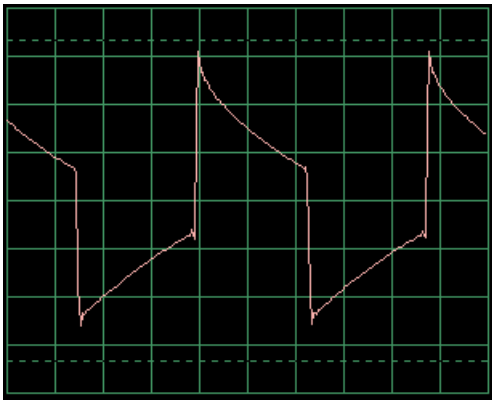
This waveform →



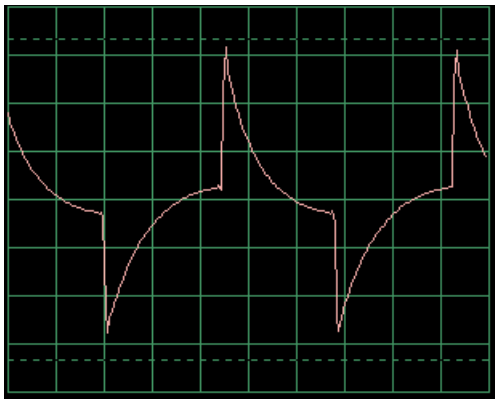
might look like this. →



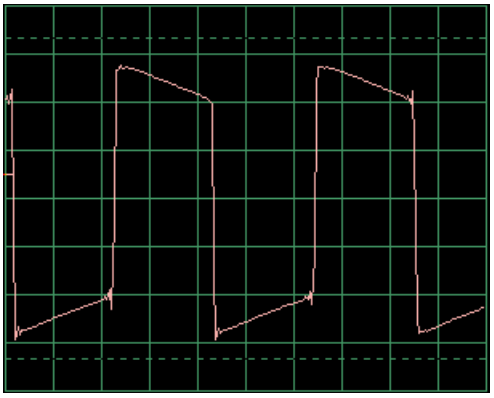
And this waveform →



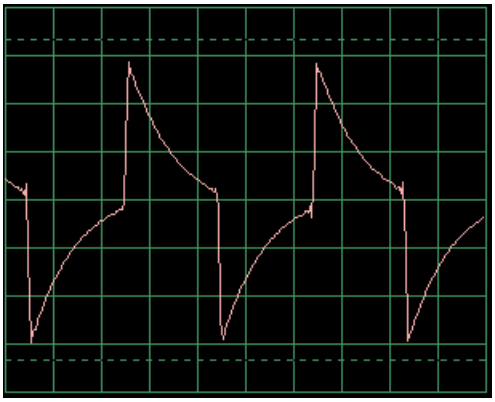
might look like this. →



And this waveform



might look like this.



Contact Elenco Electronics if you have any questions about this.

Limitations of Winscope and its interface:

By using the microphone audio input and the flexible processing power of the personal computer, we have created an inexpensive and easy-to-use way of looking at electronic signals. However, no electronic oscilloscope or spectrum analyzer ever made works on all electronic signals, and similarly Winscope has limitations. The projects in this booklet were written to minimize those limitations.

Winscope can only measure changing signals (AC voltages, >20 Hz frequency) and cannot measure fixed voltages (DC voltages, such as a battery), due to the design of the microphone input. Fixed voltages are not very exciting to look at anyway. Slow-changing or transient signals (such as when you first turn on power to a circuit) will be displayed in a distorted form.

Winscope works best on signals up to about 5 KHz, since its sampling rate is limited to 44 KHz. If you attempt to measure signals that are higher than this then you will get wrong results due to undersampling. This is a narrow range but it covers human voice and most (but not all) music. AM and FM radio frequencies cannot be measured. Every measurement you make will have some amount of random “chatter” superimposed on the signal of interest. This chatter is due to the limited sampling rate and from the PC-interface cable picking up energy from other electronic instruments in the vicinity (including room lights and your computer), hence it cannot be avoided.

Turning On Your Microphone

(For Windows 98, other Windows versions may be slightly different.)

If you don't get any signal from the PC-interface cable then your microphone may be disabled on your computer. To turn it on, follow these instructions which begin by pressing the <Start> button on the lower-left corner:

1. Select <Start> - <Programs> - <Accessories> - <Entertainment> (or <Multimedia>) - <Volume Control>.
2. Select <Options>.
3. Select <Properties>.
4. Select <Recording> in the "Adjust Volume For" box.
5. In the "Show the Following Controls" box, check <Microphone>.
6. Select <OK>.
7. In the "Microphone - Volume" box, check <Select> and set volume to about 40% of max.

Your microphone should now be turned on.

Using Winscope's full capabilities:

Winscope has 2 input channels that can be displayed at the same time. This is commonly done by electronic engineers using an oscilloscope, to show the relationship of one (or more) signals to another. However use of this requires a second microphone input, which most computers do not have. If the sound card in your computer has this then you may use all of Winscope features for 2 channels, which include X-Y and correlate modes. Use of these Winscope capabilities is beyond the introductory level of this product, use the Help menu in Winscope for information about using these features.

If you have any questions contact:

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Wheeling, IL 60090
(847) 541-3800
http://www.elenco.com
e-mail: elenco@elenco.com

WARNING:

SHOCK HAZARD - **NEVER** connect the probe to AC power or a wall electricity outlet for any reason since serious injury or damage may result.

PROJECT LISTINGS

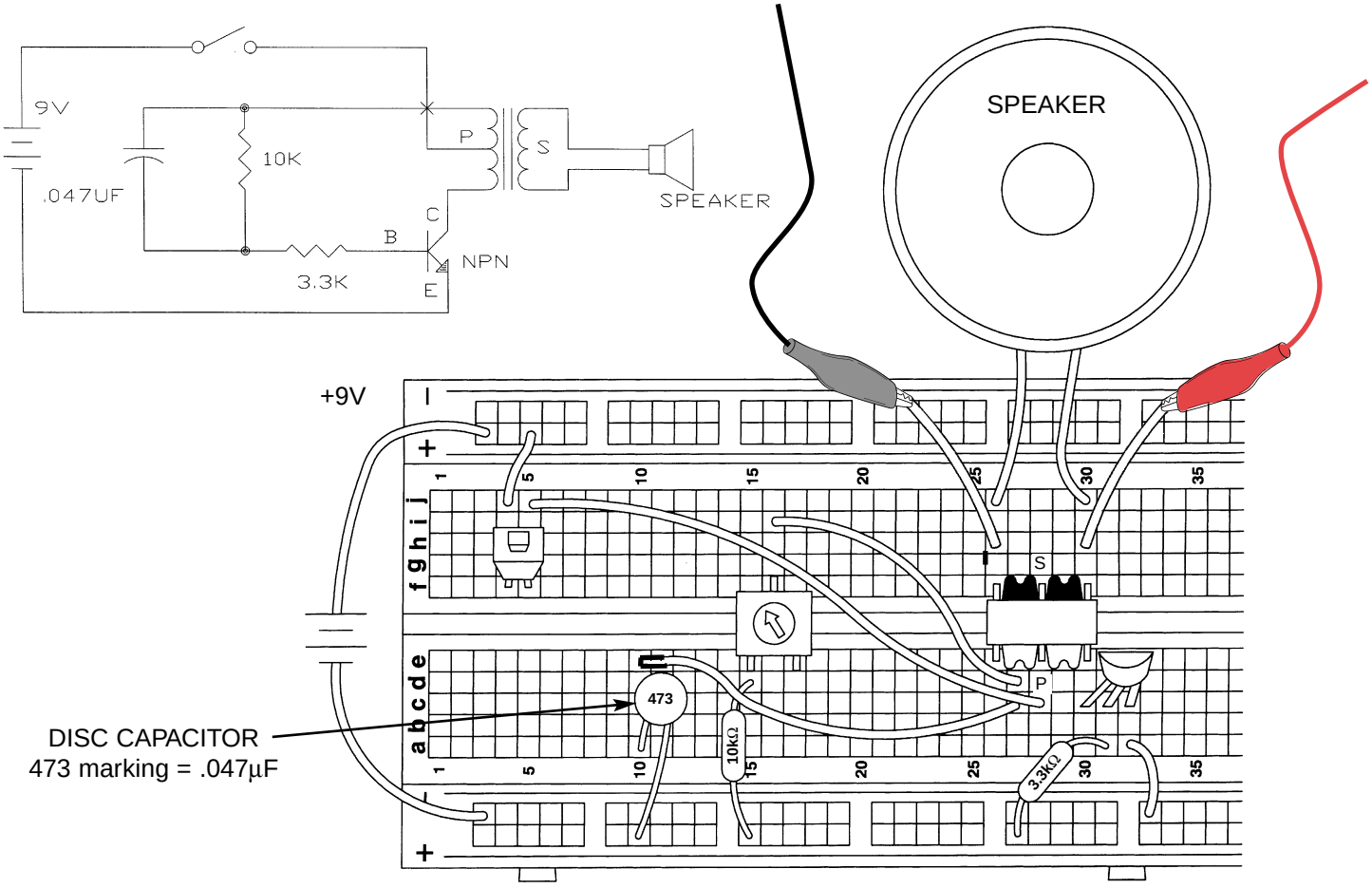
Project #	Description	Page #	Project #	Description	Page #
PC1	Pitch	7	PC5	Electronic Noisemaker PC	18
PC2	Speaker Microphone	13	PC6	Noisy Blinker PC	21
PC3	Siren PC	15	PC7	Electronic Sound PC	23
PC4	Space Gun PC	16	PC8	Electronic Rain PC	25

Project PC1 Pitch

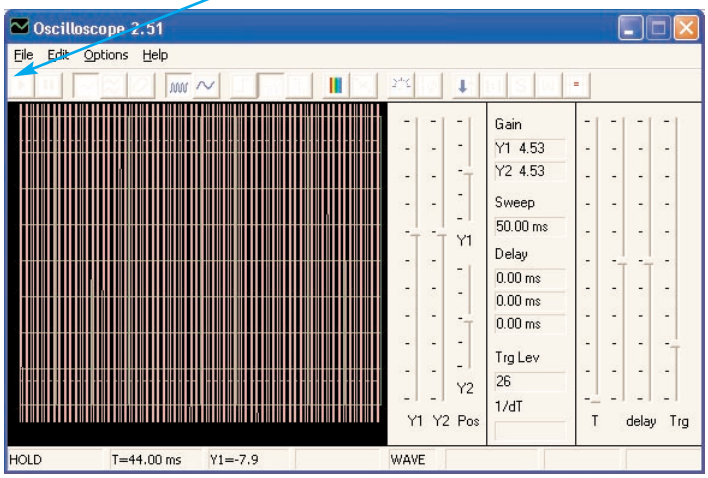
OBJECTIVE: To look at the output signal from a transistor oscillator while changing the pitch of the sound.

You will now be introduced to the Winscope features, and thereby become familiar with oscilloscopes and spectrum analyzers, and see some of the most important concepts in electronics. It is recommended that you already be familiar with the parts and assembly methods from the other manual.

Build the circuit shown and connect the PC-interface cable to the microphone input on your computer. Press the switch and vary the variable resistor. The frequency or pitch of the sound is changed. Run the Winscope software and be sure your microphone input is configured properly, as described earlier. Winscope will be used to view the electrical signal to the speaker.



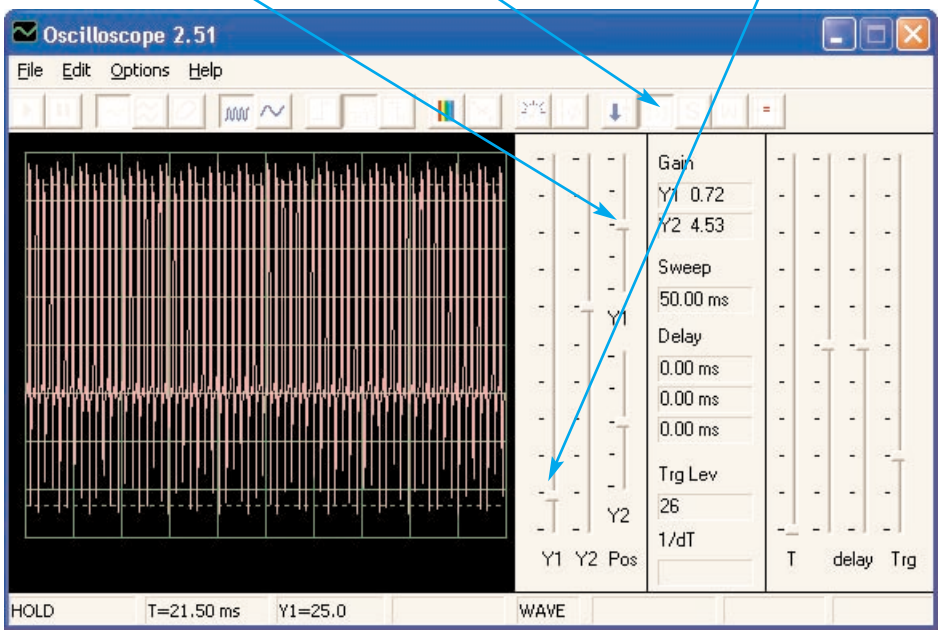
Click on the On-Line button if Winscope is currently in Hold mode and you should get a picture similar to this one:



The waveform peak is off the top of the screen because the scope gain (amplification) is set too high. You may adjust this gain by moving the Y1 gain control around (try it).

Similarly, you may adjust the position of the waveform on the screen by moving the Y1 position control around (try it).

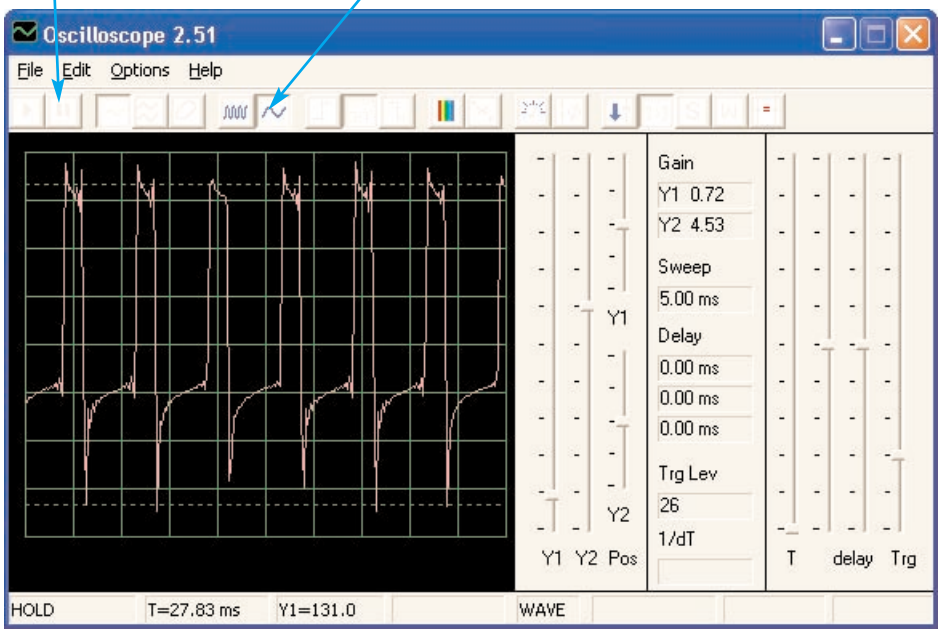
Now click on the 1:1 button to set the gain to x1 and disable the Y1 controls. You should now have a picture similar to this one:



Note that your picture may not exactly match this picture due to variances in the microphone input gain between computers, which is beyond software control. You may want to adjust the volume control of your microphone input to compensate, see note A on page 6 for more details. You may also disable 1:1 mode by clicking on its button again and then adjust the gain using the Y1 control.

The gain and position control features just described enable electronics engineers and technicians to “see” the amplitude (voltage level) of a signal. By adjusting the settings on an oscilloscope, they can look at both very large and very small voltage waveforms.

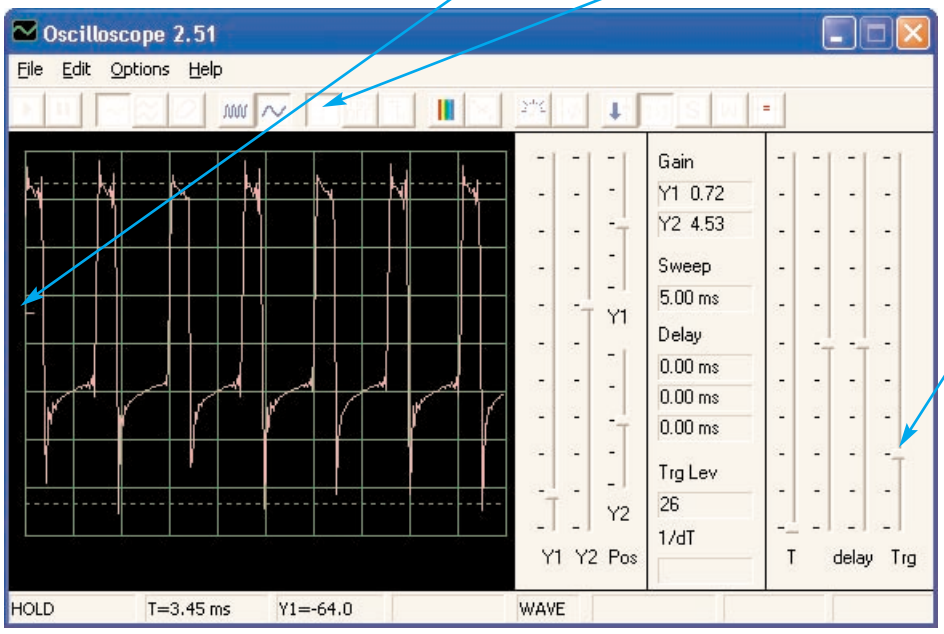
Move the variable resistor knob and watch how it changes the waveform on the computer screen. Now click on the 0.5ms/div button to change the time scale on the display. (The button to the left of it is for 5ms/div, the default.) Move the variable resistor knob around again. You may click on the Hold button to freeze the waveform on the screen, then click on On-Line to re-start.



With the time scale at 0.5ms/div and the adjustable resistor set for middle position, you should now have a picture similar to this one.

Your picture may appear different due to variations in the microphone input designs between computers. Although this is beyond software control, in some cases you may be able compensate externally. See notes B and C on page 4 for details.

Notice that the waveform seems to be randomly dancing across the screen, making it hard to study. We can fix this. Click on the “trigger positive level” button and make sure the trigger bar is in the position shown here. Notice that a small “-” appears on the left of the display as you do so.

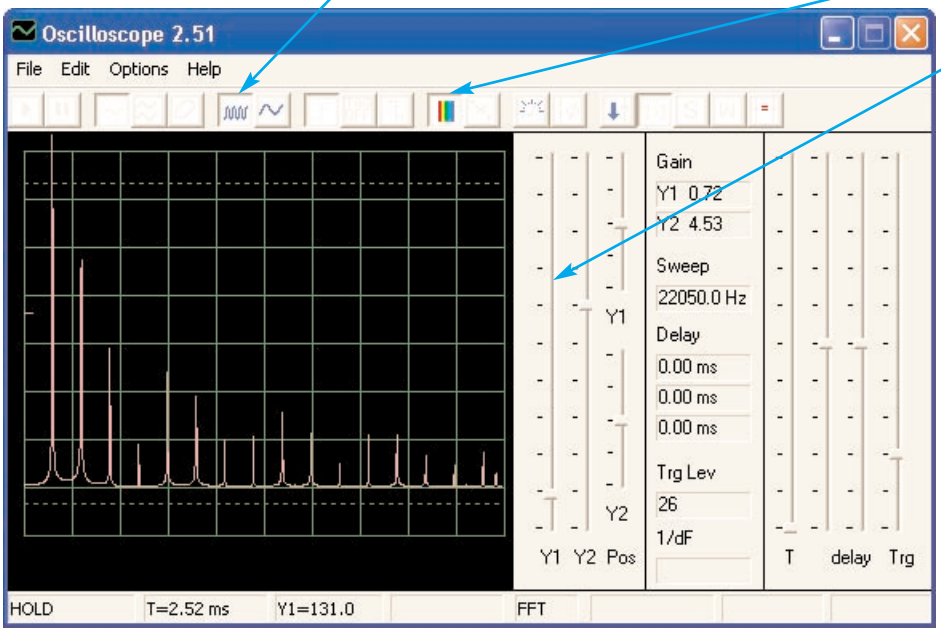


The small slash “-” represents the trigger voltage, when the signal reaches this voltage level it activates the display. This makes it easy to observe a stream of pulses like you have now, and also to record a single (non-repeating) pulse.

Move the variable resistor control and watch how it changes the waveform on the computer screen. Now you can see how changing the variable resistor changes the time between the pulses, which changes the tone of the sound you hear.

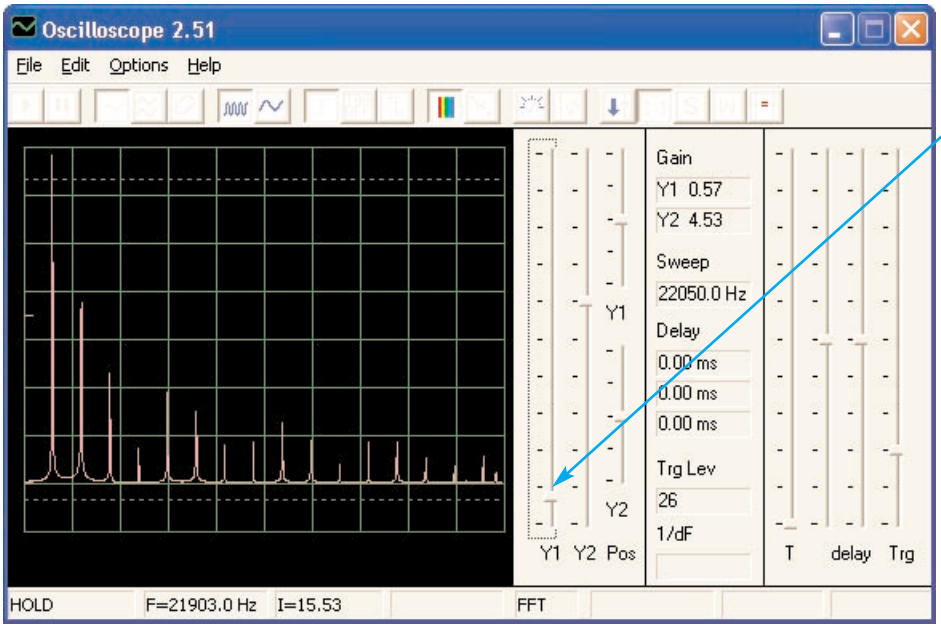
The waveform you see here is the voltage across the speaker, the peaks of the pulses occur when the transistors turn on and provide current to the speaker. Changing the amplitude of the peaks changes the loudness of the sound, changing their separation changes the tone or “pitch” of the sound. The time scale and trigger control features just described enable electronics engineers and technicians to see the relationship between parts of a waveform on their oscilloscope.

Now its time to look at your electronic signal in a different way. The oscilloscope features you have been using show you voltage (amplitude) vs ***time***, now you will see voltage vs ***frequency***. Engineers use expensive instruments called spectrum analyzers to do this, but Winscope uses a mathematical transformation called an FFT to do this. Set the Y1 gain control back to its default position for now. Click on the 5ms/div button to display a wider range, then click on the FFT button. Your display should be similar to this:



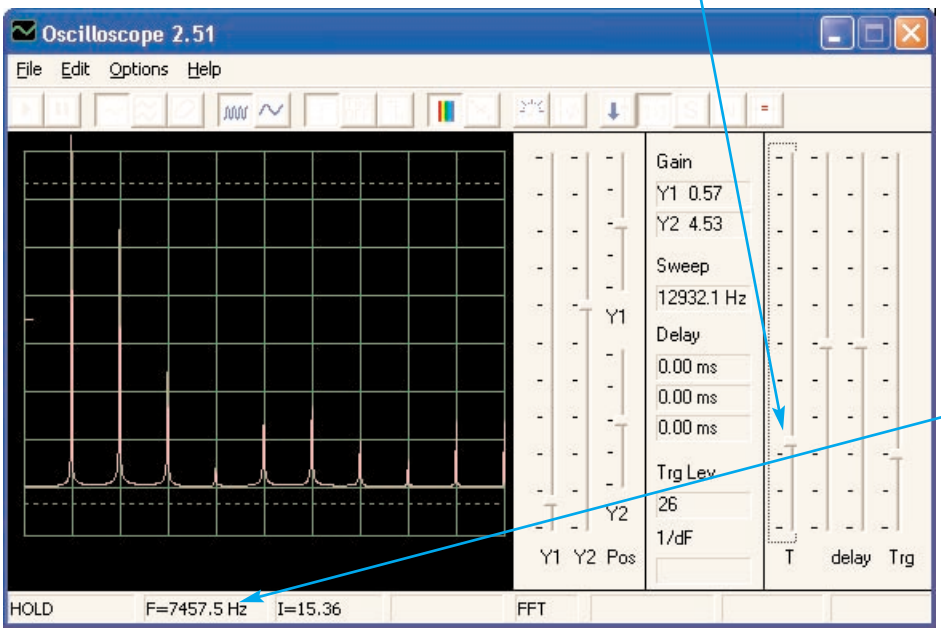
You are seeing the frequency spectrum of your signal, up to 22 KHz. Notice that most of the energy is at the low frequencies (below 7 KHz), and there is very little as you go higher.

The 1:1 gain mode does not apply to the FFT screen, so move the Y1 gain control down to here so you can see the peak energy at the low frequencies.



Move the variable resistor control and watch how it changes the frequencies on the display.

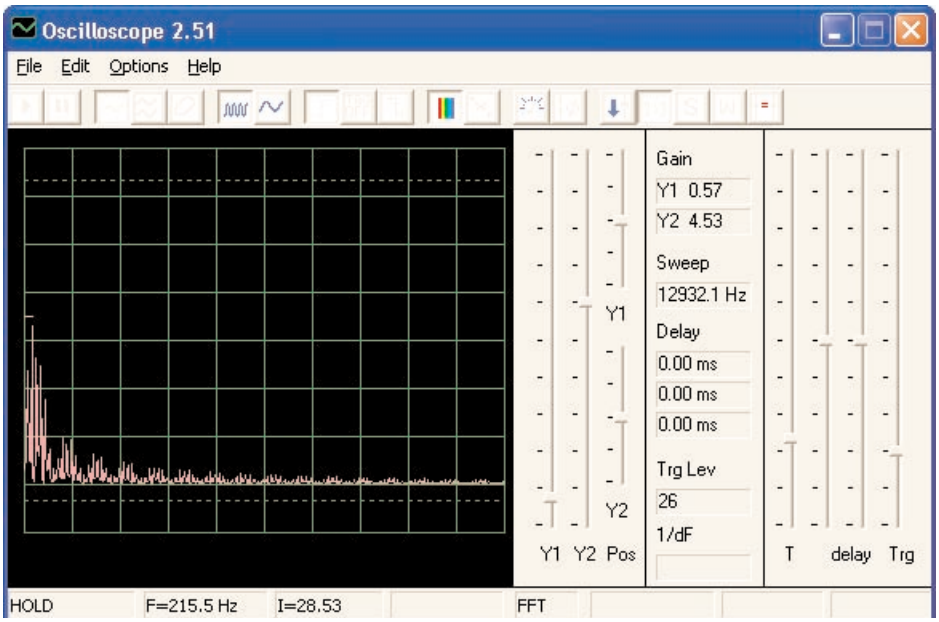
Set the variable resistor control to mid-range. In addition to the 5ms/div and 0.5ms/div settings for the horizontal scale, there is also a variable setting. See if you can set it so that all the signal peaks line up with the grid lines, as shown.



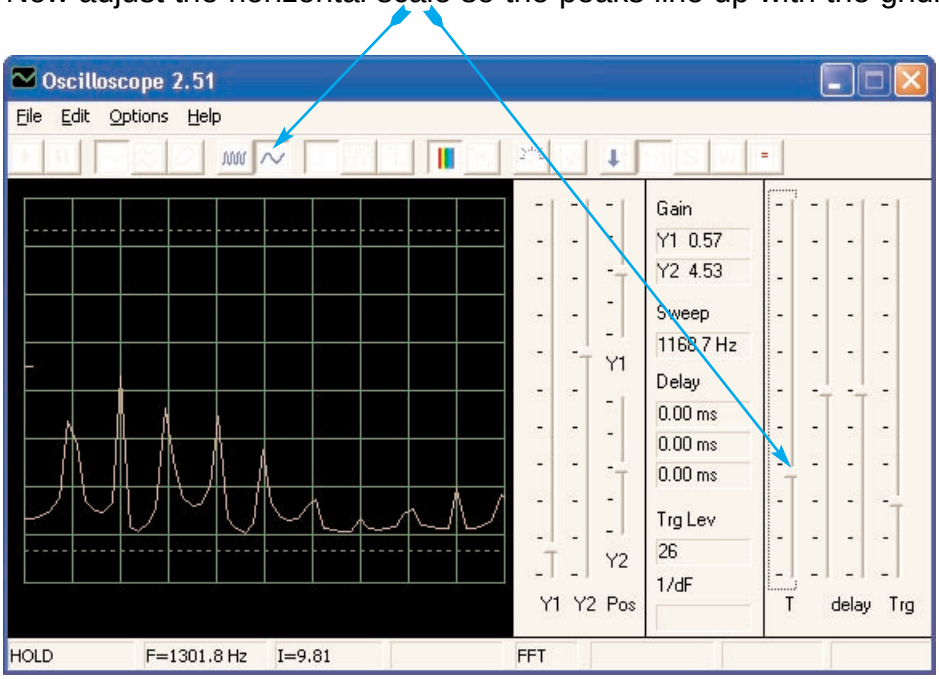
As you can see, all the peaks are equally spaced in frequency. Move your computer mouse directly over the first peak, the software displays the frequency you are pointing at. Move the mouse to the other peaks and you see they are multiples of the first frequency.

Now you can see that the tone you hear is actually a range of related frequencies combined together. The first peak is considered to be the main signal (and it is usually but not always the highest), the energy at all the other peaks determine the waveform of the signal you see on an oscilloscope.

Now modify your circuit by replacing the 0.047µF capacitor on top of the 10µF capacitor (+ side to breadboard point a10). By increasing circuit capacitance, you lower the oscillation frequency and your display should now look something like this:

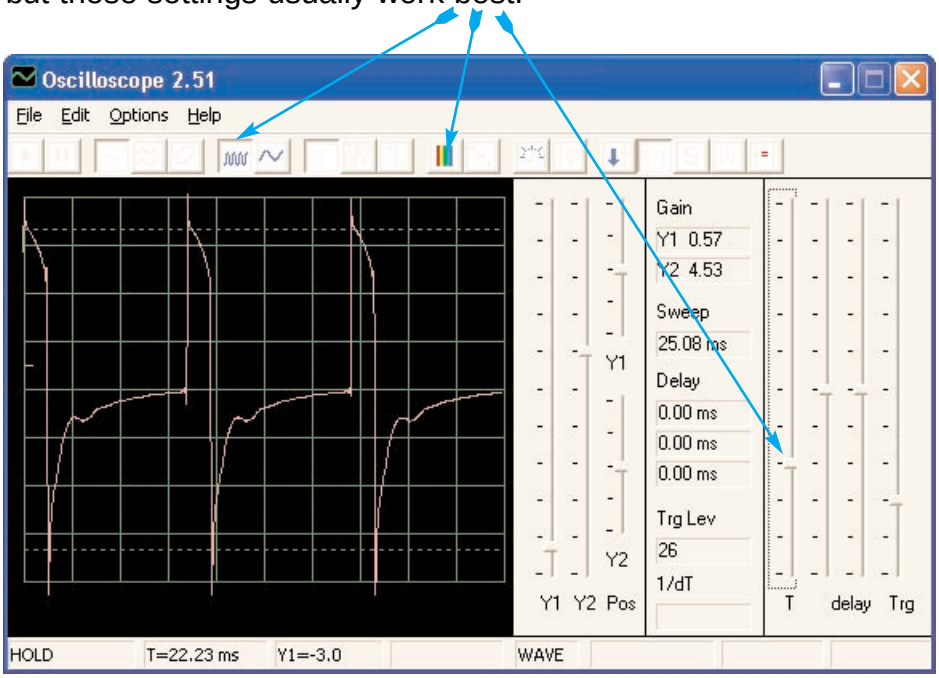


Now adjust the horizontal scale so the peaks line up with the gridlines as they did before.



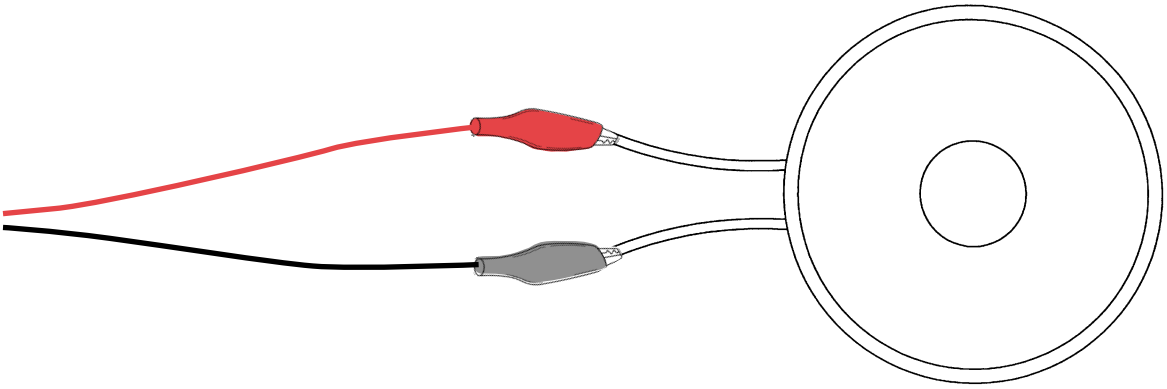
Notice that all the peaks went down in frequency by a corresponding amount and many changed in amplitude, that is why your ears hear a different sound. Notice also that in this case the left-most frequency peak no longer is the highest in voltage (your results may vary).

Now you can click on the FFT box to return to oscilloscope mode and look at the waveform with the 0.1µF capacitor in the circuit. You can observe it with the same settings as before for comparison, but these settings usually work best:



Project PC2 Speaker Microphone

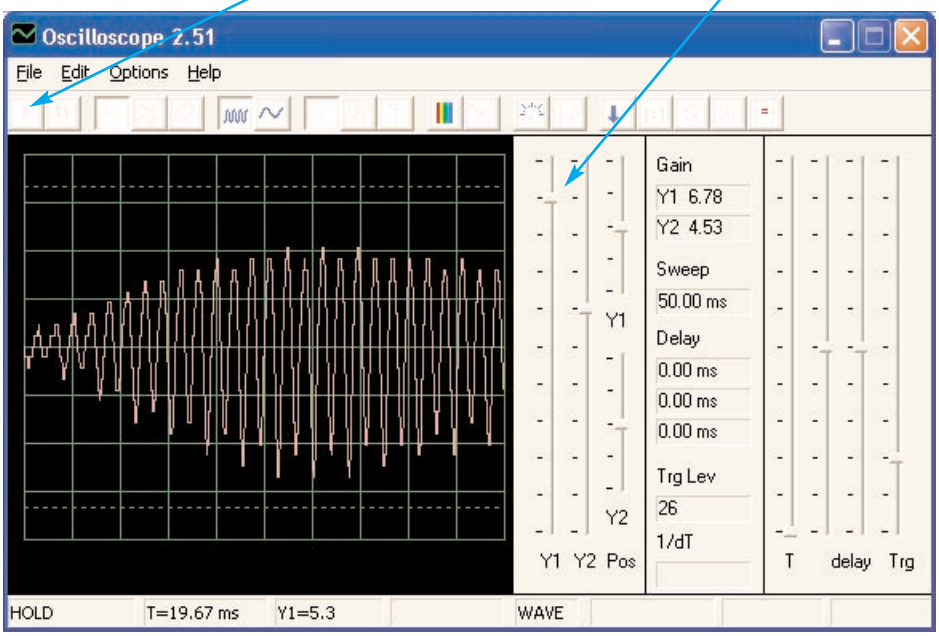
OBJECTIVE: To see what your voice looks like in electrical form.



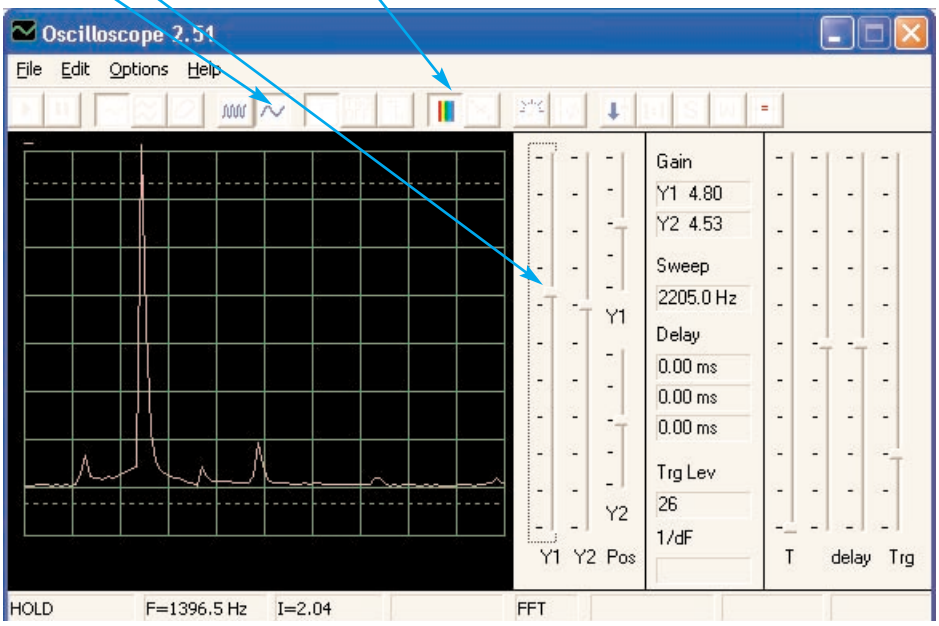
A speaker uses electrical energy to create mechanical vibrations. These vibrations create variations in air pressure, called sound waves, which travel across the room. You “hear” sound when your ears feel these air pressure variations. But if air pressure variations reach the speaker from another source, they will cause it to vibrate too. This, in turn, causes the speaker to create a small electrical signal just like a microphone does (though not very efficiently, since speakers were not designed to be microphones).

Connect the PC-interface cable directly the speaker as shown; no other parts are needed here. If continuing from the previous experiment then close the Winscope program and run it again, to reset the settings. Click on the On-Line button to activate.

Hold the speaker next to your mouth and talk into it to see what your voice looks like after the speaker converts it to electrical energy. Adjust the Y1 gain control to get the best view of it, since the amplitude is greater if you talk louder or are closer to the microphone. You may also want to increase the gain of your microphone input for this project only (see page 6 for details). Notice how the waveform is different depending on which words or tones you say.



Click on the FFT button to look at the frequency spectrum for these signals. Try the amplitude and time scales shown here to start, but your best settings will depend on what sounds you make, how loud you speak, and how close you are to the speaker.

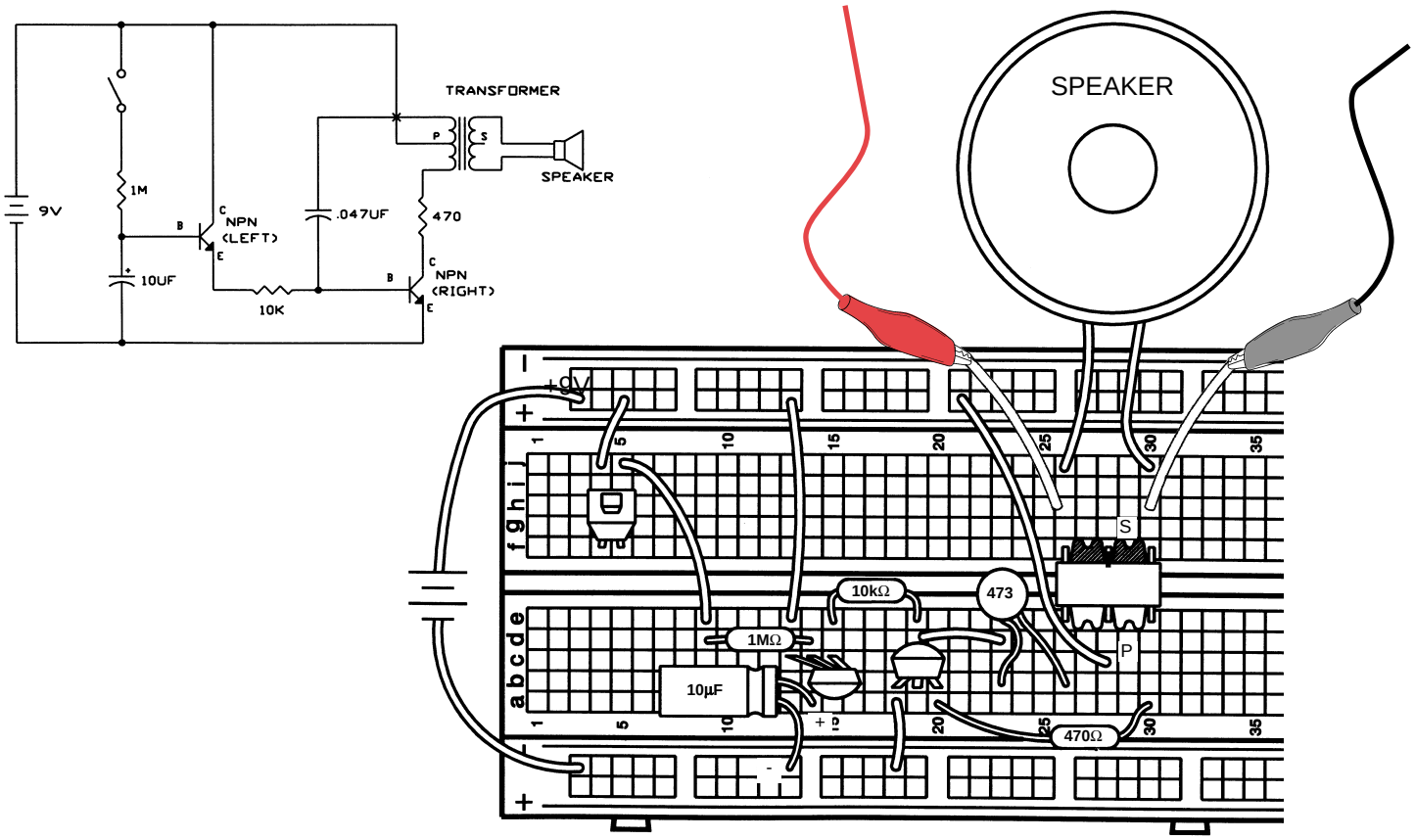


Notice that most women have higher-frequency voices than most men, and so their frequency peaks are further to the right on your display.

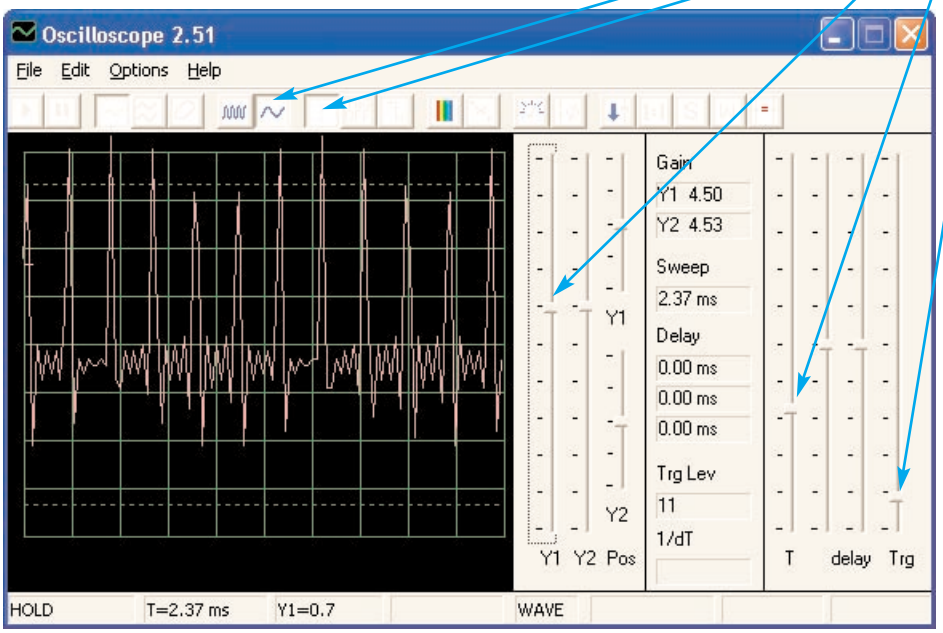
Smooth, well-rounded, and repetitive waveforms (in oscilloscope mode) have nearly all of their energy at a specific frequency. “Square” or “rectangular” looking waveforms and most music have a series of mathematically-related peaks, while “random” waveforms (like from blowing into the speaker or several people talking at the same time) have a frequency “blob” instead of distinct peaks.

Project PC3 — Siren PC

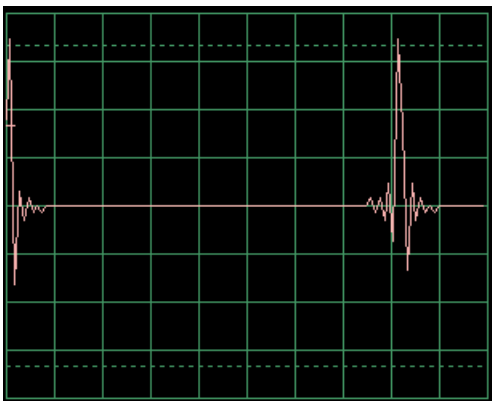
OBJECTIVE: To look at the output of a slowly changing circuit.



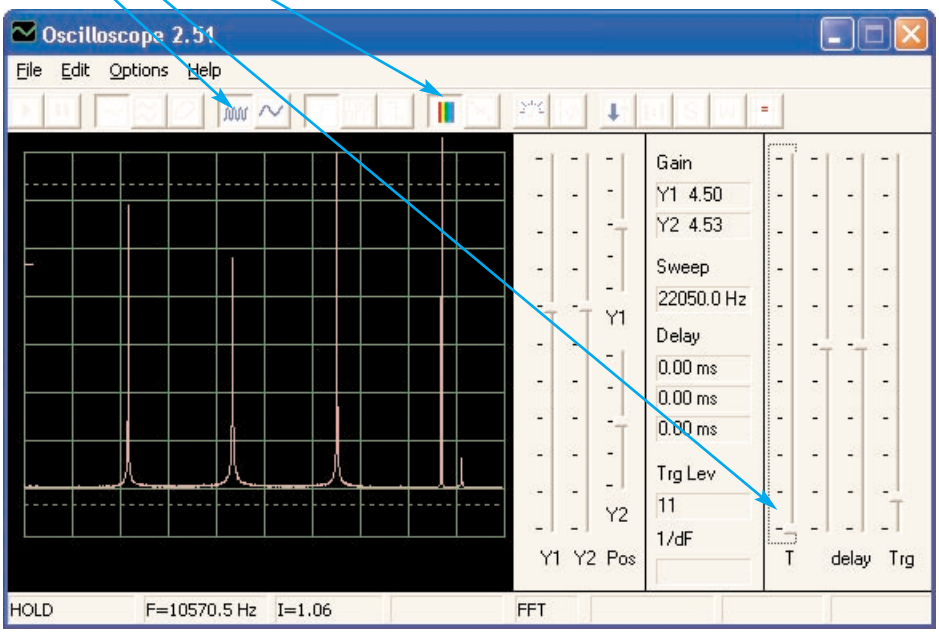
Build the circuit shown. If continuing from the previous experiment then close the Winscope program and run it again, to reset the settings. Click on the On-Line button to activate and press the switch. The circuit makes a siren sound that slowly fades away. Try the settings shown here to view it.



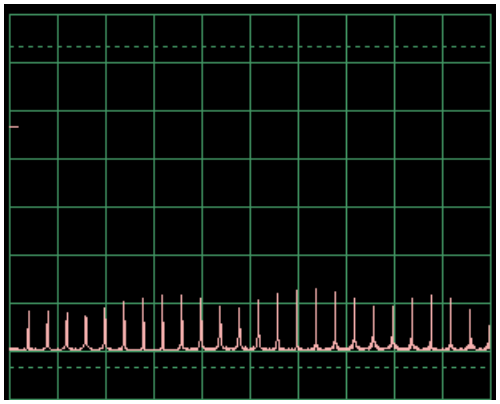
The waveform at left shows the signal just after pressing the switch, the waveform below uses the same settings and shows the waveform just before the sound stops. You see the pulses slowly spread out as the tone of the sound changes.



Now change to FFT mode to look at the frequency spectrum as the sound fades away. Try the settings shown here.

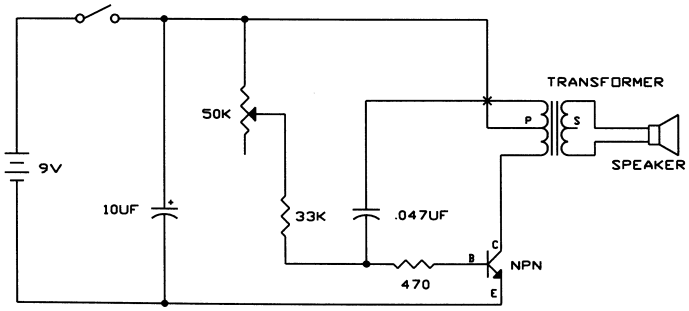


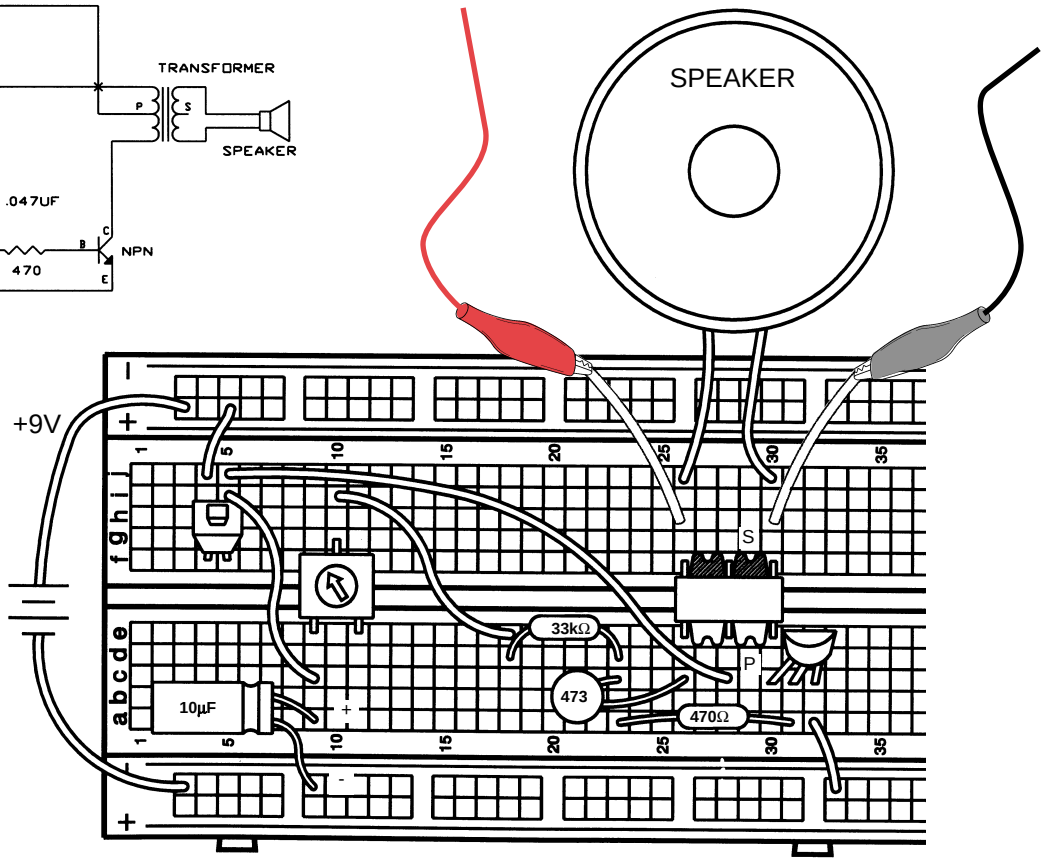
The spectrum at left is for just after pressing the switch. The spectrum below uses the same settings and shows the spectrum just before the sound stops. The frequencies and amplitude slowly get lower as the sound fades away.



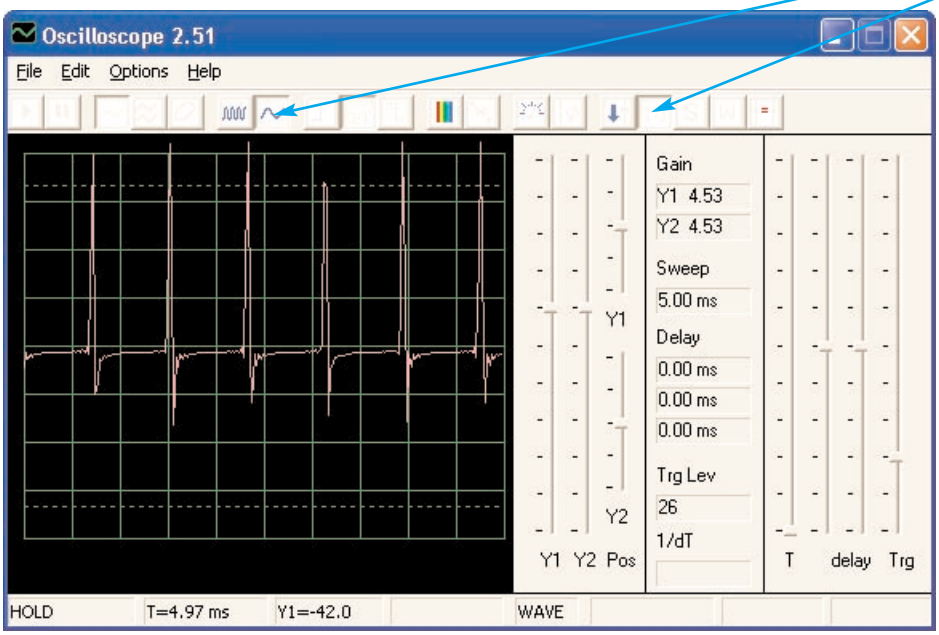
Project PC4 — Space Gun PC

OBJECTIVE: To look at the output of a space gun circuit.

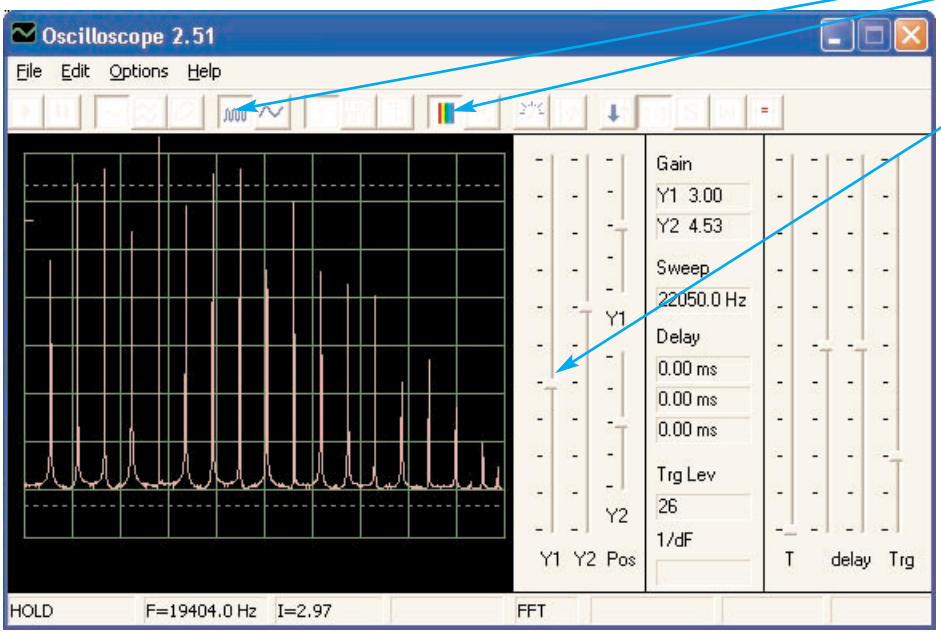




Build the circuit shown. If continuing from the previous experiment then close the Winscope program and run it again, to reset the settings. Click on the On-Line button to activate and press the switch. The circuit makes a space war sound that quickly fades away. Try the settings shown here to view it.

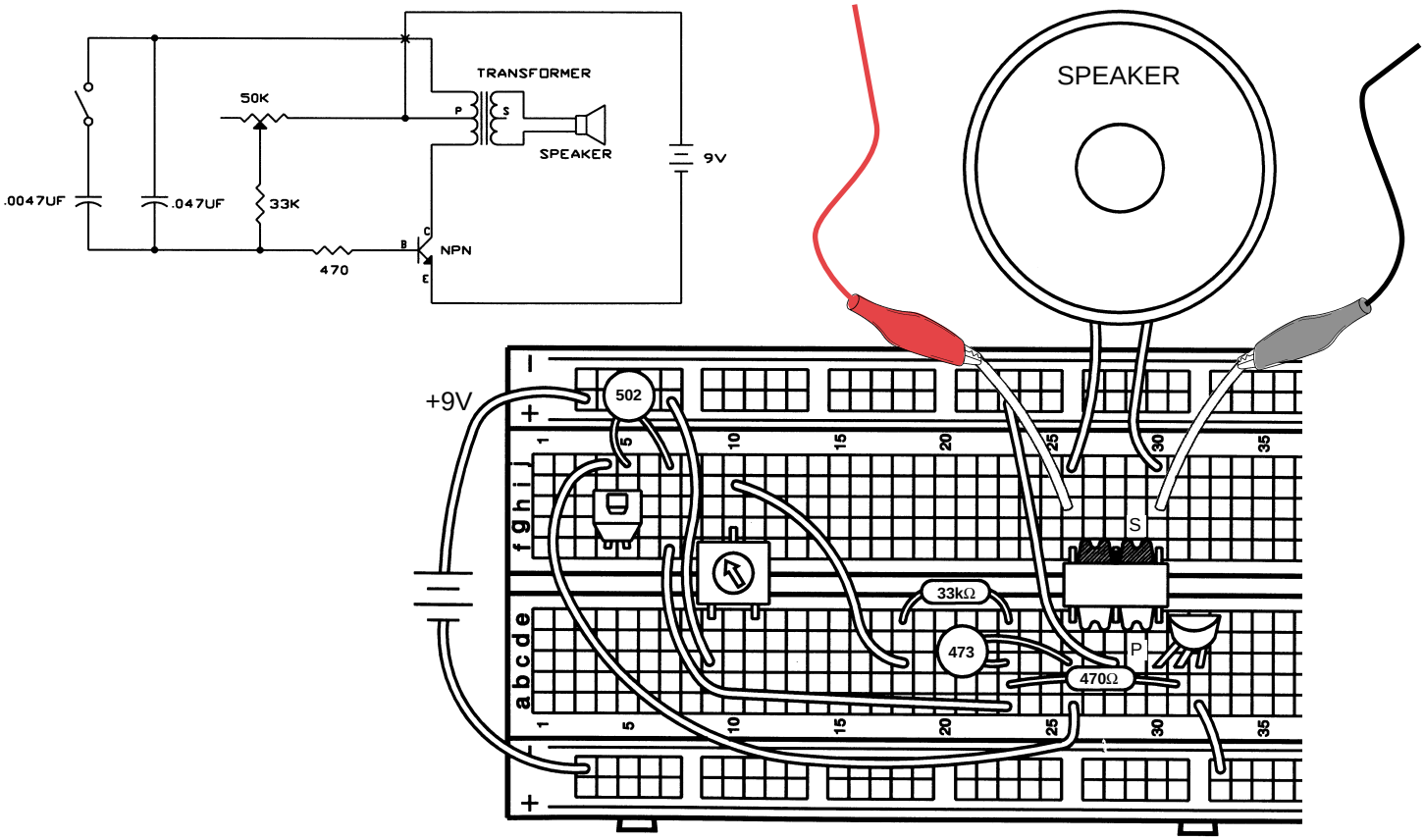


Now change to FFT mode to look at the frequency spectrum. Try the settings shown here. The spectrum varies depending on when you pressed and released the switch.

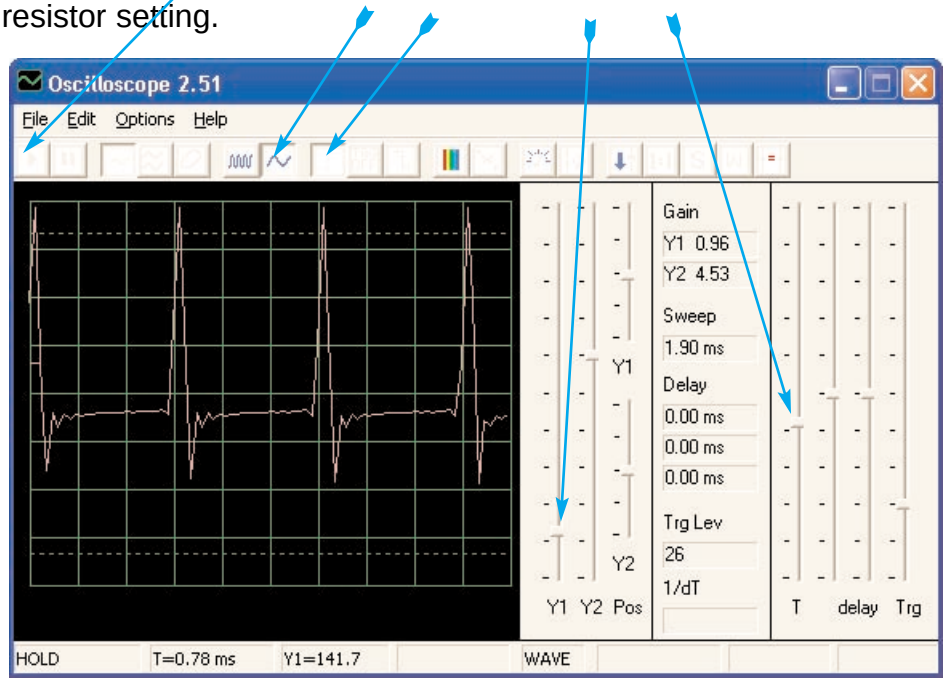


Project PC5 Electronic Noisemaker PC

OBJECTIVE: To demonstrate storage mode.

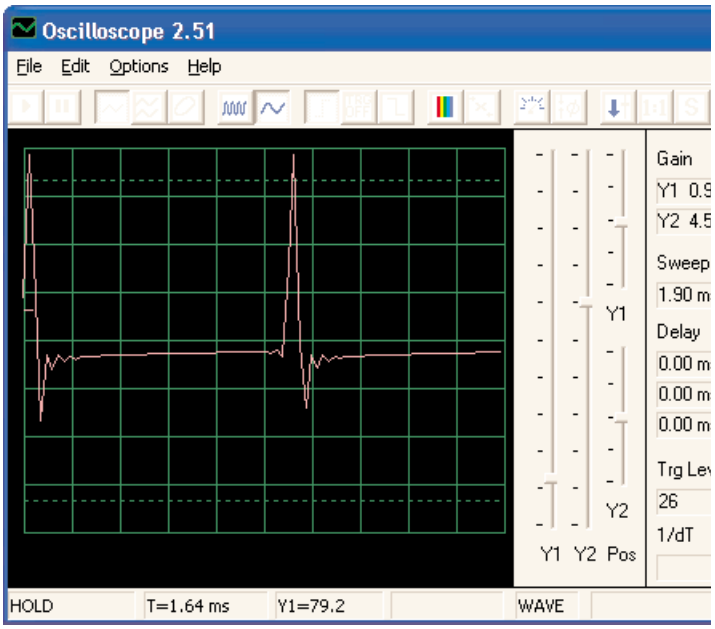


Build the circuit shown, connecting the battery last since it will turn the circuit on. If continuing from the previous experiment then close the Winscope program and run it again, to reset the settings. Click on the On-Line button to activate, and press the switch several times. Set Winscope to the settings shown below, and move the knob on the variable resistor around to change the waveform and the sound. A sample waveform is shown here, but the pattern and shape of the pulses depends on the variable resistor setting.

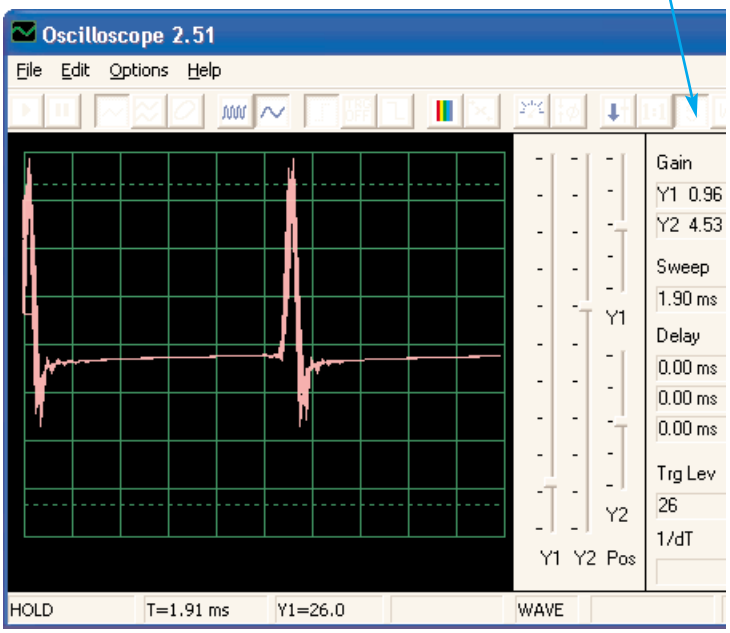


Winscope has a mode that can display multiple scans at the same time, called Storage mode. Turn the variable resistor knob to the right, change the Winscope time scale, place Winscope in Storage mode, and watch the results.

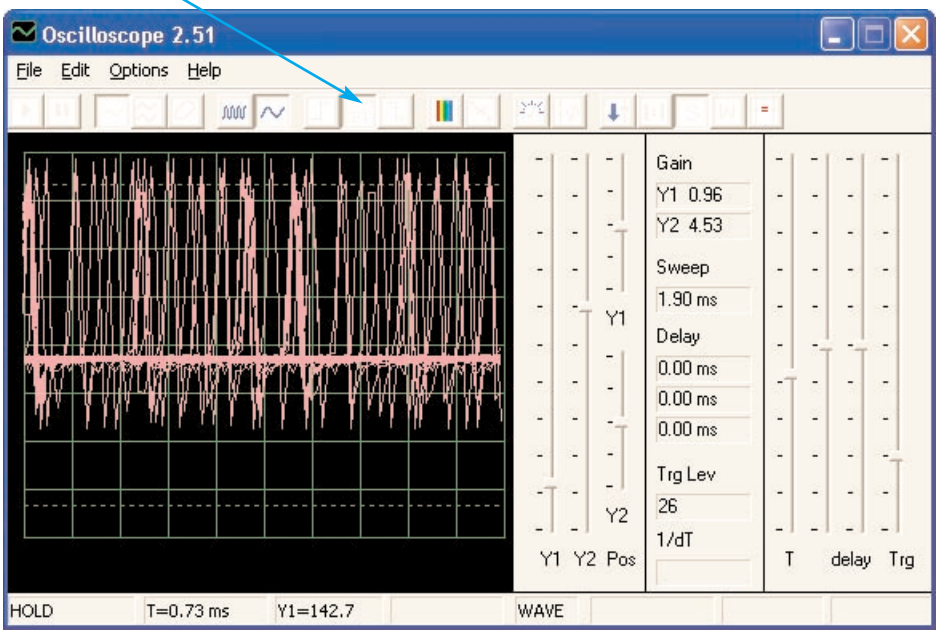
without Storage mode:



with Storage mode:

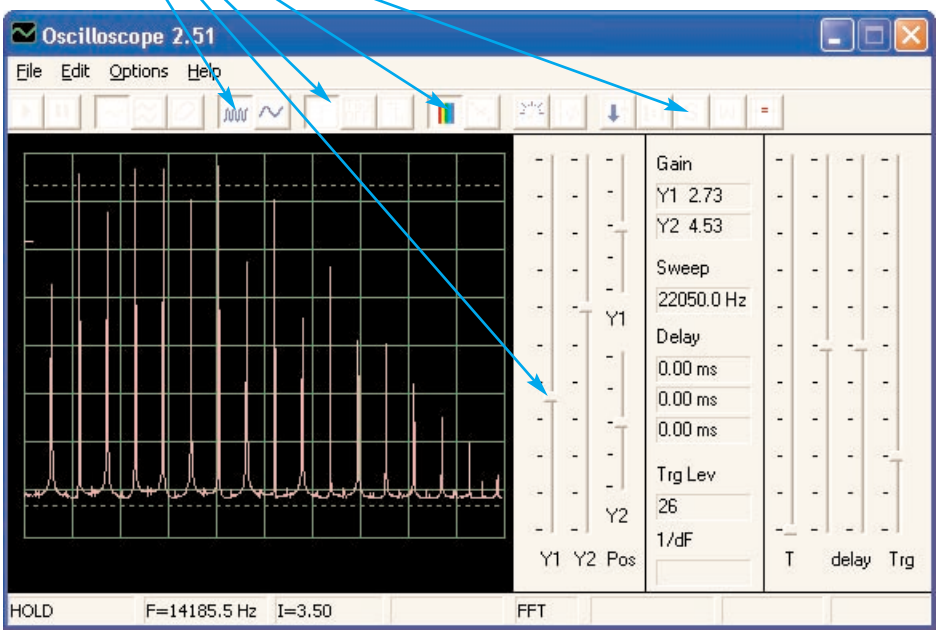


What you see here is the effect of timing variations on the trigger used for synchronization. Turn off the trigger and you will see how much variation there is without using the trigger:

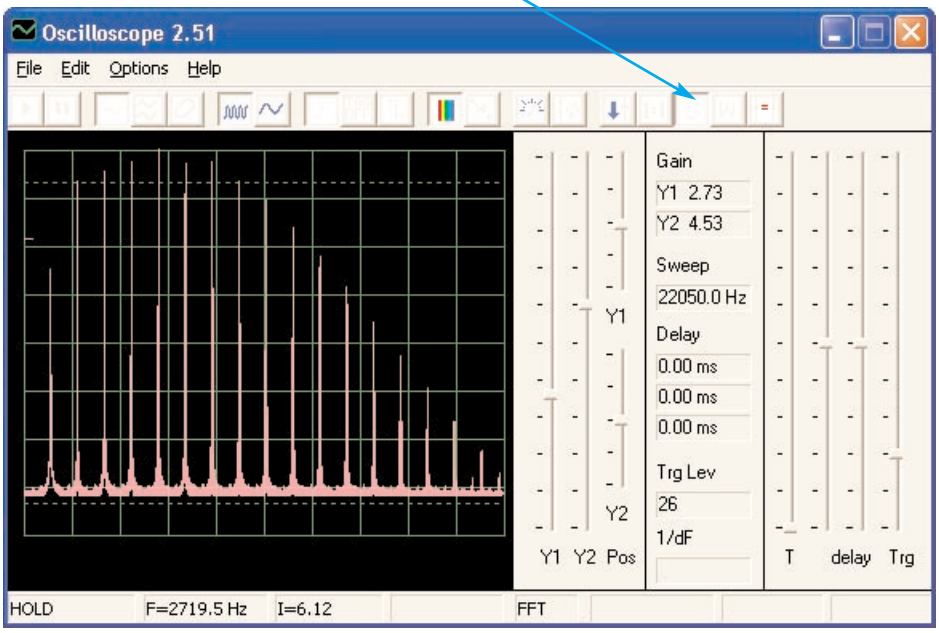


You can use Storage mode on any of the other circuit waveforms if desired.

Now turn off storage mode and turn on FFT mode to look at the frequency spectrum, try the settings shown here. Moving the variable resistor knob will change the spectrum shown.



You can also use storage mode when in FFT mode, so turn it on now.

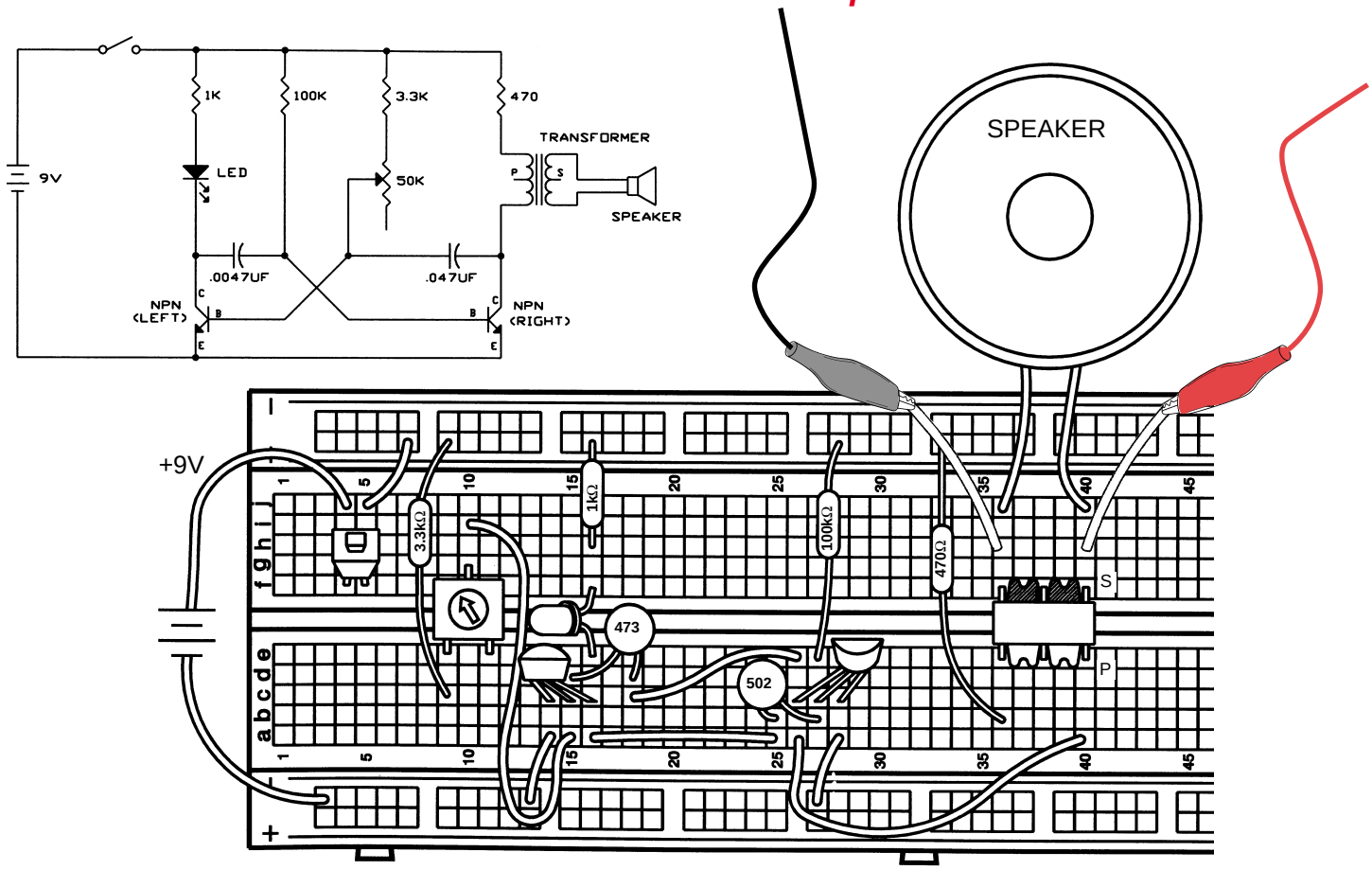


In this way you can show the peak energy achieved at each frequency. But this is only useful on a stable waveform, so if you move the variable resistor knob now the signal will fill the screen as the peaks move across the display.

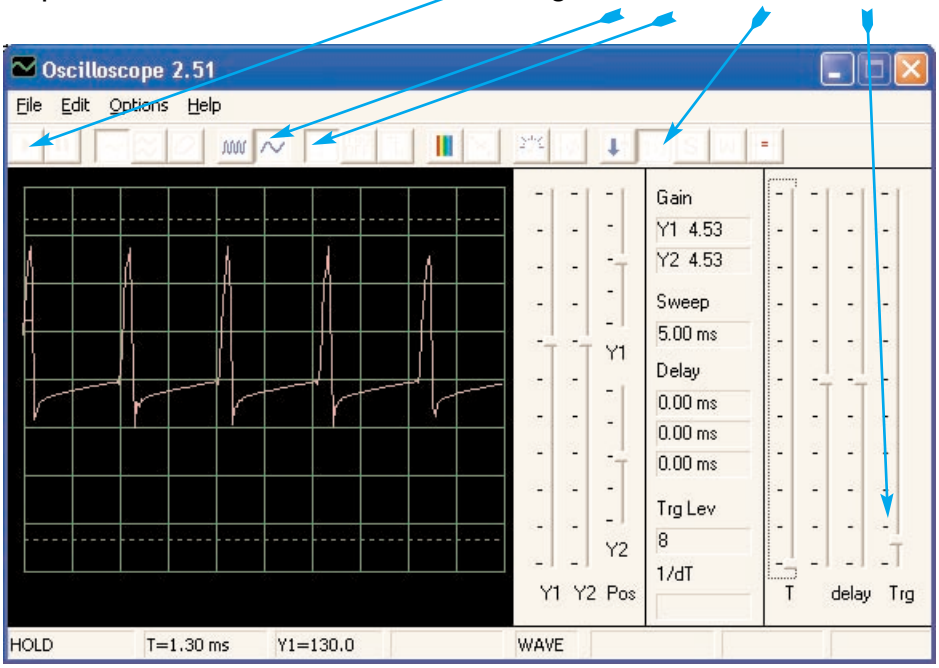
Most oscilloscopes and spectrum analyzers have a storage mode like this of some form.

Project PC6 Noisy Blinker PC

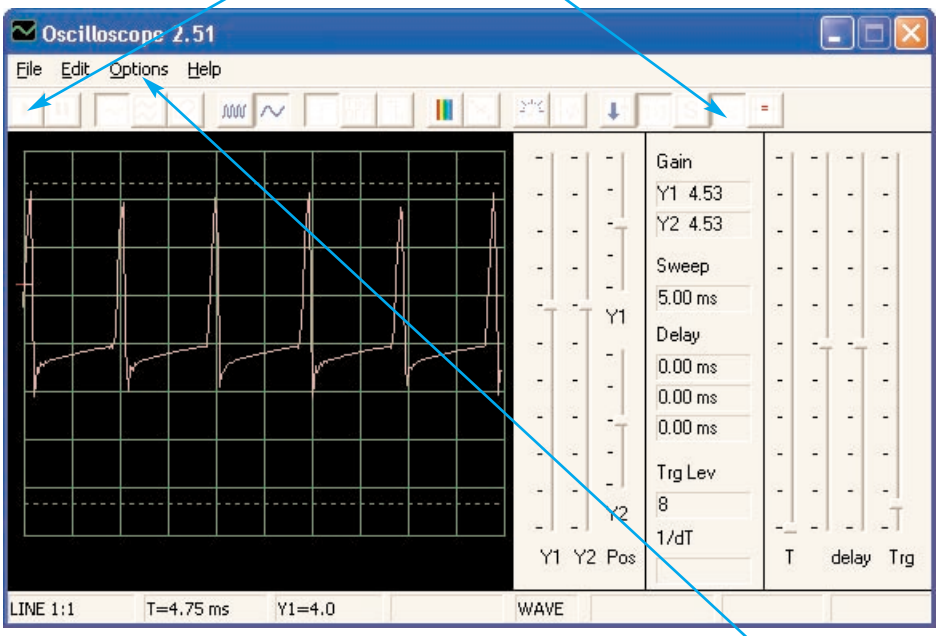
OBJECTIVE: To demonstrate wait mode with multiple colors.



Build the circuit shown. If continuing from the previous experiment then close the Winscope program and run it again, to reset the settings. Click on the On-Line button to activate, and press the switch. Set Winscope to the settings shown below, and move the the variable resistor knob around to change the waveform and the sound. A sample waveform is shown here, but the pattern and shape of the pulses depends on the variable resistor setting.

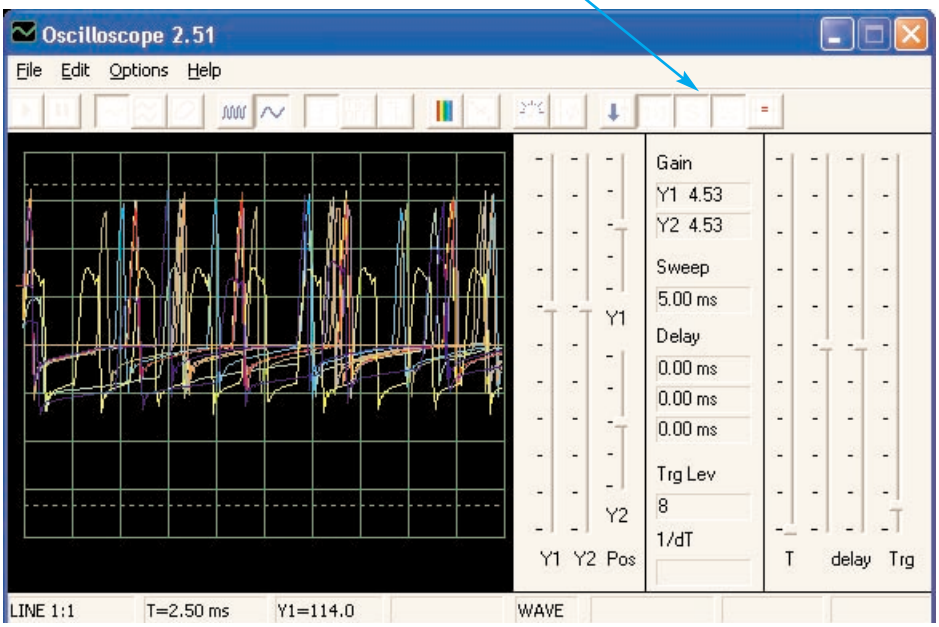


Place Winscope in Wait mode by clicking on the button for it, hold down the pushbutton switch, and then slowly press the On-Line button several times. Now release the switch and press On-Line again. Then press the switch again. You see that in Wait mode Winscope scans ("waits") until it sees a waveform that exceeds the trigger level you set, then stops. With a strong signal it will make one scan and then stop, whereas if no signal is present it keeps scanning until it finds one. You could use this to sense when someone has turned on the circuit.



You can change the color of the waveform: select <Options>, then select <Colors>, then select <Y1 Trace>. Now select the color you like and click <OK>.

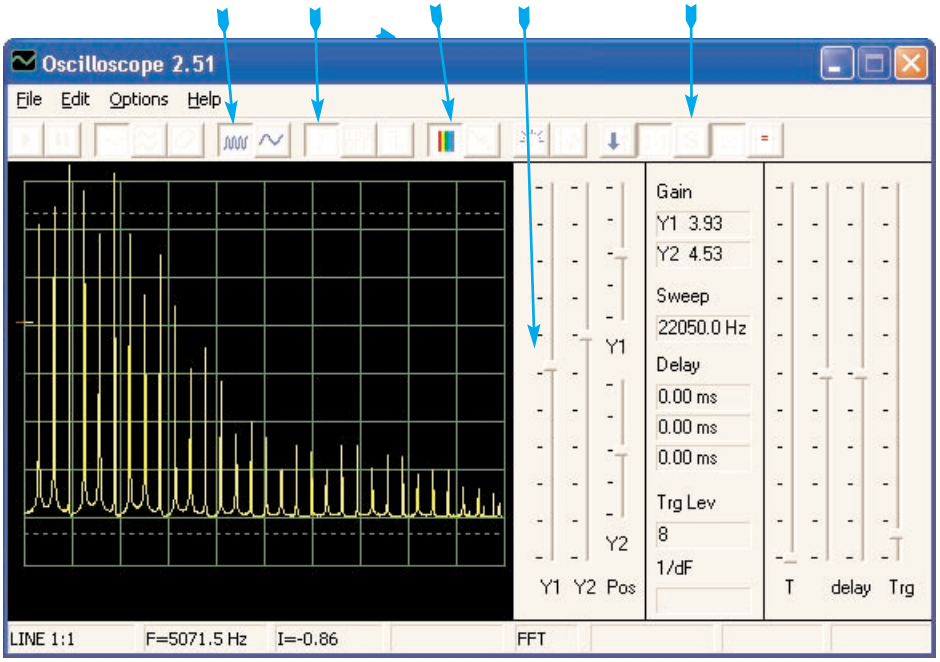
Now we will combine the wait and storage modes to display several waveforms that this circuit can create. You should have the circuit on with the variable resistor at mid-range and Winscope in Wait mode. Now turn on Storage mode. Now change the color of the Y1 trace. Move the variable resistor knob a little, then hold the circuit switch on and press On-Line once to record another waveform. Now change the color of Y1 again. Move the resistor knob again, hold down the circuit switch, and press On-Line once. Change the Y1 color, adjust the resistance, hold down the switch, and press On-Line. Change the Y1 color, adjust the resistance, hold down the switch, and press On-Line. Do this as many times as you like. Now your display should look something like this:



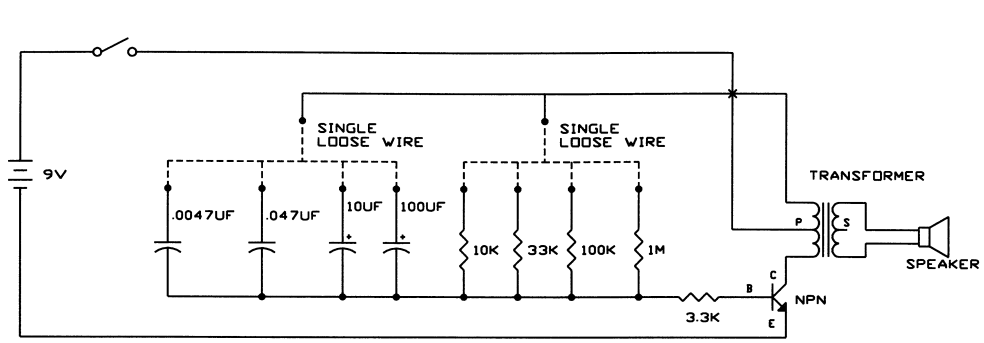
Now you see the range of waveforms this circuit can create, all at the same time. Engineers often do this to compare signals during analysis.

You can use Wait mode and different colors like this on the other circuits if you like.

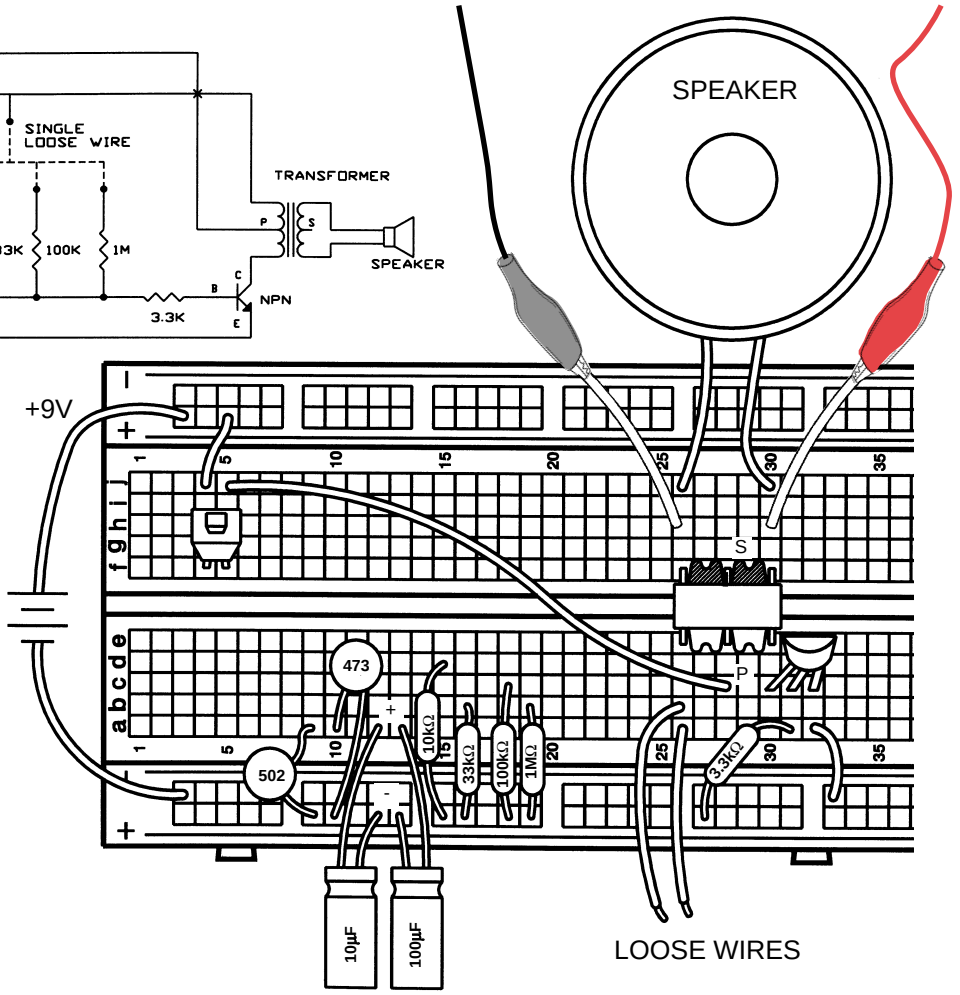
Now turn off storage mode and turn on FFT mode to look at the frequency spectrum, try the settings shown here. Wait mode does not apply in FFT mode, so it has no effect here. Moving the variable resistor knob will change the spectrum shown.



Project PC7 Electronic Sound PC



OBJECTIVE: To look at the output signal from a transistor oscillator while changing the pitch of the sound.



Build the circuit and connect the Winscope PC-interface cable as shown. There are 4 resistors and 4 capacitors connected to the 3.3kΩ resistor (we are using the (+) row of holes at the bottom to make the connections easier) and 2 loose wires connected to the transformer. Connect the transformer to one resistor and one capacitor at a time, then press the switch.

Use Winscope to view the waveforms in oscilloscope mode and the frequency spectrum using spectrum analyzer mode just like in project PC1. You may need to adjust the horizontal (time/frequency) scale depending on which resistor-capacitor combination you select. If continuing from the previous experiment then you may want to close the Winscope program and run it again, to reset the settings.

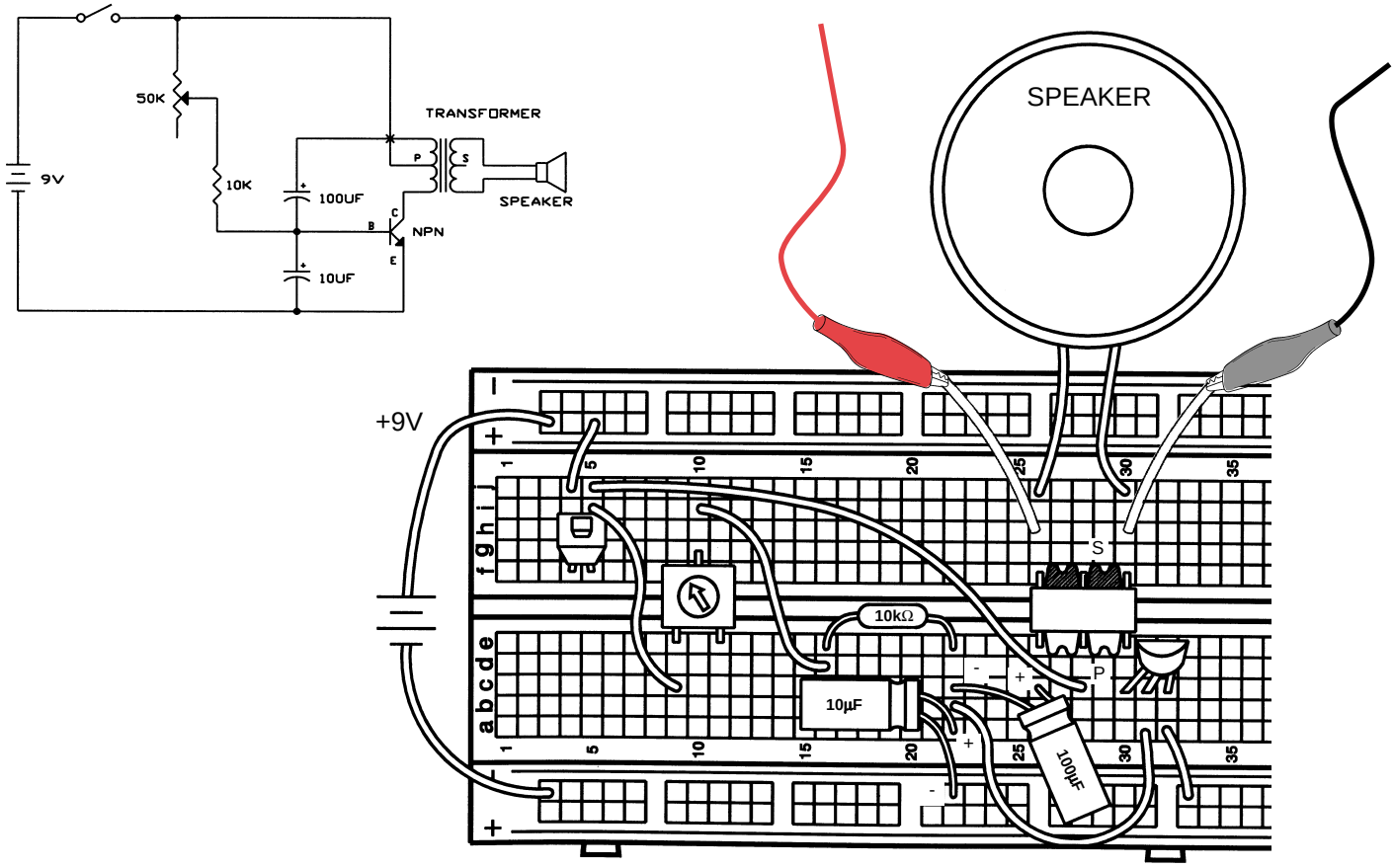
All the combinations are listed below, you don't need to try all of them but try some and see if there is a pattern in the frequency or **pitch** (a term used in music) of the sound. Record a few comments about the sounds you hear and the waveforms that correspond to them.

	10kΩ	33kΩ	100kΩ	1MΩ
0.005μF				
0.047μF				
10μF				
100μF				

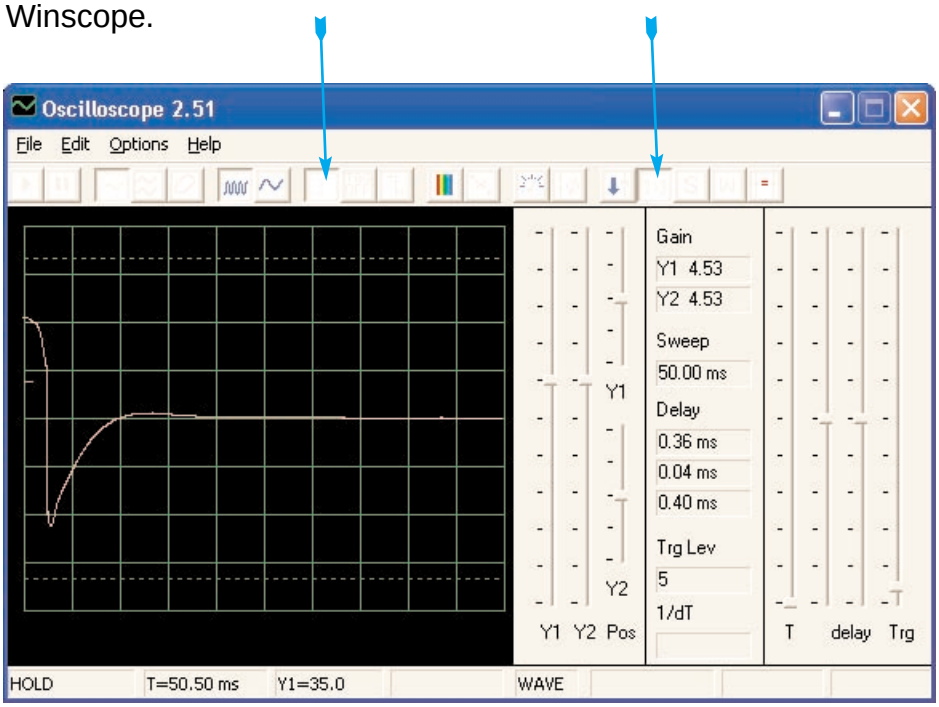
You will see that the frequency increases when you lower the resistance or capacitance. It also increases if you lower the inductance, but you don't have any other inductors you can substitute.

Project PC8 Electronic Rain PC

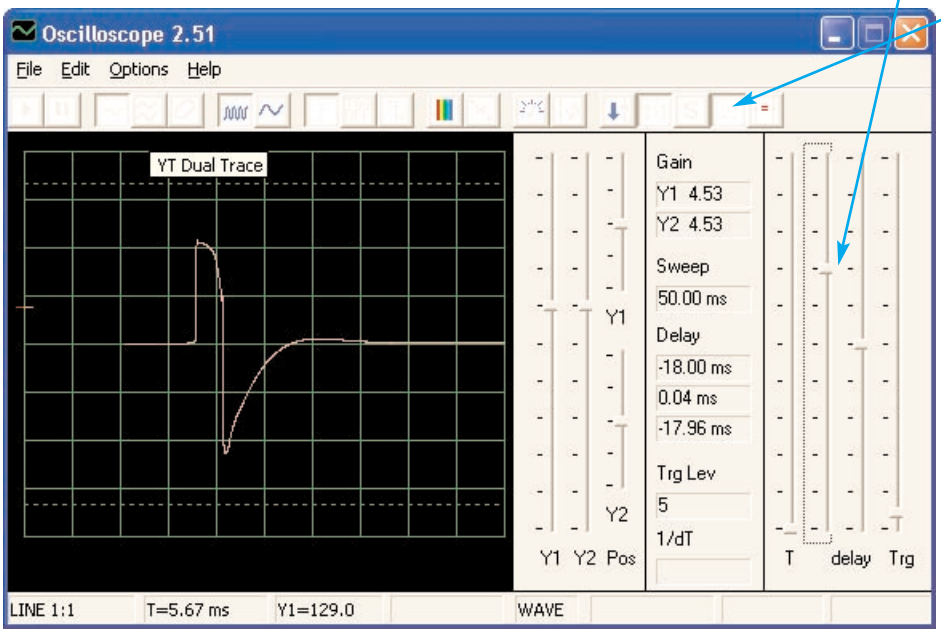
OBJECTIVE: To demonstrate wait mode with multiple colors.



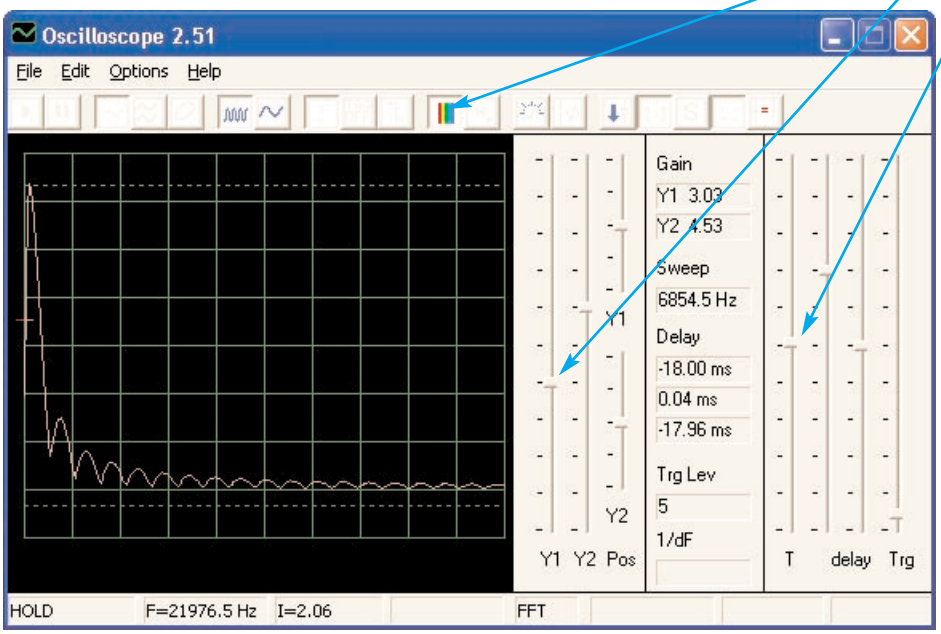
Build the circuit shown. If continuing from the previous experiment then close the Winscope program and run it again, to reset the settings. Click on the On-Line button to activate, and press the switch. You hear a sound like raindrops. Set Winscope to the settings shown below, and move the the variable resistor knob around. The “raindrops” only occur about every second and will be hard to view using Winscope.



The waveform will be easier to view if you adjust the horizontal delay, as shown. Using Wait mode also helps (press the On-Line button to trigger).



You may also view the frequency spectrum if desired, try these settings.



You've finished! Congratulations!

You may use Winscope to view signals on some of the other PK-101 circuits or to look at other points in the circuits. Just remember that Winscope cannot measure DC voltages and should only be used with signals of 20-5KHz frequency (see limitations on page 5 for details).

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