

No Writing on Left-Side Pages  
Keep these clear for grader comments.

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Each page has a header to identify the Lab, the Part, and the Page Number.

Lab Assignment 1 - Objectives / Procedures

ECE 4930

**Lab 1 - Electronic Signal Waveforms**

**Objectives:** Gain experience with configuration and display of signal waveforms in the time and frequency domains as used in electronic systems.

**Lab procedures:**

1. Select a lab bench to work on in EL 104.
2. From the lab stock room, check out appropriate BNC cables for the Function Generator and Oscilloscope.
3. Sinusoid, time domain:
  - Connect the Function Generator to the Oscilloscope. Set the Function Generator to deliver a sinusoidal signal waveform, with frequency 1 kHz.
  - Set the Oscilloscope to display the waveform in the time domain. Adjust the signal amplitude to 2 Volts, peak-to-peak.
  - Measure the period of the waveform using the Oscilloscope display.
  - Calculate the zero-to-peak and the rms amplitude values.
  - Sketch, scale, and label the time-domain waveform display.
4. Sinusoid, frequency domain:
  - With the same sinusoidal signal, use the Fourier transform capability of the oscilloscope to display the signal's spectrum.
  - Sketch, scale, and label the display as seen. Double the frequency and repeat the procedure.
  - What would be the effect of leaving the frequency the same, but doubling the amplitude?
5. Triangular waveform:
  - Change the signal waveform to a triangular wave with the same frequency and peak-to-peak amplitude as before.
  - Repeat (3) and (4) for the triangular waveform, and sketch the results in both the time and frequency domains.
  - Judging from the spectrum, estimate the frequency passband that would be required for an electronic amplifier to pass this triangular waveform with reasonable fidelity.
6. Square waveform:
  - Repeat step 5 using a square waveform.
  - Sketch the waveforms in the time and frequency domains.
  - Estimate the passband that would be required to pass this signal with reasonable fidelity.
  - Experiment with the FFT windowing functions on the Oscilloscope and comment on the relative effects on the square wave's spectrum.

Lab instructions can be pasted in.  
Anything taped or glued into the book  
must be *signed*.

Unused space should be X'd out.

*John Doe*

1/20/2005

Each page has a footer containing your *signature* and the *date*.

For all equipment, list the make, model and inventory control number (look for the USU bar code).

Give detailed descriptions of your methods. If possible, draw figures showing your experimental configurations.

Make sure all measurements are clearly marked. Where appropriate, list measured data in tables.

## Lab 1 : Equipment and Sinusoid

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Equipment used for experiments :

- Tektronics TDS 2012 oscilloscope, SN 93975.
- Tektronics CFG250 function generator, SN 58936.

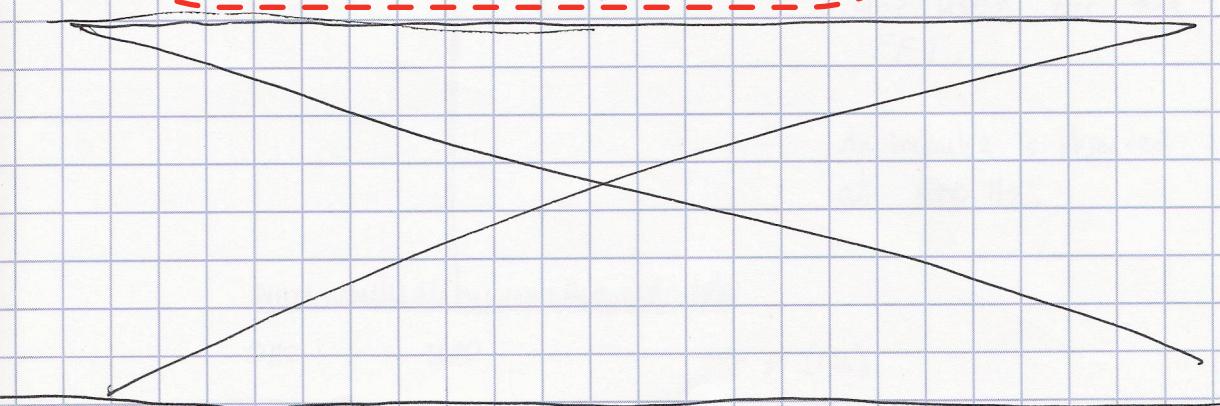
### Part 3 : Sinusoid, Time Domain.

The function generator was connected to the oscilloscope on Ch. 1 using a BNC cable. The "Main Output" connector was used on the function generator. The "Sync" connector on the function gen. was connected to the "External Trigger" on the scope.

The scope was configured to use 1V per division on channel 1, 500 $\mu$ s per division on the time axis, and the trigger source was set to "ext."

The sinusoid was adjusted to 1KHz, 2V peak-to-peak, with zero DC offset. Using the scope, the following measurements were taken:

- Period: 982  $\mu$ s
- Amplitude: 1.02 V (zero-to-peak)  
2.04 V (peak-to-peak)



Ch-Wil

1/20/2005

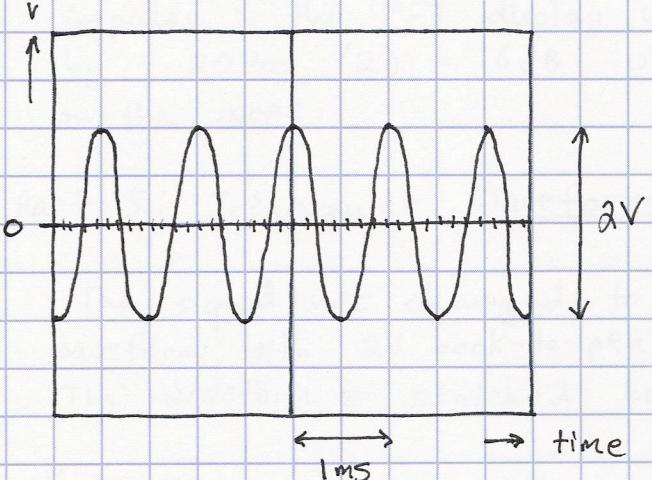
Carefully draw oscilloscope plots, and be sure to label the units per division on the vertical and horizontal axes.

Be sure to add any information that might affect the outcome of your measurements.

## Lab 1: Sinusoids

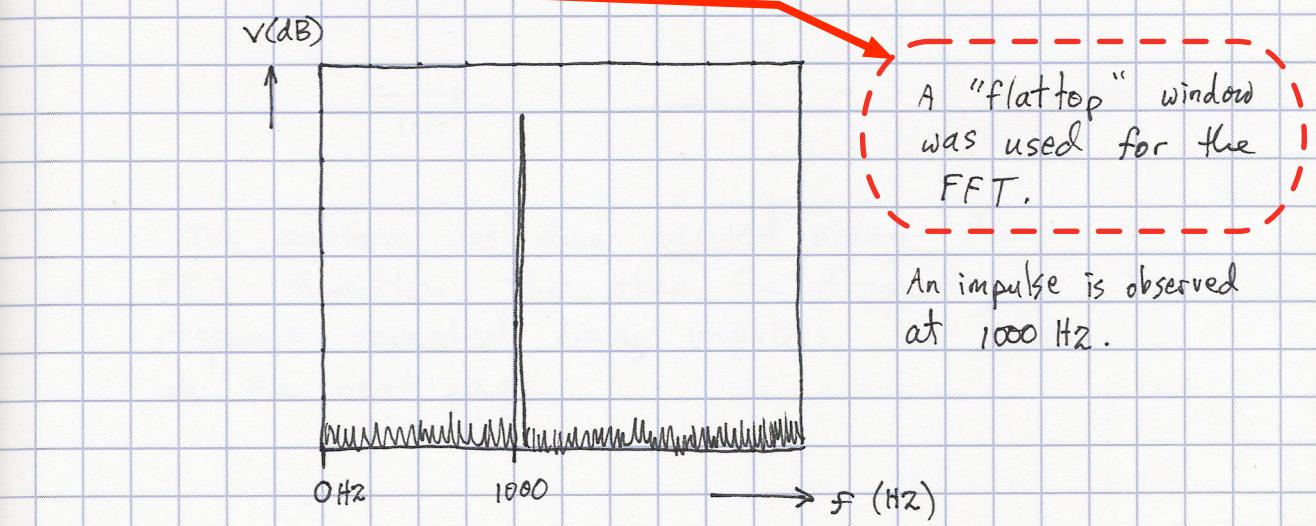
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The displayed waveform is sketched below, with  $500 \text{ mV}/\text{div}$  on the voltage scale and  $500 \mu\text{s}/\text{div}$  on the time scale.



## Part 4: Sinusoid, Frequency Domain

The scope's FFT function was accessed via the "Math Menu" button. The waveform is sketched below, showing  $10 \text{ dB}/\text{div}$  on the vertical and  $250 \text{ Hz}/\text{div}$  on the horizontal axis.



Chi Wei

1/20/2005

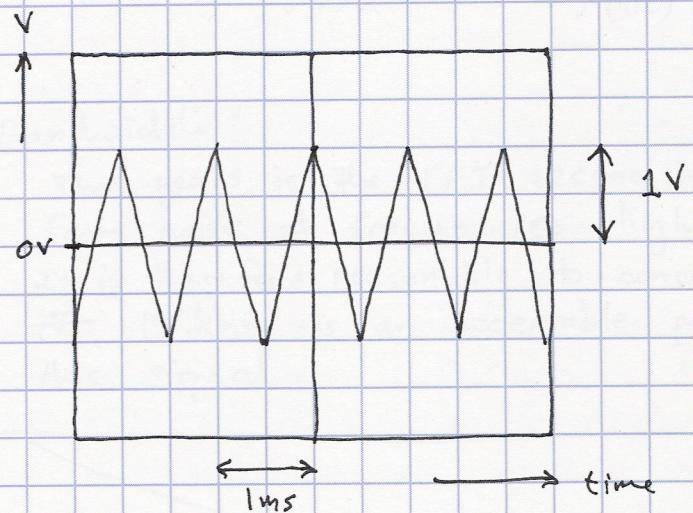
Provide any mathematical equations that you use in your calculations.

Doubling the amplitude:

If the frequency is held constant while the amplitude is doubled the height of the impulse in the FFT display will be raised by  $20 \log_{10}(2) = 6 \text{ dB}$ , which is 0.6 div on the scope.

Part 5: Triangular Waveform

The signal was changed to a triangular waveform with 2V peak-to-peak at 1kHz. The waveform is sketched below.

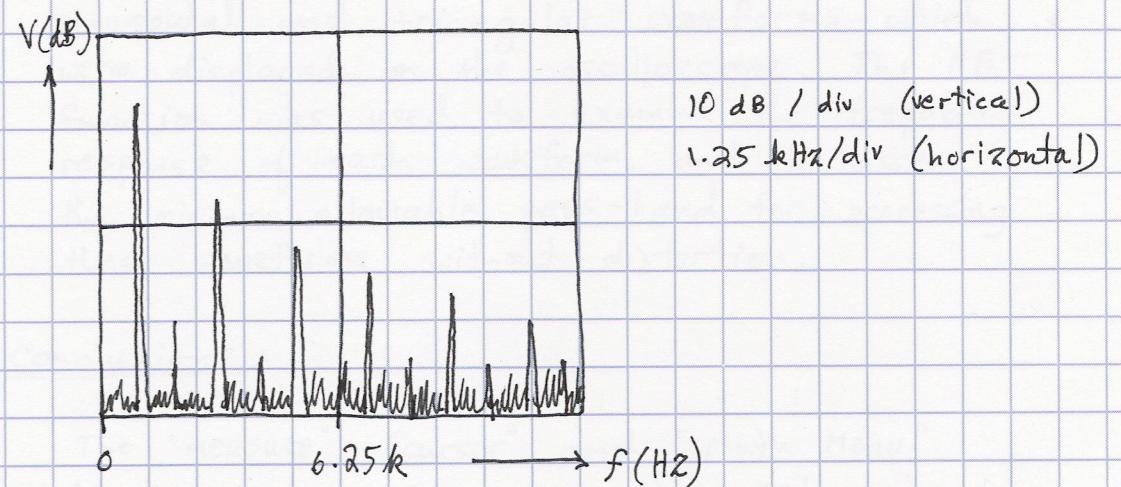


The waveform was then viewed using the FFT function. This time the frequency response revealed many impulses, as shown on the next page.

## Lab 1: Triangular Waveform

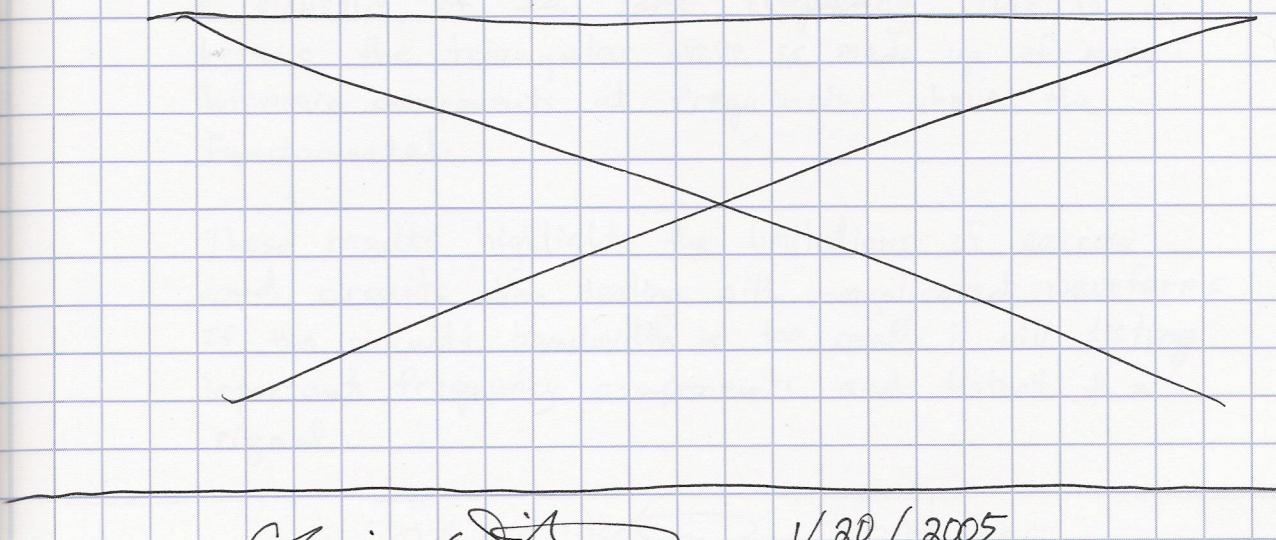
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The FFT display of the triangular waveform is shown below.



### Bandwidth:

The peaks in the FFT become indistinguishable from noise at frequencies higher than 17 kHz. It is therefore reasonable to conclude that 17 kHz is an acceptable pass-band for this signal.



Always finish your lab with a summary and conclusions. The summary should briefly state the kind of topics and experiments that were examined in the lab.

Your conclusions should reflect any knowledge gained through your experiments. Note that the lab book is not a diary. Don't say something like "I learned that signals have frequency components." Instead, try and provide professional conclusions that would be useful to someone else.

Imagine that you will be reading this lab book years from now, to remind yourself of the lab's key points. Write the conclusions in a way that will refresh your memory.

Summary :

The function generator was used to produce sinusoidal and triangular waveforms which were displayed on the oscilloscope. The FFT function was used to examine the frequency response of each waveform, and to assess the minimum allowable pass-band for processing these waveforms without distortion.

Conclusions :

The "measure," "cursor" and "Math Menu" buttons on the oscilloscope provide extremely valuable tools for examining signals. The "cursor" button is also essential for performing detailed measurements. External triggering is very useful for stabilizing the oscilloscope's display.

The FFT display revealed that a triangular waveform requires much greater bandwidth than a sinusoid of the same frequency. This is because the triangular wave is made up of many harmonic components at frequencies above the fundamental.

These results highlight the limitations of narrow-band circuits when dealing with complicated waveforms. If the circuit's bandwidth is too small, it will destroy important frequency components and distort the signal.