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# Diagram, schematic  Description automatically generatedGarbage Detector

The circuit to the right will let you see the garbage on the 110V power line. First use channel 0 of the scope to look at the output of the transformer at A. It should look more or less like a classical sinewave. The transformer serves two purposes: (1) it reduces the 110V AC to a more reasonable ~6.3V RMS, and it (2) “isolates” the circuit we’re working on from the potentially lethal power line voltage.

To see the glitches and wiggles on the power line, look at B, the output of the high-pass filter. All kinds of interesting stuff should appear, some of it curiously time dependent.

## Oscilloscope trace of garbage detector.

Create an oscilloscope trace that shows both the output of the transformer at A and the output of the filter at B. Choose vertical scaling for each channel such that the corresponding trace nearly fills the vertical space and a horizontal scaling such that there are a couple of cycles of the waveforms visible.

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## Cutoff frequency of filter.

What is the cutoff frequency of the filter circuit?

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## Estimate attenuation (in dB) at 60 Hz from oscilloscope.

Using the oscilloscope traces, estimate the attenuation (in dB) at 60Hz of the filter? Don’t be fooled and use the peak-to-peak voltage reported by the oscilloscope for the filtered output. The spikes will spoil this value. Instead, use the vertical scale setting or cursors to estimate the amplitude of the remaining 60Hz portion of the output, then compute the attenuation using .

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## Predict attenuation (in dB) at 60 Hz.

Give a rough prediction of the attenuation at 60 Hz based on your knowledge of what it is at the cutoff frequency and its rate of change for values lower than the cutoff frequency. Hint: Start at the cutoff frequency and count octaves until you get to approximately 60 Hz.

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# Design Filter to Select Signal from Signal + Noise.

Now we will try to design a filter to prefer one frequency range or the other from a composite signal formed as shown in the circuit below. The transformer adds a large 60Hz sinewave (with a peak value around 10V) to the output of the function generator. Set the function generator initially to a 10Vpp, 10­­­‑kHz sine wave.



## Visualize the composite signal.

View the output of this composite signal on your oscilloscope. Select a time per division setting where both the low frequency and high frequency components of the signal are apparent. Reduce the amplitude of the function generator and then increase it again to 10Vpp while watching the oscilloscope to make sure you understand the contribution of the function generator to the composite signal.

Capture an oscilloscope trace that clearly shows both components of the composite signal.

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## Source impedance and acceptable resistance of filter.

In order to choose the value for your filter, you will need to determine the output impedance of the signal source that you have constructed (function generator plus transformer). The output impedance of the ELVIS II function generator can be found from the [NI ELVIS II Series Specifications](https://www.ni.com/pdf/manuals/372590b.pdf) document. Look for the Function Generator section. The series resistor is included, incidentally, to protect the function generator in case the composite output is accidentally shorted to ground. The series impedance of the transformer winding is negligible at the frequencies of interest to us.

Describe the approximate output impedance of the composite signal source and provide an estimate for the desirable range of input impedance of the filter based upon the design rules that were introduced in the prelab.

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## High-pass filter design.

Design a high-pass filter that will keep most of the “signal” and get rid of most of the 60Hz “noise”. Assume that the frequency of what you consider “signal” may range from between 2kHz and 20kHz. As you design, be sure to consider what is an appropriate cutoff frequency, , what is an appropriate input impedance, and what specific resistor and capacitor values (using values available in the lab) that you will use.

Describe how you designed the high-pass filter below.

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## High pass filter output showing 1 cycle of 60 Hz

Capture an oscilloscope trace that shows both the input to and output from your filter with a time/division setting that shows approximately 1 cycle of the 60 Hz.

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## High pass filter output showing a few cycles of 60 Hz

Capture an oscilloscope trace that shows both the input to and output from your filter with a time/division setting that shows a few (~4 or 5) cycles of the 60 Hz.

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## Low-pass filter design.

Now let’s change assumptions. Suppose that we consider the 60Hz component to be the “signal” that we wish to keep and the function generator’s 10kHz component to be undesirable “noise”. Design a low-pass filter that will keep most of the “signal” and get rid of most of the “noise”.

Describe your design choices below. Be sure to justify and explain your choices for cutoff frequency and component values.

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## Low-pass filter output.

Capture a couple of different oscilloscope traces that each show both the input to and the output from the filter. Select time/division settings that will show the behavior of the filter in different regimes.

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Comment on how well your filter works to remove the noise.

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## Low-pass filter output.

Change the frequency of the noise to 20kHz. Would you expect your filter to work better or worse with noise at 20kHz compared to 10kHz? Verify your expectations with an oscilloscope capture and a discussion below.

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