In this lab, you will be working for the NSA. You just intercepted a signal transmitted by public enemy #1 Edward Snowden. It is your job to find what message was encoded in the signal.

The message consists of four characters, repeating with a total period of 1s (250ms/character). A 10 kHz sine wave was also transmitted along with this signal. This spy agency has previously been known to use the scheme given on the back to encode letters as voltage levels.

1. Connect your scope to the signal provided and take a look at it. You may note that you can sort of see several rather noisy voltage levels present. Use an appropriate low pass filter to remove as much noise as possible without losing information about the voltage levels. Record in your notebook the circuit that you built and sketch the output. Use the cursors on the scope to measure the levels present in the signal. You may have to correct for the fact that the scope contains a 1MΩ resistor between the input and ground. Can you decode the message? (It should be a word.)

2. Based on the message found in part 1, we can conclude that this was a decoy message – the real message must have been hidden in some other way. The fact that a 10kHz sine wave was also present suggests that perhaps the real message is encoded using amplitude modulation of a 10kHz carrier wave. If you are not familiar with the idea of amplitude modulation (AM), look it up. We will try to find the message in this way, using the same code (note that you probably won’t be able to get the noise low enough in part 2 or 3 to see the message, we will come back to this later in the semester). Use a high pass filter to remove the decoy message from the signal and use the scope to measure the resulting rms voltage. In the encoding scheme, the voltage levels are separated by 2.5 mV. That means we need to get the rms noise down to less than 2.5 mV. Try several high pass filters with increasing 3dB point (but always less than 10 kHz) and see how low you can get the rms voltage.

3. If you have time, try an RLC bandpass filter centered at 10 kHz. By how much can you reduce the rms noise relative to the signal? (Remember that at the peak of the bandpass filter, the transfer function < 1).

You may have concluded that you cannot remove enough noise to see the message. But we won’t give up! We will return to this problem once we have developed some more powerful techniques.
Lab 4: Using filters on a noisy signal.

Encoding scheme:

<table>
<thead>
<tr>
<th></th>
<th>(mV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>30</td>
</tr>
<tr>
<td>B</td>
<td>27.5</td>
</tr>
<tr>
<td>C</td>
<td>25</td>
</tr>
<tr>
<td>D</td>
<td>22.5</td>
</tr>
<tr>
<td>E</td>
<td>20</td>
</tr>
<tr>
<td>F</td>
<td>17.5</td>
</tr>
<tr>
<td>G</td>
<td>15</td>
</tr>
<tr>
<td>H</td>
<td>12.5</td>
</tr>
<tr>
<td>I</td>
<td>10</td>
</tr>
<tr>
<td>J</td>
<td>7.5</td>
</tr>
<tr>
<td>K</td>
<td>5</td>
</tr>
<tr>
<td>L</td>
<td>2.5</td>
</tr>
<tr>
<td>M</td>
<td>0</td>
</tr>
<tr>
<td>N</td>
<td>-2.5</td>
</tr>
<tr>
<td>O</td>
<td>-5</td>
</tr>
<tr>
<td>P</td>
<td>-7.5</td>
</tr>
<tr>
<td>Q</td>
<td>-10</td>
</tr>
<tr>
<td>R</td>
<td>-12.5</td>
</tr>
<tr>
<td>S</td>
<td>-15</td>
</tr>
<tr>
<td>T</td>
<td>-17.5</td>
</tr>
<tr>
<td>U</td>
<td>-20</td>
</tr>
<tr>
<td>V</td>
<td>-22.5</td>
</tr>
<tr>
<td>W</td>
<td>-25</td>
</tr>
<tr>
<td>X</td>
<td>-27.5</td>
</tr>
<tr>
<td>Y</td>
<td>-30</td>
</tr>
<tr>
<td>Z</td>
<td>-32.5</td>
</tr>
</tbody>
</table>