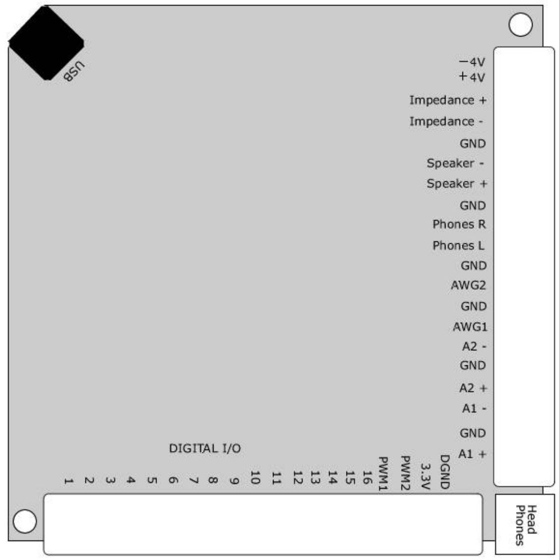
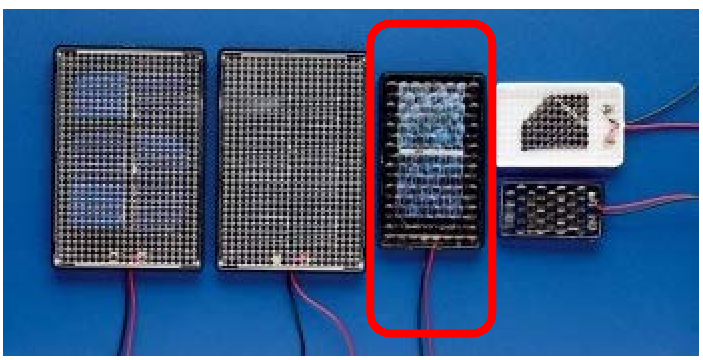
Simple, Inexpensive Optical Communications Experiment Using Mobile Studio

Necessary Components:


Mobile Studio IOBoard, Mobile Studio Desktop Software, Laptop Computer

Encapsulated High Output Solar Cell 3.0V 20mA (available from Edmund Scientific $10)



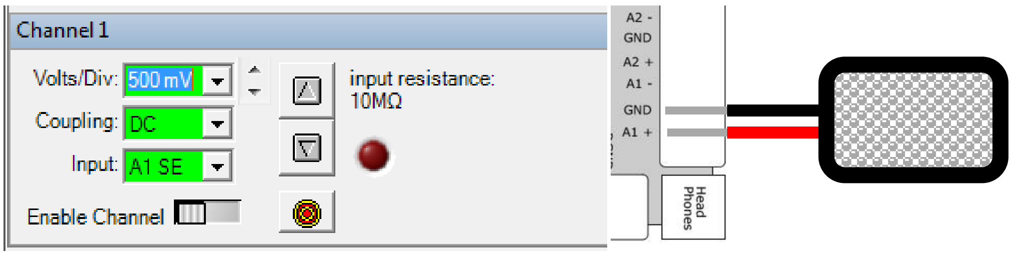
High brightness white or blue LED. 470 or 510 Ohm resistor. Wire.

Earbuds or headphones

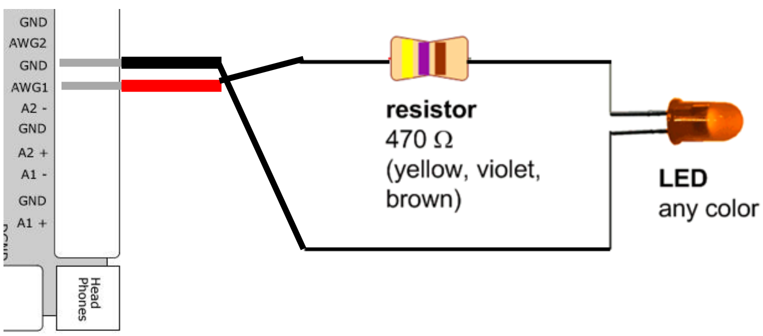
Sound Clip Selection and Download

1. Select a small number of audio files (wav format) online and download them to a convenient place on your computer. Not all files work. A few that have been tested with the Mobile Studio can be found at the following link. Note that some have DC offsets and some do not. http://hibp.ecse.rpi.edu/~connor/Mobile%20Studio/Sound%20Clips/
2. Test any files you download by listening to them to be sure they are OK.

Hardware Setup



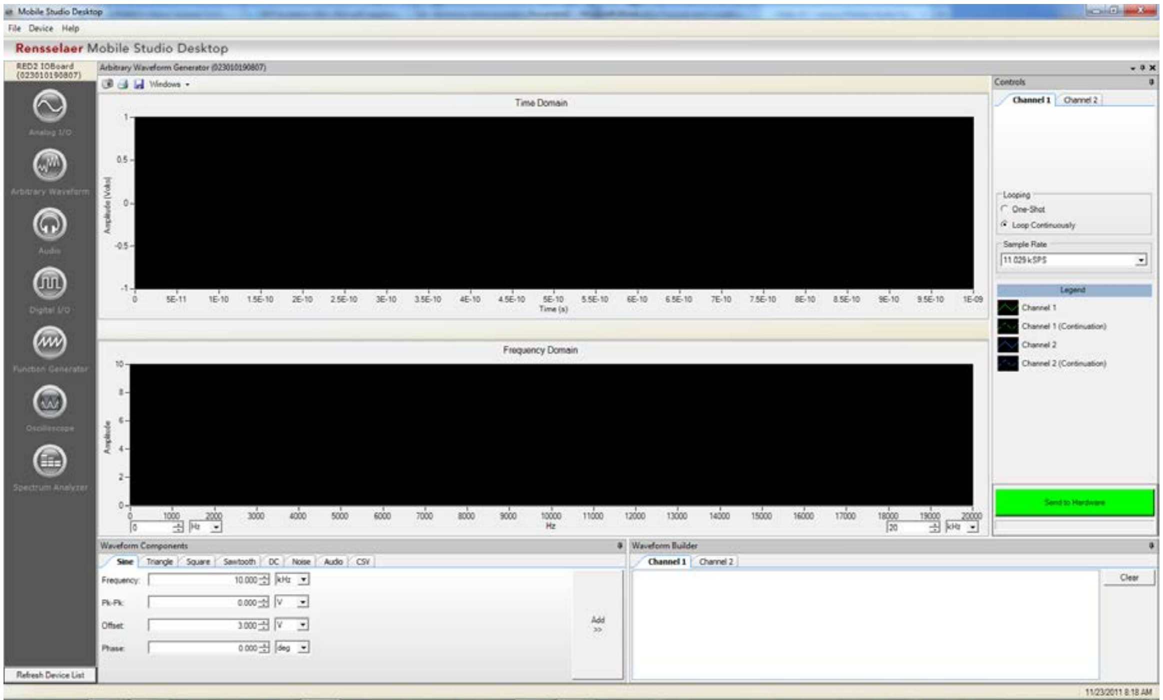

1. Connect solar cell to analog channel 1. Red wire to A1+ and Black wire to GND



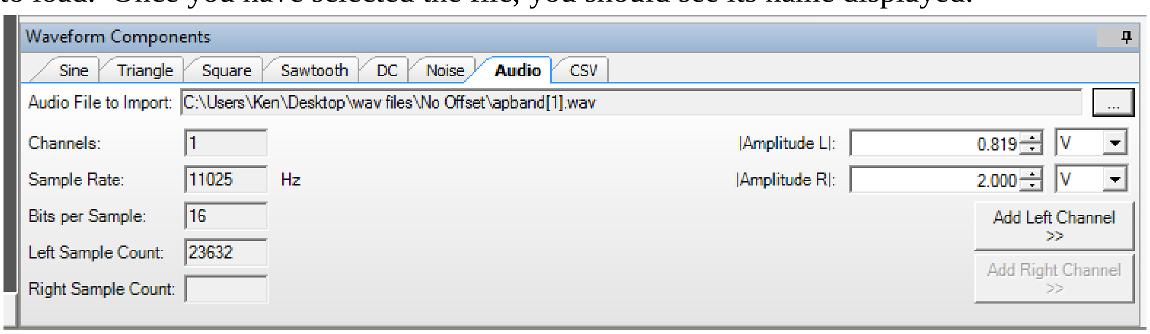

2. Connect high intensity white or blue LED in series with a 470Ω or 510Ω resistor on a small protoboard. Connect the LED-Resistor combo to AWG1 and GND. The short wire on the LED should be on the GND side. If this is backwards and you see no light from the LED, you can reverse it later.
3. Set up the solar cell and the LED so that the light from the LED shines on the cell.
4. Connect your set of ear buds to the 1/8" jack on the corner of the RED2 board.
5. If you have not already done so, connect the Mobile Studio RED2 board to your computer's USB port.

Mobile Studio Setup

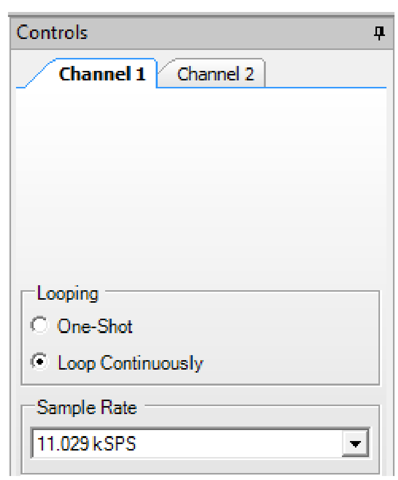
1. Start the Mobile Studio Desktop software
2. Open the Arbitrary Waveform Generator. In the bottom left region of the window, you should see a sub-window entitled 'Waveform Components.' This is used to configure the




arbitrary waveform we wish to use for our sound source. You will notice many options. Each of these options can be selected, configured and added to the waveform. Select ‘Audio.’ The first line that appears is ‘Audio File to Import.’ At the right end of this line is a button with an ellipsis (…) on it. Click this button to search for the wav file you wish to load. Once you have selected the file, you should see its name displayed.

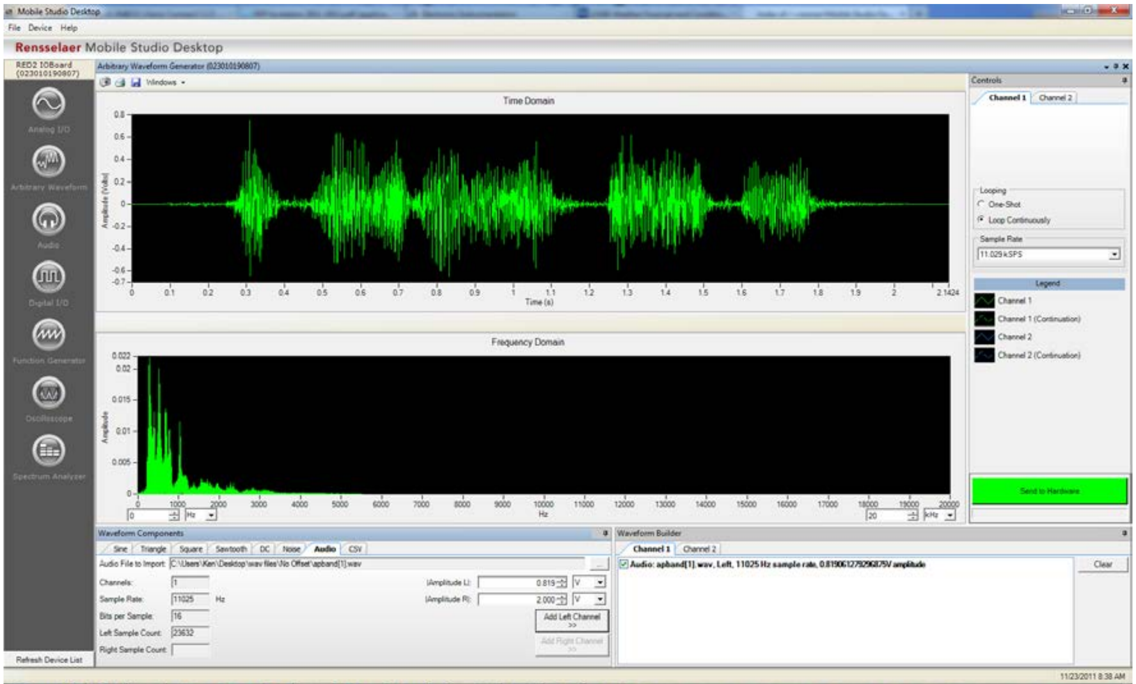



3. Before we add the wav file to the Channel 1 signal using the Waveform Builder, we need to select an appropriate sample rate. In the upper right-hand sub-window called ‘Controls,’ be sure that ‘Loop Continuously’ is selected and choose a Sample Rate of 11.029kSPS. (kilo samples per second) We may want to change the sample rate later on, but this usually works and is a good place to start. If the sample rate is too high, the wav file will be truncated and we will only hear part of it. If the sample rate is too low, the audio will be distorted. For this demo, it is not necessary to play with this, but, if you

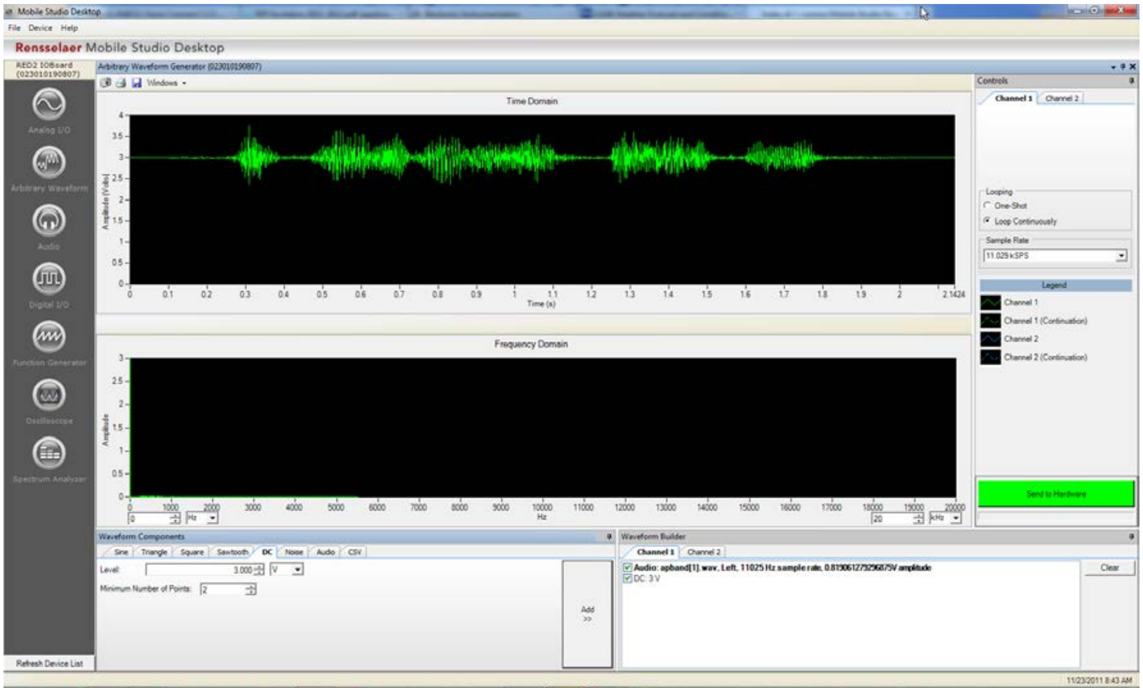


have time, it is an interesting exercise.

4. Click on the ‘Add Left Channel’ button in the ‘Waveform Components’ window.

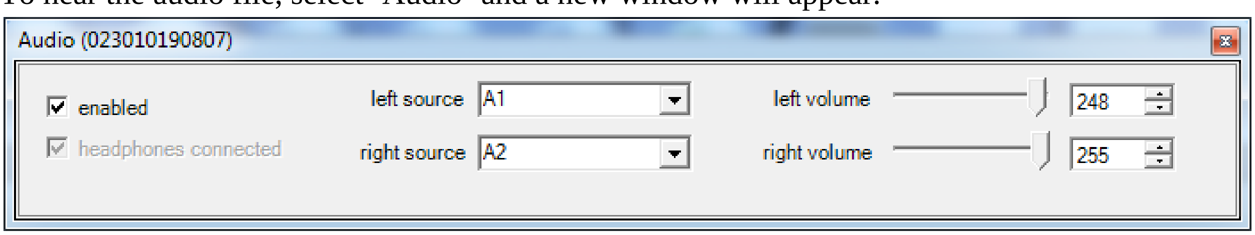



The file I have selected (One Day at Band Camp), has no DC offset, so the signal appears in the top window, as it will look on the scope and in the bottom window as it will look using the spectrum analyzer. The scope signal indeed shows no offset. To be able to drive a white or blue LED (both are actually blue LEDs), the signal requires an offset. Select DC from the Waveform Component tabs and set the level to 3V. Click the ‘Add’ button to add this offset to the waveform. The signal will seem to disappear from the Spectrum Analyzer because the DC level overwhelms everything else in the signal. It is still there, just not easy to see. In the scope window, you should now see the 3V offset.




Both components in the signal are now listed under the Waveform Builder. If you have selected a file with a DC offset (the samples at the hibp address have an offset of 1V), the DC level you should add should increase the offset to 3V, which should be displayed as such on the scope signal (upper trace) on the Arbitrary Waveform window.

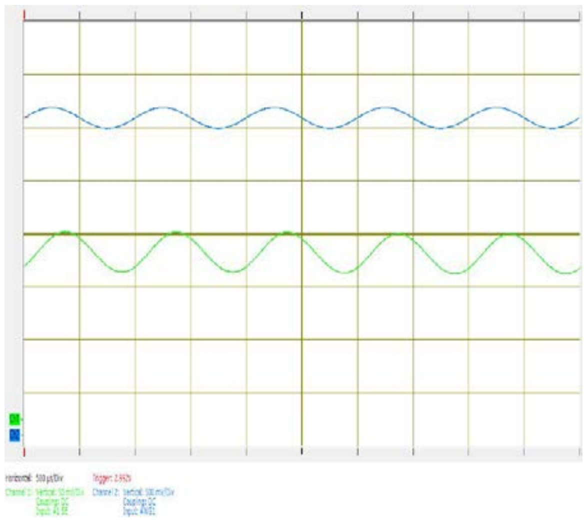
5. With the waveform now built, click the green ‘Send to Hardware’ button which will load the signal in AWG1. Close the Arbitrary Waveform Generator Window. Your LED should now be on. If I is not, pull it out of the protoboard and re-insert it with the wires reversed.
6. Open the Oscilloscope. Set the Channel 1 Volts/Div to 500mV, the coupling to DC and the input to A1 SE. Set the Horizontal Time/Div to 20.0ms and turn off the Trigger (select Off). If your LED is shining on the solar cell, you should see a signal on the scope that changes with time as the sound file is played back over and over. This step is essential because there is a small bug in the audio setup for the Mobile Studio so that the gain of the amplifier is affected by the vertical voltage scale used by the scope.
7. To hear the audio file, select ‘Audio’ and a new window will appear.

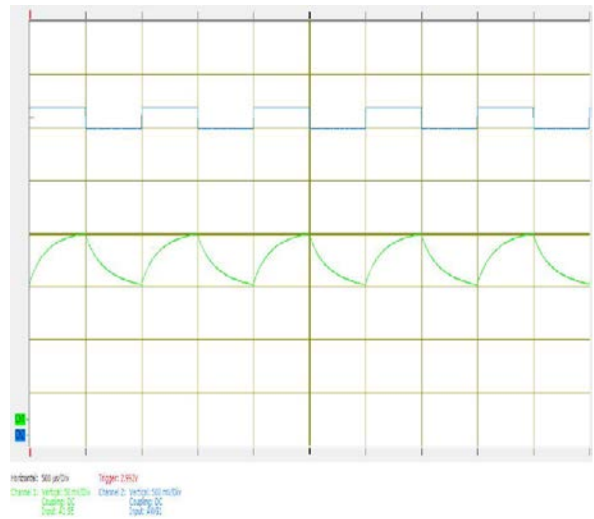


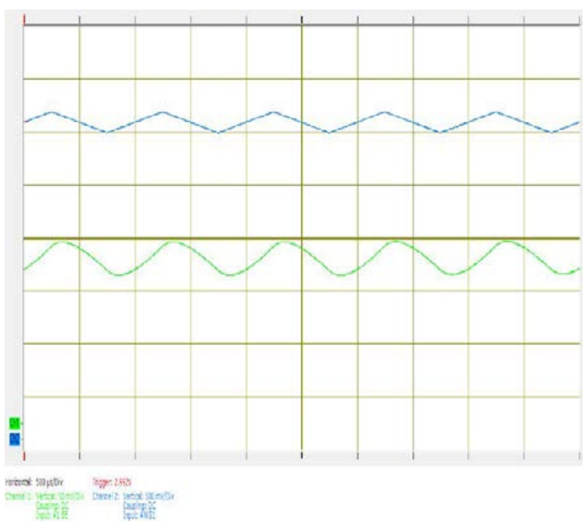

Be sure that ‘enabled’ is checked and A1 is chosen for the left source. You should now be able to hear the audio file in the left ear bud. If you still have the scope on, you should also be able to see the signal detected by the solar cell. If you block the cell with your hand, the sound should go away. You can also move the cell or the LED to show that direct illumination is required to communicate the audio signal from the LED to the solar cell.

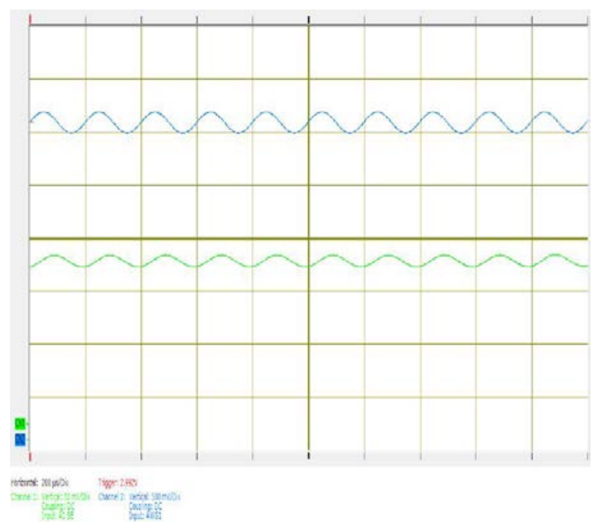
Appendix: Frequency Response

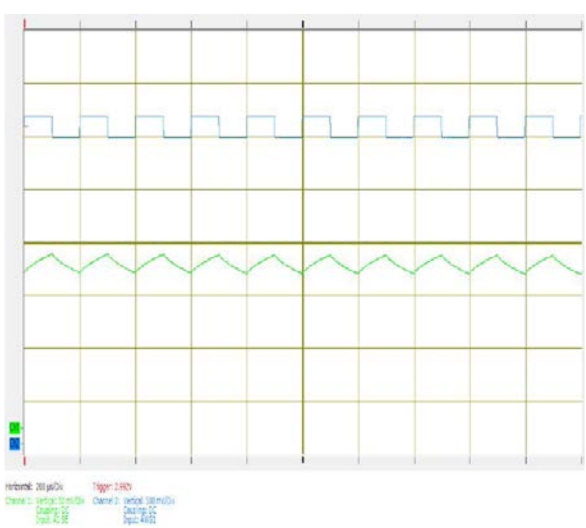
Just for completeness, the function generator was used to generate input and output plots with different frequencies and waveforms to check the frequency response of the system. The 3V offset was maintained for simplicity, even though the output amplitude was slightly larger at 3.5V. A blue LED was placed about 5cm from the solar cell in a relatively dark room. There were two lights on, but neither provided any direct illumination. The first three figures that follow are for 1kHz and the second 3 for 5kHz. Input is blue and output is green. The vertical scale for input is 500mV/div and for output is 50mV/div. The system responds at least to 20kHz but at reduced output values. A Bode plot will show more, but the setup for that is a bit more complex.

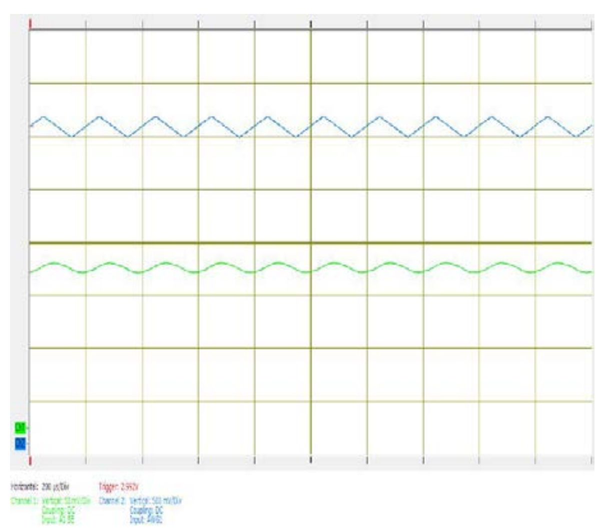


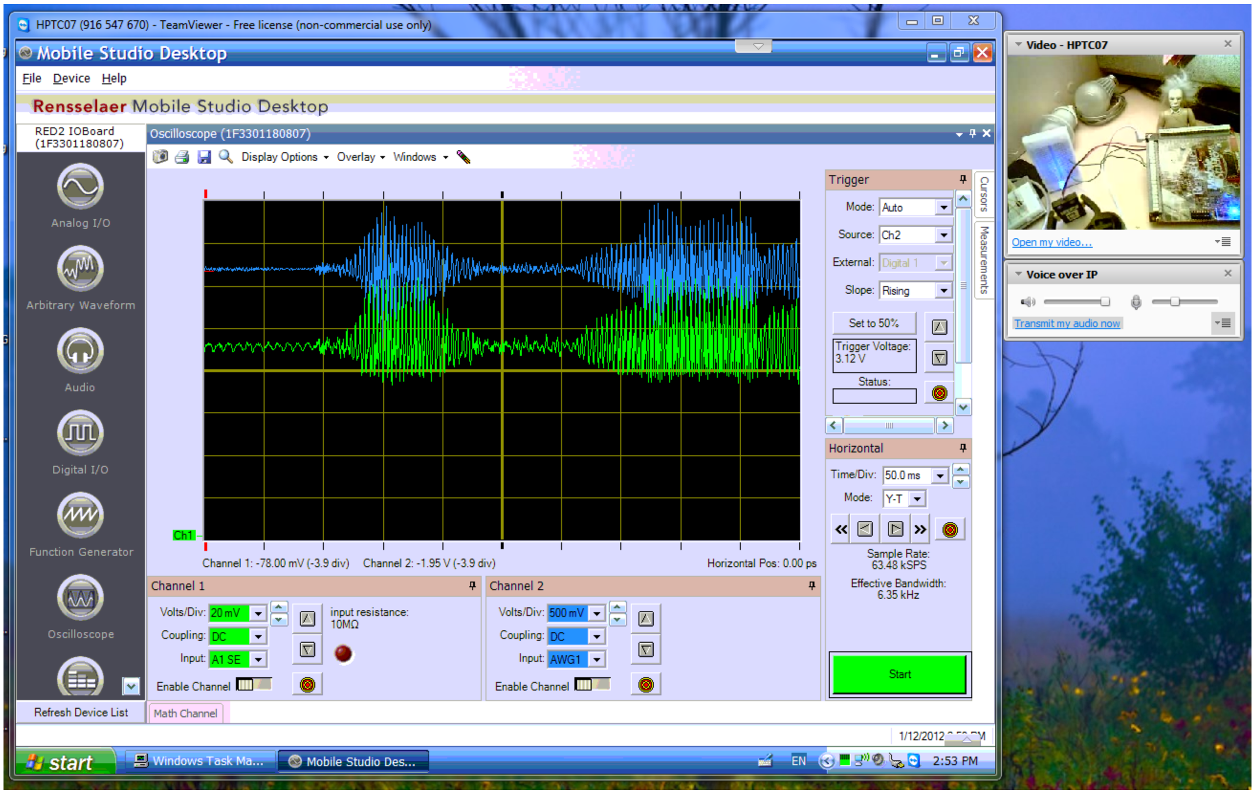













An extra bonus with this demo is that it can be run remotely. Shown above is the screen capture for a laptop in Wisconsin running the experiment on a tablet PC in New York. The small window at the upper right is video showing the setup with the Mobile Studio board, the blue LED (on the protoboard at the lower left) and the solar cell below the protoboard. Holding the Mobile Studio board is a posable Einstein figure and the light bulbs show the scale of the set up. With the configuration as set up in New York, it is possible to hear the sound of the signal from the small speaker on the tablet.