Introduction to LowLight FFT Demo

1) Examine a sine wave in the time domain with an oscilloscope and the frequency domain with the FFT
   a) Link the function generator output to both the FFT input and the scope input. **Remember a 50-ohm terminator on the end!**
   b) Turn on the function generator and configure it to produce a sine wave with an amplitude of 0.5 Vpp and a frequency of 4300 Hz and check the scope to make sure everything is working correctly. Procedure is as follows:
      i) Turn on the SRS DS345 Function Generator.
      ii) **To select a sine wave output:** Press the [UP]/[DOWN] arrow keys by the BNC FUNCTION OUTPUT until the sine waveform is highlighted in green. To select another type of waveform output, you just press the [UP]/[DOWN] arrow keys until the desired waveform is highlighted in green.
      iii) **To set the frequency of the output:**
              (1) Press the [FREQ] button.
              (2) Type 4300 using the number pad.
              (3) Set the new frequency by pressing the [Hz/Vpp] button.
      iv) **To set the amplitude:**
              (1) Press the [AMPL] button.
              (2) Type .5 using the keypad.
              (3) Set the new amplitude by pressing the [Hz/Vpp] button.
   v) **In General:** To select a frequency, amplitude, offset, or phase of the output wave:
      (1) First press one of those 4 buttons in the FUNCTION area on the front panel.
      (2) Enter the desired value with the keypad.
      (3) To make the new setting take effect press the appropriate units key in the right column of the ENTRY area.
   c) Turn on the SR760 FFT in default mode, set the SPAN to 6.25 kHz and switch the display to linear magnitude:
      i) Hold down the back-arrow key and turn on the power. Hold down the back-arrow key until all of the internal tests have completed and the FFT has started taking data. This starts the FFT in default mode. Note: occasionally you may see the FFT freeze and display the message: “Calibrating Offset”. This is normal and nothing to worry about. Just wait until it’s done before continuing.
      ii) Set the SPAN:
              (1) Press the [FREQ] button in the MENU area.
              (2) Press the top-most soft key new the monitor (the one corresponding to the span). 100 kHz should be highlighted in green. Note: if you pressed the wrong soft key, just hit the [FREQ] button in the MENU area and try again.
              (3) Turn the SPIN KNOB counter-clockwise until the highlighted number reads 6.25 kHz. The span has now been set to 6.25 kHz.
      iii) Set the display mode to Linear Magnitude:
              (1) Press the [MEAS] key in the MENU area.
(2) Press the soft key second from the top (it corresponds to DISPLAY). Again, if you hit the wrong soft key, just press the [MEAS] key in the MENU area and try again.

(3) You should now see the following choices: Log Mag, Lin Mag, Real Part, Imag Part, Phase. Press the soft key corresponding to Lin Mag (the second from the top). If you make a mistake, just press the correct soft key. The FFT should now be displaying the linear magnitude of the Fourier components instead of their log magnitudes. Notice how all the noise disappears (we will come back to this later).

(4) Now press the [AUTOSCALE] button located in the right column of buttons in the ENTRY section. This will re-scale display. You should now see a single peak on the FFT screen.

d) If everything is working properly, you are now ready to examine a single sine wave in the time and frequency domain.

i) Look at the sine wave on the oscilloscope. What you should see is a sine wave with an amplitude of 250 mV (0.5 Vpp) and a frequency of 4.3 kHz. If the amplitude is not what you would expect it to be, make sure you have a 50-ohm terminator. As you know, the scope is plotting the voltage output of the function generator as a function of time. It is representing the function generator’s output in the “time domain”.

ii) Now look at the FFT. First measure the position and amplitude of the peak you should be seeing. To do this:

(1) Press the [MEAS] button. This will change the SPIN KNOB’s function.

(2) Dial the SPIN KNOB until the cursor on the screen locks to the peak. This should happen when the peak is between the two vertical dashed lines.

(3) Read the location (frequency and amplitude) of the cursor in the upper left-hand corner of the screen.

(4) You should find that the peak is located around 4.3 kHz and has an amplitude of about 250 mV. Note that the values may not be exactly 4.3 kHz and 250 mV. The reasons for this will be discussed later in the lab.

iii) A single peak on the FFT display corresponds to a single sine wave with a frequency and amplitude given by the height and location of the peak.

iv) Now vary the frequency of the sine wave and watch what happens on the scope and the FFT.

(1) Vary the frequency:

(a) On the DS345 Function Generator, press the [FREQ] button. You should now see that the sine wave has a frequency of 4.3 kHz (the green FREQ should be lit up under the readout).

(b) Now press the [STEP SIZE] button in the MODIFY section. Now both FREQ and STEP should be lit up in green under the display.

(c) Using the UP/DOWN arrows directly above the [STEP SIZE] button, adjust the STEP SIZE to read 100.000. This will determine how much the frequency will change when you press the UP/DOWN keys later.

(d) Now press the [FREQ] or [STEP SIZE] button. The screen should read 4300 Hz and only FREQ should be lit up in green under the display.
(e) Now press the UP/DOWN keys in the MODIFY section. The frequency reading should change in steps of 100 Hz since you have just adjusted the STEP SIZE to 100 Hz.

(f) Watch the peak move back and forth on the FFT.

v) Now vary the amplitude of the sine wave and watch what happens.

1. Press the [AMPL] button on the DS345 Function Generator. AMPL should be lit up in green under the main display, which should read 0.500 Vpp.
2. Now press the [STEP SIZE] button in the MODIFY section (STEP should light up).
3. Using the keypad in the ENTRY section, enter .05 and set the value by pressing the [Hz/Vpp] key
4. Press either the [AMPL] or [STEP SIZE] buttons.
5. Adjust the amplitude with the UP/DOWN keys in the MODIFY section.
6. Watch how the height of the peak changes in correspondence with the change in amplitude.

(e) Now change the input waveform to a square wave and a triangle wave.

(f) You should now have a fairly good idea as to how the FFT treats a purse sine wave and how to take simple measurements.

2) Examine 2 sine waves mixed together
a) Add two sine waves together:
   i) Make sure the SR560 Voltage Preamplifier has nothing hooked up to its inputs. Then turn it on.
   ii) Make sure the SOURCE is selected to be A – B (A minus B). If it is not, press the button in the SOURCE area until A – B is lit up. This means that the output will be an amplified version of the difference of the A and B inputs.
   iii) Press the center ROLLOFF button until DC is highlighted in the FILTER CUTOFFS area. This will remove any band pass filters.
   iv) Choose the GAIN MODE to be LOW NOISE.
   v) Select the GAIN to be 1 (we don’t need to amplify the signal).
   vi) Turn on the two function generators (if they aren’t already) and set them to produce the following sine waves:
      1. One should have an amplitude of 0.5 Vpp and a frequency of 100 Hz.
      2. Give the other one an amplitude of 0.1 Vpp and a frequency of 1000 Hz.
   vii) Connect the outputs of two function generators to the SR 560 Voltage Preamplifier (inputs A and B).
   viii) Connect the 50-ohm output of the SR560 to the FFT and the scope. Remember the 50-ohm terminator!
   ix) Look at the scope and FFT outputs (you may have to hit [AUTOSCALE] on the FFT). Notice how the FFT represents the two sine wave components. Now vary the frequencies and the amplitudes of the sine waves until you feel comfortable with what you’re seeing and doing.
3) **Low Signal Hidden in Noise**
   a) Now we’ll explore how an FFT can help you recover signals deeply buried in noise. To do this, keep both function generators on and connected to the preamp as above in 2).
   b) Now set the function generator outputs as follows:
      i) Set one to be a sine wave with amplitude of 0.05 Vpp and a frequency of 1000 Hz.
      ii) Set the other to be white noise (press the [UP]/[DOWN] arrow keys in the FUNCTION section of the function generator until NOISE is highlighted) with an amplitude of 1.0 Vpp.
   c) Look at the output on the scope. Hopeless, isn’t it? You probably couldn’t even tell there was a signal there! (You can look at the signal and noise separately by pressing the button in the SOURCE section on the SR560 Voltage Preamp.)
   d) Look at the output n the FFT. There’s a peak at 1kHz! Measure the amplitude. Pretty neat, huh?
   e) Although the white noise has an amplitude 20x that of the sine wave, when you spread out the power of the white noise over 30 MHz or so (maximum output frequency of the function generator), the amount of power in any given frequency interval is much smaller than that stored in the pure sine wave around it’s frequency.