

## Bryan 316 Lab How-To's

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## **Reset Scope to Defaults**

Sets the baud rate to 19200, logic analyzer thresholds to 1.4V, etc.

- a) Press the Save/Recall key
- b) Press the Default Setup soft key

## FFT (Fast Fourier Transform)

Displays the Discrete Fourier Transform of the selected channel.

- Press the Math key
- Press the FFT soft key below the display
- To configure the FFT, press the Settings soft key below the display
  - Source – Select which channel's FFT is to be displayed
  - Span – Use the Entry Knob to set the range of frequencies to be displayed.
  - Center – Use the Entry Knob to set the frequency to be displayed in the center of the display.
  - Preset
    - Sets the Span to display the full bandwidth of the FFT. This is the selected sampling rate of the scope divided by 2.
    - Sets the Center to Span/2 (i.e.,  $F_s/4$ ).
    - Sets the Amplitude Scale to 10 dBVrms/div (see below)
    - Sets the Offset to -34 dBVrms (see below)
  - More FFT
    - Scale – Use the Entry Knob to set the dBVrms/div (decibels relative to 1 Volt RMS?? per division).
    - Offset – Use the Entry Knob to set the dBVrms level of the center horizontal line on the display.
    - Window – Select between Hanning windowing, Flat Top windowing, and Rectangular (no windowing) applied prior to computing the FFT.

Using the Cursors when displaying the FFT

Create an FFT display as described above and then:

- Press the Cursors key
- Press the Source soft key until Math is selected
- Press the X Y soft key until X is selected. Now, the Entry knob will display the frequency at the cursor location.
- Press the X Y soft key until Y is selected. Now, the Entry knob will display the amplitude in dBVrms at the cursor location.

### FFT Example

Connect the function generator to channel 1, and set the function generator to create a 1V, 1KHz sine wave. Configure channel 1 for 500mV/div and 20mS/div. Press the Math key and then the FFT soft key and then the Settings soft key. Set the Source to 1. Then Span should be set to 5KHz, and the Center to 2.5Khz. If this isn't the case, press the Preset soft key.

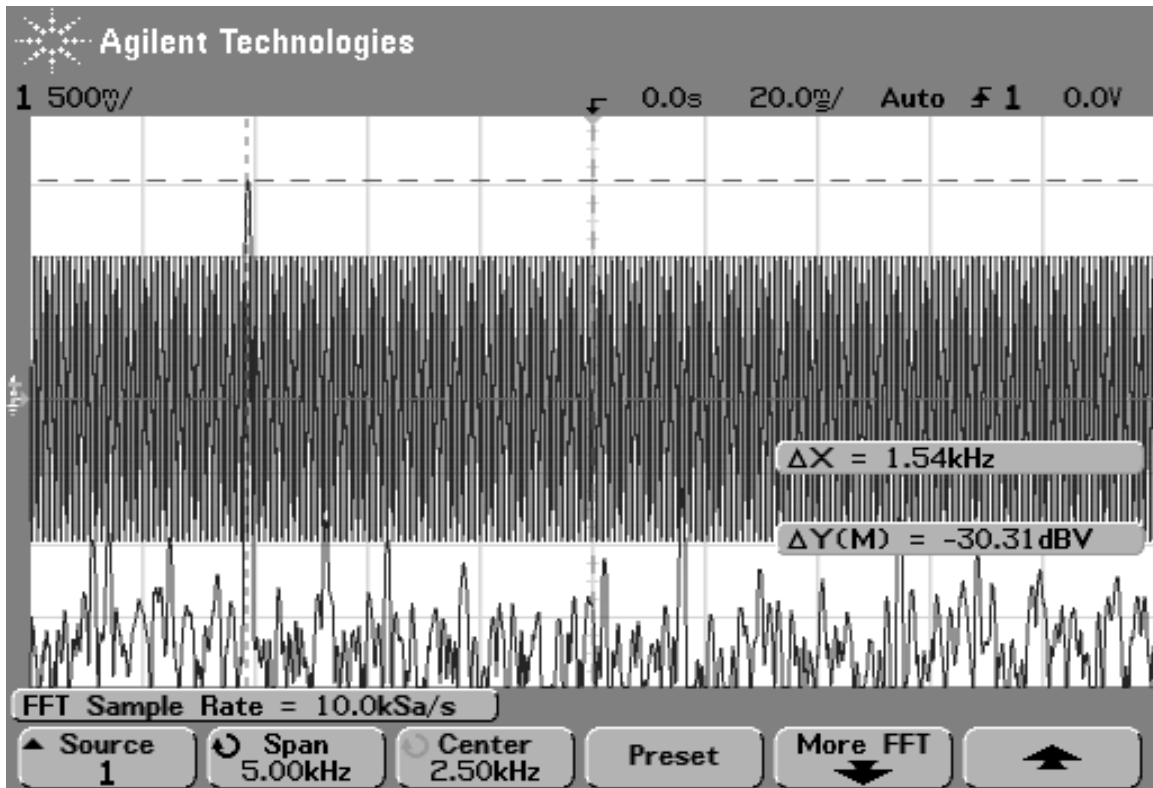


Figure 1. 1V, 1KHz tone Time Domain and Frequency Domain

Now, do the following steps to zoom in on the peak in the FFT.

- Press the Center soft key and using the Entry knob, change the Center frequency to 1 KHz. Now, zoom in on the peak by changing the Time/Div knob to 1 mS/div.
- Press the Cursors key and then the Source soft key until Math is selected.
- Select the X1 cursor and use it to measure the frequency of the peak. The peak should be at 1 KHz.
- Select the Y1 cursor and use it to measure the amplitude of the peak. It should be approximated -3 dBVrms. ( $V_{\text{Peak}} = 1$ ,  $V_{\text{rms}} = 1/\sqrt{2}$ .  $\text{dBVrms} = 20 \cdot \log(1/\sqrt{2}) = -3 \text{ dBVrms}$ )
- Press the Math key, the Settings soft key, More FFT soft key and change between Hanning, Flat Top, and Rectangular windows to see the difference.

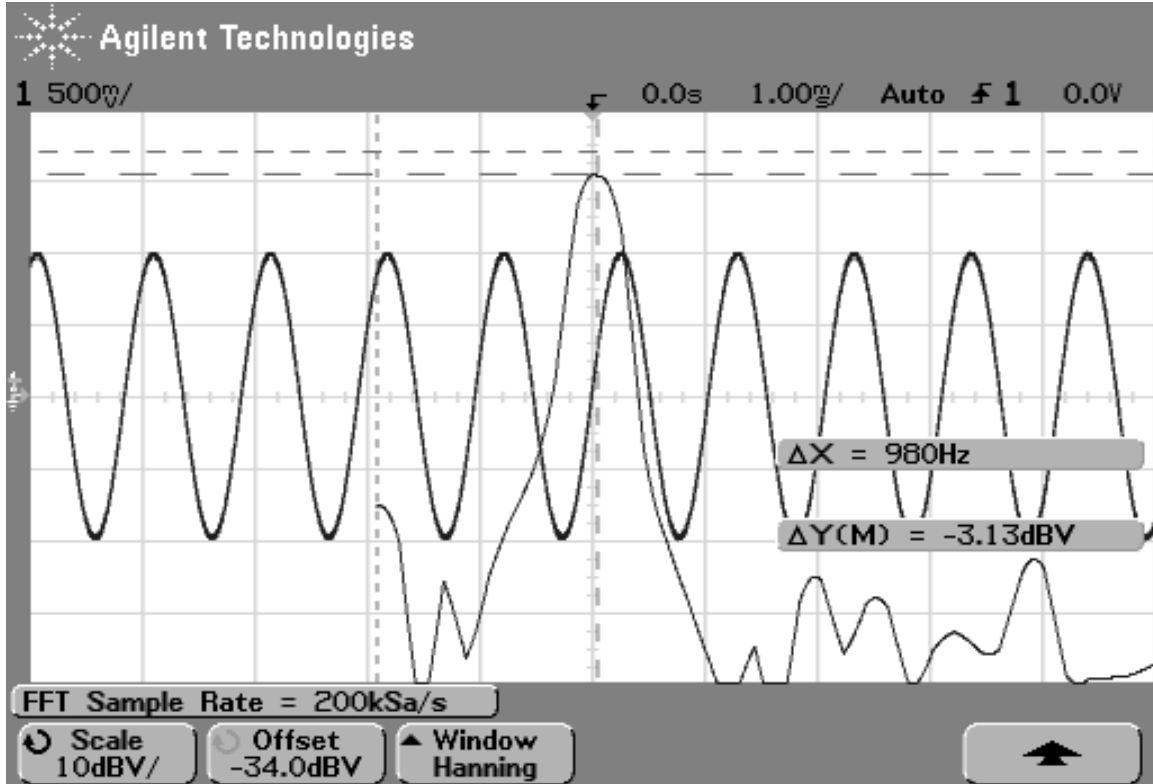


Figure 2. Hanning Windowing – Good for measuring 2 tones close together in frequency.

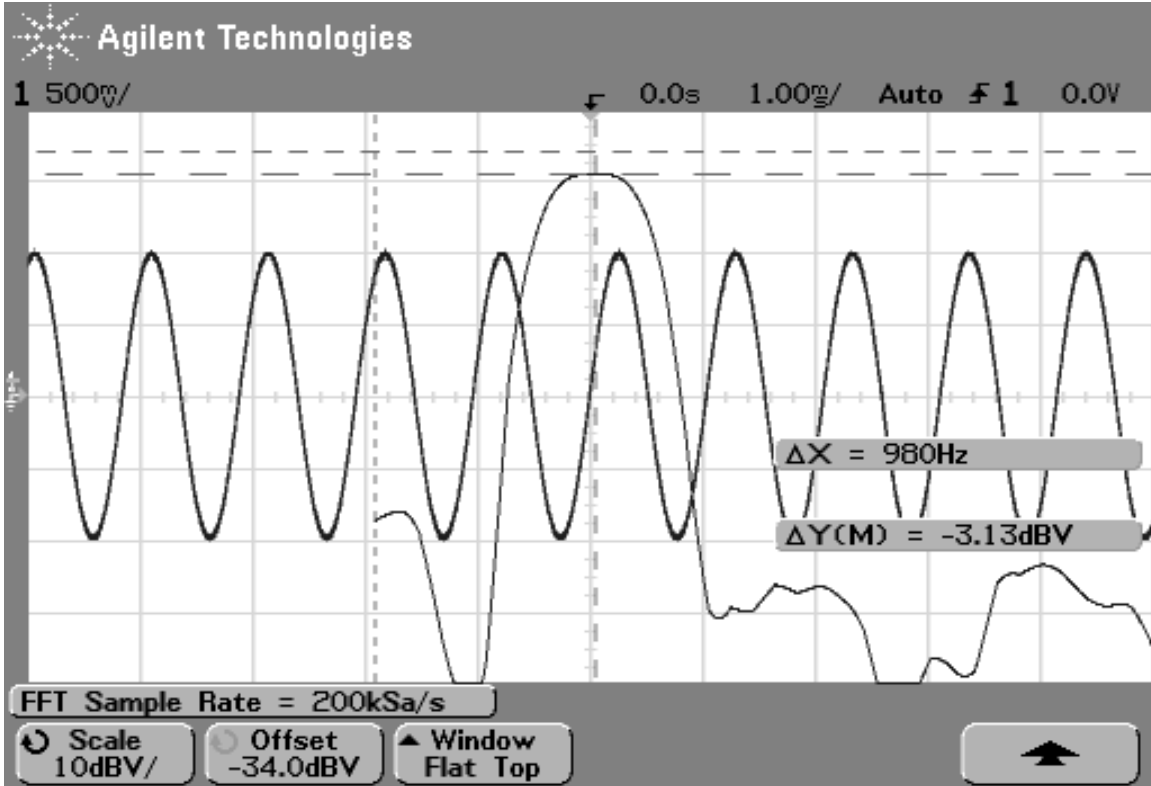


Figure 2. Flat Top Windowing – Good for measuring amplitude of a single tone.

## Signal Averaging

When you are displaying noisy periodic signals, you can improve your signal to noise ratio by using averaging.

- Press the Acquire key
- Press the Averaging soft key
- Using the Entry knob, select the number of averages displayed
- As a courtesy to others, reset this to Normal when done

## Configure Output Load for High-Z on the HP33120A

The reason why your unloaded (high load impedance relative to 50 ohms) output voltage measures 2x the displayed value is because the Signal Generator is assuming that it is driving a 50 ohm load with its 50 ohm output. If this were true, i.e., the load was 50 ohms, then the measured and displayed output voltages would be the same. However, if this is not true, i.e., output is unloaded, then the measured value will be twice the displayed voltage.

To change the output termination settings to High Z:

- Press the Shift key, then the Enter key to enter the Menu.
- Press the > key 3 times until the display shows D: SYS MENU
- Press the ▼ so the display shows 1: OUT TERM
- Press the ▼ so the display shows HIGH Z or 50 OHM
- Press the > until the display shows HIGH Z
- Press the Enter key after you make your selection

To make changes permanent:

- Press the Shift key, then the Enter key to enter the Menu.
- Press the > key 3 times until the display shows D: SYS MENU
- Press the ▼ key so the display shows 1: OUT TERM
- Press > key so the display shows 2: POWER ON
- Press ▼ key to display LAST STATE
- Press enter



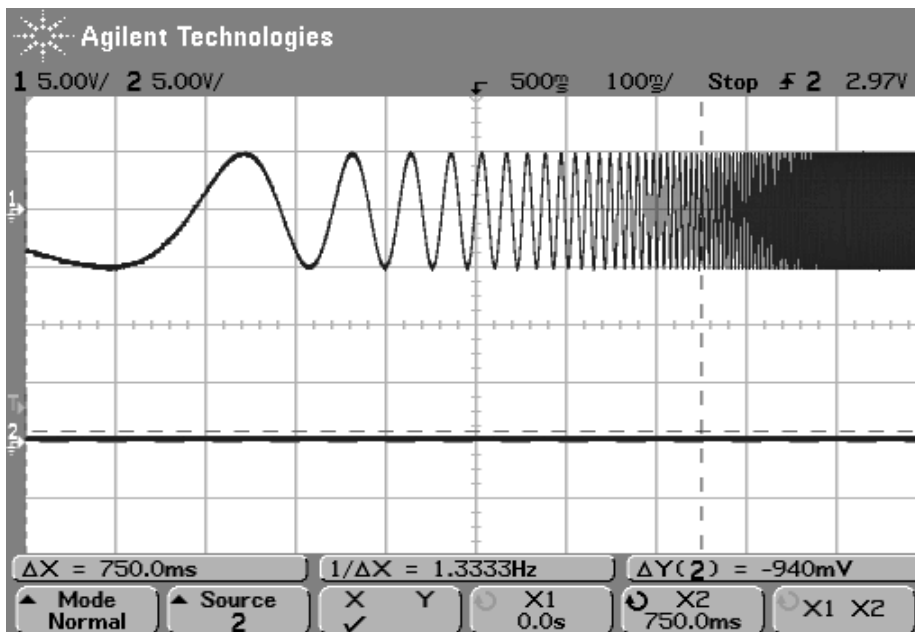
## Frequency Sweep on the HP 33120A

The HP33120A can be configured to sweep a sinusoid through a range of frequencies. You can access the Frequency Sweep parameters through the menu. Press Shift-Menu, ► to display **B: SWP MENU**. Press the ▼ one time and then ► to cycle through

1. START F – Sweep starts with this frequency
2. STOP F – Sweep ends at this frequency
3. SWP TIME – Sweep duration (from start freq to stop freq)
4. SWP MODE – Linear or logarithmic sweep (change in frequency per unit time)

When one of the 4 Menu Items are displayed, press ▼ to modify or view the current value. Use the arrow keys and the knob or the Enter Number button to change the value. Press Enter after you change the value. Repeat this procedure until you have set all 4 values. Press Shift-Sweep to enter the sweep mode.

For example, set START F to 1 Hz, STOP F to 1KHz, SWP TIME to 1 sec and SWP MODE to Log. Connect the OUTPUT to channel 1 of the scope and the SYNC signal to channel 2. Trigger on the SYNC signal. With the trigger position at the left edge of the screen, and 100 ms per division, you should see the following image on the scope.



So what is the frequency  $f$  of the sweep at some time  $t$ ?

Let  $d$  be the number of decades from STOP F to  $f$

and  $D$  be the total number of decades from START F to STOP F.

$$\text{STOP F} = \text{START F} * 10^D$$

$$f = \text{START F} * 10^d$$

$$\text{So, } D = \log\left(\frac{\text{STOP F}}{\text{START F}}\right) \text{ and } d = \log\left(\frac{f}{\text{START F}}\right)$$

$$\text{But } d = \frac{D \text{ (decades)}}{\text{SWP TIME (sec)}} * t \text{ (sec) decades also.}$$

$$\text{Therefore, } \log\left(\frac{f}{\text{START F}}\right) = \frac{D}{\text{SWP TIME}} * t$$

and finally,

$$f = \text{START F} * 10^{\frac{\log\left(\frac{\text{STOP F}}{\text{START F}}\right)}{\text{SWP TIME}} * t}$$

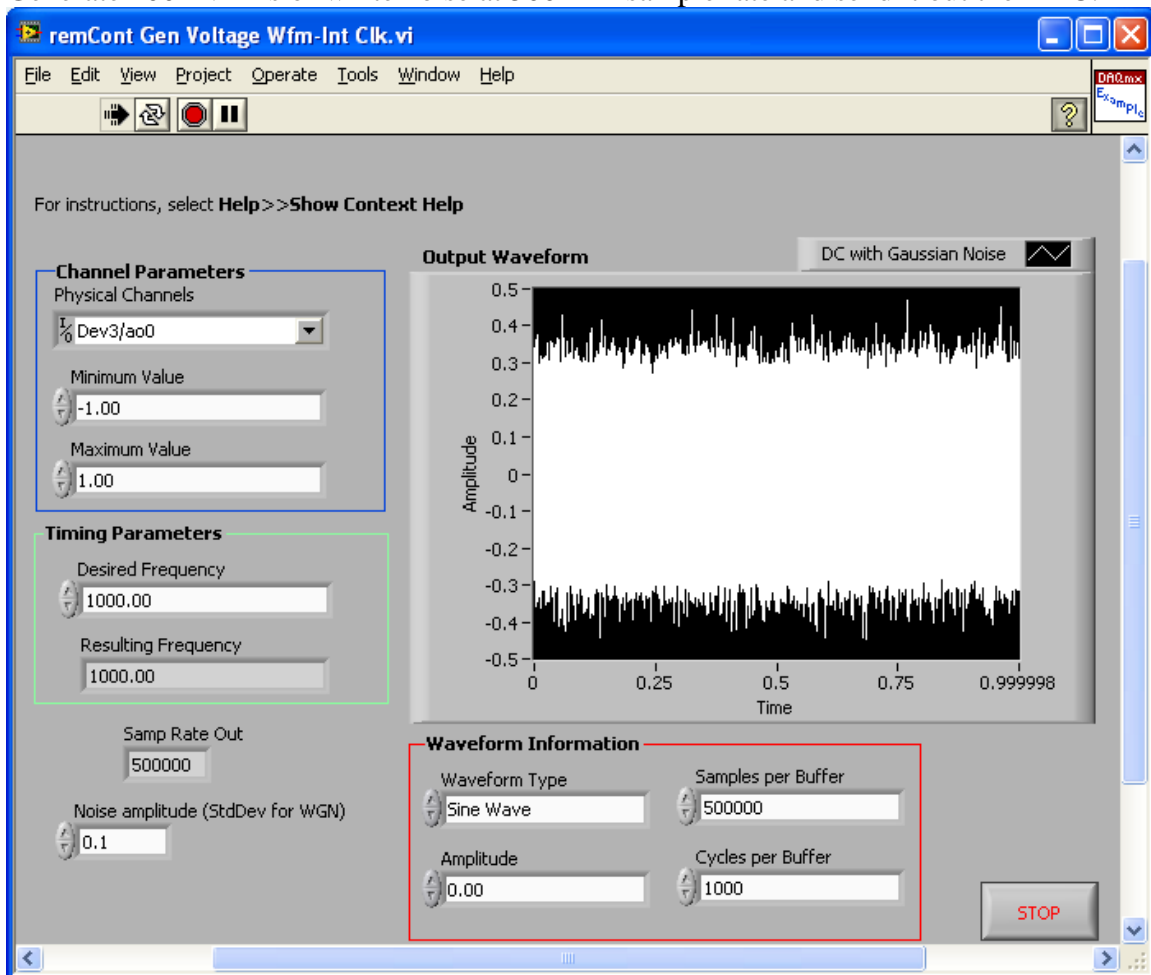
## **Protek B845 DMM RMS Measurement**

Press the AC/DC button in to select RMS/DC voltage measurements.

This measurement is bandlimited to 10KHz. Use the HP 3478A DMM for wider bandwidths (400KHz).

## How to Measure Noise using the HP3580A

Generate 100mV rms of white noise at 500KHz sample rate and send it out the DAC.



Since it is white, the power spectral density is constant and the total power is  $\sigma^2$ .

$$\text{Power Spectral Density} = N_0 = \sigma^2 \cdot BW$$

$$N_0 = 0.1^2 \cdot F_s / 2 = 0.1^2 \cdot 250000 = 40 \text{ nV/Hz}$$

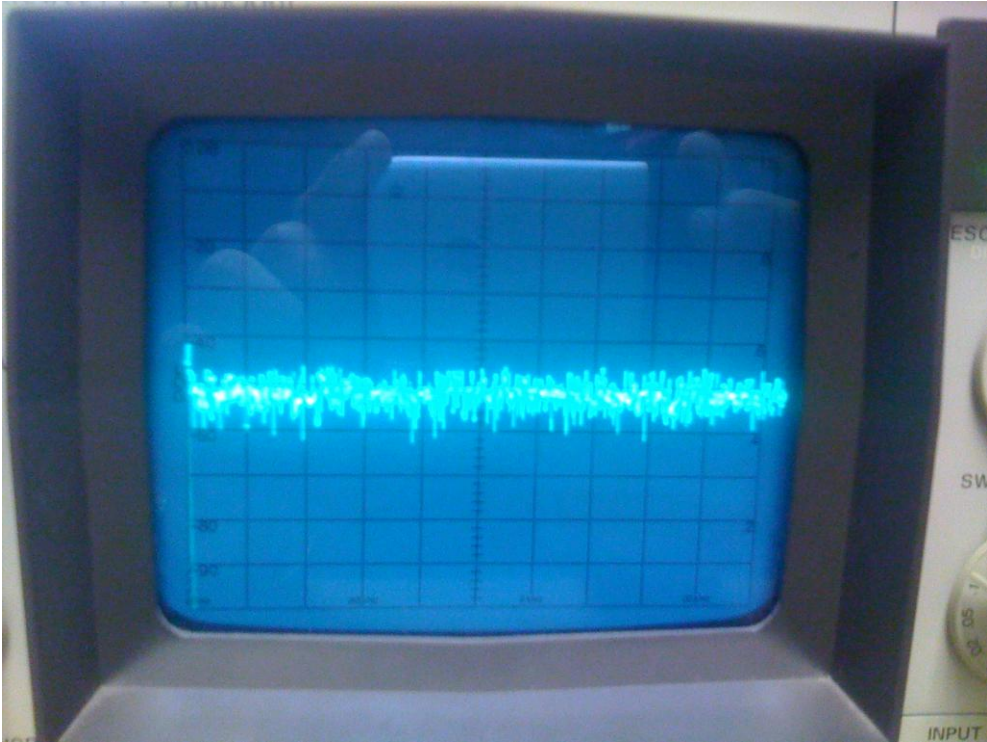
With the HP3580A display smoothing at 100Hz. Compute the power in 100 Hz of bandwidth by integrating the Power Spectral density. This is easy since the PSD is constant ( $N_0$ ).

$$P_{100} = 40 \text{ nV/Hz} \cdot 100 \text{ Hz} = 4 \mu\text{W}$$

$$V_{\text{rms-100}} = \sqrt{4 \mu\text{W}} = 2 \text{ mV}$$

$$V_{\text{rms-100-dBV}} = 20 \cdot \log(2 \text{ mV}) = -54 \text{ dBV}$$

Looking at the HP3580A in the (fuzzy) picture below, we see this -54dB at the min and the max is about 10 dB greater.



Here is a picture of the settings on the HP 3580A:

