FFT Laboratory Experiment 4
A Sum of Sinusoids

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Purpose:
This experiment illustrates how the FFT can be used to analyze the spectral content of a signal which consists of a sum of two sinusoids. A similar analysis using time-domain techniques can be difficult to perform on an oscilloscope.

Procedure:
1. Use two signal sources[4] and a resistor to construct the circuit shown in Figure 5.1. Alternatively, use an Agilent33120A Function/Arb Generator to create the required waveform.
2. Use the oscilloscope to verify that the v_1 and v_2 waveforms have the proper amplitude and frequency settings.
3. Use *Autoscale* to obtain a time-domain display of the voltage across the resistor. Since the voltage across the resistor is the sum of two sinusoids, and since the sinusoids have different fundamental frequencies, (which are not precisely harmonically related) the resulting time-domain display is unstable. Using the *Run* and *Stop* controls, it is possible to take “snapshots” of the resulting oscilloscope traces. This is illustrated in Figure 5.2.
4. As described in previous experiments, turn on the FFT display and turn off the time domain display on channel 1. Use the settings shown in Figure 5.3 to display the spectral content of the input signal. The *Cursors* controls can be used to accurately measure the frequency location of each sinusoid. It is also interesting to observe the effect of altering the effective sampling rate. Use the *Time / Div* control to slowly increase the sampling rate, allowing the FFT display to stabilize after each step increase. Note that it becomes increasingly difficult to distinguish the two sinusoids as the sampling rate is increased.
5. Adjust the frequency of source v_2 to 20 kHz. Use *Autoscale* to display the time-domain waveform. The resulting time-domain display is not stable.

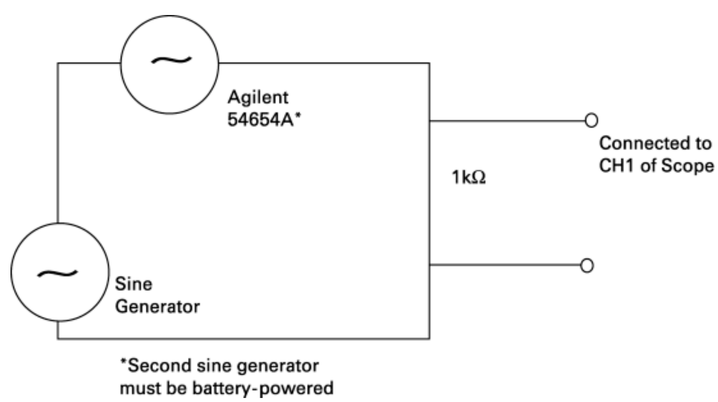


Figure 5.1
Circuit for Experiment 4. The voltage source $v_1(t)$ is a 3.5 *V* (peak-to-peak), 1 kHz sinusoid, and the voltage source $v_2(t)$ is initially set to be a 3.5 *V* (peak-to-peak), 2 kHz sinusoid.

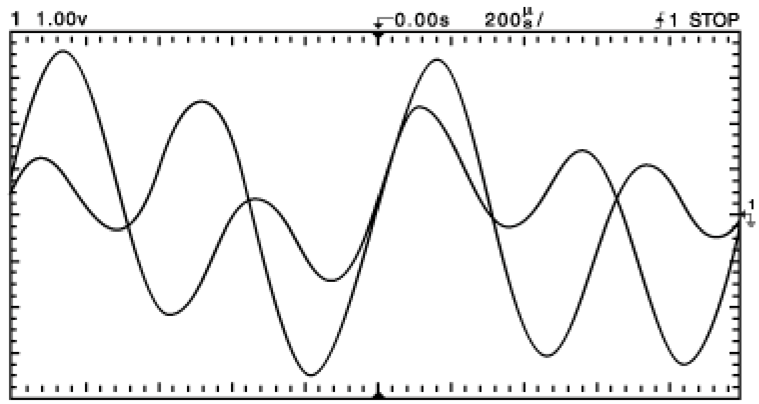
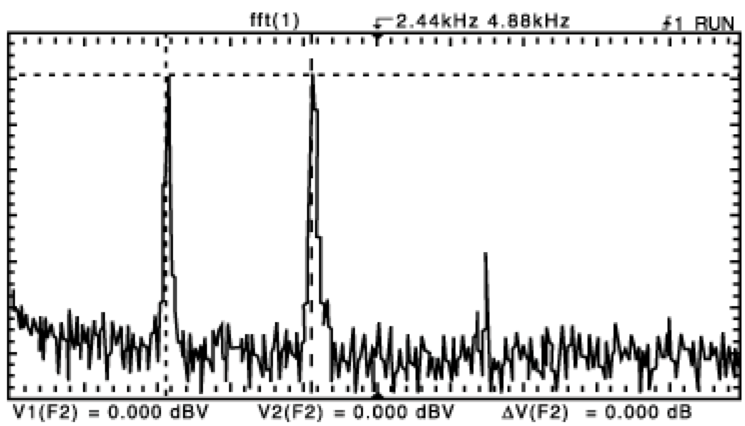


Figure 5.2

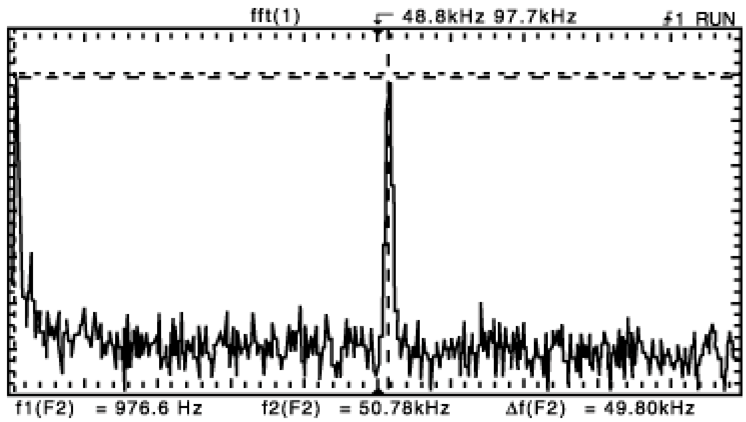
A time-domain display of the voltage across the resistor in Figure 5.1. This display was obtained by using the *Run* and *Stop* controls.



Function2: Menu		
Effective Sampling Rate	**Units/div**	**Ref Level**
10.00 kSa/s	**10.00 dB**	**10.00 dBV**
FFT Menu		
Center Freq.	**Freq. Span**	**Window**
2.441 kHz	**4.883 kHz**	**Hanning**

Figure 5.3

The 1024 point DFT (Magnitude) of a signal which consists of a summation of two sinusoids. Each sinusoid has a peak-to-peak voltage of 3.5 *V*. The fundamental frequencies of each sinusoid are nominally 1 kHz and 2 kHz, respectively.



Function2: Menu		
Effective Sampling Rate	**Units/div**	**Ref Level**
200 kSa/s	**10.00 dB**	**10.00 dBV**
FFT Menu		
Center Freq.	**Freq. Span**	**Window**
48.83 kHz	**97.66 kHz**	**Hanning**

Figure 5.4

The 1024 point DFT (Magnitude) of a signal which consists of a summation of two sinusoids. Each sinusoid has a peak-to-peak voltage of 3.5 *V*. The fundamental frequencies of each sinusoid are nominally 1 kHz and 20 kHz, respectively.

6. Turn on the FFT display and turn off the time-domain display on channel 1. Use Figure 5.4 for assistance in adjusting the FFT menu settings. In Figure 5.4, both frequency components are easily distinguished.

7. Adjust the *Freq. Span* and *Cent. Freq.* settings from the FFT Menu to “zoom-in” on the 1 kHz component. Use the *Cursors* controls to measure the display width of the 1 kHz component. At 31 *dB* down from the peak, the width is roughly 220 Hz. Notice that when the *Time / Div* control is used to reduce the effective sampling rate to 20 *kSa* / s, the high frequency term aliases to a lower frequency which is near the 1 kHz term.

Questions

1. How does the presence of a high frequency component affect the spectral resolution for analyzing narrowband components of the signal?

2. Based on the results of this experiment, why would it be difficult to use the FFT module to analyze the bandwidth of a “typical” amplitude modulated signal?

Conclusions

1. A stable time domain waveform is not required when using the Agilent 5465xA FFT module for performing a frequency domain analysis, as long as the time base sweep speed is slower than 50 ms/div. (see the Product Note 54600-4 for details).

2. It can be difficult to resolve narrowband frequency components when the input signal contains high frequency components. The effective sampling rate must be large in order to avoid aliasing, and thus, the resulting spectral resolution is poor.

[4] The Agilent 54654A Training Kit signal board can be used to generate the 1 kHz sinusoid. If two sources are used, one source must be floating, so scope ground does not short out or Interfere with signal. Alternatively, the Agilent33120A Function/Arb Generator can be programmed to generate a waveform equivalent to the sum of two sinusoids. This is accomplished using a PC and Agilent BenchLink/Arb software.

Answers to Questions

1. Because of the large sampling rate required to prevent the high frequency components from aliasing, the spectral resolution of a 1024 point DFT can be inadequate for analyzing narrowband frequency components.

2. Usually, the carrier frequency of an AM signal is much larger than the bandwidth of the modulating signal. The spectral resolution problems, mentioned in the previous answer, make a bandwidth analysis difficult using a 1024 point DFT.