Experiment 1
Spectral Analysis

1. Objectives:

   • To investigate the frequency spectra of different signal waveforms.

   • To verify three basic properties of the Fourier transform; namely the linearity (super position), time-shifting, and time (frequency) - scaling properties.

2. Prelab Assignment:

   1. (a) Find the exponential Fourier series for the periodic signal waveforms shown in Figure (1).

      (b) Determine the rms-value of each frequency component (up to the 6th harmonic) for all signals.
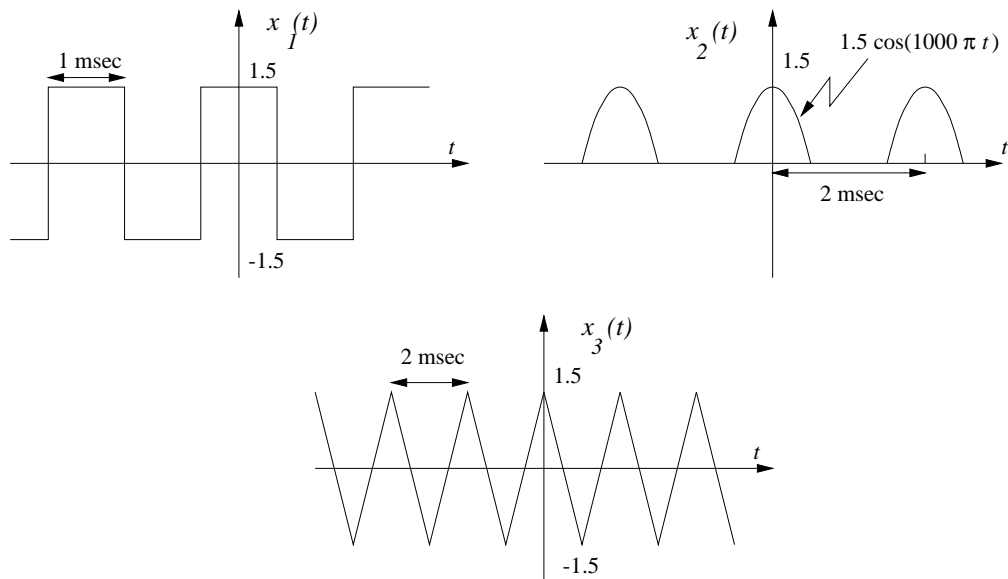

Figure (1)

   2. (a) Find the exponential Fourier series expansion for the time-shifted version of the halfwave rectified sinusoidal signal:

$$y(t) = x_2(t - 1\text{msec})$$

(b) Determine the exponential Fourier series expansion for the signal $z(t)$, where:

$$z(t) = x_2(t) + y(t)$$

what kind of signal waveform does $z(t)$ represent?

(c) Determine the rms-value of each frequency component (up to the 6th harmonic) for $z(t)$.

3. (a) Find the Fourier transform of:

$$v(t) = +3\text{rect}(t/1\text{msec})\text{volts}$$

(b) Use part (a), together with the time-scaling property, to find the magnitude of the Fourier transform for:

$$y(t) = +3\text{rect}(t/0.5\text{msec})\text{volts}$$

3. Equipment:

- Model SR760 FFT Spectrum analyzer

- Oscilloscope: Tektronix TDS 340A

- Function generator CFG 253

- Dual DC-power supply ± 8V (RPI bench P/S)

4. Procedure:

A. Line spectra of periodic signals

1. Familiarize yourself with the controls of the spectrum analyzer [your instructor will give you a quick run on how to use the analyzer]. Use the following control settings: [Start freq: 0.0 Hz, Span: 6.25kHz].

2. Use the oscilloscope to adjust the output of the function generator to 3V (p-p) sinusoid @ 500 Hz. Display this signal on the spectrum analyzer and record your results in table (1).

3. Set the output of the function generator to 3V (p-p) square wave @ 500 Hz; display the signal spectrum and record in Table (1).

   Repeat the step using a triangular wave instead of a square wave.

Table (1)

Signal Type	Frequency Component	
	Frequency (Hz)	Amp (Vrms)
Sinusoid		
Square Wave		
Triangular Wave		

B Time (Frequency) Scaling

4. Set the symmetry - control of the function generator fully clockwise. Adjust the frequency dial of the generator to generate a single pulse [1 msec duration] repeated at a relatively slow rate ($\approx$ 7.5 msec). Display this signal on the frequency analyzer. Plot the spectrum display on Graph (1).

5. Adjust the frequency of the function generator to generate a single pulse of 0.5 msec duration repeated at a relatively slow rate. Display this signal on the frequency analyzer, and plot the spectrum on Graph (1).
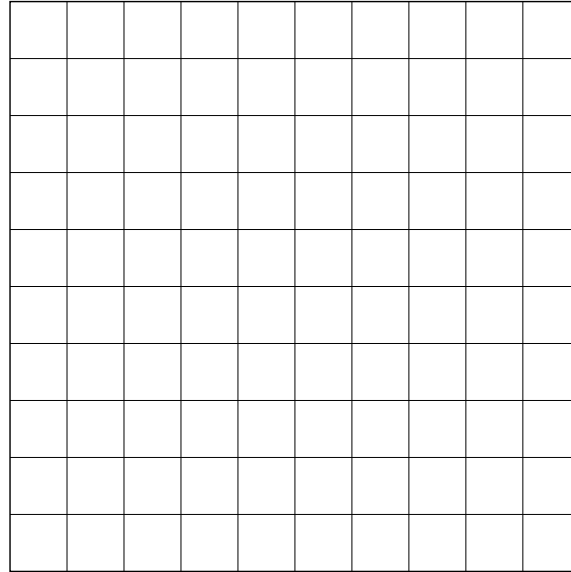
Graph (1)

C Superposition and Time-Shifting Properties

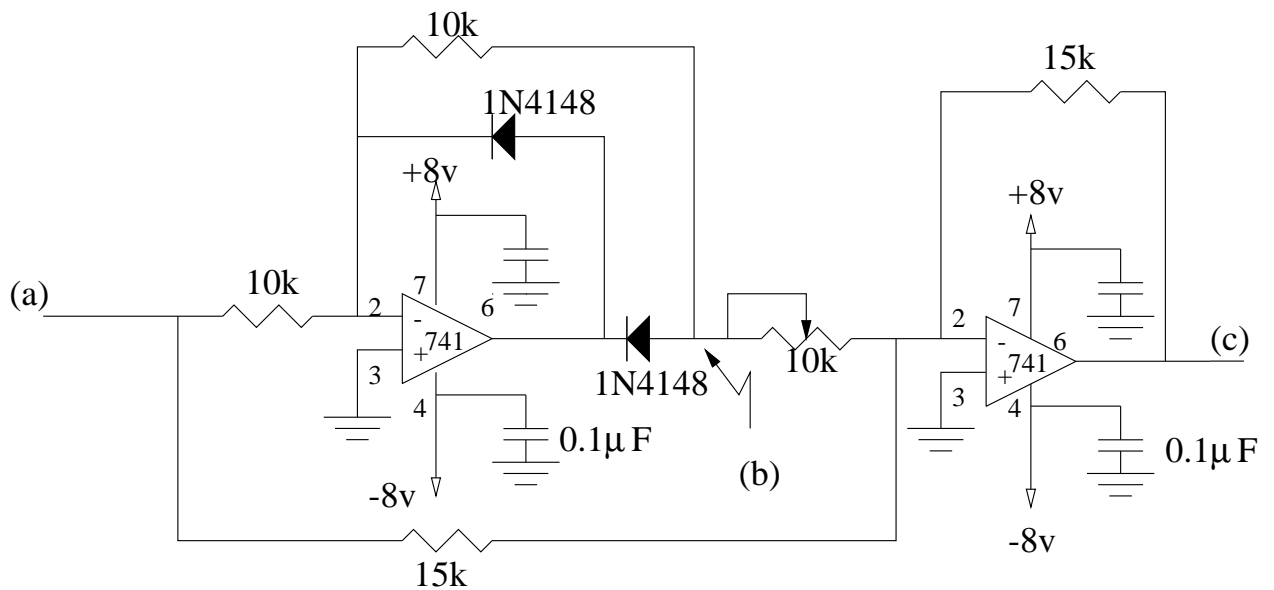6. Connect the precision full-wave rectifier circuit shown in Figure (2)

Figure (2)

7. Apply a 4V(p-p) sinusoid @ 500Hz to the input terminals of the above circuit. Display both waveforms at nodes (b) & (c) on the oscilloscope; adjust the 10kΩ-pot to ensure that the signal at node (c) is a full-wave rectified sinusoid.

8. With the spectrum analyzer's control set as in step 1, display the spectrum of the signal at node (b) and record your results in Table (2).

9. Display the signal at node (c) on the spectrum analyzer and record your results in Table (2)

Table (2)

Signal Type	Frequency Component	
	Frequency (Hz)	Amp (Vrms)
Half Wave Sinusoid		
Full Wave Sinusoid		

5. <u>Comments and Conclusions:</u>

1. How are the nulls of the envelope of the amplitude spectrum and the separation between the spectral lines determined for:

   (a) the 50% duty-cycle square wave,
   (b) the triangular wave

2. Compare the frequency content of the square wave with that of the triangular wave.

3. Compare the frequency spectrum of the 1 msec-pulse with that of the 0.5 msec-pulse; both are of equal amplitude.

4. Compare the frequency content of the full-wave rectified sinusoid with that of the half-wave rectified signal.

5. What would be the frequency spectrum of the difference signal, $D(t) = x_2(t) - y(t)$? [see the prelab assignment]. What kind of signal waveform does $D(t)$ represent?