MULTISIM DEMO 13.3*: ANALYSIS OF A SQUARE WAVE

As introduced in the textbook, all periodic signals can be represented as nothing more than the summation of sine waves of specific amplitudes and frequencies. We will add a series of sine waves in succession to see the gradual production of a square wave.

As we can readily derive using the Fourier Theorem, a square wave can be expressed by the simple sum of equations:

$$v(t) = \frac{2 \cdot A}{\pi} \sum_{m=1}^{\infty} \frac{1}{n} \cdot \sin(n \cdot \pi \cdot t) \quad \text{V} \qquad \text{where } n = 2m-1$$

Let's use the ABM Source in Multisim to progressively add up to the ninth harmonic component of a square wave possessing an *A* of 2 V and a frequency of 10 kHz.

Build the simple circuit shown in Fig. 13.3.1 composed of an ABM_VOLTAGE source, a Spectrum Analyzer, and an Oscilloscope. Double click on each of the instruments to bring up their control/viewing panels, and position them so that you can read both at the same time but still have access to the ABM_VOLTAGE source to alter its Voltage Value equation.

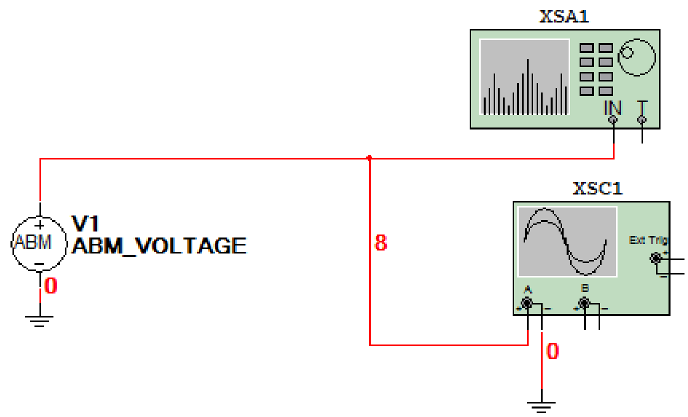

Figure 13.3.1 Measuring the output of the ABM source using both an oscilloscope and a spectrum analyzer.

With the oscilloscope and the spectrum analyzer we can get a view of the signal we are creating in both the time domain and the frequency domain. Be sure to use the cursors to explore the frequency peaks in the spectrum analyzer output and the frequency and amplitude of the overall waveform in the oscilloscope screen as you progress through the following experiments.

The First Harmonic

The first harmonic is composed of $\frac{2\cdot 2}{\pi}\sin(2\pi\cdot 10\times 10^{3}\cdot t)$ which corresponds to an ABM Voltage Value Equation of 2*2/PI*sin(10000*2*PI*TIME). Insert this into the ABM source and simulate. The instrument outputs should resemble Fig. 13.3.2 below.

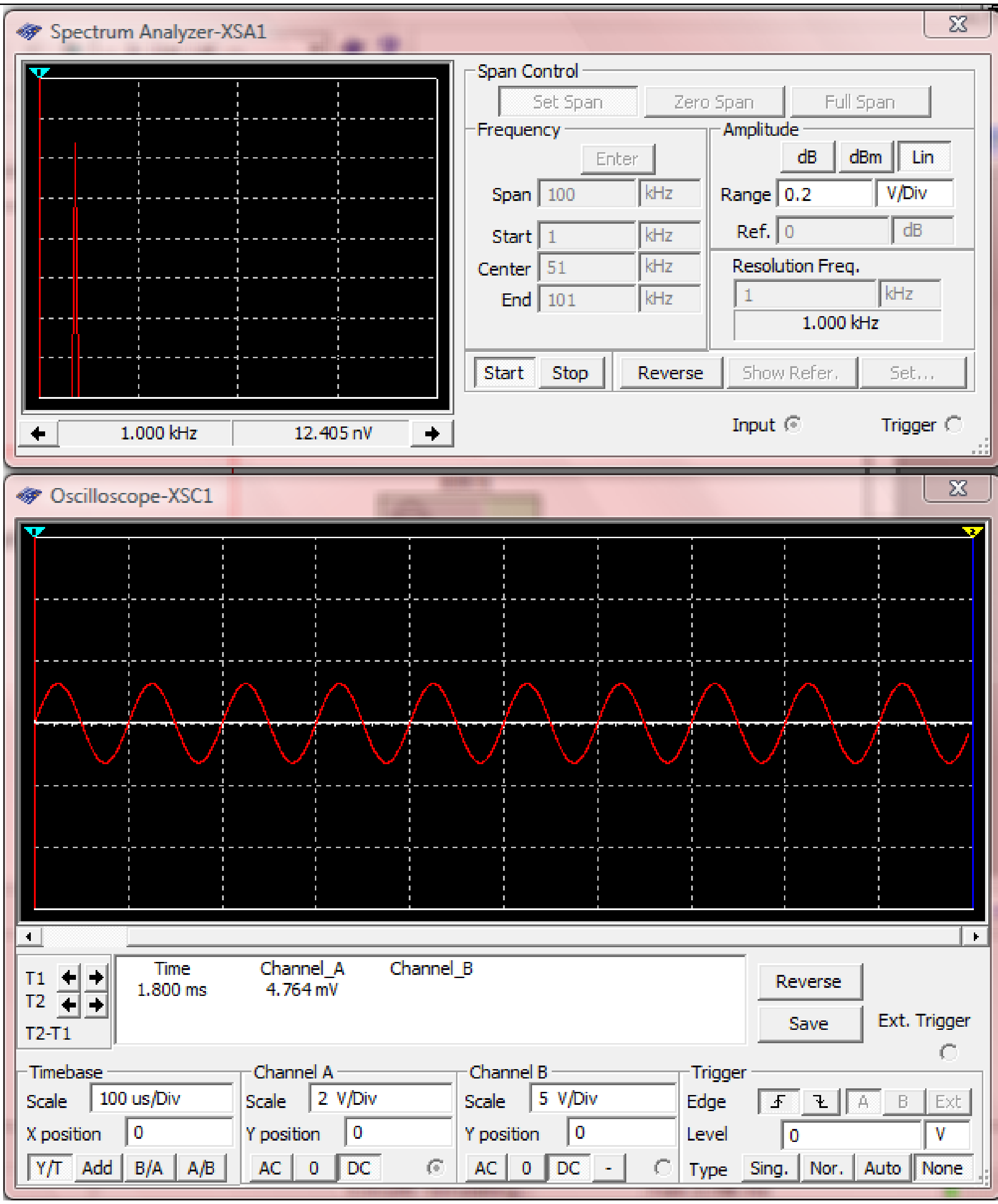

Figure 13.3.2 Oscilloscope and Spectrum Analyzer Readout for first harmonic only.

The First and Third Harmonics

The third harmonic component is $\frac{2\cdot 2}{3\pi}\sin(2\pi\cdot 3\cdot 10\times 10^3\cdot t)$ which corresponds to an ABM Voltage Value Equation of 2*2/(3*PI)*sin(30000*2*PI*TIME). Add this into the ABM source and simulate, but remember to keep the first harmonic component as well! The instrument outputs should resemble Fig. 13.3.3 below.

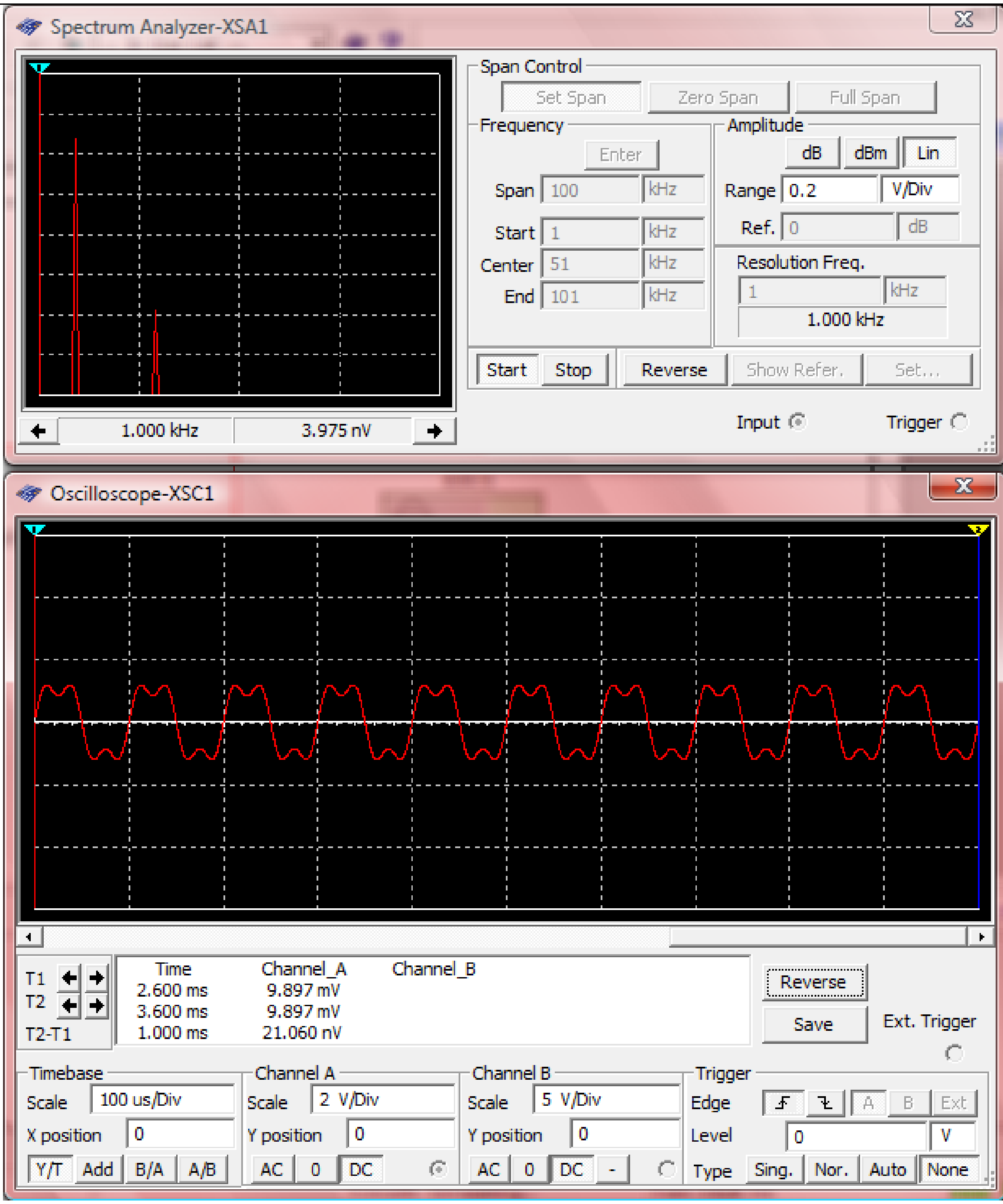

Figure 13.3.3 Oscilloscope and Spectrum Analyzer Readout for first and third harmonics.

The First through Fifth Harmonics

The third harmonic component is $\frac{2\cdot 2}{5\pi}\sin(2\pi\cdot 5\cdot 10\times 10^{3}\cdot t)$ which corresponds to an ABM Voltage Value Equation of 2*2/(5*PI)*sin(50000*2*PI*TIME). Add this into the ABM source and simulate, but remember to keep the first and third harmonic components as well! The instrument outputs should resemble Fig. 13.3.4 below.

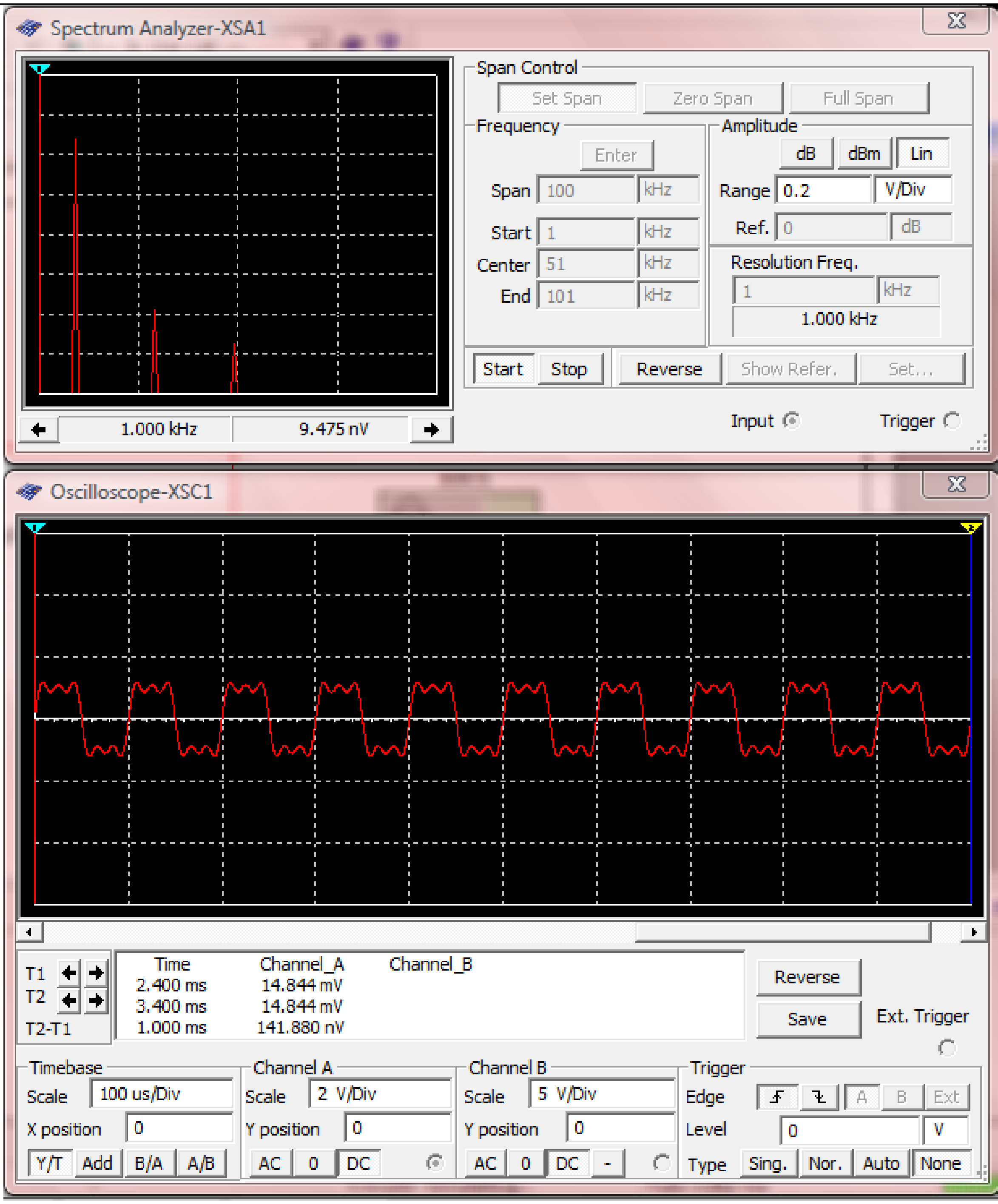

Figure 13.3.4 Oscilloscope and Spectrum Analyzer Readout for first through fifth harmonics.

The First through Seventh Harmonics

The third harmonic component is $\frac{2\cdot 2}{7\pi}\sin(2\pi\cdot 7\cdot 10\times 10^{3}\cdot t)$ which corresponds to an ABM Voltage Value Equation of 2*2/(7*PI)*sin(70000*2*PI*TIME). Add this into the ABM source and simulate, but remember to keep the first, third, and fifth harmonic components as well! The instrument outputs should resemble Fig. 13.3.5 below.

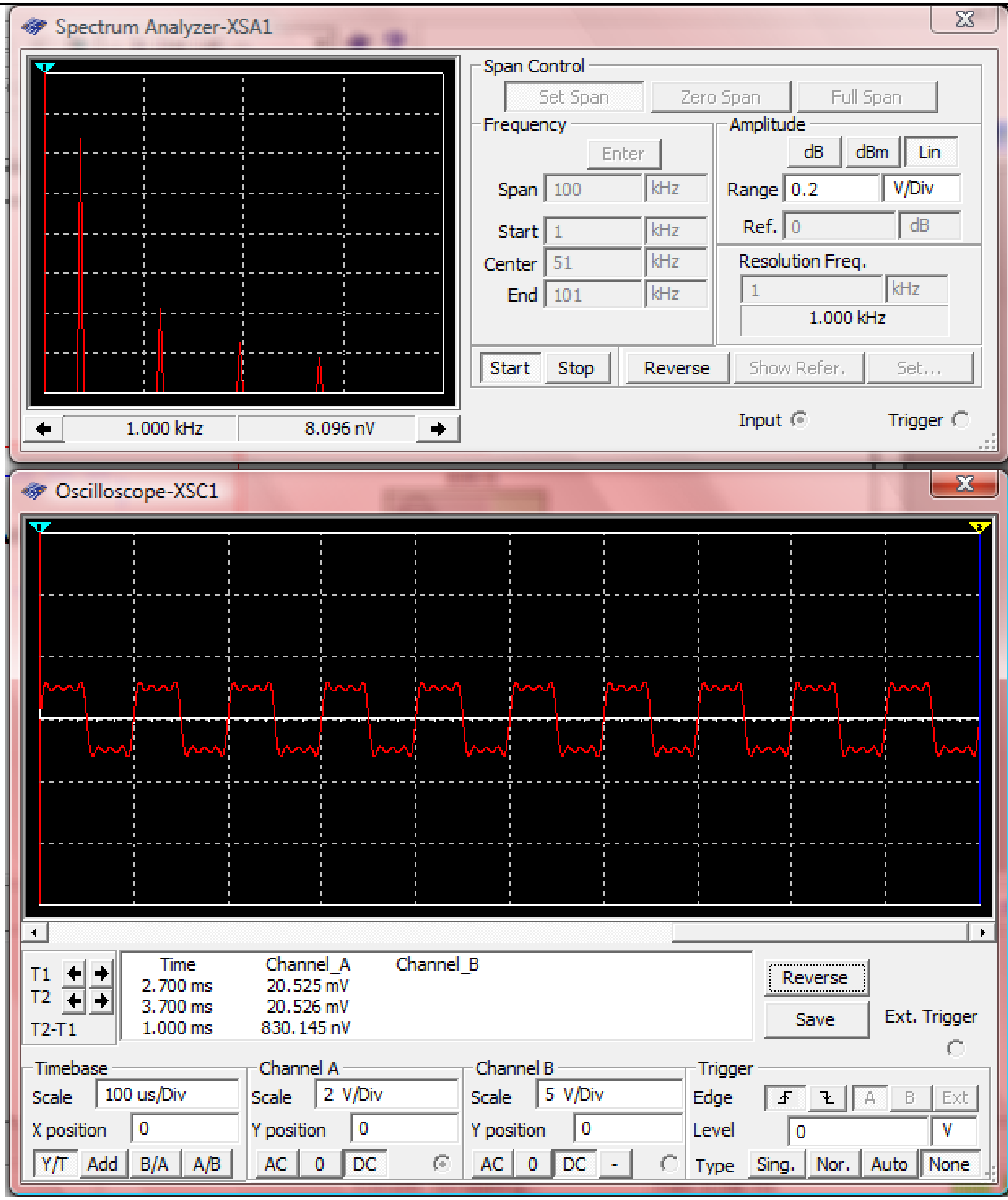

Figure 13.3.5 Oscilloscope and Spectrum Analyzer Readout for first through seventh harmonics.

The First through Ninth Harmonics

The third harmonic component is $\frac{2\cdot 2}{9\pi}\sin(2\pi\cdot 9\cdot 10\times 10^3\cdot t)$ which corresponds to an ABM Voltage Value Equation of 2*2/(9*PI)*sin(90000*2*PI*TIME). Add this into the ABM source and simulate, but remember to keep the first, third, fifth, and seventh harmonic components as well! The instrument outputs should resemble Fig. 13.3.6 below.

Figure 13.3.6 Oscilloscope and Spectrum Analyzer Readout for first through ninth harmonics.