Multitone Generator

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Danville Signal Processing
2010 comp.dsp Conference

Multitone Signal:

A composite of several sine waves, where each sine wave can have distinct amplitude, phase and frequency.

A Multitone signal is useful for testing the frequency response of a system quickly.

Stepped sine or swept sine measurements can have significant setting time issues.

A quick visual observation or simple level measurement can be used for production testing.

Phase Accumulator Sine Generator:

The phase-accumulator method calculates the angle $\theta = \omega_0$ nT, required at the next same time. You can think of the phase accumulator as a modulo counter that counts from 0 to 2π in n steps.

The simplest phase-accumulator signal generator uses a table of precalculated sine or cosine values at angle θ_n

$$\theta_n = 2\pi * \Delta f_0 * n/F_s$$

where

Δf_0 is the frequency increment
F_s is the sample rate
n is the step size

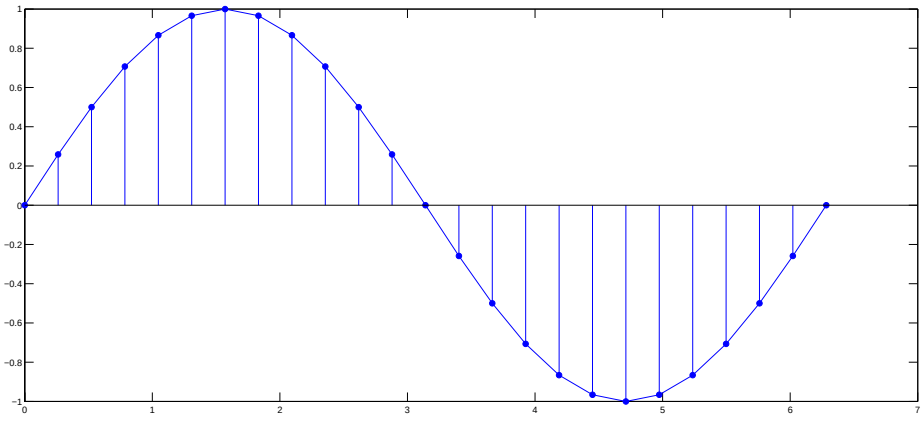
For example, a generator with 10 Hz resolution and 48000 Hz sampling will have 4800 sine or cosine coefficients. Our angles are going to be 0, $2\pi/4800$, $2\pi * 2/4800$, …… $2\pi * 4799/4800$.

The next step is to calculate the desired frequency of the generator.

$$\Delta\theta = f/\Delta f_0$$
$$\theta_n = (\theta_{n+1} + \Delta\theta) \text{ MOD } n$$

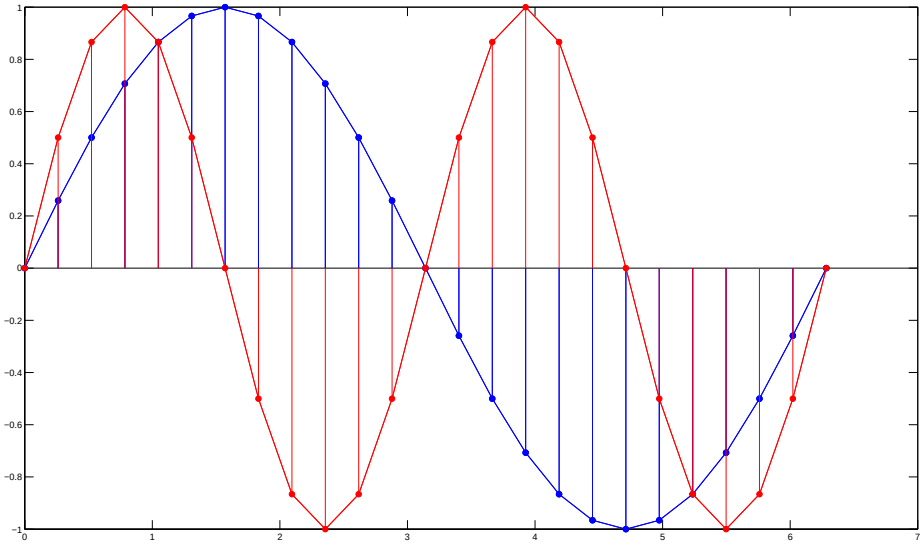
Using the previous example, if we want our generator to output 310 Hz, we increment the phase accumulator by 31

Here is an example with 24 sine values where the phase is incremented by 1. This is the lowest frequency available with this table and is equal to the frequency increment Δf_0

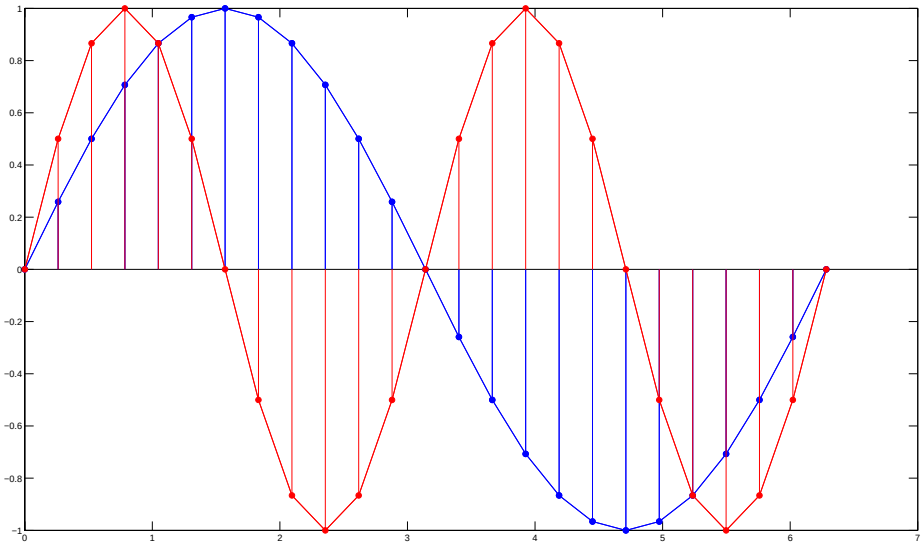


We could generate higher frequencies by stepping in larger multiples of Δf.

For example, we could also step by increments of 2 as shown below:



Multitone Signals



Given a table length of 24, notice that the higher frequency actually rotated around the phase table twice.

We could choose to store each phase increment of this frequency in a smaller table of length 12 and increment by 1.

If the table length was 24 and still used an increment of 1, we would store 2 cycles ($2 * 2\pi$).

Multitone Signals

Determine phase tables of size N where each desired frequency repeats exactly at n=0.

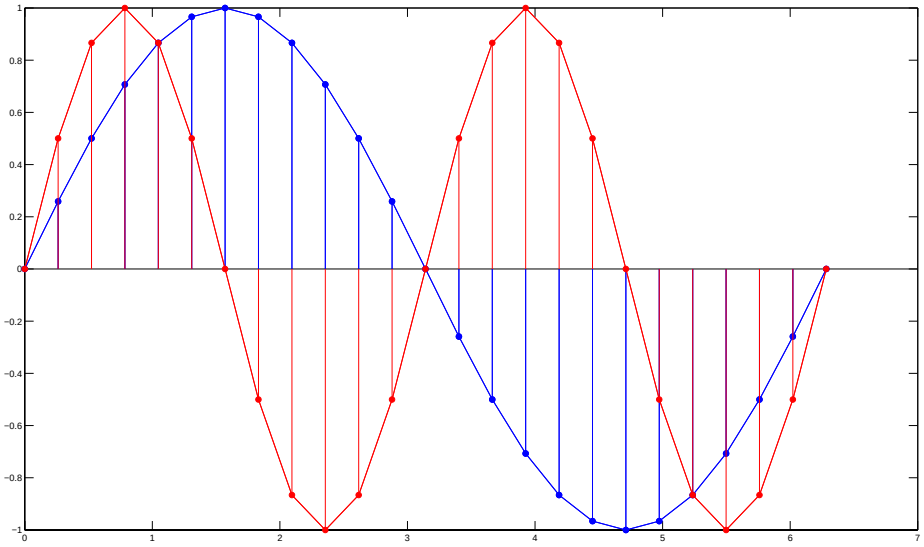
This means that the lowest possible frequency would be represented by 1 cycle (2π), the next by 2 cycles (4π), 3 cycles (6π), etc.

The highest frequency would be

$$f_{max} = F_s (N-2)/2N$$

By superposition, each table could be summed together into a single table of size N.

To prevent overflow, the values of the composite table are rescaled by dividing each value by the number of tones.



Individual sine tones

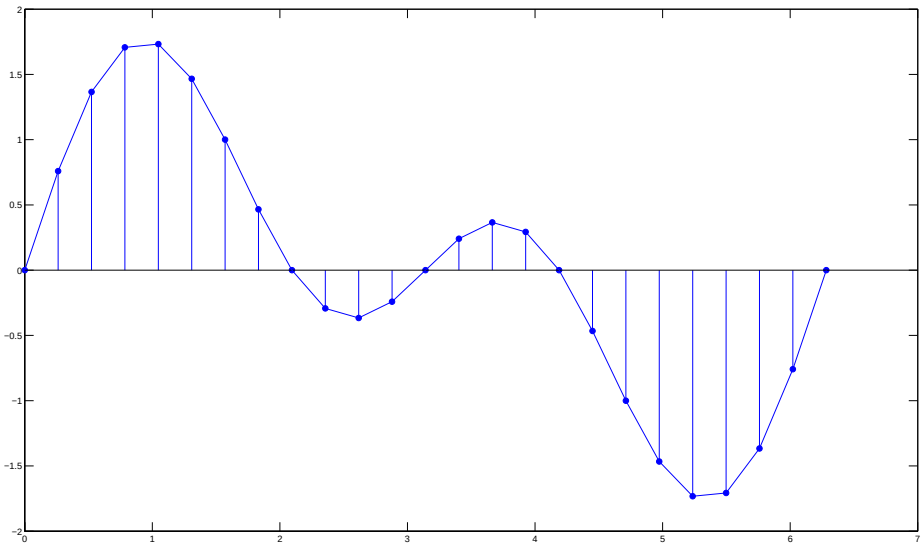


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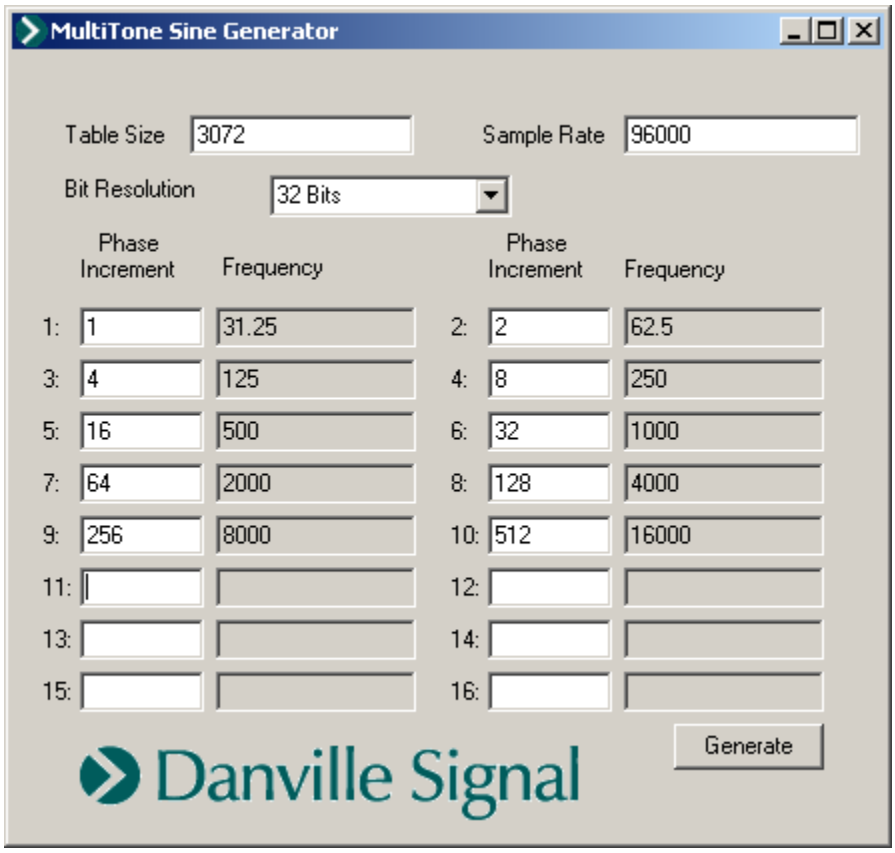
Table Generation

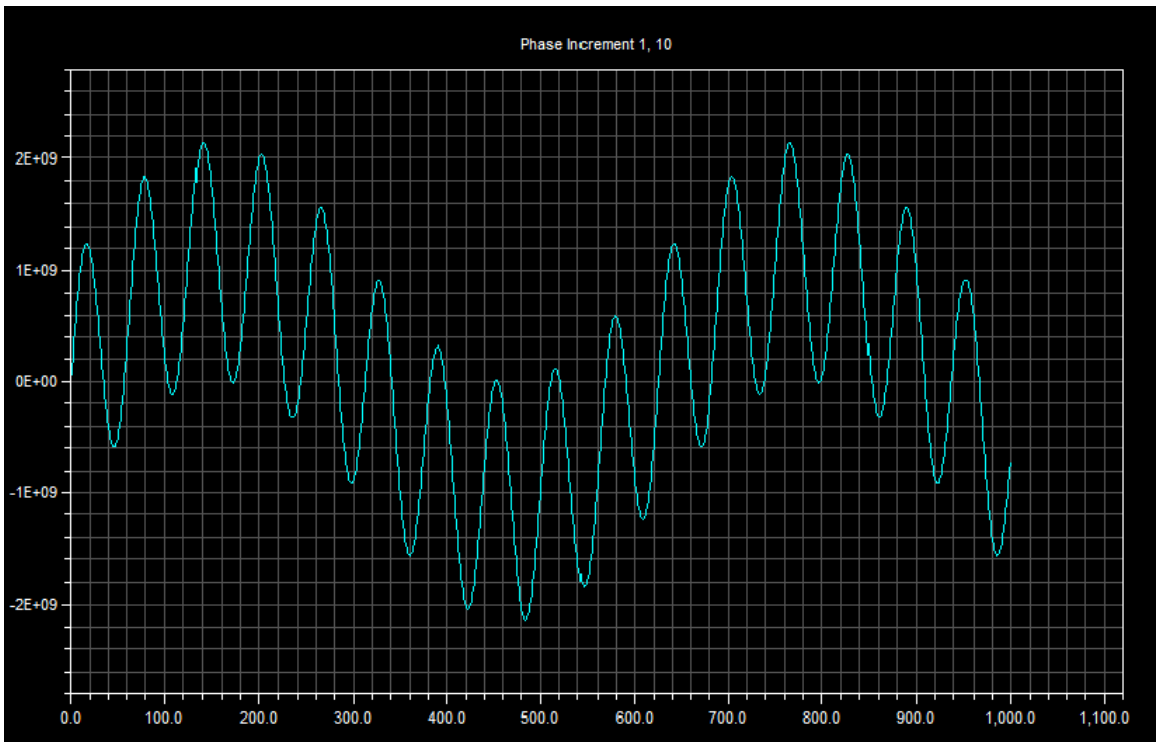
The Danville Signal multitone generator program generates a phase table for multitones with up to 16 sinusoids. Although, there is no specific requirement for multitones to be the same amplitude or starting phase, this program assumes amplitude of 1 and starting phase of 0 for sines.



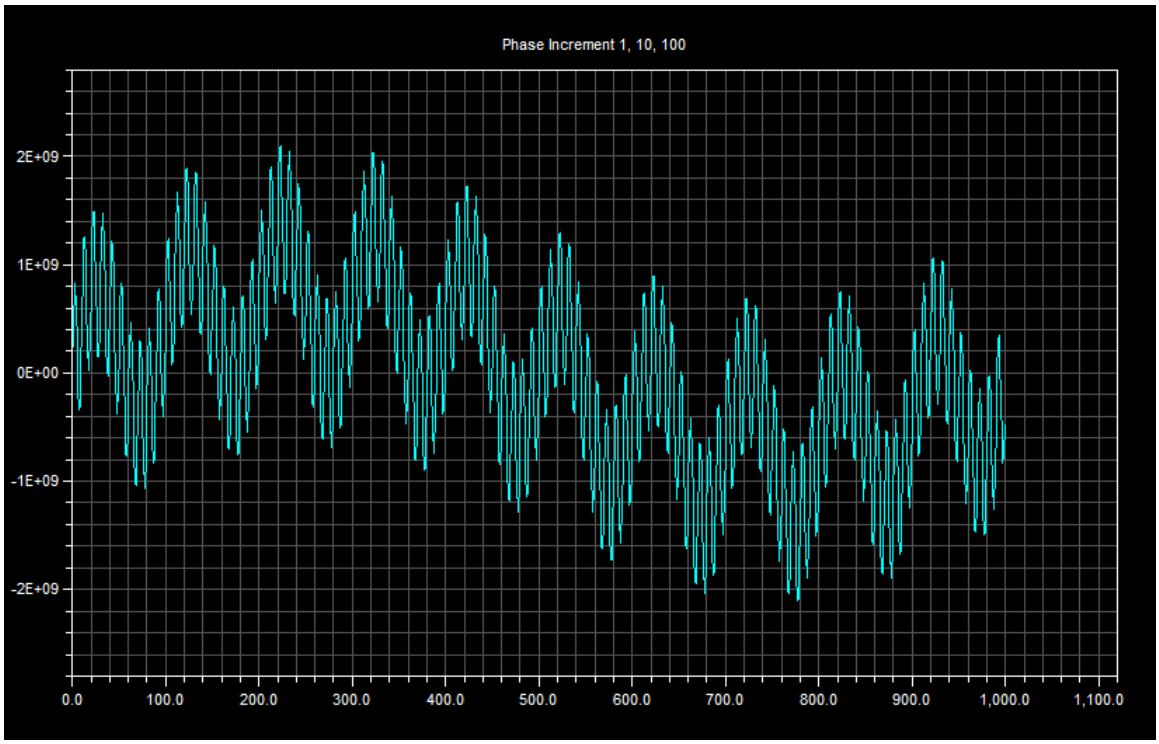
The above example creates octave specified sine waves with a 1000 Hz center frequency.

You can request a copy of the Danville Signal multitone generator program sending an email to dsp@danvillesignal.com

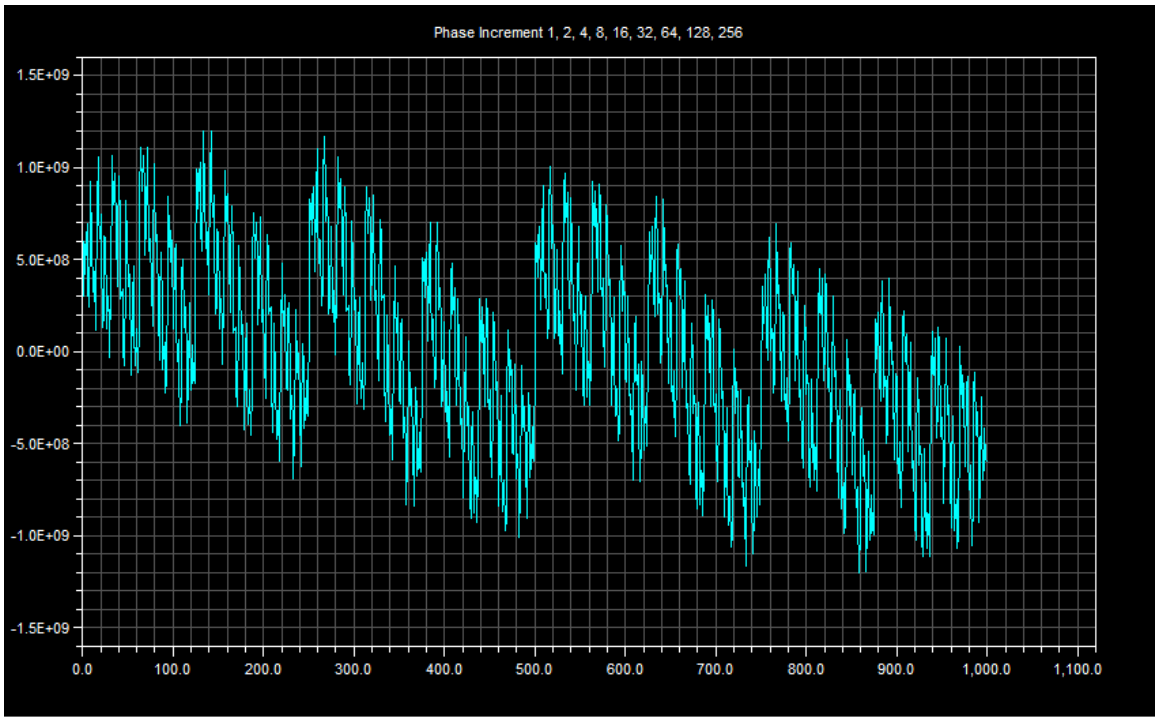
Examples from Analog Devices VisualDSP++5.0 for SHARC (simulator)



f = 1 & 10



f = 1, 10 & 100



Octaves

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