# Users Manual

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# Signal Maker Users Manual

1.  **Introduction**

    Signal Maker is a wave file generation utility.  It allows the user to quickly and easily generate a wide variety of test signals.  The wave files are stored as 16 bit, mono signals intended to be played back at 44.1 kHz.  The waves are always saved with the highest sample value set to 0dBFS (be careful during playback!)

    Signals can be colored with virtually any useful spectral shape and the crest factor can be controlled precisely.  The use of the resultant wave file as a test signal eliminates the need for external filters, noise generators, CD players, clipping circuits, etc.  Copies of the file can be distributed to different test sites so much of the test setup is perfectly duplicated with the play back of the digital signal.  May sources of variation are eliminated.

    The graphic below shows the Signal Maker screen.  The calculated spectrum is plotted against the target as well as a third octave response.
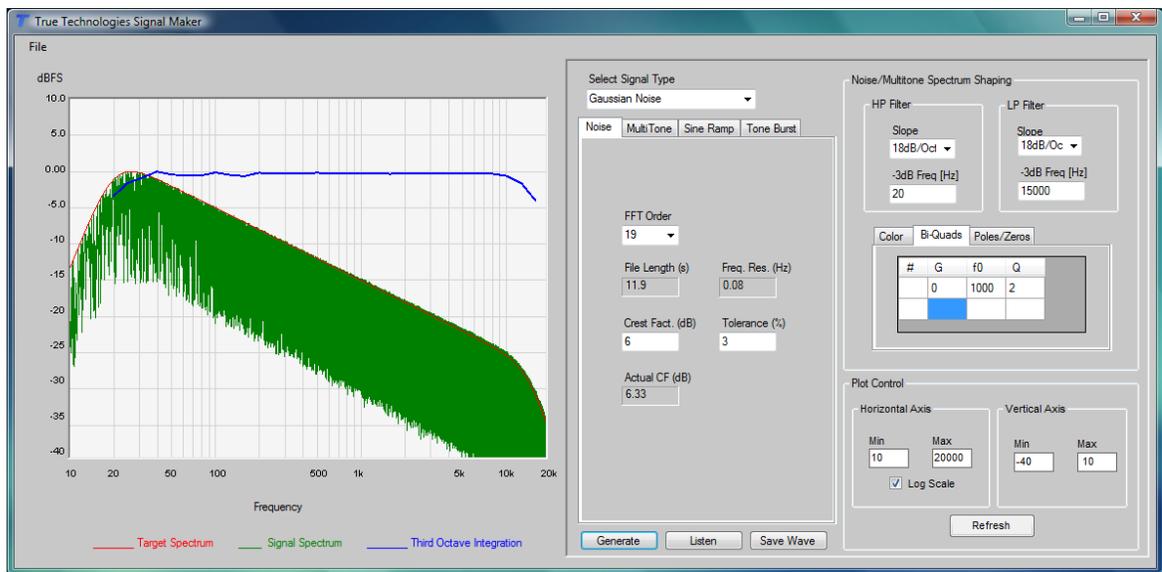
## 2. <u>Signal Types</u>

To begin creating a signal, select the signal type from the drop down box.  The choices are Gaussian Noise, Tone(s), Sine Ramp (tone warbles), and Tone Bursts.  The panel for setting up the particular type of signal will be brought forward.  The following describes the options for each.

### 2.1.  Gaussian Noise

First select the FFT Order from the drop down.  The number of samples in the file will be $2^{FFTOrder}$ and the resulting file length in seconds will be displayed along with the frequency resolution between bins in the FFT used to generate the noise.

The Crest Factor (CF) can also be entered with a tolerance.  The program will iteratively run the noise through a soft clipping algorithm until the desired crest factor is reached.  If the CF is not attainable, the software will give up and the resulting CF will be displayed.

All of the options for spectrum color and filtering are available for processing the underlying Gaussian noise.

## 2.2. Multitones

By selecting the Tone(s) signal type from the drop down, one or more pure tones will be generated. The setup panel for this option is shown below. The FFT Order must be selected and this determines the number of samples in the wave file, the file length in seconds and the spacing between possible tone frequencies (FFT bins.) When tones are generated at FFT bin frequencies, they will have an integral number of cycles in the wave so the beginning and ends of the wave will meet with the same sample value and slope. This ensures there will be no clicks or pops when the wave file is played on a loop. It also allows for FFT analysis of recorded signals of DUTs excited with this type of test signal (using other analysis tools.)
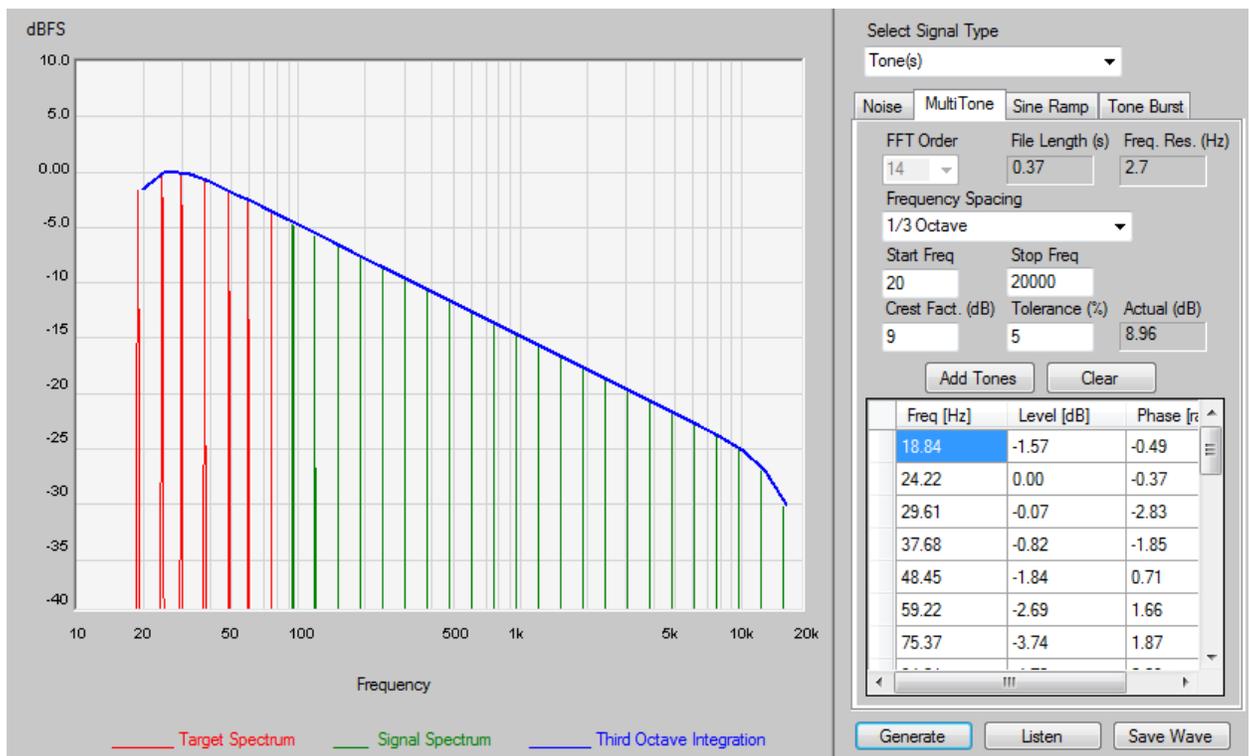


To generate the Multitone signal (or a single tone) select the frequency spacing option from the drop down box. The example above shows a third octave spacing. Also enter the lowest and

highest tone you want to include in the wave.  The tones in this signal spread from 20 Hz - 20 kHz.

Enter the desired Crest Factor.  The software will randomize the phase between tones and check the resultant CF.  If it does not reach the targe value, it will try again with up to 20 attempts.  If the CF is not achieved in this number of tries, it probably is not possible, but the software will ask if another 20 tries should be made.

Before clicking the Generate button, you must click the Add button to fill the frequencies, level, and phase of each tone into the table.  You can edit the values or add new ones.  For a single tone, enter it into the start frequency and leave the stop frequency blank.  Multiple sets of tones can be added.  To clear the table and start over, click the Clear button.

Note the Levels in the table are relative values.  The final wave is always saved with the highest sample value set to 0dBFS.

When the set of desired tones is shown in the grid, click the Generate button.  The actual frequencies generated are the FFT bin frequencies that are closest to the values in the table.  For less error between grid frequencies and actual frequencies, choose a larger FFT order.  The maximum error will be ½ the shown Frequency Resolution.

The Spectral coloring options and the filtering options are available for Multitones.  In the example above, the color was set to Pink and High Pass and Low Pass filters were added at 20Hz and 15 kHz respectively.  The crest factor was entered as 9dB and the software reported back the actual value was 8.96 dB.

2.3   Sine Ramps.

A sine ramp is a pure tone that ramps up and down in frequency. Fast sine ramps are often referred to as tone warbles.  Below is an

example of a Sine Ramp.  In this case, the tone ramps from 40 Hz to 150 Hz and then back down again in 0.37 seconds.  The total up/down cycle time is determined by the FFT Order selected and is indicated in seconds.

A heating tone can be added if desired.  This can be useful when trying to sort out whether heat is a primary factor in a loudspeaker driver failure mode or if it is purely mechanical stress.

The signal created in the example below would be useful for exercising a woofer that has a nominal resonance frequency around 80 Hz and Z min around 500 Hz.  The woofer will be run through the region of maximum excursion regardless of the actual resonance frequency.  The heating tone will result in maximum and controlled current flow/power dissipated in the driver.

Note, the spectrum of the sine ramp indicates a pink nature with the level falling off at -3dB/octave.  However, an inspection of the wave form will reveal the peaks at all frequencies are equal.  The apparent drop off in the frequency domain is due to the higher frequencies being present for a smaller percentage of the total signal duration.  This is due to the logarithmic nature of the timing ramp.
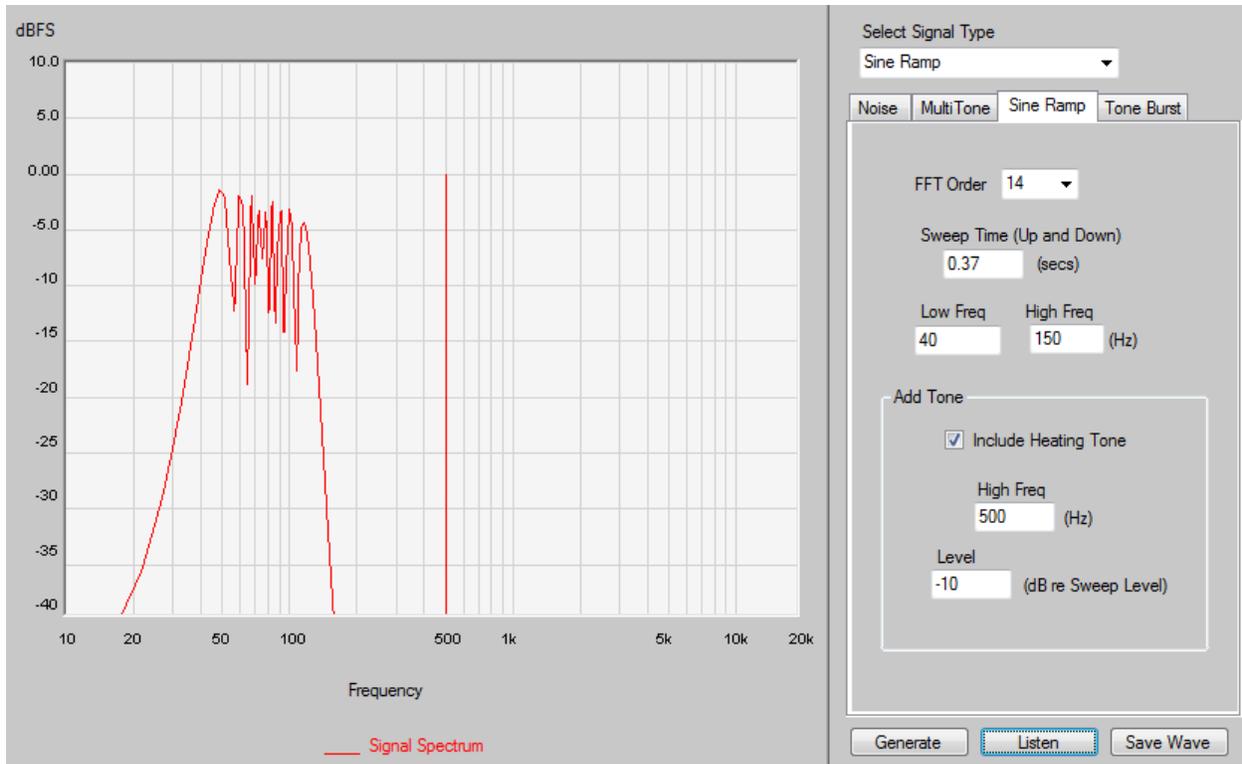
### 2.4. Tone Bursts.

The Tone Burst signal type allows for bursts at any frequency with a specified number of cycles for each burst. In the example below, a 100 Hz burst of 6.5 cycles is generated. The wave file is 1 second long so this is the period of the burst when the wave is set to loop. As with the Sine Ramp signal, a heating tone can be added to the Tone Bursts. Note the burst is tapered on both ends using a raised cosine window.
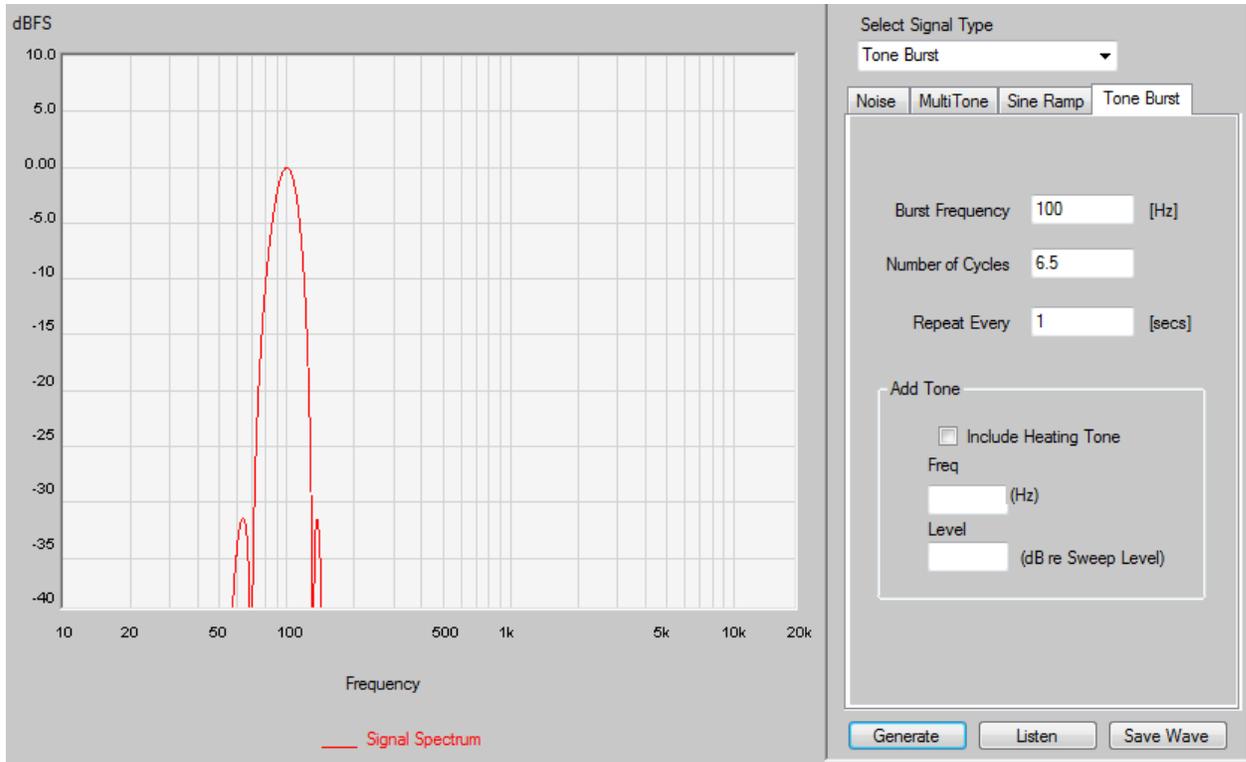
## 3. Coloring the Spectrum

The panel on the upper right controls the spectrum coloring and filtering options and is shown below.  High Pass and Low Pass filters can be added simply by selecting the filter slope and entering the half power frequency for each.  They are Butterworth filters.

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The color tab offers 4 options for the underlying spectrum shape. White, Pink and Brown are options as well as EIA/RS-426B.  When selecting the latter, the noise panel is automatically setup with a 19th order FFT and 6dB Crest Factor that is dictated by the spec.  After clicking Generate, the spectrum shown below is created.  After choosing RS426B, the signal type can be changed to Multitones if desired and/or High and Low Pass filters can be applied to further restrict the bandwidth of the signal.
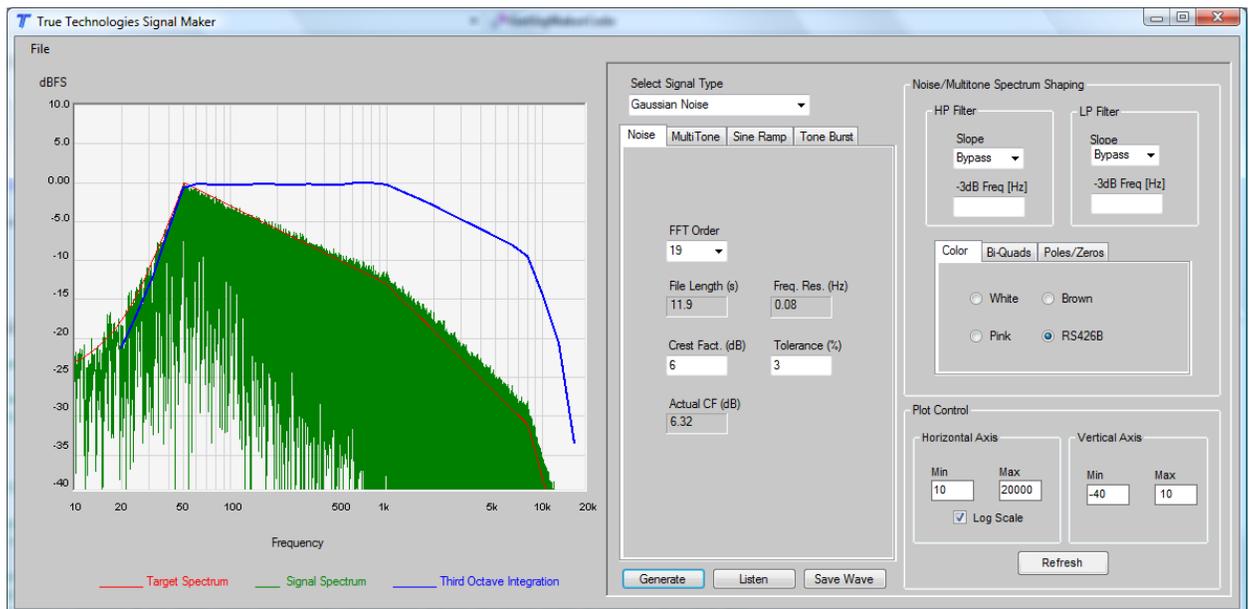


Bi-Quad and shelving filters can also be added to create almost any desired spectral shape.  The two grids for adding the parameters for these filters are show below.

| # | G | f0 | Q |
|---|---|------|---|
|   | 10 | 1000 | 2 |
|   | -20 | 500 | 3 |

| P/Z | f0 |
|-----|------|
| P | 400 |
| Z | 1500 |

These parameters were applied to white noise with an 18dB/Octave HPF at 40Hz and a 36dB/Octave LPF at 15 kHz to yield this result.
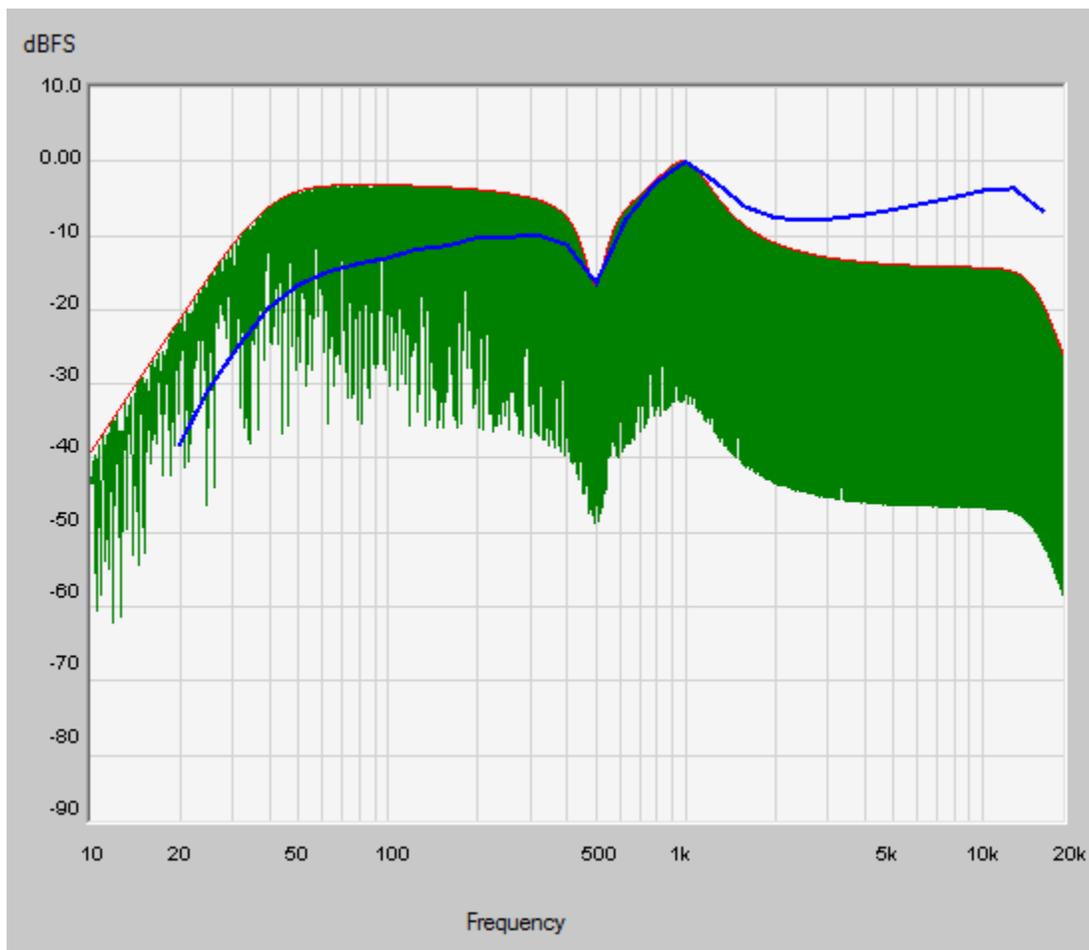
## 4.  Auditioning and Saving the Wave File

Once the desired signal is generated the Listen button will play the signal through the default audio device setup in the Windows control panel.  THE GENERATED WAVE HAS A PEAK LEVEL OF 0dBFS!!  Be very careful not to play it through speakers or headphones without first turning down the volume.  Failure to do so can result in damage to play back devices or to listener hearing.

When auditioning the signal, be sure there is not a repetitive nature to noise signals.  If there is, a longer FFT Order should be used.  Also be sure no pops or clicks are noted in other signals.  Slight adjustments of the parameters might be required if this is the case.

If the auditioned signal is satisfactory, then it can be saved by clicking the Save Wave button.  The default directory is Wave Files under the main Signal Maker directory.

## 5. References

For information on the RS426B signal creation and the soft clipping algorithm used to set the crest factor for noise signals, see Don Keele's AES Convention Paper 5451, 111th convention, 2001 September 12-14.