Creating Custom Multitone with Agilent U8903A Audio Analyzer

Application Note

Introduction

A multitone waveform is an audio signal comprised of multiple tones. Figure 1 shows an example of a multitone signal consisting of 20 tones from 1 kHz to 20 kHz. Multitone waveforms are widely used in modern audio measurements to test consumer and professional audio devices, broadcast devices, and internet audio. A multitone is an ideal test signal for an open-loop audio test where the analyzer does not need to coordinate with the generator. This feature allows an audio signal to be tested over a long distance, such as audio via internet, or a playback device such as a mobile phone.
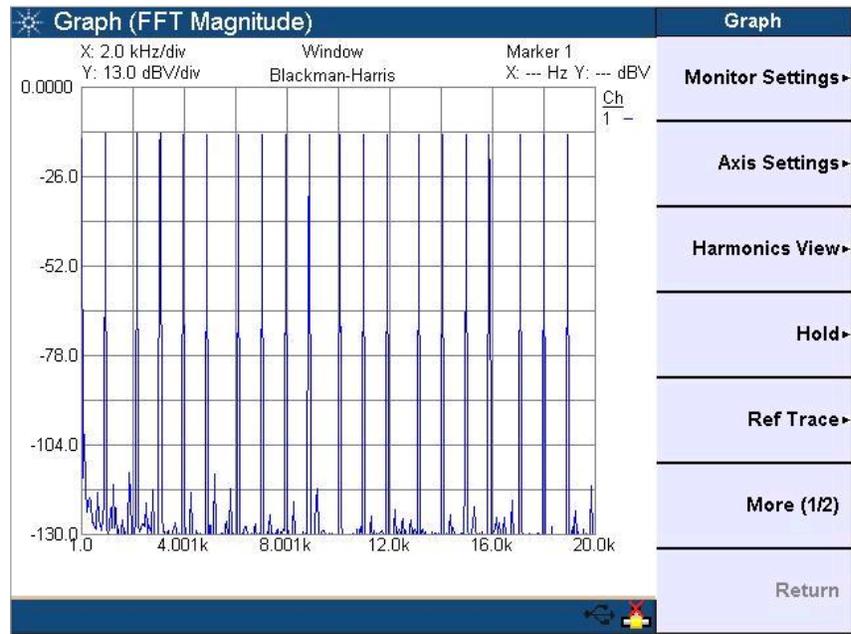

Figure 1. An example of a multitone signal consisting of 20 tones

Standard multitone signals have evenly-spaced tones with equal amplitudes as shown in Figure 1. However standard multitone signal do not represent real-world test conditions, making it necessary to create custom multitones.

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For example, when testing a filter, additional tones can provide detailed characterization of specific frequency ranges, such as the rising and falling edges of the filter curve. When testing a pre-amplifier, it may be desirable to lower individual tone amplitudes to avoid overloading the device under test (DUT). In other cases, it may be necessary to create custom multitones defined by industry standards such as Dolby or DTS.

Creating a custom multitone waveform with the Agilent U8903A audio analyzer is quick and convenient. This application note shows the Agilent U8903A audio analyzer can be used to create a standard multitone and then used to modify the parameters of the standard multitone to create a custom multitone waveform. Throughout the example, bold text is used to indicate keys on the instrument. Text in [ ] refers to softkeys presented on the instrument's screen.

Process Overview

There are four basic steps to creating custom multitone signals:

1. Create a standard (equally-spaced) multitone waveform.
2. Modify the frequency, amplitude, and phase values.
3. Verify the custom multitone waveform.
4. Save and recall the multitone waveform as an arbitrary file.

To illustrate this process, the following sections demonstrate how to create a custom, six-tone multitone waveform as specified in Table 1.

Table 1. The parameters for the six-tone custom multitone waveform to be created.

Tone number	1	2	3	4	5	6
Frequency	2 kHz	3.5 kHz	4.8 kHz	5 kHz	5.2 kHz	5.5 kHz
Relative amplitude	10 mVrms	10 mVrms	20 mVrms	20 mVrms	20 mVrms	20 mVrms
Phase	Random phase					
Total amplitude	1 Vrms					
Crest factor	< 3.2					
DC offset	0 Vrms					

Notes:

1. The relative amplitude shown in Table 1 is a relative value. The actual amplitude of the multitone is determined by the total amplitude setting. The sum of the individual tone amplitudes is not the multitone's amplitude. Most multitone testing requires only the amplitude of the whole multitone. In this example, the total amplitude is 1 Vrms, not 100 mVrms (= 10 Vrms + 10 Vrms + 20 Vrms + 20 Vrms + 20 Vrms + 20 Vrms).

2. Determining each tone's amplitude can be calculated with the formula:
$Vrms = \sqrt{V1^2 rms + V^2 rms + ... + Vn^2 rms}$. Vrms is the multitone amplitude and Vnrms is the amplitude of number n tone. Knowing the relative amplitude of each tone, each individual tone's amplitude can be calculated using this formula. For example the amplitude of 3.5 kHz tone is 235.7 mVrms.

Creating a Standard Multitone Waveform

The initial step is to create a standard, equally-spaced multitone.

1. Press **Generator** [Generator] until AG1 appears in the top frame of the Analog Generator window.

2. In the Analog Generator channel 1 (AG1) frame, press **[Waveform]** then select Multitone from the drop-down menu and press **Enter.**

3. Select **[Waveform Config],** and then enter the following values:
   ◦ **[Start Freq]** (start frequency): 2 kHz
   ◦ **[Stop Freq]** (stop frequency): 5.5 kHz
   ◦ **[Tones Count]:** 6
   ◦ **[Amplitude]:** 1 Vrms

Use the default values for the other parameters. Figure 2 shows the AG1 frame on the Analog Generator screen after selecting these parameters.
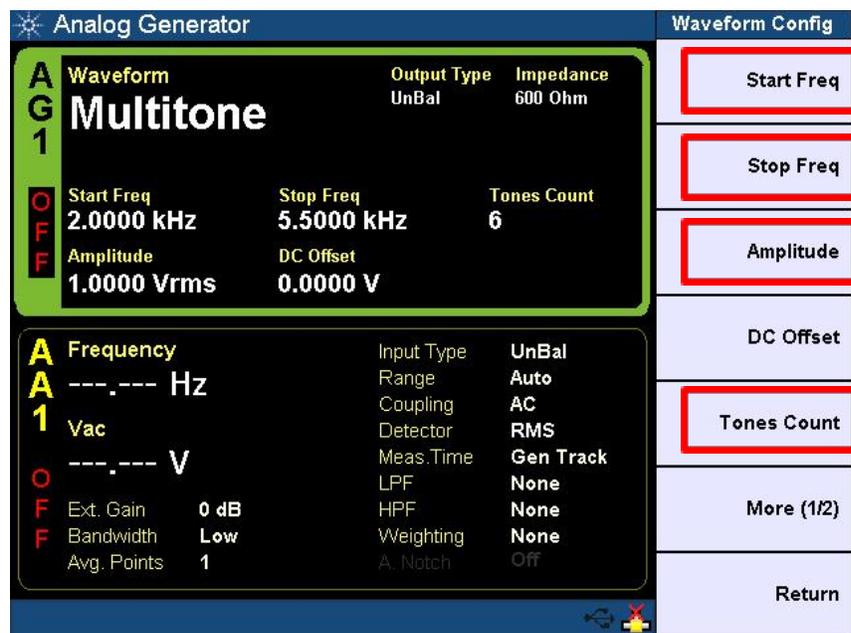

Figure 2. A standard multitone with 6 tones

Modifying Frequency, Amplitude, and Phase

Using the standard multitone, in this section the frequency, amplitude, and phase will be modified to create a custom multitone.

1. From the Analog Generator Waveform Config screen, press **[More (1/2)].**

2. Set both **[Record Length]** and **[Waveform Length]** to 8192 (points). Note: the record length should be equal to or greater than the waveform length.

3. Press **[Create Custom].** The screen will display a list of tones which will be modified.

3

4. Using the arrow key [arrow key icon] and **Enter,** select and set the frequency and relative amplitude of each tone per the specifications listed in Table 1. The Phase values should remain at the default values.

Note that the resulting tone frequency shown on the display will not be identical to the value entered. For example, if 2 kHz is entered the listed value will be 1.9836 kHz. This is due to the limited number of sampling points used in creating the waverform. The frequency value is rounded to an integer number of points that have a complete cycle within the multitone waveform. The greater the number of sampling points set in Waveform Length, the closer the resulting value will be to the entered value. The U8903A supports up to 32,768 points. However, the greater the number of sampling points chosen, the longer it will take to build the waveform.

5. To modify the crest factor, press **[Randomize Phase]** to apply a random phase to each tone. Most multitone testing requires the design of low-crest-factor test signals. To lower the crest factor, press **[Randomize Phase].** Alternatively, the phase of each tone may be entered individually to generate a preferred crest factor.

6. Press **[Apply Settings]** and **[Yes]** to confirm all of the settings.

The display should look similar to that shown in Figure 3, and the values for Phase will be ramdomized. In the list, the amplitude of each tone is the relative value.

Analog Generator				Unit
Start Freq: 1.9836 kHz		Tone Count: 6		Apply Settings
Stop Freq: 5.4932 kHz		Crest Factor: 3.1797		

Tone	Frequency	Amplitude	Phase	
6	5.4932 kHz	20.000 mVrms	-32.625 °	Go To Tone

Tone	Frequency	Amplitude	Phase	
1	1.9836 kHz	10.0000 mVrms	43.8400 °	Randomize Phase
2	3.5095 kHz	10.0000 mVrms	10.6835 °	
3	4.8065 kHz	20.0000 mVrms	-16.4688 °	
4	4.9973 kHz	20.0000 mVrms	21.7627 °	
5	5.1880 kHz	20.0000 mVrms	2.4118 °	Set All to 0° Phase
6	5.4932 kHz	20.0000 mVrms	-32.6250 °	

Set All to 0 dBV

More (1/2)

Return

Figure 3. Six tone multitone signal with adjusted parameters

Verifying the Custom Multitone Waveform

1. The multitone waveform can be verified using the U8903A's Frequency Domain function.

2. Connect the analog generator of channel 1 (AG1) to the analyzer channel 1 (AA1) using a BNC cable as shown in Figure 4.

Figure 4. Connecting AG1 to AA1

3. Press **Frequency Domain.** The U8903A will display the spectrum of a custom multitone.

4. Press **[Monitor Setting]** and set **[Points]** to 8192.
   Remember the larger the number of points, the better resolution of the spectrum, but it will lengthen the time needed to refresh the spectrum graph.

5. Press **[Return]** to go back to main menu.

6. Press **[Axis Settings]** and then **[Grid Settings].**

7. Set the **[Left]** to 1700 Hz, **[Right]** to 6000kHz, and **[Bottom]** to –140dBV.

8. Press **OUTPUT On/Off** to enable the generator output, and press **CHANNEL Run/Stop** to start the analyzer. Now the spectrum of the custom multitone will look like Figure 5.
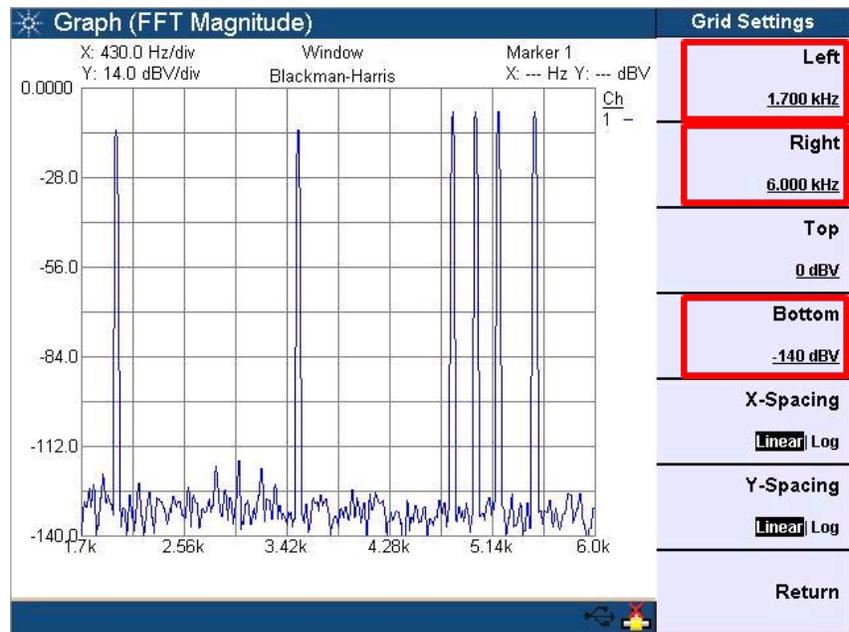

Figure 5. Spectrum of a custom multitone

Save and Recall the Multitone Signal Definition

A custom multitone waveform can be saved or recalled as an arbitrary file, and used by other audio analyzers or signal processing programs.

Saving a multitone to a portable device

1. Press **Generator** `Generator` and **[Waveform Config].**

2. Press **[More (1/2)].**

3. On the second page menu, press **[Save as Arb File].** This will launch the U8903A File Manager.

4. Plug a portable drive into the USB port on the front panel of the U8903A.

5. Select **[Source]** and change it to Storage 1 which is the portable drive.

6. Select **[Save]** to save the multitone signal to the portable drive.

Recalling a multitone from a portable drive

1. Press **Generator** `Generator` to return to the main menu of the Analog Generator window.

2. Select **[Waveform]** and then select Arb Waveform (not multitone), from the drop-down menu.

3. In **[Waveform Config],** set **[Amplitude]** to 1 Vrms.

4. Press **[Recall File] > [Select Source] > [Internal]** and change the setting to Storage 1 (which is the portable drive).

5. Select File and press **[Recall]** to build the multitone signal from the arbitrary file.

Note that when recalling a multitone definition file from a portable drive, the resulting waveform is processed as arbitrary waveform, not a multitone waveform. The amplitude of the recalled multitone file must be set to some value since the default value is zero.

6. Press **OUTPUT On/Off** `On/Off` to enable the generator output. The waveform can be verified on the U8903A Frequency Domain window as described previously.

Conclusion

Creating a custom multitone is normally considered a complex and time consuming job. Now, with the Agilent U8903A, a custom multitone waveform can be created in just four steps. The U8903A makes it easy to create a standard, equally-spaced, multitone waveform, and then modify the frequency, amplitude, and phase values to create a custom mulitone waveform. The multitone waveform can be verified using the U8903A's Frequency Domain function. The custom multitone can also be saved and recalled as an arbitrary file, and used by other audio analyzers or signal processing programs.

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