Application Report
SLEA012 – March 2003

TAS3103 Equalization Filters

Jim Coates (TI Dallas) *Digital Audio Solutions*

ABSTRACT

The TAS3103 Digital Audio Processor is a three-channel audio processor. Many audio-processing features are provided in the TAS3103 including up to sixteen biquad filter structures per channel for implementing speaker equalization (EQ) filters. This application note describes six EQ examples that utilize these biquad filters. The examples chosen illustrate the use of different filter parameters to optimize listening enjoyment for different environments and listener requirements. The biquad filter coefficients required to implement the examples are also given and all examples assume an audio sampling rate of 44.1 kHz.

Contents

Figures

Introduction

Six EQ filter examples are presented in this application note.

- Easy Country Listening
- Jazz
- Rap Automotive
- Rock Lite
- Rock Heavy
- Resonance Notch

The titles of the first five EQ filters indicate the type of music the filters address. The notch EQ example addresses the use of EQ filters to remove spectral components that can produce speaker resonance.

All six examples can be found in the TAS3103 GUI supplied with every TAS3103EVM, and a discussion of how to access these examples using the TAS3103 GUI is included in this application note.

A description of the purpose of each EQ filter implementation, along with a spectral plot of the filter's transfer function, is included. The filter coefficients for the EQ filters are also included. Configuration files can be developed from these listings to implement the EQ filter examples without having to use the TAS3103 GUI and a TAS3103EVM.

Accessing EQ Filter Examples Using TAS3103 GUI

Having loaded the software supplied with the TAS3103EVM, the TAS3103 GUI can be found at

C:\Program Files\Texas Instruments Inc\DAP Config Tool 2.0\DASDCT.exe

Double clicking on the DASEDC.exe file brings up the two panels shown in Figure 1

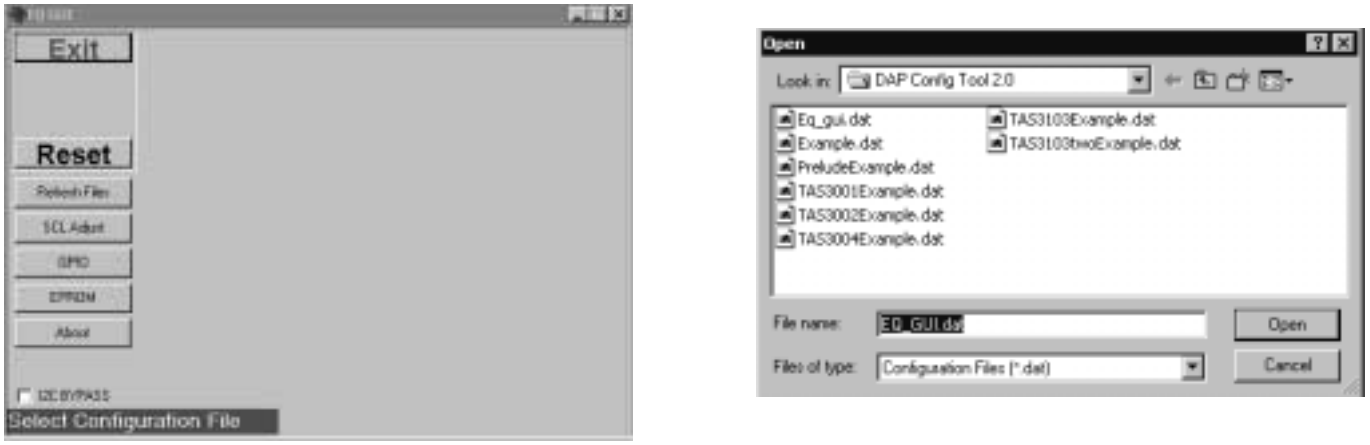

Figure 1. TAS3103 GUI Startup Panels

If the TAS3103EVM is hooked up to a PC by (1) connecting the “paddle” board to the parallel port of the PC and (2) attaching a cable between the “paddle” board output connector and the TAS3103EVM, the EQ_GUI.dat file is the correct file selection. (The “paddle” board and connecting cable are supplied with every TAS3103EVM). Clicking on the Open button brings up the left panel shown in Figure 2.

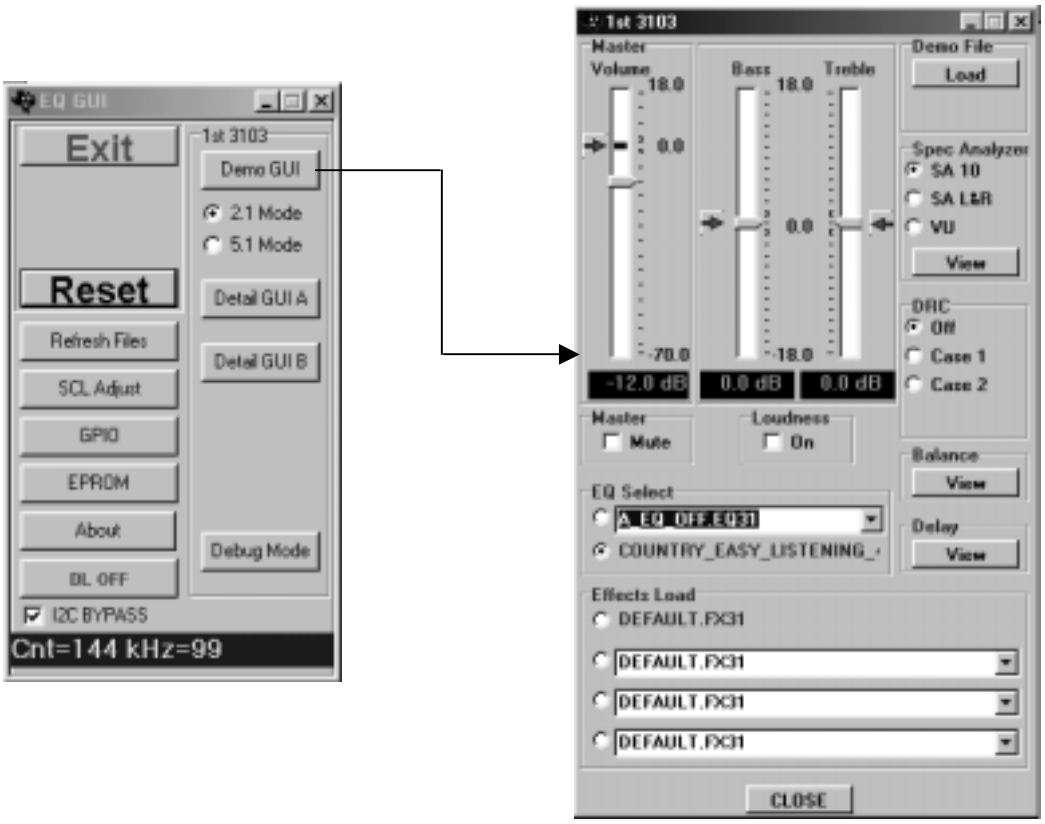

Figure 2. TAS3103 GUI Working and DEMO Panels

Clicking on the Demo GUI button brings up the Demo panel - the right panel in Figure 2. The 2.1 mode option is selected when the panel comes up, but for the purpose of accessing the EQ examples, the 5.1 mode option can also be selected. Country_Easy_Listening_44 is the EQ filter selected when the panel comes up. Clicking on the down arrow on the window that reads A_EQ_OFF.EQ31 can access the other five EQ filter examples. The selection A_EQ_OFF.EQ31 is a seventh EQ filter selection that turns off equalization by setting all the biquad filters in the TAS3103 as pass through devices. The extension .EQ31 identifies the selection as an equalization or EQ filter.

Upon making a selection, the filter coefficients are automatically downloaded to CH1 and CH2 in the TAS3103. The stereo input on input port SDIN1 is processed with the selected EQ filter, and then output on output port SDOUT1.

Creating EQ Filter Configuration Files

The EQ filter examples can also be downloaded into the TAS3103 by creating configuration files from the listings in this Application Note. The listings can be directly imported into a configuration file and downloaded to a TAS3103 via the I^2C bus, as the sub-addresses for each of the three channels in the TAS3103 are included in the listings. Figure 2-16 (page 2-18) in the *TAS3103 Data Manual (SLES038A)* illustrates the protocol that must be used in communicating with the TAS3103 via the I^2C bus.

If a configuration file does not include a given biquad, that biquad is not affected by the I^2C bus download. This means, for example, that if the TAS3103 contains an EQ filter that requires four biquad filters to implement, and a new biquad filter that requires only two biquad filters to implement is downloaded, only the first two biquads in the TAS3103 will be affected. The next two biquad filters in the channel will retain the coefficients from the previous EQ filter. To avoid such an occurrence, those biquads not included in the listings should be downloaded with coefficients that implement a pass through filter. Figure 3 illustrates a configuration file that implements the Easy Country Listening EQ filter for CH1 in the TAS3103, and ensures that those biquad filters that are not used are set as pass through structures. Sub-addresses X4F - X5A are the CH1 biquad filter sub-addresses, sub-addresses X5B - X66 are the CH2 biquad filter sub-addresses, and sub-addresses X67 - X72 are the CH3 biquad filter sub-addresses.

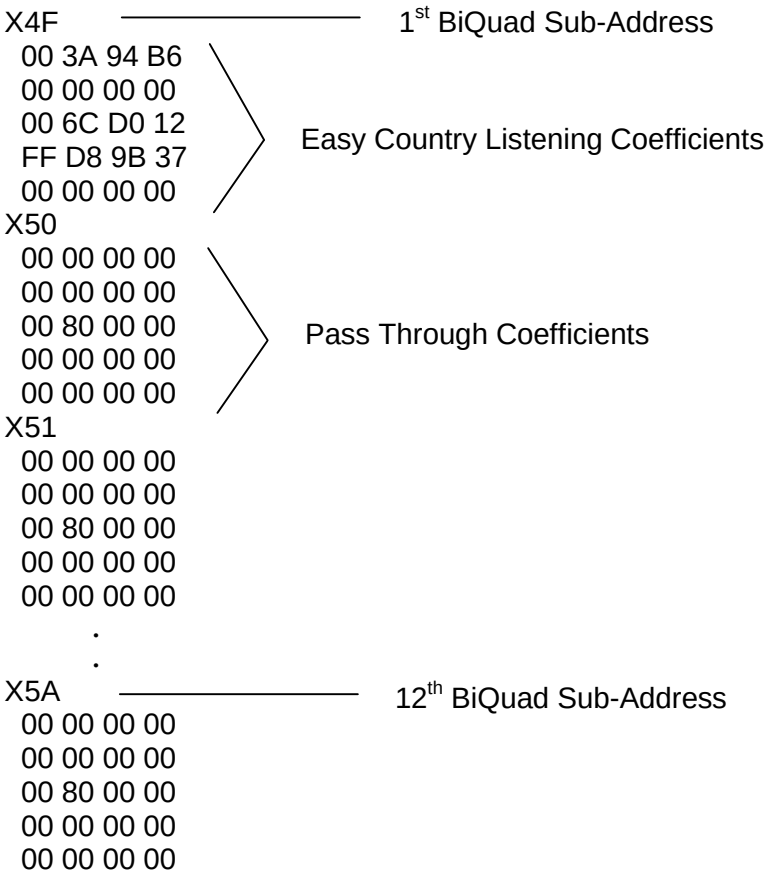

Figure 3. TAS3103 Configuration File For Easy Country EQ Filter

EQ Filter Details

Details of the six EQ filter examples are given below. A brief description of the intent of each EQ filter is given, followed by the frequency plot of the filter, followed by the biquad coefficients required to implement the filter. Coefficient listings are given for all three EQ channels in the TAS3103. The coefficient values are the same in all three listings; only the sub-addresses are different. The intent of the listings is to allow a user to copy the listings from this document and paste them directly into his TAS3103 configuration (.cfg) file.

Easy Country Listening

Easy Country Listening presents a gentle bass boost at 80 Hz, coupled with a treble shelf cut at 2 kHz, to provide an audio output that is relatively rich in bass but subdued at higher frequencies. The net effect is a soft, rich audio sound.

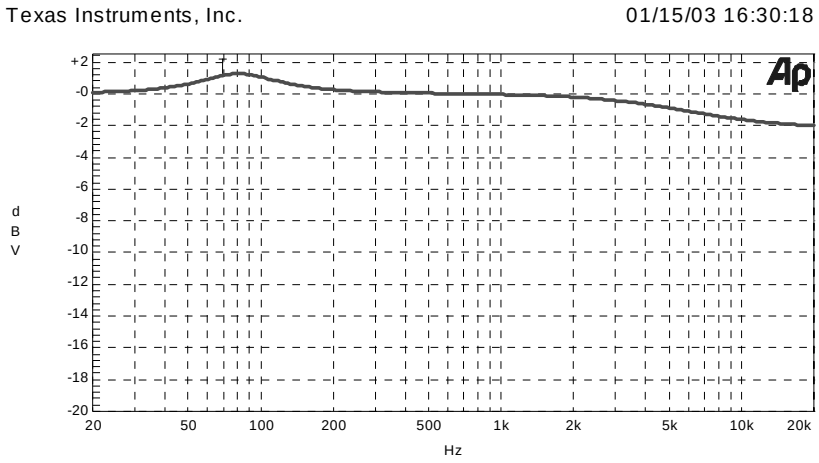

Figure 4. Easy Country Listening Frequency Response

CH1 Sub-Address Download

X4F
00 3A 94 B6
00 00 00 00
00 6C D0 12
FF D8 9B 37
00 00 00 00

CH2 Sub-Address Download

X5B
00 3A 94 B6
00 00 00 00
00 6C D0 12
FF D8 9B 37
00 00 00 00

CH3 Sub-Address Download

X67
00 3A 94 B6
00 00 00 00
00 6C D0 12
FF D8 9B 37
00 00 00 00

Figure 5. Easy Country Listening BiQuad Coefficients

Jazz

Jazz implements a treble shelf at 2 kHz to bring forward the percussion components of the incoming audio to enrich the audio sound presentation for jazz instrumentals and vocals.

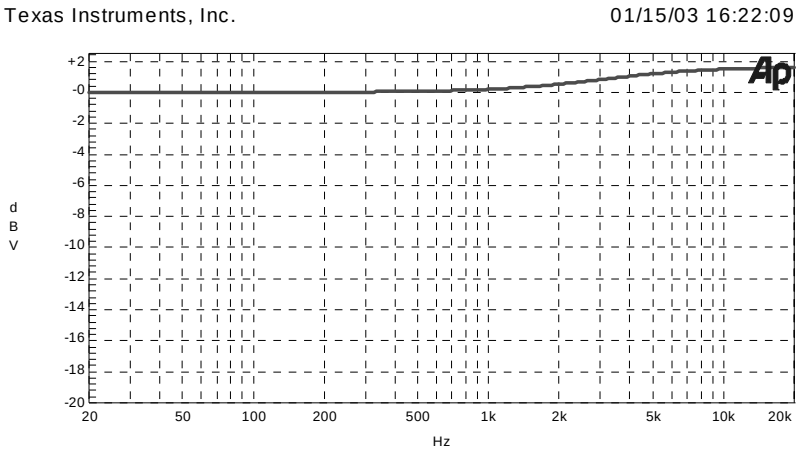

Figure 6. Jazz Frequency Response

CH1 Sub-Address Download

X4F
00 3A 94 B6
00 00 00 00
00 B6 90 A0
FF 8E DA A9
00 00 00 00

CH2 Sub-Address Download

X5B
00 3A 94 B6
00 00 00 00
00 B6 90 A0
FF 8E DA A9
00 00 00 00

CH3 Sub-Address Download

X67
00 3A 94 B6
00 00 00 00
00 B6 90 A0
FF 8E DA A9
00 00 00 00

Figure 7. Jazz BiQuad Coefficients

Rap Automotive

Rap Automotive implements a boost in bass frequencies between 35 and 120 Hz, and a treble shelf at 850 Hz to enhance percussion instrumentation. This enriches the strong beat and articulated sound of RAP. Cutting the volume in a band from 200 to 750 Hz further enhances the effect. The roll off below 35 Hz alleviates speaker distortion that can accompany lower frequency sounds.

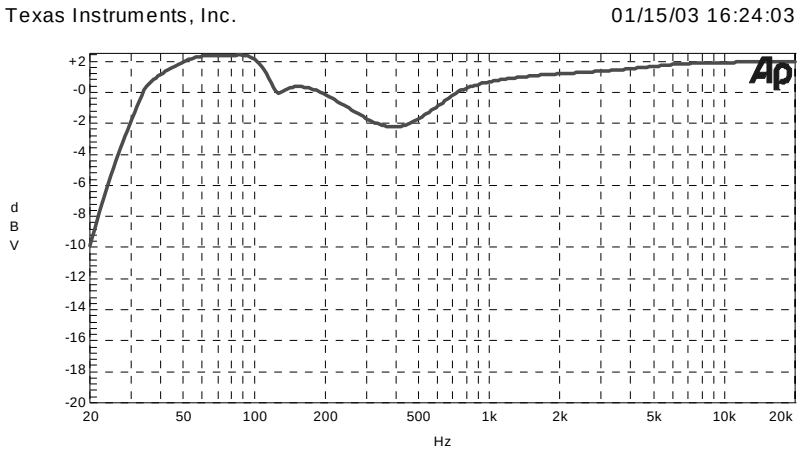

Figure 8. RAP Automotive Frequency Response

CH1 Sub-Address Download

X4F
00 FF 7B F3
FF 80 83 C9
00 7F BE 0A
FF 00 83 EB
00 7F BE 0A
X50
00 FF 39 ED
FF 80 C5 7A
00 7F 9D 1C
FF 00 C5 C7
00 7F 9D 1C
X51
00 FF A0 5E
FF 80 5D 3E
00 80 64 CE
FF 00 5F A2
00 7F 3D F4
X52
00 FF 86 1C
FF 80 74 83
00 80 7D F6
FF 00 79 E4
00 7F 0D 87
X53
00 FE FE 55
FF 80 F8 20
00 7F C9 B4
FF 01 01 AB
00 7F 3E 2C
X54
00 F5 B1 45
FF 89 E8 74
00 7E 8D 9C
FF 0A 4E BB
00 77 89 F0
X55
00 6E F2 EC
00 00 00 00
00 B1 49 A6
FF 5F C3 6D
00 00 00 00
X56
00 7B 0D 58
FF D4 7C 37
00 A6 57 C2
FF 48 30 1B
00 41 EE 94

CH2 Sub-Address Download

X5B
00 FF 7B F3
FF 80 83 C9
00 7F BE 0A
FF 00 83 EB
00 7F BE 0A
X5C
00 FF 39 ED
FF 80 C5 7A
00 7F 9D 1C
FF 00 C5 C7
00 7F 9D 1C
X5D
00 FF A0 5E
FF 80 5D 3E
00 80 64 CE
FF 00 5F A2
00 7F 3D F4
X5E
00 FF 86 1C
FF 80 74 83
00 80 7D F6
FF 00 79 E4
00 7F 0D 87
X5F
00 FE FE 55
FF 80 F8 20
00 7F C9 B4
FF 01 01 AB
00 7F 3E 2C
X60
00 F5 B1 45
FF 89 E8 74
00 7E 8D 9C
FF 0A 4E BB
00 77 89 F0
X61
00 6E F2 EC
00 00 00 00
00 B1 49 A6
FF 5F C3 6D
00 00 00 00
X62
00 7B 0D 58
FF D4 7C 37
00 A6 57 C2
FF 48 30 1B
00 41 EE 94

CH3 Sub-Address Download

X67
00 FF 7B F3
FF 80 83 C9
00 7F BE 0A
FF 00 83 EB
00 7F BE 0A
X68
00 FF 39 ED
FF 80 C5 7A
00 7F 9D 1C
FF 00 C5 C7
00 7F 9D 1C
X69
00 FF A0 5E
FF 80 5D 3E
00 80 64 CE
FF 00 5F A2
00 7F 3D F4
X6A
00 FF 86 1C
FF 80 74 83
00 80 7D F6
FF 00 79 E4
00 7F 0D 87
X6B
00 FE FE 55
FF 80 F8 20
00 7F C9 B4
FF 01 01 AB
00 7F 3E 2C
X6C
00 F5 B1 45
FF 89 E8 74
00 7E 8D 9C
FF 0A 4E BB
00 77 89 F0
X6D
00 6E F2 EC
00 00 00 00
00 B1 49 A6
FF 5F C3 6D
00 00 00 00
X6E
00 7B 0D 58
FF D4 7C 37
00 A6 57 C2
FF 48 30 1B
00 41 EE 94

Figure 9. RAP Automotive BiQuad Coefficients

Rock Lite

Rock Lite implements a boost in bass frequencies between 35 and 120 Hz and a boost in treble frequencies between 1 kHz and 16 kHz to enhance the beat and percussive nature of rock music. Cutting the volume in a frequency band between 200 and 750 Hz further enhances the effect. The roll off below 30 Hz alleviates speaker distortion that can accompany lower frequency sounds. The roll off above 16 kHz sets the sound stage back – hence the term “lite”. The high frequency roll off also reduces the high frequency distortion that sometimes accompanies rock recordings.

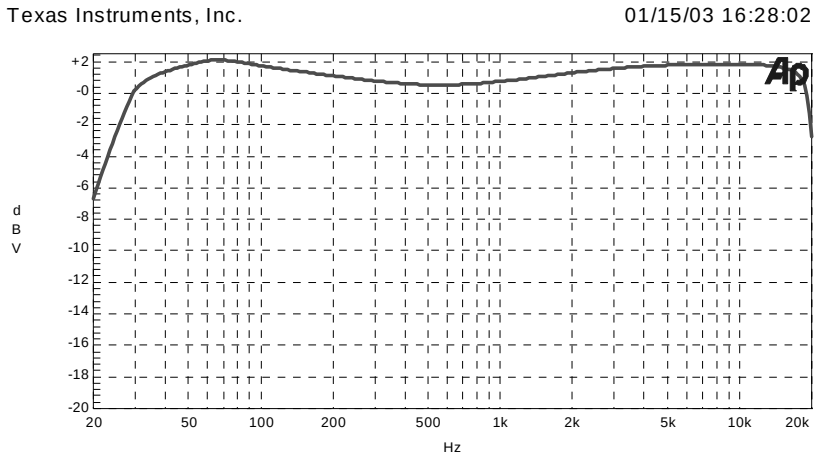

Figure 10. Rock Lite Frequency Response

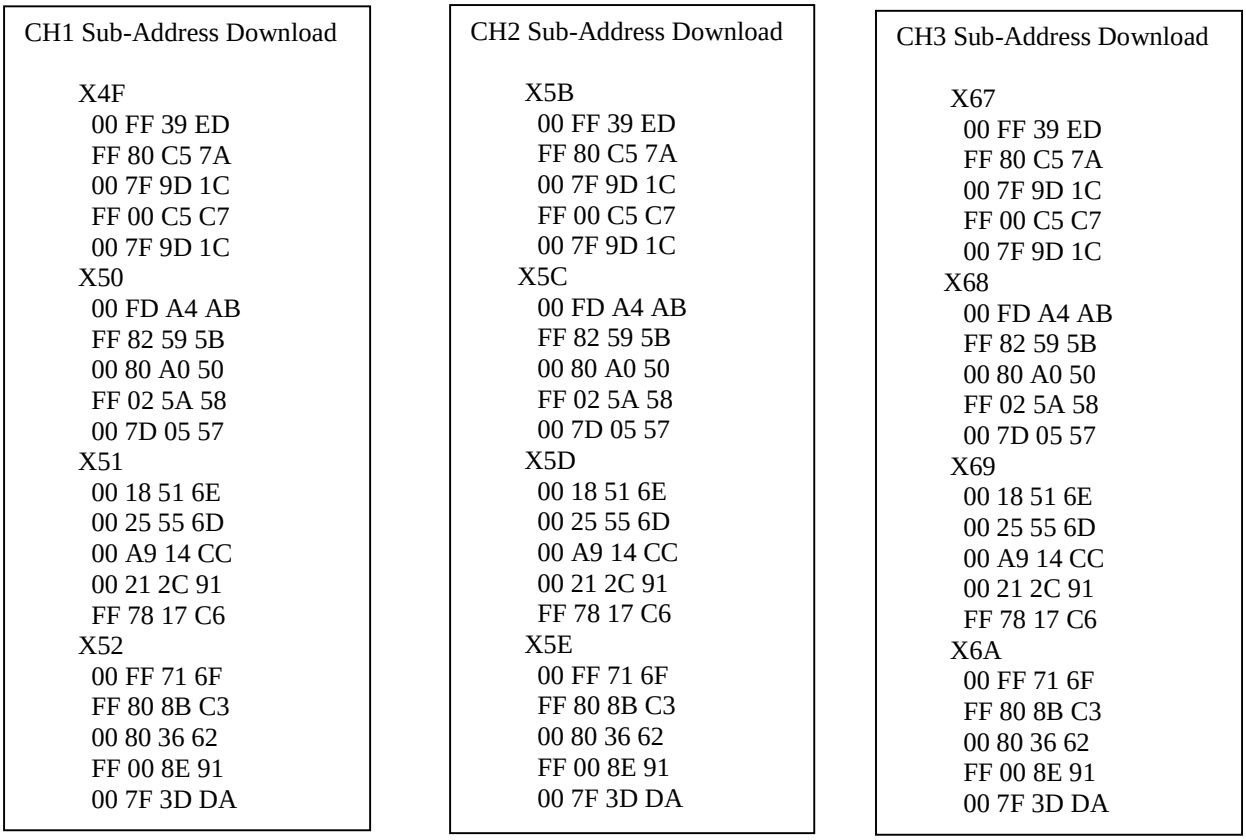

Figure 11. Rock Lite BiQuad Coefficients

Rock Heavy

Rock Heavy implements the same effects as Rock Lite, except for bass and treble roll offs. In Rock Heavy, there is significantly less bass roll off, allowing all bass audio components to be output for speaker systems that can handle the full bass range without distortion. The absence of cuts in the upper treble frequencies brings the sound stage forward – hence the term "heavy".

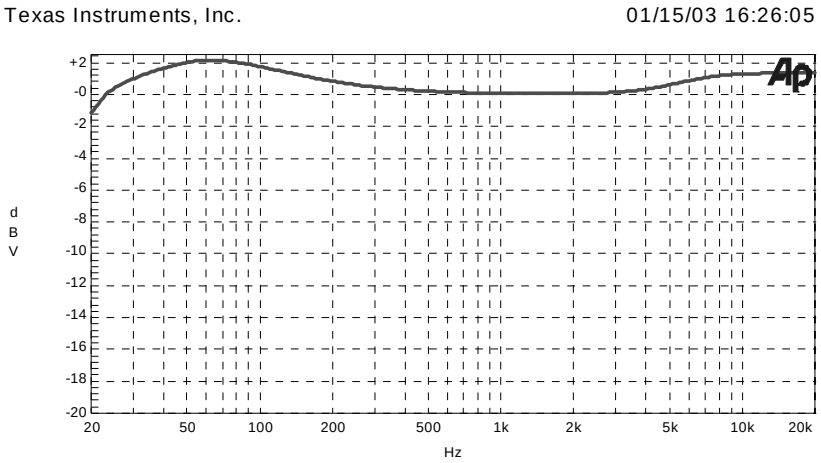

Figure 12. Rock Heavy Frequency Response

CH1 Sub-Address Download

X4F
00 FF 43 65
FF 80 BA 38
00 80 C9 53
FF 00 BC 9B
00 7E 7C 75
X50
00 62 F6 C2
FF DC 40 08
00 A3 CA 1C
FF 66 D8 B1
00 36 26 68
X51
00 7F A2 C2
00 00 00 00
00 7F D1 61
FF 80 2E 9F
00 00 00 00

CH2 Sub-Address Download

X5B
00 FF 43 65
FF 80 BA 38
00 80 C9 53
FF 00 BC 9B
00 7E 7C 75
X5C
00 62 F6 C2
FF DC 40 08
00 A3 CA 1C
FF 66 D8 B1
00 36 26 68
X5D
00 7F A2 C2
00 00 00 00
00 7F D1 61
FF 80 2E 9F
00 00 00 00

CH3 Sub-Address Download

X67
00 FF 43 65
FF 80 BA 38
00 80 C9 53
FF 00 BC 9B
00 7E 7C 75
X68
00 62 F6 C2
FF DC 40 08
00 A3 CA 1C
FF 66 D8 B1
00 36 26 68
X69
00 7F A2 C2
00 00 00 00
00 7F D1 61
FF 80 2E 9F
00 00 00 00

Figure 13. Rock Heavy BiQuad Coefficients

Resonance Notch

Arithmetic resolution is a key parameter in the precise implementation of notch filters. Resonance Notch implements a notch at 7.5 kHz. Such a notch serves to eliminate a resonance that occurs in many stiff or metal cone speaker systems. The example also highlights the benefits of the TAS3103's 48-bit precision in filter implementation by illustrating that the notch can be applied without adversely effecting audio quality.

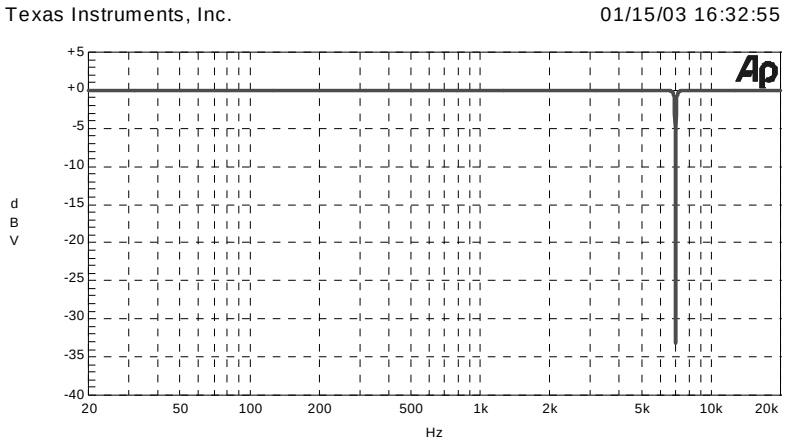

Figure 14. Resonance Notch Frequency Response

CH1 Sub-Address Download

X4F
00 89 E8 CD
FF 81 CF 93
00 7F 18 36
FF 76 17 33
00 7F 18 36

CH2 Sub-Address Download

X5B
00 89 E8 CD
FF 81 CF 93
00 7F 18 36
FF 76 17 33
00 7F 18 36

CH3 Sub-Address Download

X67
00 89 E8 CD
FF 81 CF 93
00 7F 18 36
FF 76 17 33
00 7F 18 36

Figure 15. Resonant Notch BiQuad Coefficients

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third–party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Mailing Address:

Texas Instruments
Post Office Box 655303
Dallas, Texas 75265