D2 Audio DSP

D2 Audio Customization GUI v3 Sound Processing and Audio Algorithms

Abstract

The D2 Audio Customization GUI v3 software design tool provides complete design flexibility enabling the user to define and build a complete audio sound processing system. Drag-and-drop inserting of individual audio processing blocks builds a customized audio path signal flow.

An extensive library of sound processing blocks enables a rich and powerful palette of programmable audio functions for virtually any consumer audio application. Highly flexible configuration supports accuracy of audio adjustment and control precision for premium performance consumer audio solutions. This application note provides a high level summary of these audio algorithms.

Contents

List of Figures

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1. Overview

The D2 Audio Customization GUI v3 software provides an easy-to-use graphical interface allowing you to build a customized audio signal flow and control with D2 Audio DSP Digital Audio Processor based amplifiers. Individual audio algorithms are supported through a library of audio processing blocks provided with the D2 Audio Customization GUI v3 program.

The designer builds the audio path signal flow by clicking each desired block from the audio library and dragging it into the signal flow workspace. Figure 1 on page 4 shows an example that includes the block library adjacent to the signal flow window.

As many multiples desired of the same block type can be added, and there is no limit to the order of their placement or how they are interconnected. Each block that is dragged into the signal flow becomes a unique instance of that block's algorithm into the project's system firmware, complete with its own dedicated controls and registers.

The audio blocks supported in D2 Audio Customization GUI v3 are listed Table 1. This table provides a brief overview of the audio algorithm function. Details and equations for each parameter are provided in the D2 Audio Customization GUI v3 User's Manual.

Table 1. D2 Audio Customization GUI v3 - Audio Algorithm Blocks

Audio Blocks	Audio Processing Function
Volume	Volume control blocks provide level and trim adjustments within the signal flow. Continuous adjustment through programmable gain ranges supports attenuation to -100dB and gain to +24dB. A single 24-bit register value provides gain setting and also supports selectable audio phase inversion.
Shared Volume	Shared Volume blocks implement multiple channels of level attenuation. The number of channels is configurable and a single 24-bit register value equally controls all channel levels. Volume is continuously adjustable from unity gain to -100dB.
Mixers	Mixers provide individually-adjustable inputs that are summed together and passed to their output. Each input mixing level is controlled with its own 24-bit register that provides continuous adjustment from unity gain to -100dB, along with full audio path cut-off and optional input phase inversion supporting sum and difference mixers. Audio block choices include 2-input, 4-input, and configurable N-input mixers accommodating as many inputs as desired.
Router	Routers perform independent channel routing assignment, connecting any input to any output. Number of channels is configurable with up to 64 inputs and 12 outputs.
Stereo A/B Switch	The A/B Switch provides stereo routing selection to switching either of two pairs of stereo inputs to its output. It operates as a double-pole, double-throw type of switch to the audio flow.
Tone Control	Tone Controls are shelving filters providing independent of gain and frequency adjustment for bass and treble tone settings. Frequency and gain are continuously and independently adjustable for both the bass and treble settings, supporting gain ranges of -14dB to +14dB.
Parametric Equalizers	Parametric Equalizer (EQ) blocks provide an adjustable bandpass or band-reject frequency response. With frequency-domain parameter settings of frequency, gain, and bandwidth or Q, parameters are continuously and independently adjustable. EQs are provided as individual audio blocks, and as blocks with groups of 3-Band and 5-Band EQs.
Biquad Filter (Frequency Domain Configuration)	The Biquad block is a frequency-domain parameter entry biquad filter implemented as a second-order biquad algorithm, providing configurable high-pass, low-pass, and all-pass filtering functions. First or second filter order can be selected, and parameter setting entries of frequency and damping coefficient are continuously adjustable. Bypass and polarity phase inversion is also supported.
Biquad Filter (z-Domain Configuration)	The z-Domain Biquad is a second order biquad digital algorithm that operates from direct entry of z-transform coefficients. The filter supports individual user entry coefficients enabling nearly any second order filter synthesis per cascadable block.
Filter - Crossover	The Crossover Filter blocks provide high-pass or low-pass filtering using frequency domain adjustment settings. Blocks are implemented from two cascaded second-order biquad elements, with selections that directly implement Linkwitz-Riley, Butterworth, or Bessel filter presets. Slope setting is adjustable from 6, 12, 18, or 24dB per octave, frequency and damping coefficients are continuously adjustable, and bypass, active or mute functions are supported.
FIR Filter	The FIR filter is a configurable n-tap finite impulse response filter implementation. The number of taps and their coefficient values are defined in the audio signal flow simply through a user-generated list of tap coefficients for the FIR structure.

Table 1. D2 Audio Customization GUI v3 - Audio Algorithm Blocks (Continued)

Audio Blocks	Audio Processing Function
Excursion Control	Excursion Control is a specialized algorithm that dynamically controls audio based on frequency and level. Excursion Control boosts the low frequency response to compensate for physically-limited low-frequency capabilities of small loudspeakers and subwoofers at low listening levels. As listening levels rise, it dynamically adjusts its boost enabling an optimum sub-woofer listening experience at all loudness levels.
Delay	Delay Blocks introduce an adjustable delay of a channel's audio data. Buffer size is fully user-configurable, supporting adjustment over a range as small as milliseconds, to over 1 second.
Compressor	Compressors provide threshold-dependent level adjustments, implementing dynamic attenuation at configurable rates as the control signal level increases. Headroom level is configurable, supporting adjustable threshold ranges from -94dB to +36dB. Ratio, threshold, and attack/release times are also fully adjustable. Compressors incorporate a side chain input for algorithm control, supporting compressing or limiting operation from inputs independent of the processed channel audio signal flow.
Compressor/Expander	The Expander Compressor implements dynamic low level signal expansion, or an upward compression to audio levels. The Expander Compressor operates similar to the Compressor Blocks, but implements dynamic low level signal expansion for an upward compression to audio levels. Adjustable settings include gate threshold and ratio, expansion threshold, ratio, expansion gain limit, and attack and release times.
Envelope Voltage Controlled Amplifier	The Envelope VCA processes its control input to establish an amplitude envelope signal representing the audio path input level. The Envelope VCA operates similar to the compressor block, but uses its side chain input to establish an amplitude envelope of the audio level. Controls are similar to that of the Compressor Block.
Reverb	The Reverb Block is a 2-channel stereo reverb processor. It provides adjustable reverb time and damping settings, and its built-in mixer includes adjustments for both dry and wet audio levels.
Chime Generator	The Chime Generator contains three oscillators, each with adjustable frequency and gain. When triggered, the oscillators initially produce full programmed output levels that then decrease at their programmable decay time rate.
RMS Level Meter	RMS Meters provide a real-time indication of the signal levels through the audio processing path. Visible in the D2 Audio Customization GUI v3 signal flow, they provide continuous level indication. Measured data in the meter's registers can also be read by system controllers for monitoring levels in a final production system.
Fade-Pan	The Fade-Pan control provides level adjustment of four input channels to four output channels. Implementation includes a Rear/Front fade adjustment, and a Left/Right balance adjustment. Controls are continuously adjustable, providing unity gain at mid-point settings, and attenuating output levels of its channels as the respective control is adjusted away from that channel's direction.
Mono Mixer	A Mono Mixer is a threshold-gating mixer that routes the sum of either or both of its two inputs into its output, based on a control level input. This threshold-controlled mixing supports processing of input audio that can be mono on both Left and Right, or containing content on only one of Left or Right. This summed audio then passes equally to stereo processing and output system channels.
Dither Generator	The Dither Block generates a random noise (dither) pattern at a shaped-spectrum low level. This noise is available to sum into the audio path using a mixer, pushing up low-order bits of low-level audio. This process enables improved uniform audio quality when digital bit depth truncation is required because of interfacing equipment. Audio signal flow data is normally processed and output in digital format as 24 bits.
Harmonics Generator	The Harmonics Generator provides a harmonic spectrum content from audio presented to its input. Harmonic order and amplitude is programmable, supporting customized audio processing features.
Compound Blocks	Compound blocks are not specific algorithms, but are user-built from combinations of individual algorithm blocks or with nesting of other user-built blocks. Therefore, each compound block contains unique instances of every individual algorithm used in its building. Compound blocks are available for use in the same, or future projects. They can also be user-encrypted for IP protection.

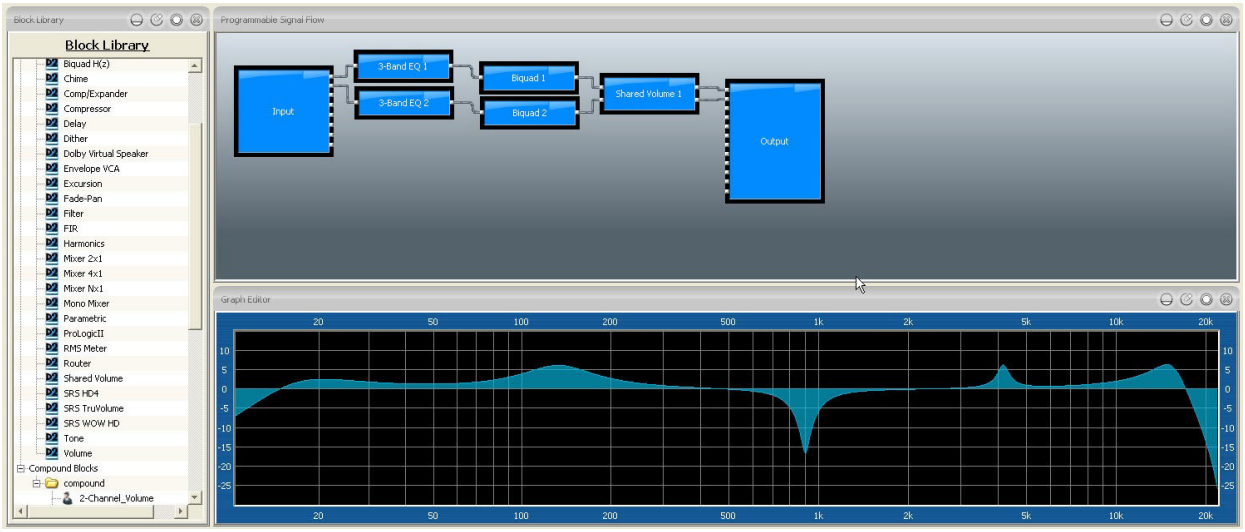

Figure 1. D2 Audio Customization GUI v3 Block Library and Signal Flow

1.1 Interactive Control and Real-Time Graphing

D2 Audio Customization GUI v3 provides dedicated controls for each audio block. Selecting the block within the audio signal flow also opens and displays that block's control panel. Depending on the audio function, adjustment can be made by dragging and moving a slider or knob, selecting a pull-down choice menu, or entering a numeric value. All entry methods are real-time, and the connected hardware immediately receives its register commands to adjust parameter settings as you make the on-screen adjustment.

In addition to control knobs and buttons, D2 Audio Customization GUI v3 provides a flexible and useful graphical display of the actual audio response by simply selecting an audio block within the signal flow.

The graphic display shows either magnitude or phase of the selected block as shown in Figure 2. Also, the program supports series or parallel audio path responses for multiple selected blocks, enabling system-level performance display.

The graphic display does more than provide indication. The block's controls are integrated into the display graph, where dragging of the graph's points causes actual real-time adjustment of parameter settings, duplicating the adjustment entries that are supported on the block's control panels.

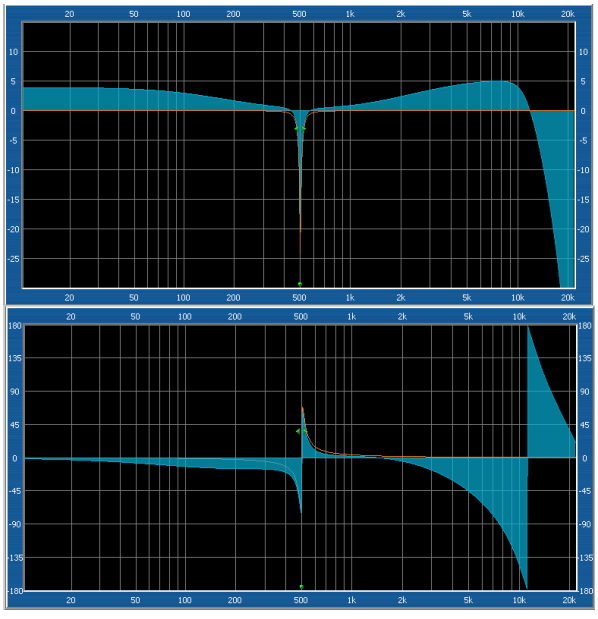

Figure 2. Magnitude and Phase Graphing of Multiple Audio Blocks

1.2 Audio Processing Block Controls

Each audio processing block is assigned its own registers providing adjustment controls for the parameters associated with its audio function. Some blocks use one register only, while other blocks with multiple control settings can use multiple registers for each control. The parameter equations for all of the audio blocks are provided in the D2 Audio Customization GUI v3 User's Manual.

1.3 Third Party Virtualization and Enhancements

Enhancement processing and virtualization algorithms from third-party technology providers are available to add to D2 Audio Customization GUI v3. As permitted through license agreements from the providers, these algorithms are supplied to the designer where they integrate into the D2 Audio Customization GUI v3 software, and appear as additional audio block choices within the Block Library. When in the Block Library, they are added to a project by simply dragging into the signal flow as with any other audio block.

Controls and graphical adjustments are included for these blocks. Register definitions are also included for each of the user controls associated with these blocks.

1.4 Dynamic Register Addressing Architecture

D2 Audio Customization GUI v3 supports building of any signal flow with no restriction of the order of occurrence of any audio block, or any limit to repeated deleting or addition during signal flow editing. As audio algorithm blocks are edited, added, or removed, the user-space memory addresses for each register changes.

However, each instance of each block has its own unique label identifier where that identifier is clearly known and visible on the signal flow workspace.

Because each and every algorithm is assigned its own dedicated register for its parameter settings, the D2 Audio Customization GUI v3 generates a variable-to-address mapping for each build of each project. This mapping is provided as a text file in a header file format that can be directly included within a system controller's software build. As multiple iterations of a signal flow are created during the design process, a new header file is created matching each revision. Simply including the header file within the system controller compile automatically passes these new register addresses without need for repeated system code editing.

2. Revision History

Rev.	Date	Description
0.00	May.23.19	Initial release

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(Rev.4.0-1 November 2017)

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