APOGEE TECHNOLOGY, INC.

EB-8001

Evaluation Platform for the DDX-8001

FEATURES

MULTI-CHANNEL DIGITAL AUDIO SOLUTION

- 5.1 OUTPUT CHANNELS
- FOR DVD and A/V RECEIVERS
- MINI/MICRO COMBO, POWERED SPEAKERS
- 6x50/65W, 6/8Ω, <10% THD (DDX-2100)
- 6x62/75W, 6/8Ω, <10% THD (DDX-2120)
- 6x80/75W, 6/8Ω, <10% THD (DDX-2160)

TYPICAL PERFORMANCE

- THD+N < 0.04% (1W, 1kHz)
- SNR: 100dB (I^2S), 98dB (S/PDIF)
- >88% EFFICIENCY

INPUT/OUTPUT

- DUAL S/PDIF COAX/OPTICAL (STEREO)
- I^2S INPUT/OUTPUT (8 CHANNELS)
- DSD INPUT (6 CHANNELS)
- STEREO ANALOG INPUTS
- SAMPLE RATES FROM 32 TO 192kHz @ 24 BITS
- STEREO AND SUBWOOFER LINES OUT
- STEREO HEADPHONE OUTPUTS

DIGITAL PREAMP FEATURES

- VOLUME, BALANCE, BASS, TREBLE
- PARAMETRIC EQ, BASS MANAGEMENT
- AUTO MUTE, DUAL LIMITERS

1. GENERAL DESCRIPTION

The EB-8001 is an evaluation amplifier that showcases Apogee's patented all-digital, high efficiency Direct Digital Amplification (DDX®) technology. The board features the DDX-8001 Controller which provides full digital audio preamplifier functions and three DDX-2160/2120/2100 Power Devices which provide power amplification for six speakers. The EB-8001 allows DSD, I^2S, S/PDIF or analog input. Additional outputs include Stereo Headphone Output and three channels of Line Outputs. The board includes digital volume, balance, bass, treble, EQ and limiting controls and local power regulation. Automatic fault protection guards the circuit from undervoltage, overcurrent and overtemperature conditions. A comprehensive graphical user interface is provided for effortless control of all the DDX-8001's features, including on-the-fly EQ control.

ORDERING INFO:

EB-8001-00 – Evaluation Board for DDX-8001
(uses DDX-2100 power devices)
EB-8001-01 – Evaluation Board for DDX-8001
(uses DDX-2120 power devices)
EB-8001-02 – Evaluation Board for DDX-8001
(uses DDX-2160 power devices)

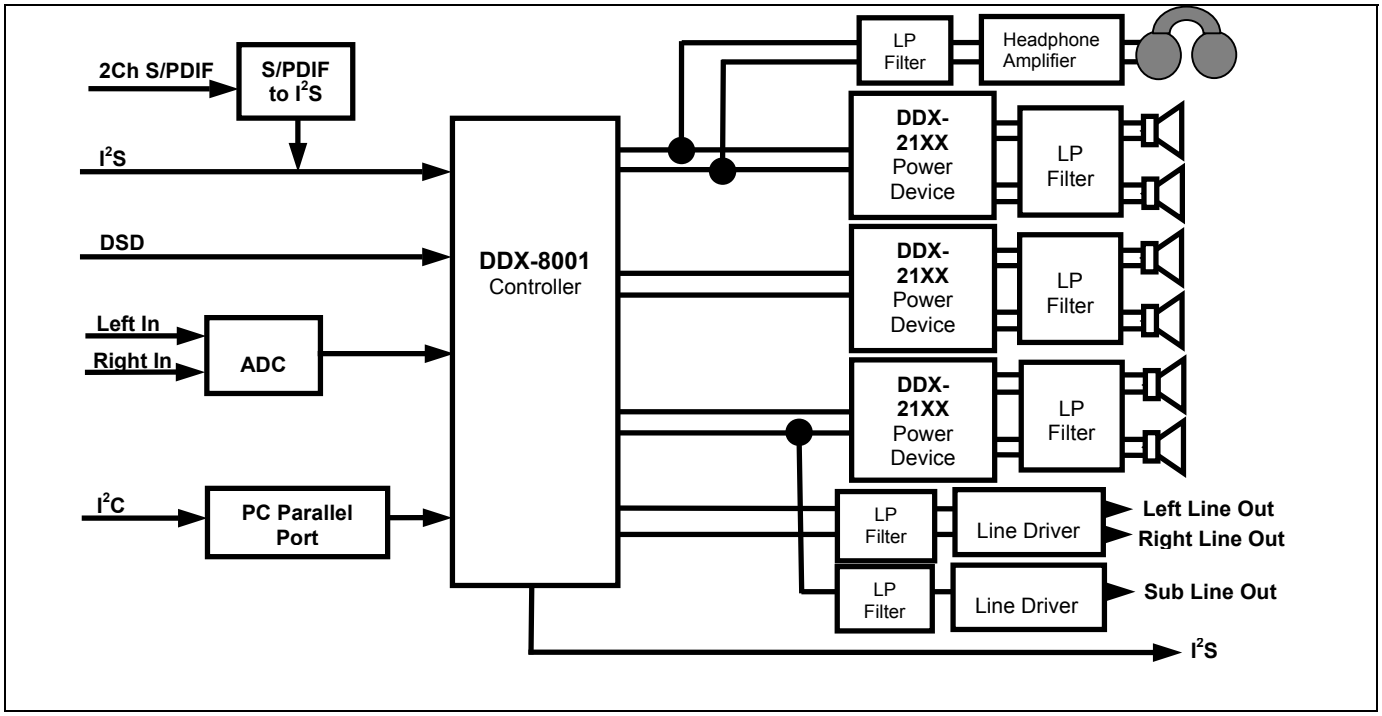


Figure 1 - EB-8001 Block Diagram

2. RECOMMENDED OPERATING CONDITIONS [1]

SYMBOL	PARAMETER	MIN	TYP	MAX	UNIT
VL	Logic Power supply voltage - J2 Terminal block	11.4	12.0	12.6	V
VCC	H-Bridge Power supply voltage - J11 Terminal block	9	33	36	V
V_{IH}	Logic inputs, High - J10, 12, 13, 14 Headers	2.0		5.0	V
V_{IL}	Logic inputs, Low - J10, 12, 13, 14 Headers			0.8	V
Fs	PCM Input Sample Rate - I^2S Input on J6 PCM Input Sample Rate - S/PDIF Input	32 32		192 96	KHz
T_A	Ambient Operating Temperature	0		50	°C

Note 1. Performance not guaranteed beyond recommended operating conditions.

3. ELECTRICAL CHARACTERISTICS [2]

Refer to circuit Sheets 1-12. Vcc=34V, f=1kHz, TA=25C, RL=6Ω, measurement bandwidth=20kHz unless specified otherwise.

SYMBOL	PARAMETER	CONDITION	MIN	TYP	MAX	UNIT
Po	DDX-2160 Output Power per Channel.	THD+N <1%, R_L=6Ω, Vcc=33V (Note 1)	62			Wrms
		THD+N <10%, R_L=6Ω, Vcc=33V (Note 1)	80			Wrms
		THD+N <1%, R_L=8Ω, Vcc=36V (Note 2)	60			Wrms
		THD+N <10%, R_L=8Ω, Vcc=36V (Note 2)	75			Wrms
	DDX-2120 Output Power per Channel	THD+N <1%, R_L=6Ω, Vcc=29V (Note 1)	45			Wrms
		THD+N <10%, R_L=6Ω, Vcc=29V (Note 1)	62			Wrms
		THD+N <1%, R_L=8Ω, Vcc=36V (Note 2)	60			Wrms
		THD+N <10%, R_L=8Ω, Vcc=36V (Note 2)	75			Wrms
	DDX-2100 Output Power per Channel.	THD+N <1%, R_L=6Ω, Vcc=26V (Note 1)	37			Wrms
		THD+N <10%, R_L=6Ω, Vcc=26V (Note 1)	50			Wrms
		THD+N <1%, R_L=8Ω, Vcc=33V (Note 2)	50			Wrms
		THD+N <10%, R_L=8Ω, Vcc=33V (Note 2)	65			Wrms
UVP	Undervoltage Protection Threshold			7	9	V
I_L	VL supply current – J15 Power	VL= +12.0V		180		mA
I_{CC}	Vcc supply current in Powerdown			4		mA
	Vcc quiescent current	Damped State (Muted)		70		mA
	Vcc supply current – J11 Power	6-Channel switching @ 384KHz. Dither signal applied		225		mA
		6 channels driven to 0dBFS (62W) outputs (DDX-2160)		12.8		A
		6 channels driven to 0dBFS (60W) outputs (DDX-2120)		11.4		A
		6 channels driven to 0dBFS (50W) outputs (DDX-2100)		10.3		A
I_{SC}	Short circuit output current limit	DDX-2160, Each output	4.5	6.0	8.0	A
		DDX-2120, Each output	4.0	6.0	8.0	A
		DDX-2100, Each output	3.5	6.0	8.0	A

THD+N	Total Harmonic Distortion + Noise	Po=1.0 Wrms Po= 50 Wrms	0.04 0.13	%
SNR	Signal-to-Noise Ratio, all channels	A-weighted, I^2S input, MCLK on J14	100	dB
		A-weighted, S/PDIF input	98	dB
		A-weighted, analog input	97	dB
SNR(LO)	Line Output SNR, all channels	A-weighted, S/PDIF input	98	dB
		A-weighted, analog input	95	dB
η	Efficiency	Po=6 x 50W into 8Ω	88	%
CX	Output Channel Cross Talk (all Vcc supplies linked)	Left output at 9W to Right channel	-60	dB

Note 1: Limited by Current
Note 2: Limited by Voltage

4. EB-8001 OVERVIEW

The EB-8001 is an all-digital audio amplifier evaluation board that demonstrates the application of Apogee's DDX-8001 digital audio processor and DDX-2160/2120/2100 power devices.

4.1. HARDWARE DESCRIPTION

The EB-8001 amplifier contains six channels of audio amplification. The -02 version, using DDX-2160 power devices, is rated at up to 6x80W RMS. The EB-8001 includes one DDX-8001 digital audio processing IC and three DDX-2160/2120/2100 power devices. The EB-8001 is shipped with jumpers configured for S/PDIF input operation. Figure 4 shows the physical location of connectors.

A CD containing the Graphical User Interface (GUI) is included with the board. The GUI communicates I^2C serial information through the PC's parallel port in accordance with the protocol detailed in Section 2 of the DDX-8001 datasheet. Additionally, control and status bits are sent and monitored via the parallel port. The hardware circuit is described on Sheet 2 of the schematic. It consists of a DB-25 connector with a one to one pin mapping from the PC's parallel port and several inverting buffers to send and receive information.

4.2. DDX-8001 OVERVIEW

The DDX-8001 Controller is a 3.3V digital integrated circuit that converts serial PCM digital audio signals into PWM drive signals. PWM output formats include DDX® Ternary and Binary. These PWM signals are then amplified by the DDX-2160, DDX-2120, DDX-2100 or DDX-2060 for audio output. The DDX-8001 provides volume, bass, treble, EQ, muting and limiter functions under I^2C control. A block diagram of the DDX-8001 is shown in Figure 2.

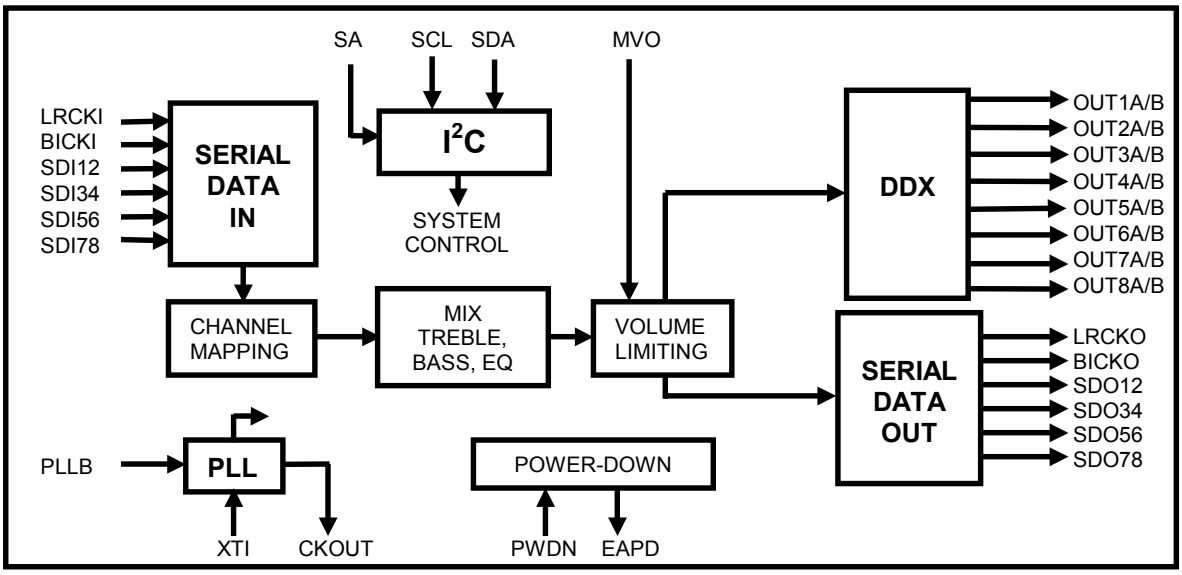


Figure 2: DDX-8001 Block Diagram

4.3. DDX-2160/2100/2120/2160 OVERVIEW

The DDX-2160/2120/2100 Power Devices are dual channel H-Bridges that can deliver over 80 watts per channel of audio output power. The DDX-2160/2120/2100 includes a logic interface, integrated bridge drivers, high efficiency MOSFET outputs and protection circuitry. Two logic level signals per channel are used to control high-speed MOSFET switches to connect the speaker load to the input supply or to ground in a bridge configuration, according to Apogee's patented damped ternary PWM. The DDX-2160/2120/2100 includes over-current, thermal and under-voltage lockout with automatic recovery. A thermal warning status is also provided.

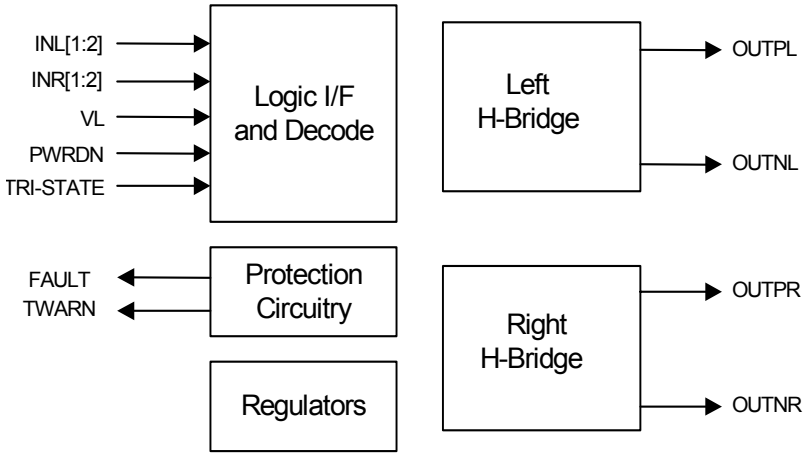


Figure 3. DDX-2160/2120/2100 Block Diagram

5. SCHEMATIC DESCRIPTION

5.1. DIGITAL SIGNAL PROCESSING (SHEET 4)

The DDX-8001 converts pulse code modulated (PCM) digital audio input signals into DDX® pulse-width-modulated (PWM) digital output signals. Six of the eight available input channels are connected to three stereo

output power devices. Signals from I^2S or the S/PDIF receiver are applied as inputs to the DDX® processor. Output PWM signals from the DDX® processor are applied to the inputs of the DDX® power stage.

The DDX-8001 has eight independent volume control registers that have an adjustment range from +48dB to -78dB in 0.5 dB increments. Each channel also has an associated Trim adjustment of +10dB to -10dB. In addition, the Master Volume is adjustable from 0dB to –127dB in 0.5dB steps. Tone control registers boost or cut treble and bass by +/-12dB, in 2dB steps. EQ filters are IIR biquads, configurable by programmable coefficients. The DDX-8001 GUI software is provided to simplify generation and download of the filter coefficients, enabling on-the-fly equalization changes.

5.2. POWER OUTPUT (SHEETS 5, 6, 7)

The DDX-2160/2120/2100 provides power amplification by translating logic level PWM signals into power level signals. These power level signals are applied to passive two-pole lowpass filters, and provide low distortion audio power to the load. The output filter functions to prevent unwanted high frequency switching signals from reaching the load. The output filters on Sheets 5, 6 and 7 are designed for 6Ω loads.

A thermal warning (TWARN) signal is output by the DDX-2160/2120/2100 if the junction temperature exceeds 130°C. The thermal warning is indicated on the GUI by a red spot in the Power Status area on the Control tab. The DDX-2160/2120/2100 automatically shuts down when it reaches 150°C and automatically restarts after cooling ~25C.

5.3. SUPPLY VOLTAGE, REGULATORS (SHEET 9)

The EB-8001 contains onboard 5V and 3.3V power regulation for logic circuitry. Separate power supply inputs are available for the logic supply as well as the output power section. Input protection is provided for the amplifier by diode D8. This diode will protect from overvoltage and reverse power connection. Reset Supervisor U18 is used for power-on-reset and power-off sequencing.

Applying Logic Power, VL, then Output Power, VCC, is the preferred power on sequence. Removing VCC then VL is the preferred power off sequence.

5.4. HEADERS JUMPERS AND SWITCHES (SHEETS 1, 2, 3, 4, 9)

Sheet 1: J2 is the PSC Select Jumper. Shorting pins 1 & 2 selects Power Supply Correction (see DDX-8001 Datasheet, Section 3.9.1). Shorting pins 3 & 4 connects Left Analog Input to the ADC.

Sheet 2: Header J4 selects PC control when pins 1 & 2 and 3 & 4 are shorted.

Sheet 3: J6 is the Oscillator Select jumper. Shorting pins 1 & 2 connects the onboard 12.288MHz crystal oscillator to the MCLK line.

Sheet 4: Header J6 has the Serial Output Data for external use.

Sheet 9: Header J10 is the RB-86xxx Interface. Header J13 has eight channels of DSD inputs. Header J14 is the External I^2S Input connector. Header J12 is the External I^2S Select. Momentary pushbutton SW1 provides a global RESET signal.

5.5. S/PDIF INPUT/OUTPUT INTERFACE (SHEET 3)

The DDX-8001 controller's data interface is serial I^2S for inputs and outputs. The EB-8001 input accommodates coaxial or optical S/PDIF digital audio interfaces using a digital audio receiver IC. Either input may be used. S/PDIF interfaces will support sample rates from 32kHz to 96kHz. LED D7 is the S/PDIF Unlock indicator.

5.6. ANALOG INPUT (SHEET 1)

Line level analog data is converted to I^2S -formatted, 24 bit digital data. A jumper must be installed on J12, pins 1 & 2, 5 & 6, 7 & 8 and 9 & 10 to connect the ADC data to the DDX-8001. The GUI is used to select the ADC, which is on Channels 3 and 4, as the input source.

5.7. LINE OUTPUTS (SHEETS 10 & 11)

DDX-8001 output channels 6, 7 and 8 are processed and buffered for use as Subwoofer, Left and Right Line Outputs, respectively. These analog outputs can then be used for inputs to analog recorders, processors or amplifiers.

5.8. HEADPHONE AMPLIFIER (SHEET 8)

Plugging headphones into J9 automatically disables the speaker outputs and enables the headphone amplifier. Standard 32Ω headphones can then be driven at levels up to 800mW.

6. ADDITIONAL INFORMATION

6.1. PERFORMANCE MEASUREMENTS

Class D amplifiers produce measurable switching noise outside the audio bandwidth. Apogee's DDX® amplifier uses a patented PWM modulation scheme that significantly reduces this noise compared to typical Class D designs. However, in order to obtain accurate performance measurements in the audio band (i.e., 20Hz to 20kHz), additional filtering is required. The Typical Performance data was taken using an AES17 brick wall measurement filter with a break frequency of 20kHz. This type of filter is often provided as part of audio measurement systems. Typical performance measurements for the evaluation board are shown in Figures 9 through 18.

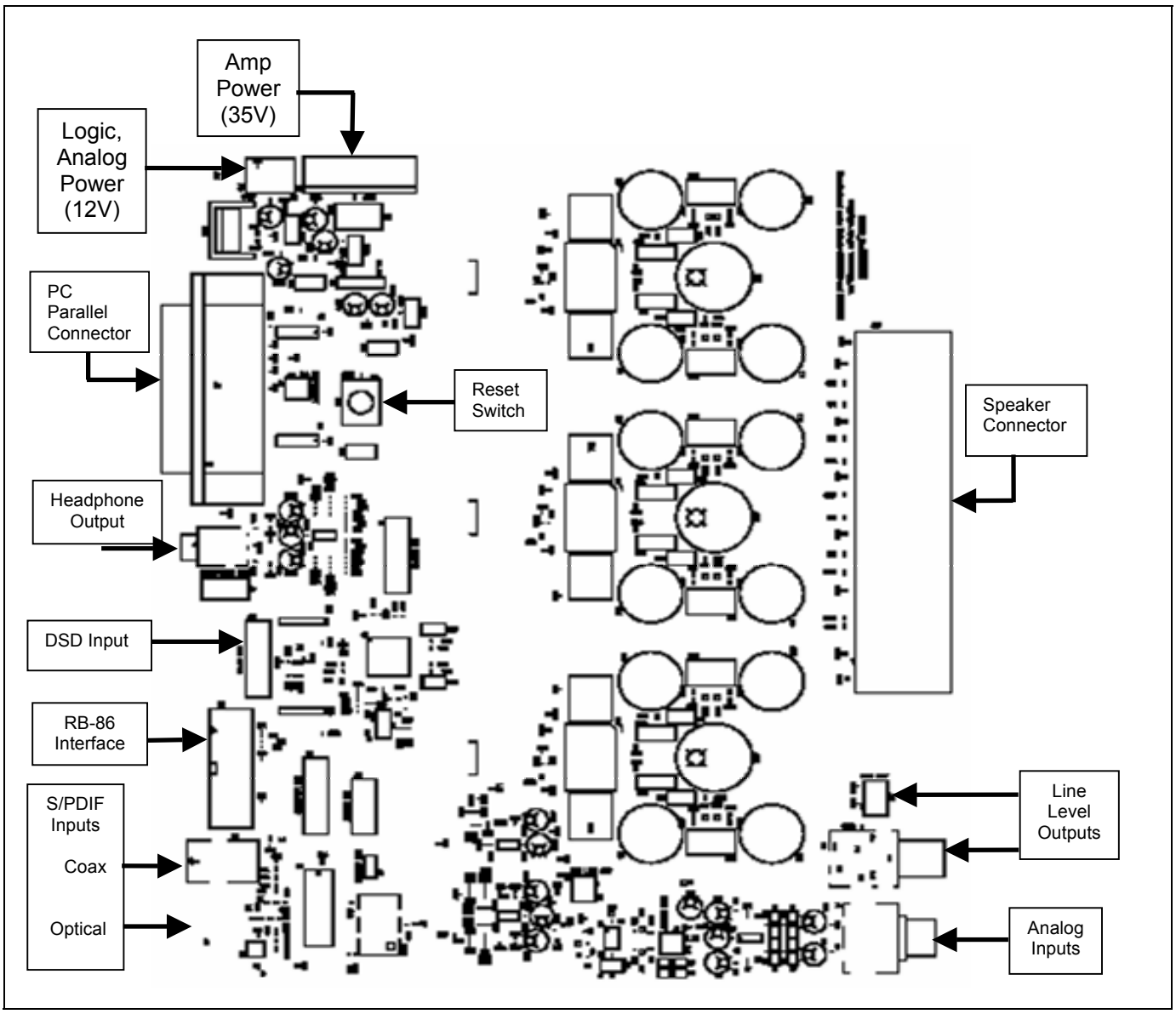


Figure 4. : Assembly Drawing

6.2. CONFIGURE EB-8001 FOR 2-CHANNEL SPDIF INPUT:

(1 to 6 Channel Output, I^2C Control from PC)

6.2.1. Jumper Settings:

- **J12** – Short pins **3-4, 5-6, 7-8 and 9-10** to connect SPDIF Receiver I^2S output to DDX-8001 I^2S input.
- **J14** – Short pins **1-2 and 3-4** to ground unused I^2S inputs.

6.2.2. Speaker Connections:

- Connect 6Ω (recommended) speakers to **J20**. For headphone operation, see Section 6.3.76.

6.2.3. Connection to Computer:

- Use the supplied parallel port cable to connect **J3** to PC parallel port.

6.2.4. Power Connections:

- Connect **12V and GND to J15**. The square pad on the underside of the pc board is pin 1 and should receive 12V. In other words, facing the wire openings of the green Phoenix connector, Ground goes in the left-hand opening, and +12V goes in the right.
- Connect **10V to 35V to J11 pins 3 and 4**, and **GND to J11 pins 5 and 6**. The square pad on the underside of the pc board is pin 1. Pin 1 should be left unconnected. Pin 2 can be connected to GND or left unconnected. Be sure to apply the +12V to the board **BEFORE** applying the 10 to 35V.

6.2.5. Configuring GUI Software:

- Run the DDX-8001ControlPanel.exe software.
- Go to “Registers” page of GUI.
- Click the “Power Up” button to start the DDX-8001.
- Click “Test Board I/O”, If “passed” it is OK, proceed to next step. If “failed” then perform manual board reset by pressing SW1 button and try again, if still “failed” then make sure connections are OK.
- Go to “I/O” page of GUI.
- Select S/PDIF source in Input Interface section.
- Optical S/PDIF link is the default. If S/PDIF source is Coax, make this selection in the S/PDIF Connector section.
- Sampling rates of 32, 44.1 and 48kHz and MCLK=256Fs is the default. For other values, update Sample Rate and Clock in the Input Interface area.
- Go to “Control” page of GUI.
- S/PDIF delivers only two channels of audio, on Channels 1 and 2. To evaluate all 6 channels, select Channel Source of Ch1 for Channels 3 and 5, and Ch2 for Channels 4 and 6, for example.
- Click “Ext Amp Power Up” to enable DDX-21xx power devices.
- Increase “ALL” master volume control from -127.5dB to the desired level, as high as 0dB. Additional gain, up to +58dB, is available by adjusting individual channel volumes and Trim.

6.2.6. Headphone Connections and Operation:

- Plug Stereo Headphones into J9. This automatically disables the power devices driving the speakers.

6.3. CONFIGURE EB-8001 FOR 2-CHANNEL ANALOG INPUT:

(1 to 6 Channel Output, I^2C Control from PC)

6.3.1. Jumper Settings:

- **J2** – Short pins **3-4** to select two channel analog input.
- **J12** – Short pins **1-2, 3-4, 5-6, 7-8 and 9-10** to connect SPDIF Receiver I^2S output to DDX-8001 I^2S input.
- **J14** – Short pins **1-2 and 3-4** to ground unused I^2S inputs.

6.3.2. Speaker Connections:

- Connect 6Ω (recommended) speakers to **J20**. For headphone operation, see Section 6.3.7.

6.3.3. Analog Input Connections:

- Connect line level analog inputs to RCA connectors on **J1**.

6.3.4. Connection to Computer:

- Use the supplied parallel port cable to connect **J3** to computer parallel port.

6.3.5. Power Connections:

- Connect **12V and GND to J15**. The square pad on the underside of the pc board is pin 1 and should receive 12V. In other words, facing the wire openings of the green Phoenix connector, Ground goes in the left-hand opening, and +12V goes in the right.
- Connect **10V to 35V to J11 pins 3 and 4**, and **GND to J11 pins 5 and 6**. The square pad on the underside of the pc board is pin 1. Pin 1 should be left unconnected. Pin 2 can be connected to GND or left unconnected. Be sure to apply the 12V to the board **BEFORE** applying the 10 to 35V.

6.3.6. Configuring GUI Software:

- Run the DDX-8001ControlPanel.exe software.
- Go to “Registers” page of GUI.
- Click the “Power Up” button to start the DDX-8001.
- Click “Test Board I/O”, If “passed” it is OK, proceed to next step. If “failed” then perform manual board reset by pressing SW1 button and try again, if still “failed” then make sure connections are OK.
- Go to “I/O” page of GUI.
- Select ADC (Analog to Digital Converter) source in Input Interface section.
- Go to “Control” page of GUI.
- The ADC delivers only two channels of audio, on Channels 3 and 4. To evaluate all 6 output channels, select Channel Source of Ch3 for Channels 1, 3 and 5, and Ch4 for Channels 2, 4 and 6, for example.
- Click “Ext Amp Power Up” to enable DDX-21XX power devices.
- Increase “ALL” master volume control from -127.5dB to the desired level, as high as 0dB. Additional gain, up to +58dB, is available by adjusting individual channel volumes and Trim.

6.3.7. Headphone Connections and Operation:

- Plug Stereo Headphones into J9. This automatically disables the power devices driving the speakers.

7. GRAPHIC USER INTERFACE (GUI) FOR THE EB-8001

7.1. GUI: CONTROL TAB

The Control tab contains Volume, Tone, EQ, Muting and Limiter settings, Filtering and Scaling, QSurround 5.1, Gain and Limiting, Bass Management, Thermal and Headphone Status, Max Power Correction and AM Mode Enable. Detailed GUI information is available under the Help pulldown.

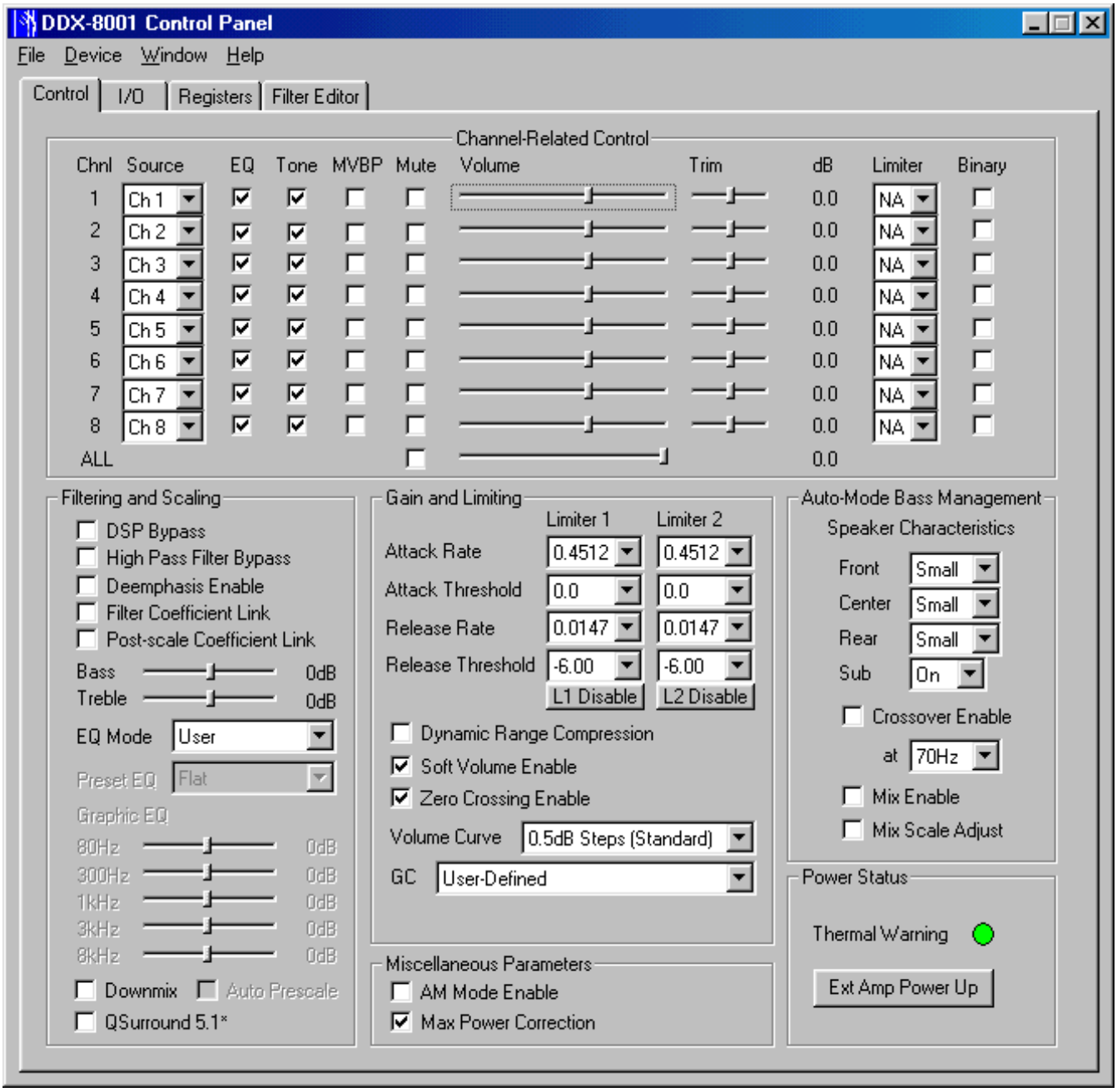


Figure 5 –GUI: Control Tab

7.2. GUI: I/O TAB

The I/O tab contains Input and Output Interface configuration. PWM Timing can be adjusted to improve THD and Crosstalk performance with certain connections.

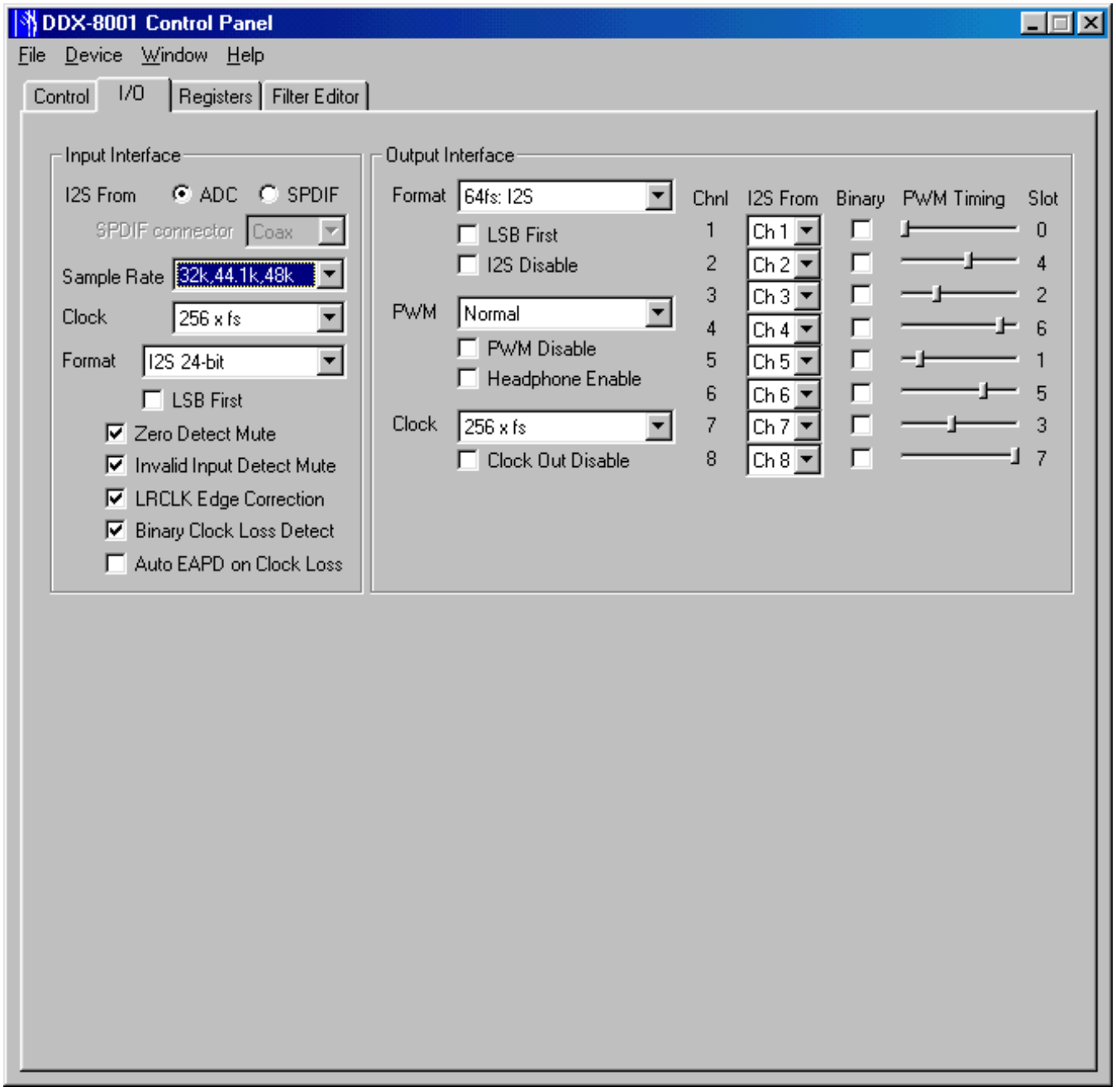


Figure 6 –GUI: I/O Tab

7.3. GUI: REGISTERS TAB

Direct Register Access allows writing or reading individual registers' contents. Filter, Scaling and Mixing coefficients, explained in Section 5 of the DDX-8001 datasheet, can be entered from their respective areas. Finally, PC Port address and board I/O can be tested. The board can be powered up or down, or reset in the Direct Device Access and Diagnostics area. Filter Coefficients can also be created by the Filter Editor (Refer to 7.4, Filter Editor).

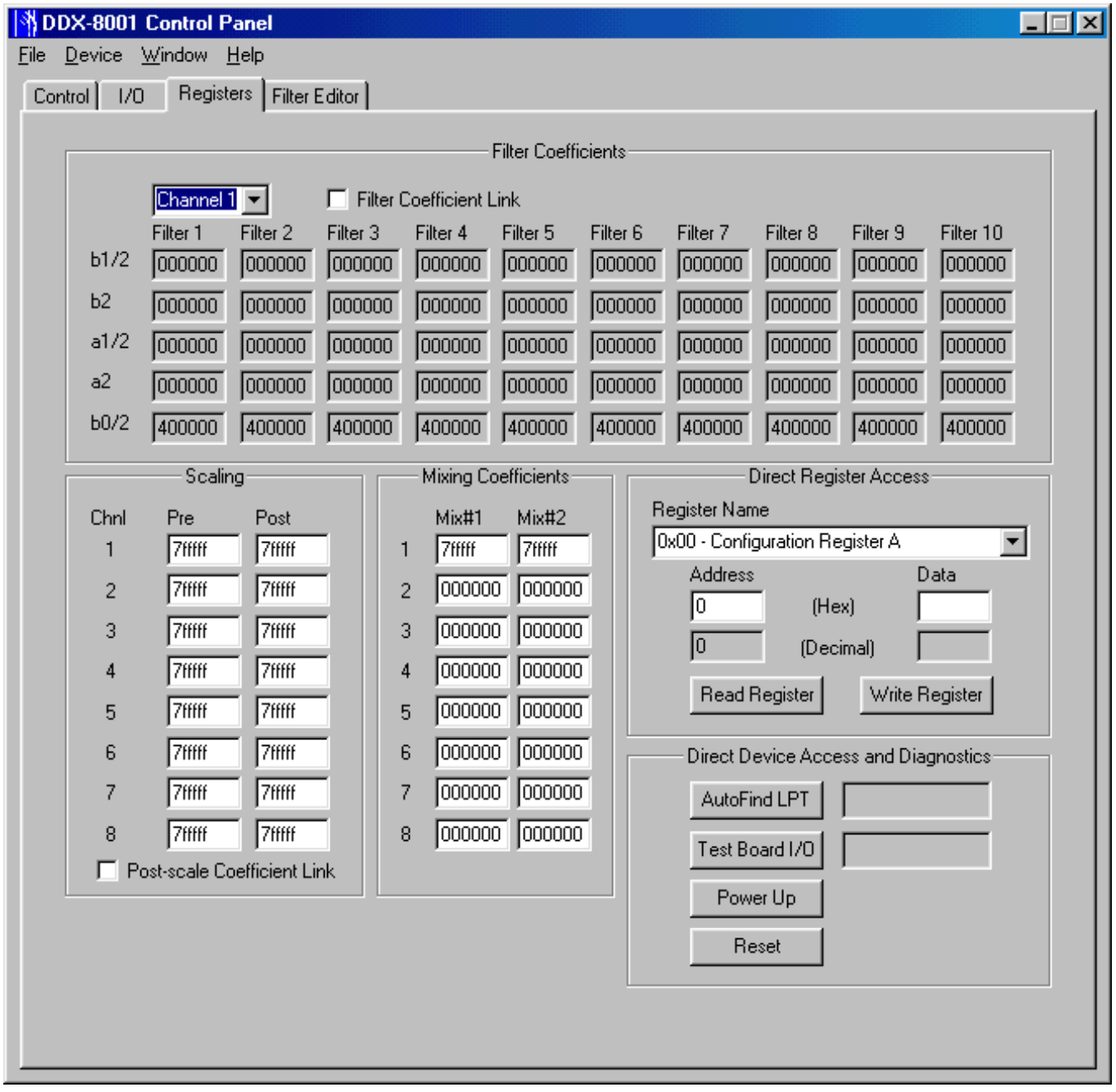


Figure 7 – GUI: Registers Tab

7.4. GUI: FILTER EDITOR TAB

Up to 10 filters can be programmed for each of the 8 channels. Set the frequency and gain by dragging the round filter point with the mouse, or by clicking on the knobs and dragging up or down. Checking the Filter Coefficient Link box allows all eight (8) channels to share a single set of filter data. If a given filter is not available as a user-defined filter (due to the effective EQ mode), that filter will be disabled (grayed-out buttons and knobs) and the frequency response curve will not be affected by the settings for that filter.

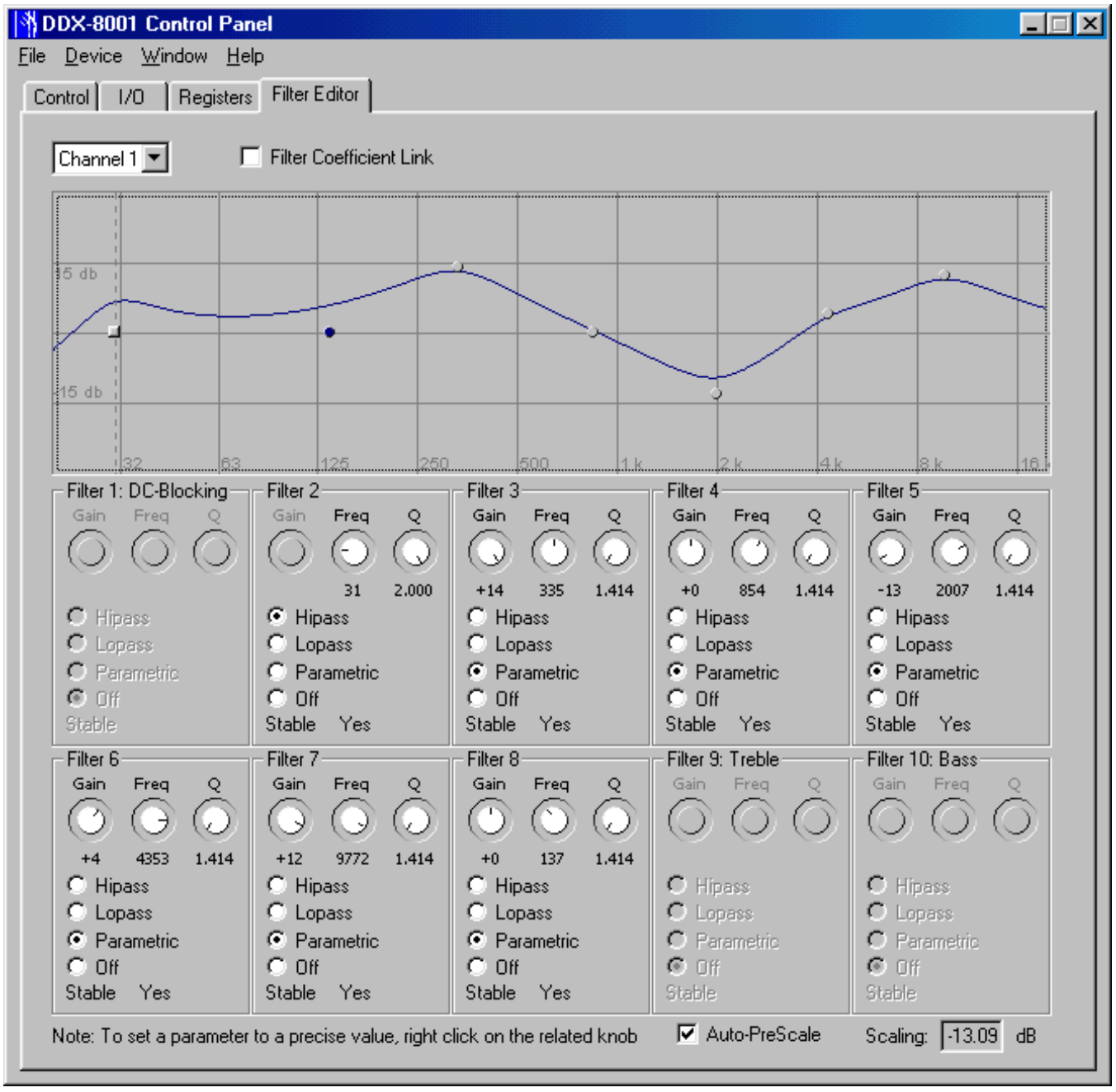
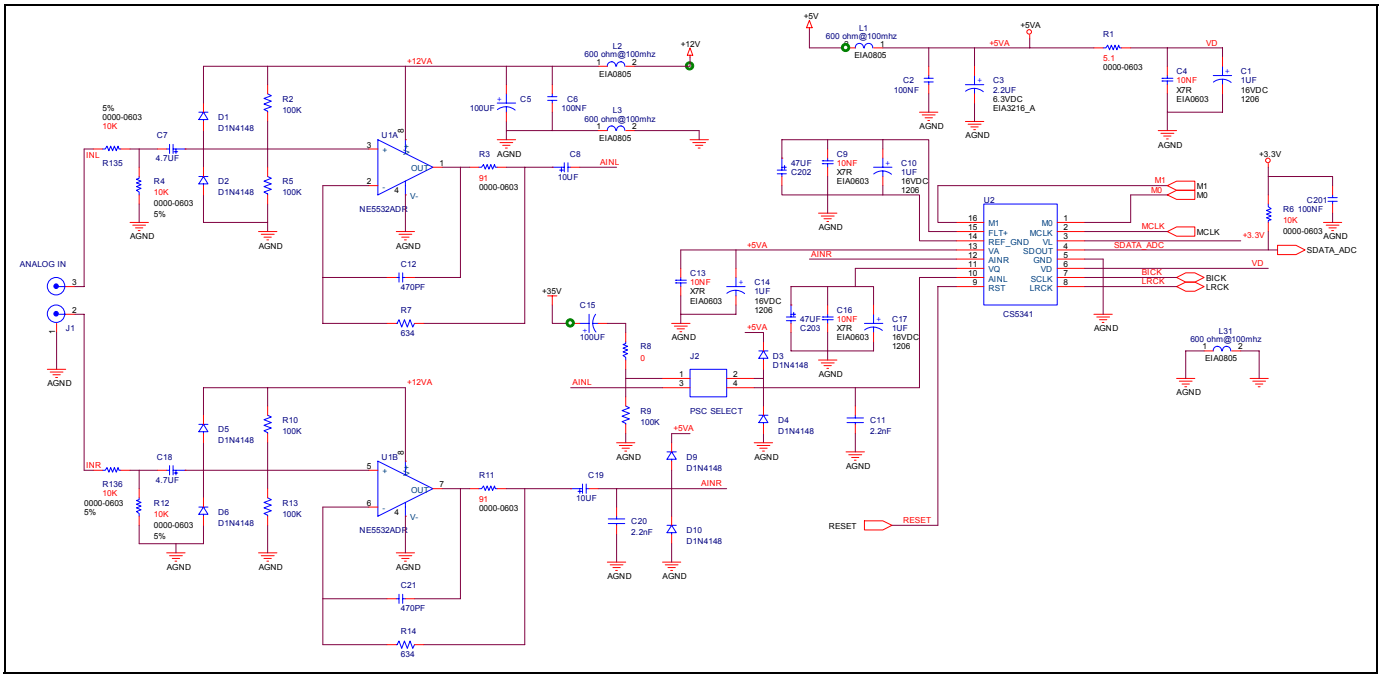
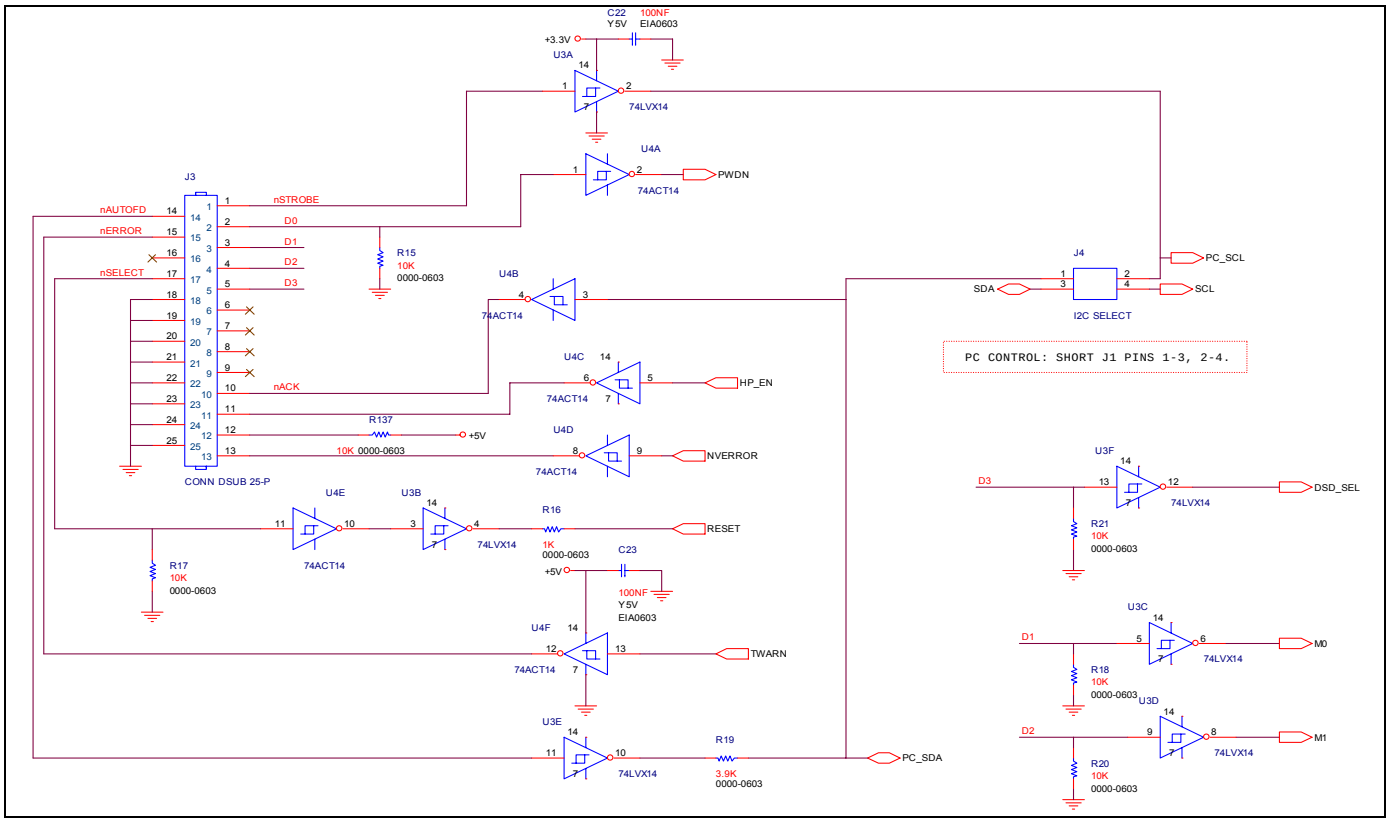


Figure 8 – GUI. Filter Editor Tab

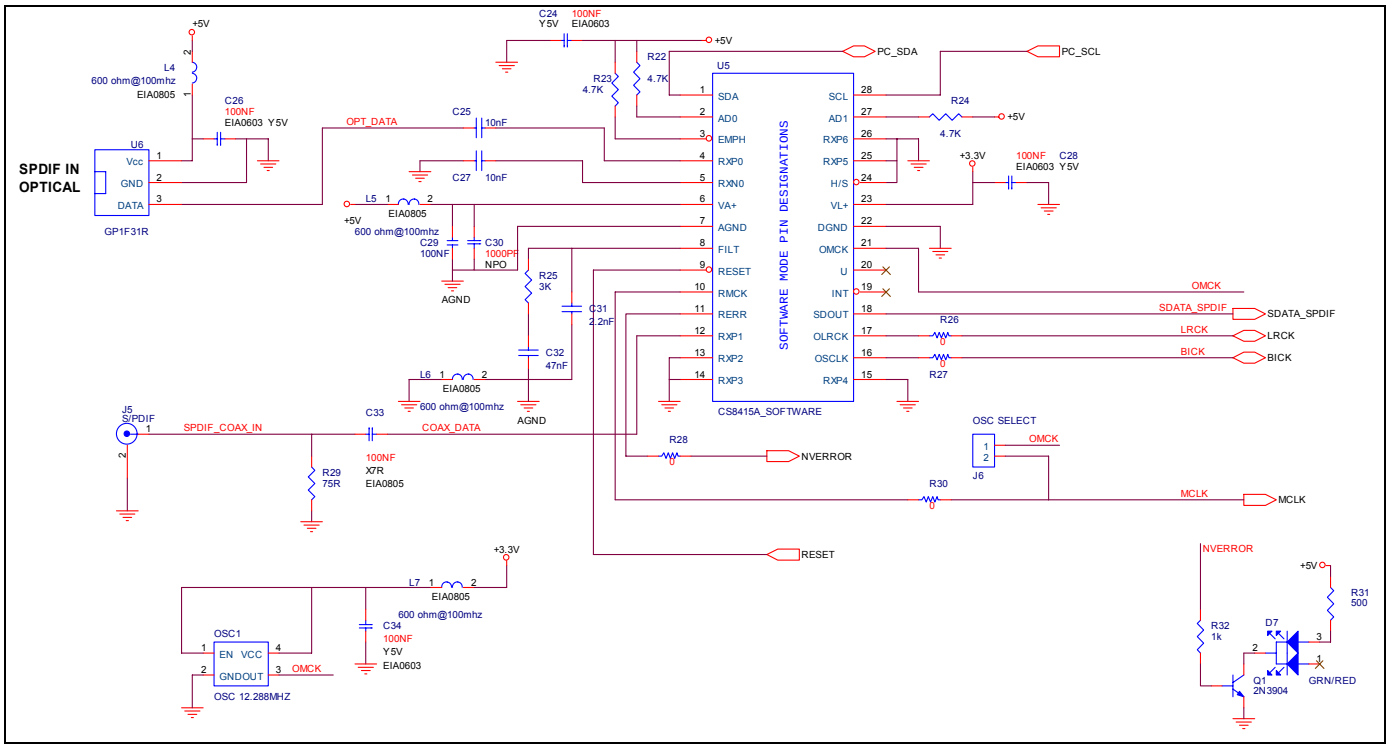
8. EB-8001 SCHEMATIC:



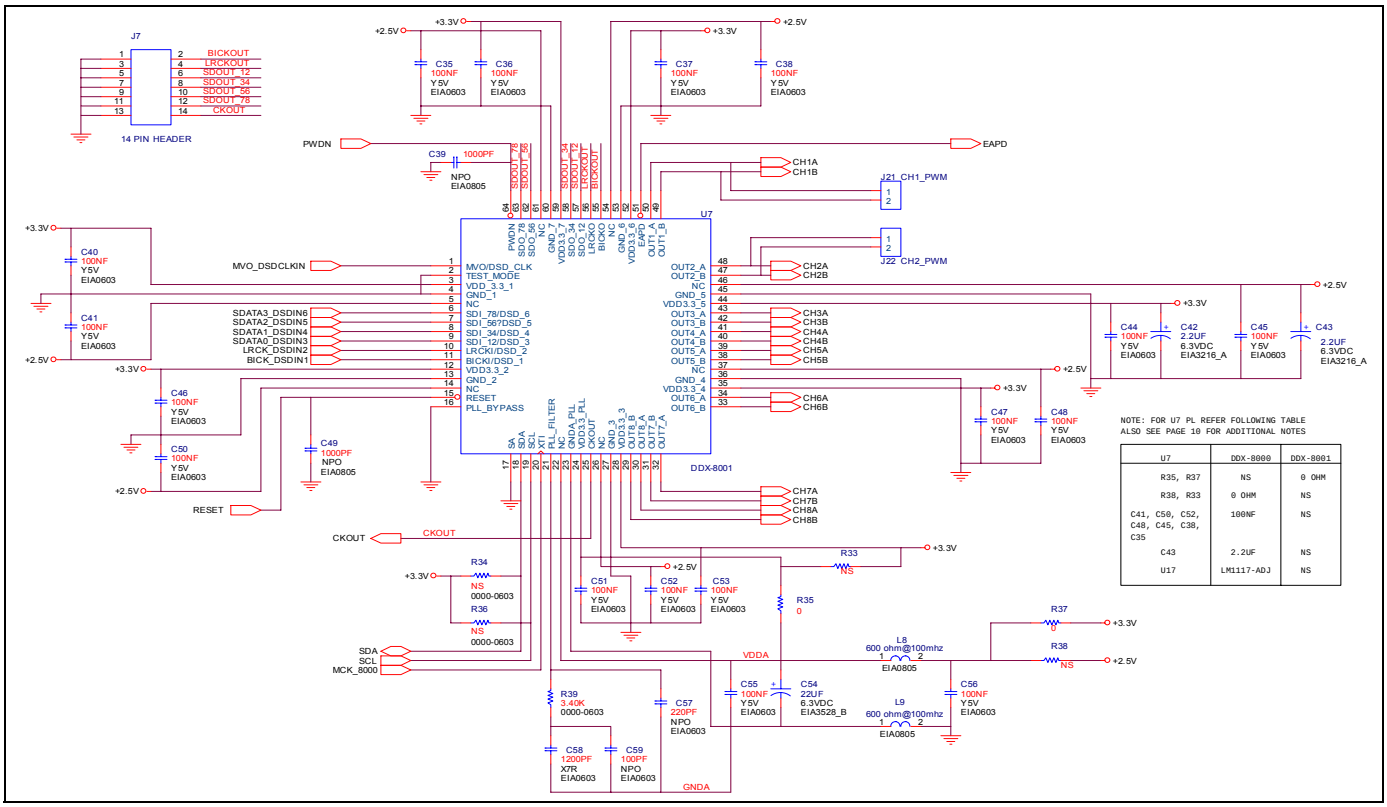
Sheet 1. Analog Input



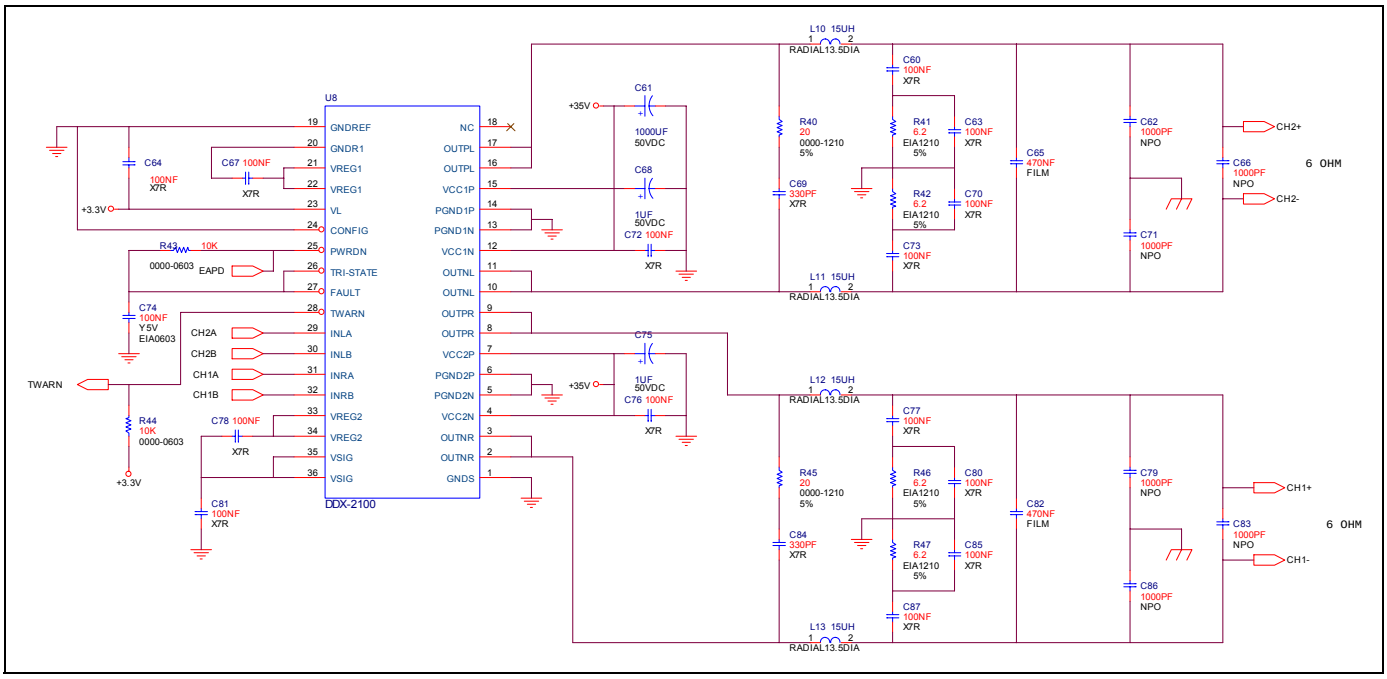
Sheet 2. PC Interface



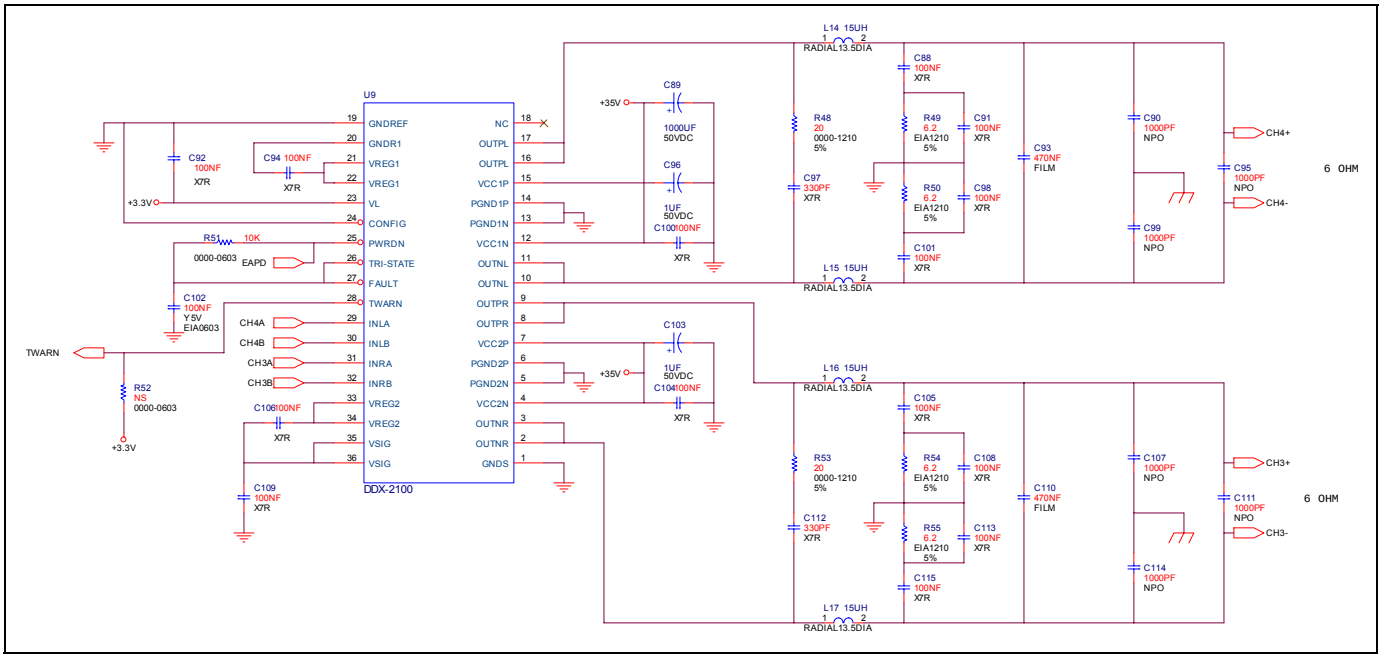
Sheet 3. S/PDIF Input



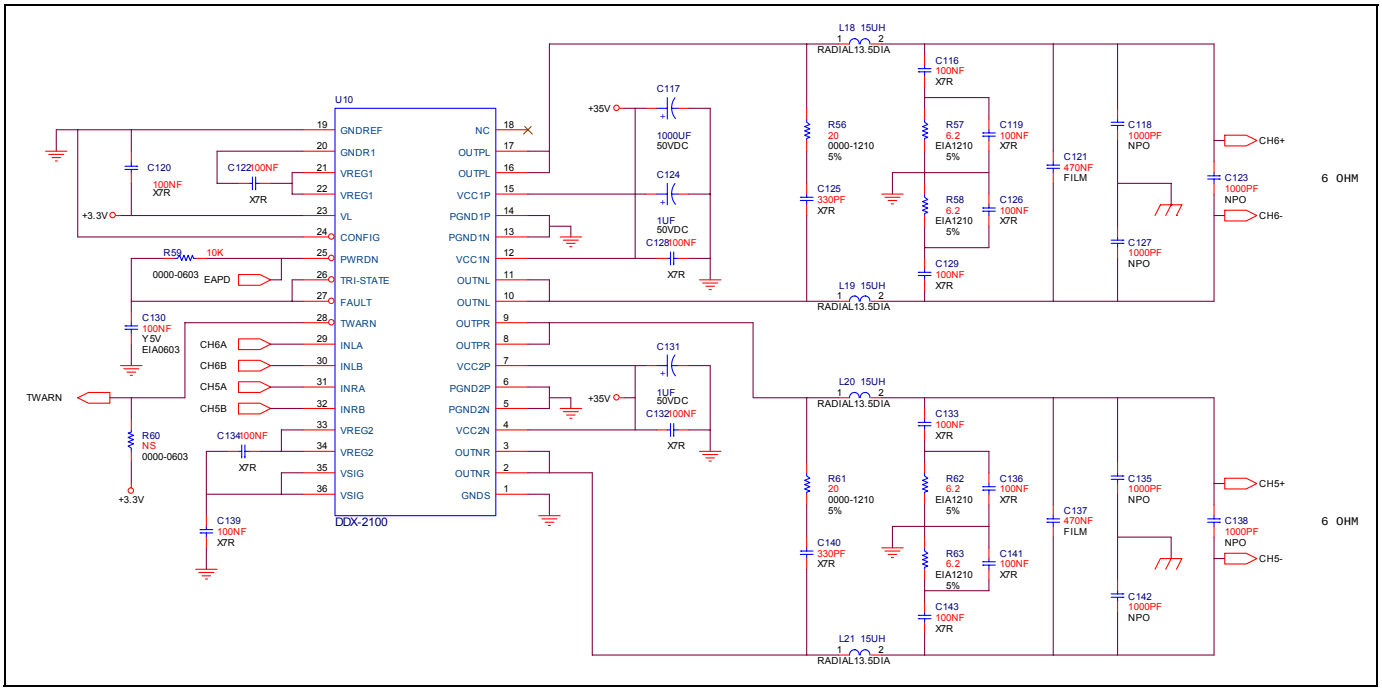
Sheet 4. DDX Digital Audio Processing



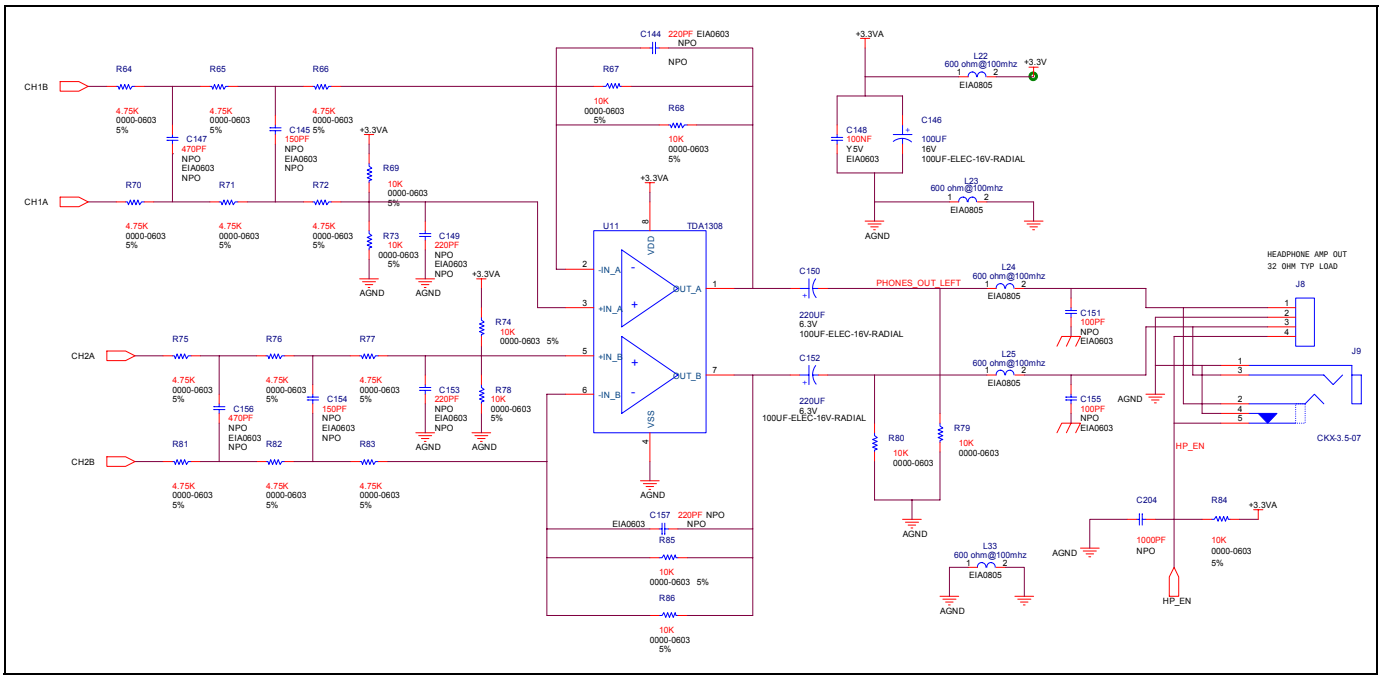
Sheet 5. Left & Right Output



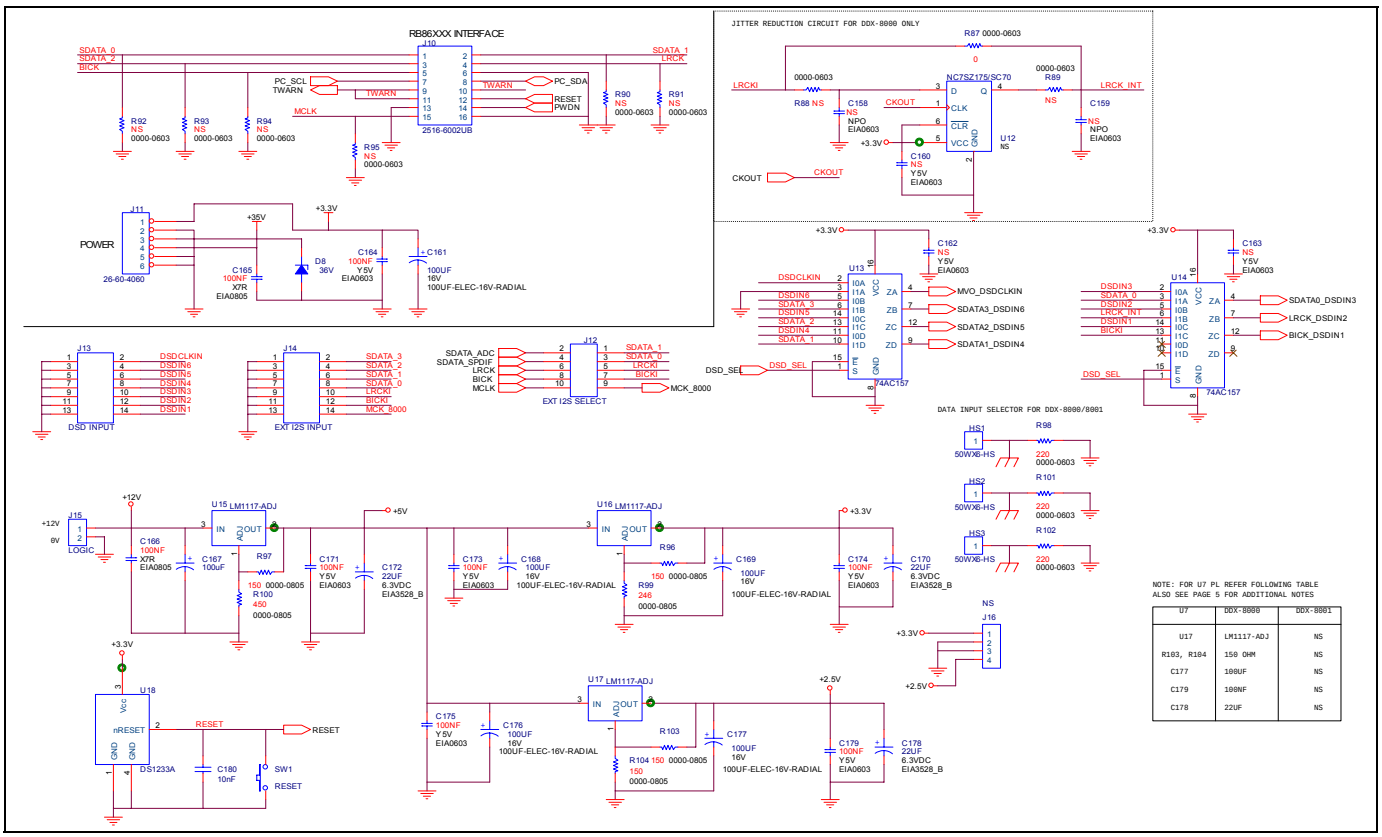
Sheet 6. Left & Right Surround Outputs



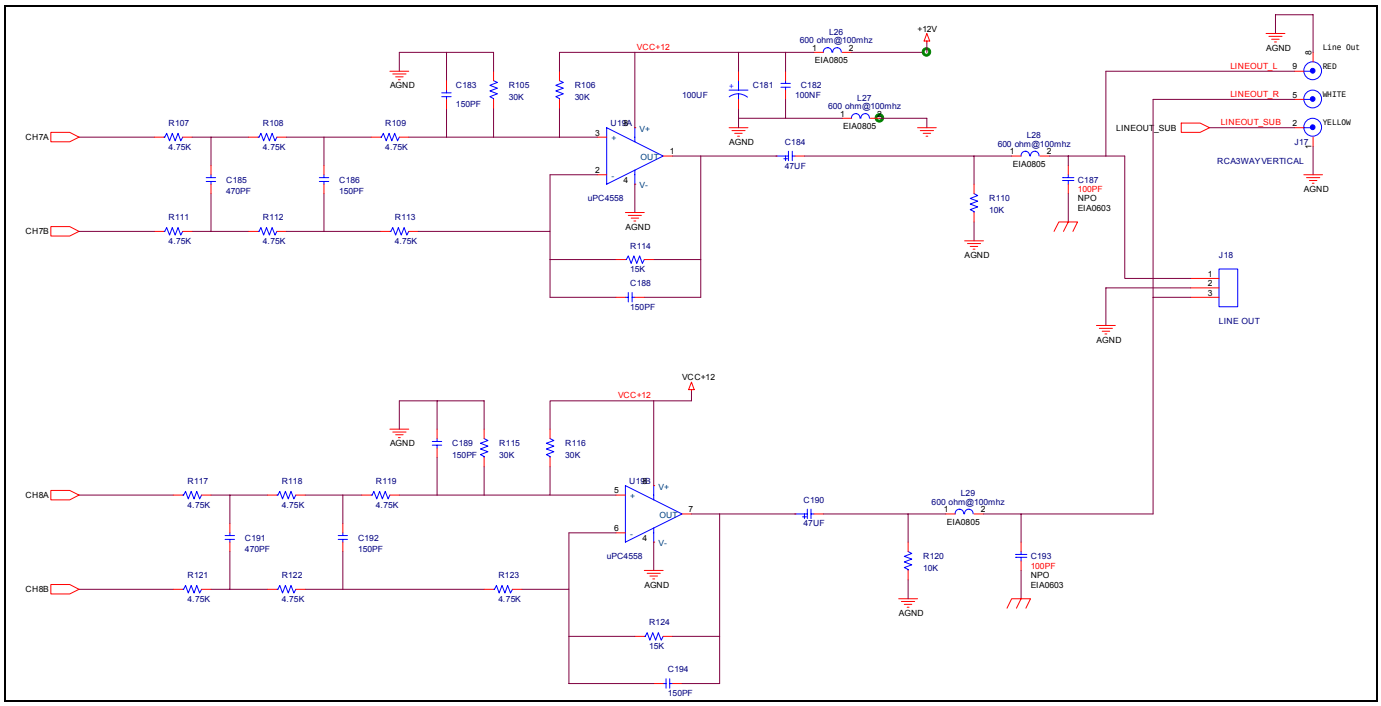
Sheet 7. Center & Subwoofer Outputs



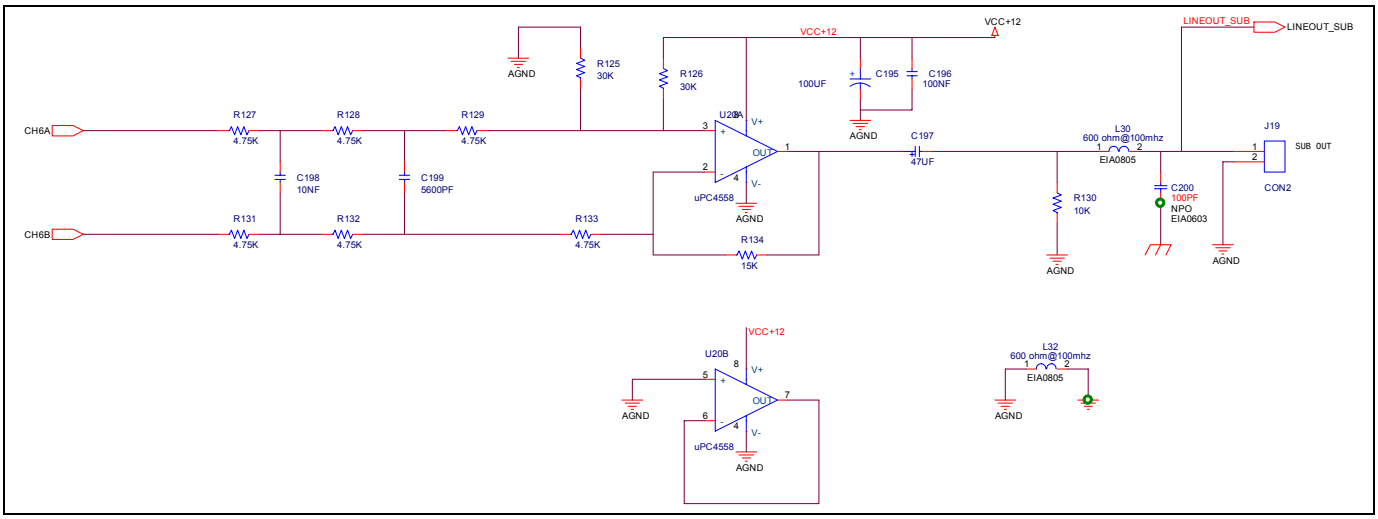
Sheet 8. Headphone Amplifier



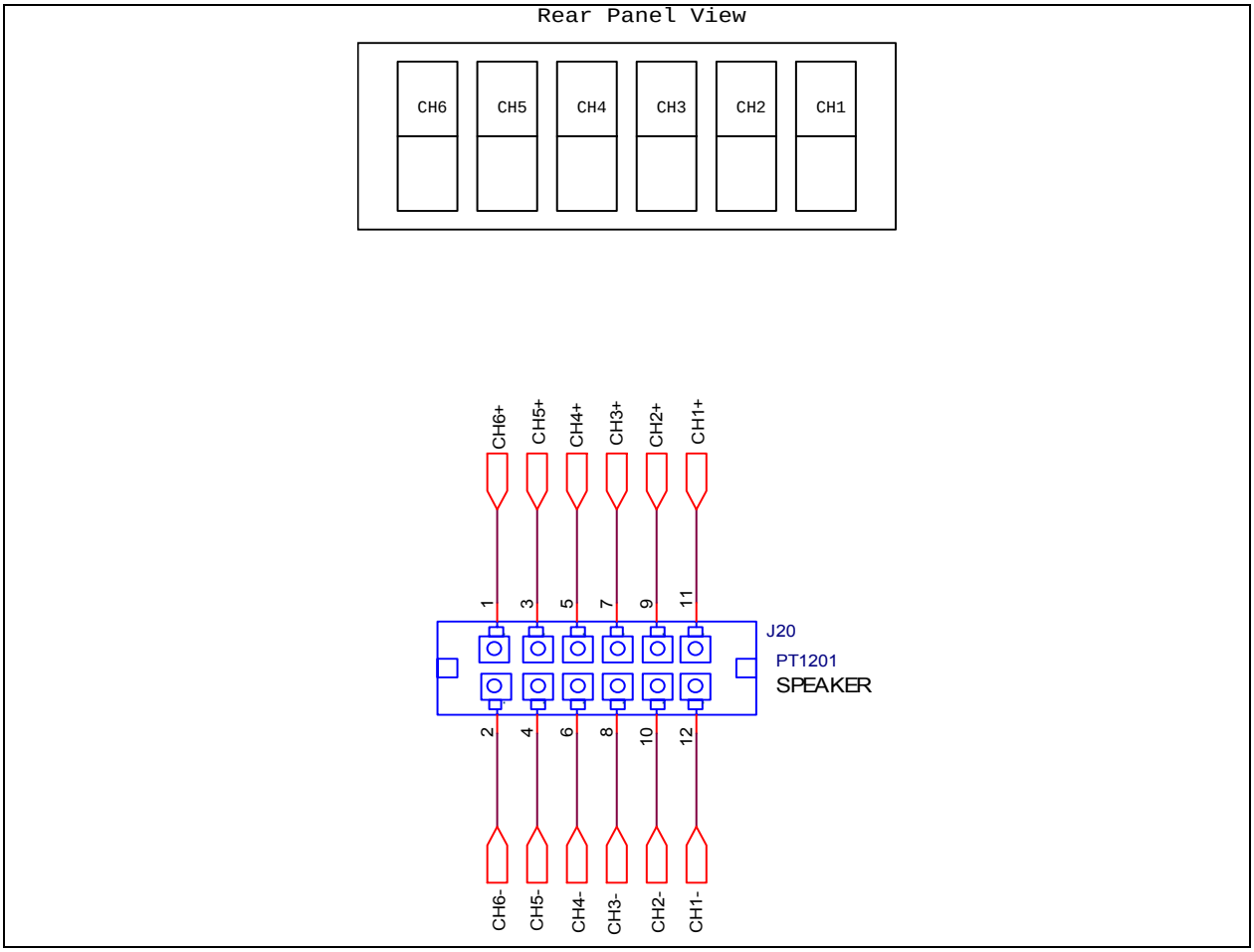
Sheet 9. Configuration Jumpers, Input/Output Connectors, Power



Sheet 10. Left & Right Line Outputs



Sheet 11. Subwoofer Line Out



Sheet 12. Speaker Connectors

9. TYPICAL PERFORMANCE CHARACTERISTICS, VCC=34V, 6Ω LOADS.

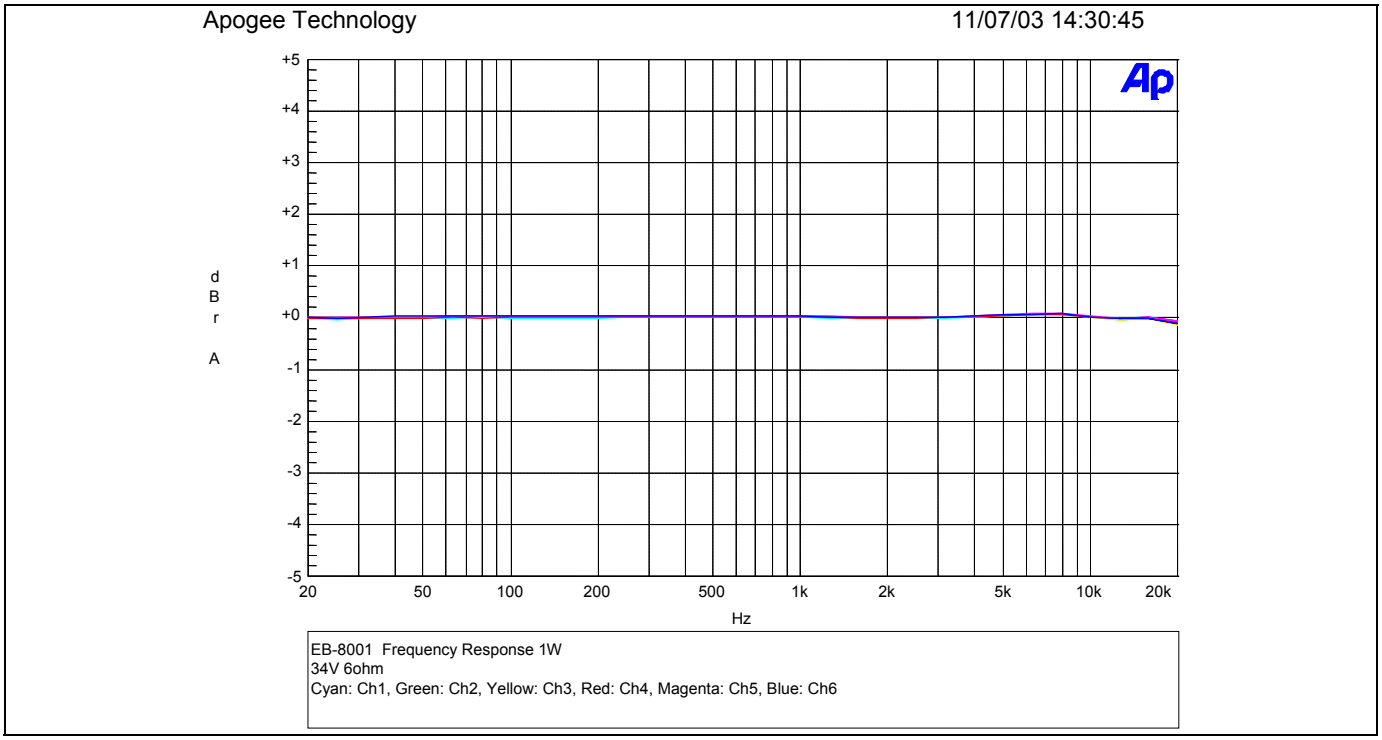


Figure 9. Frequency Response

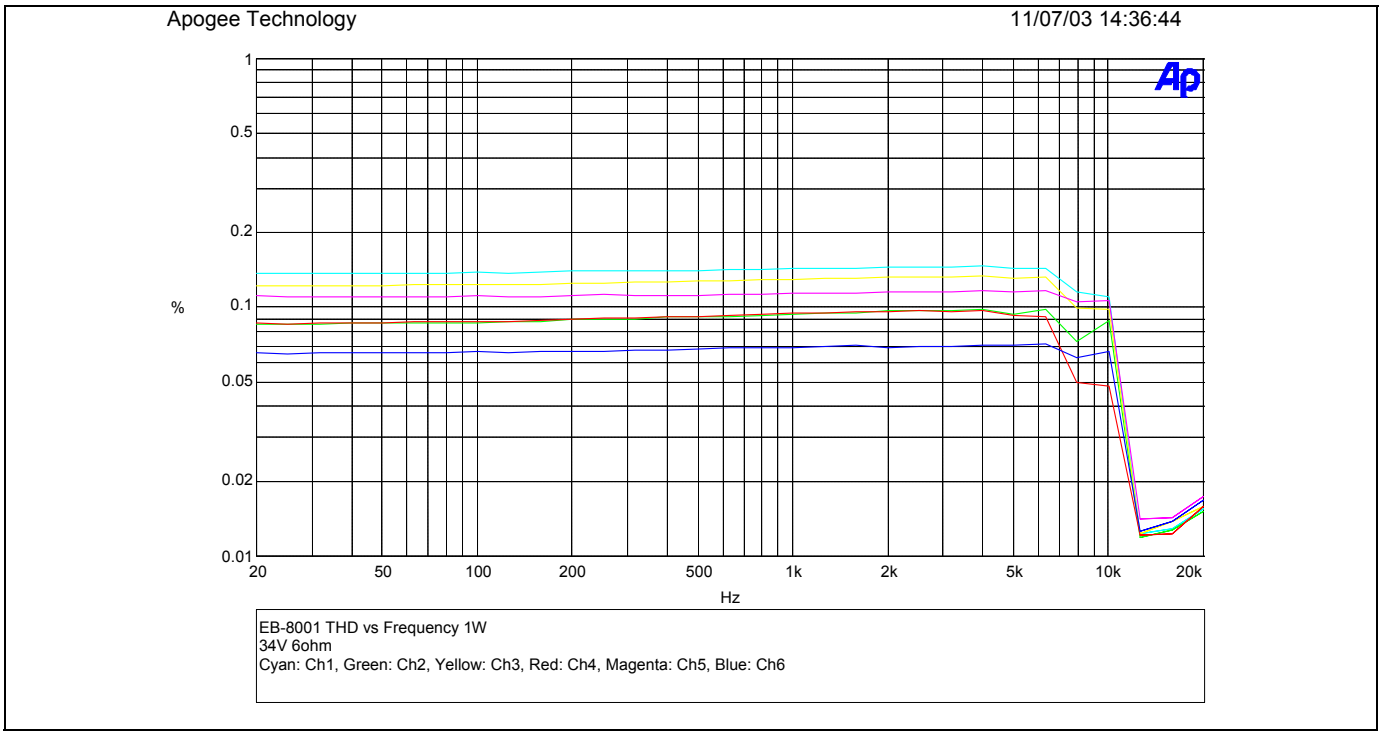


Figure 10. 1W THD vs. Frequency

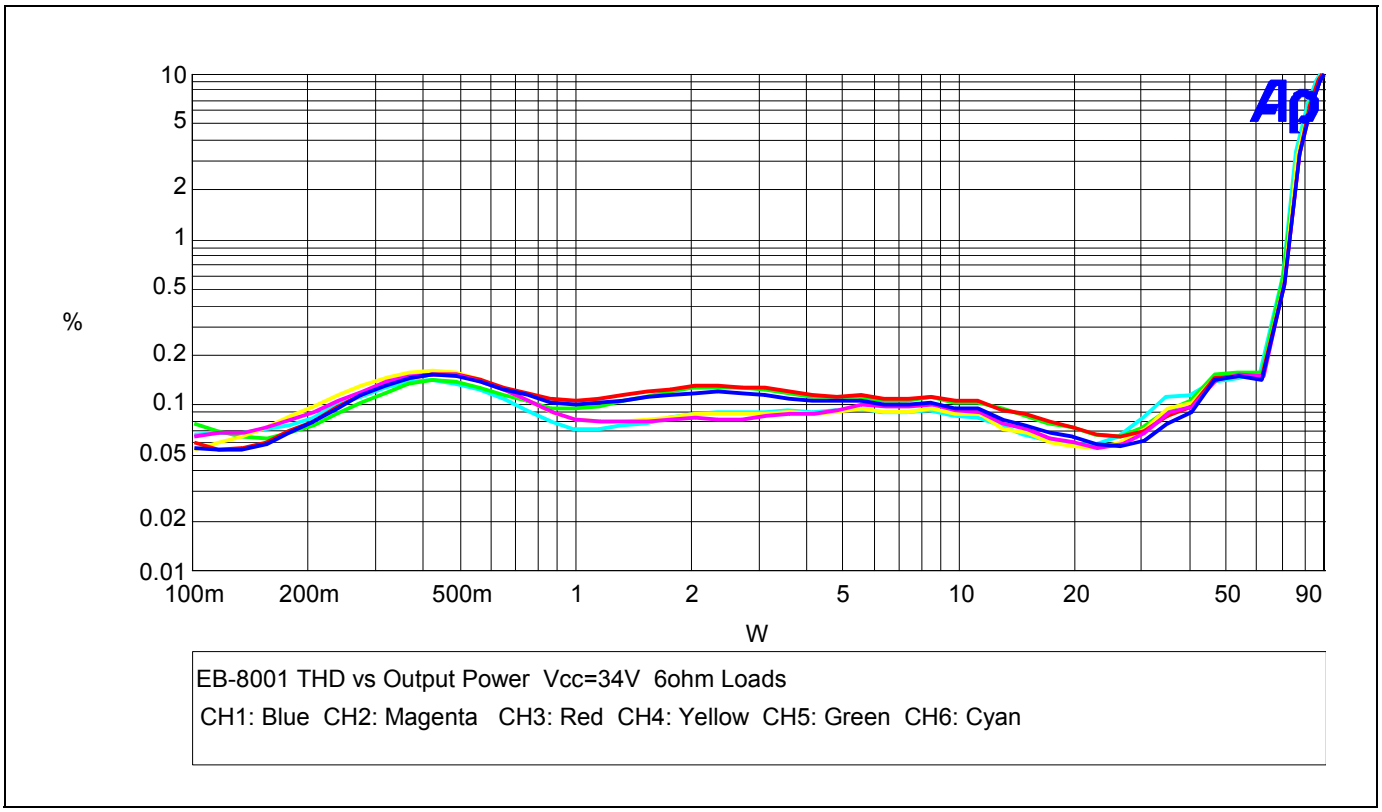


Figure 11. THD vs Power

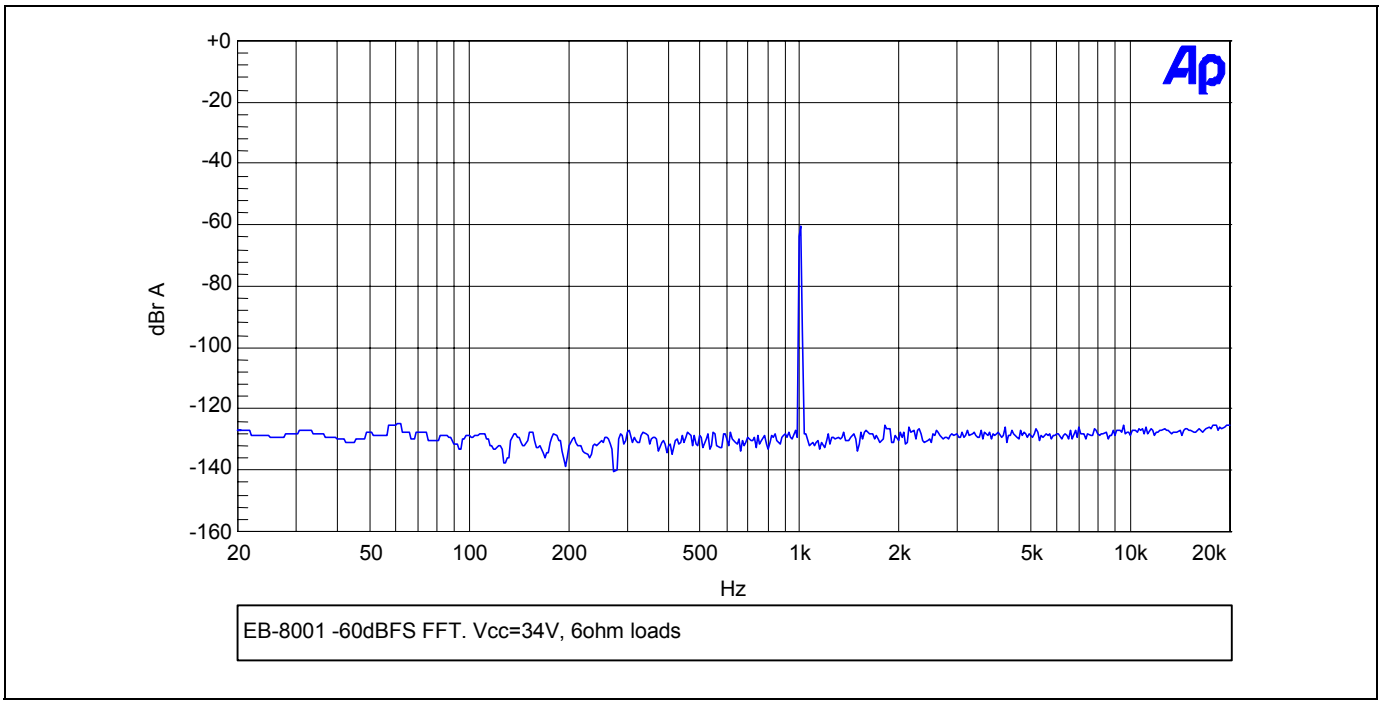


Figure 12. FFT: -60dB, 1kHz Output

10. TYPICAL PERFORMANCE CHARACTERISTICS, HEADPHONE OUTPUTS.

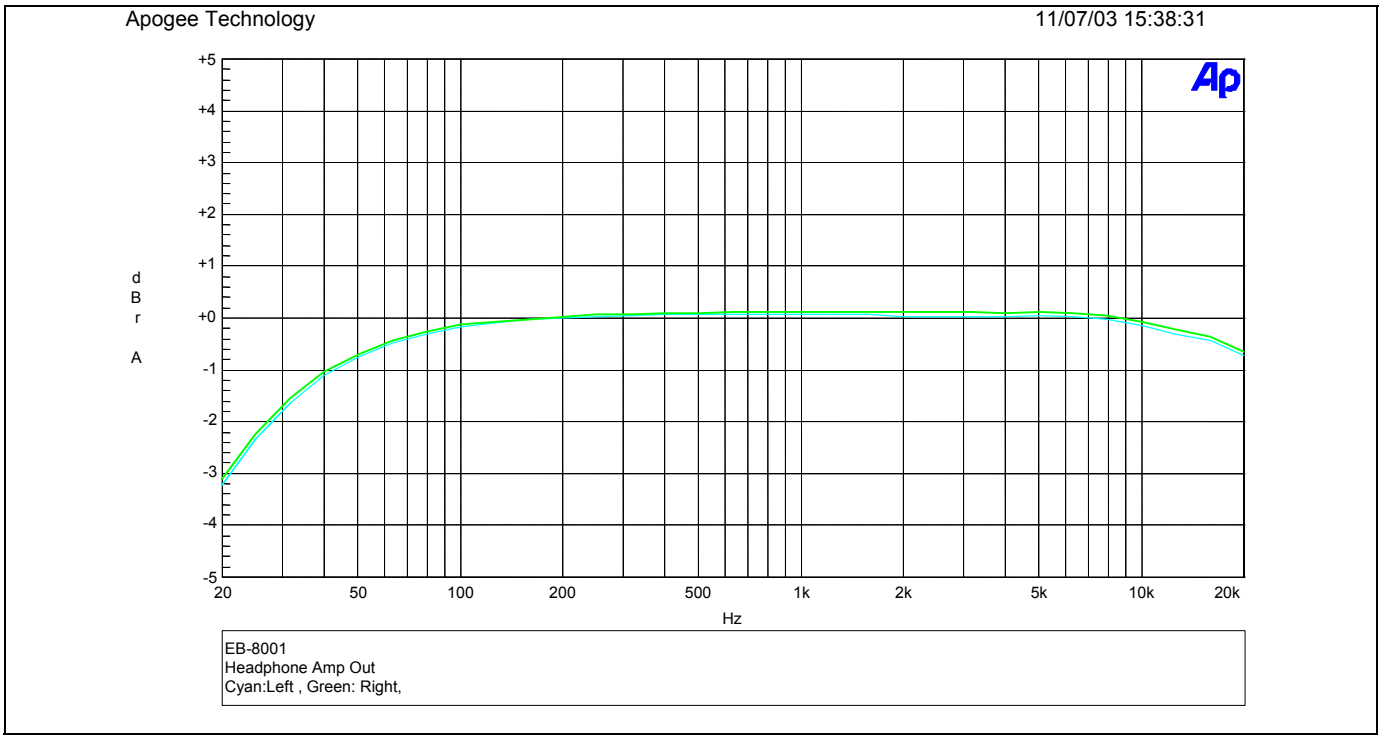


Figure 13. Headphone Amplifier Frequency Response

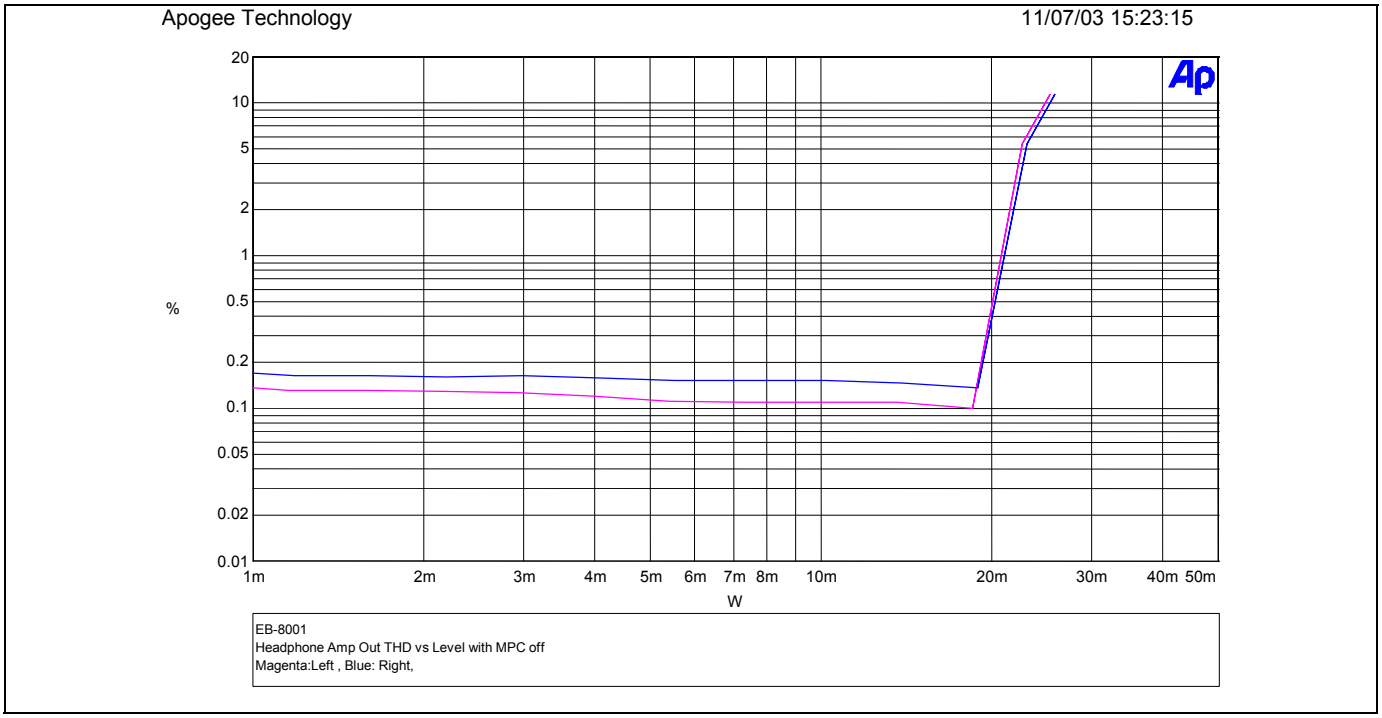


Figure 14. Headphone Amplifier THD vs. Power

11. TYPICAL PERFORMANCE CHARACTERISTICS, LINE OUTPUTS.

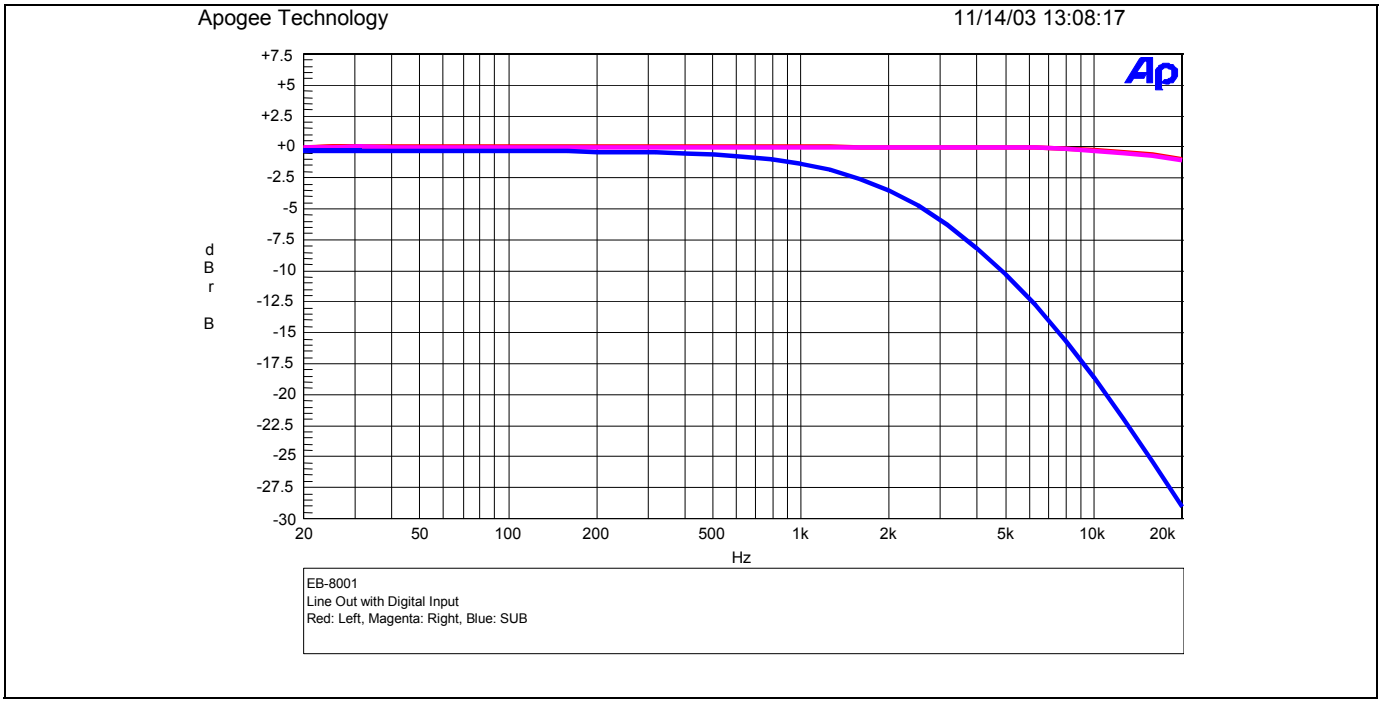


Figure 15. Line Outputs Frequency Response

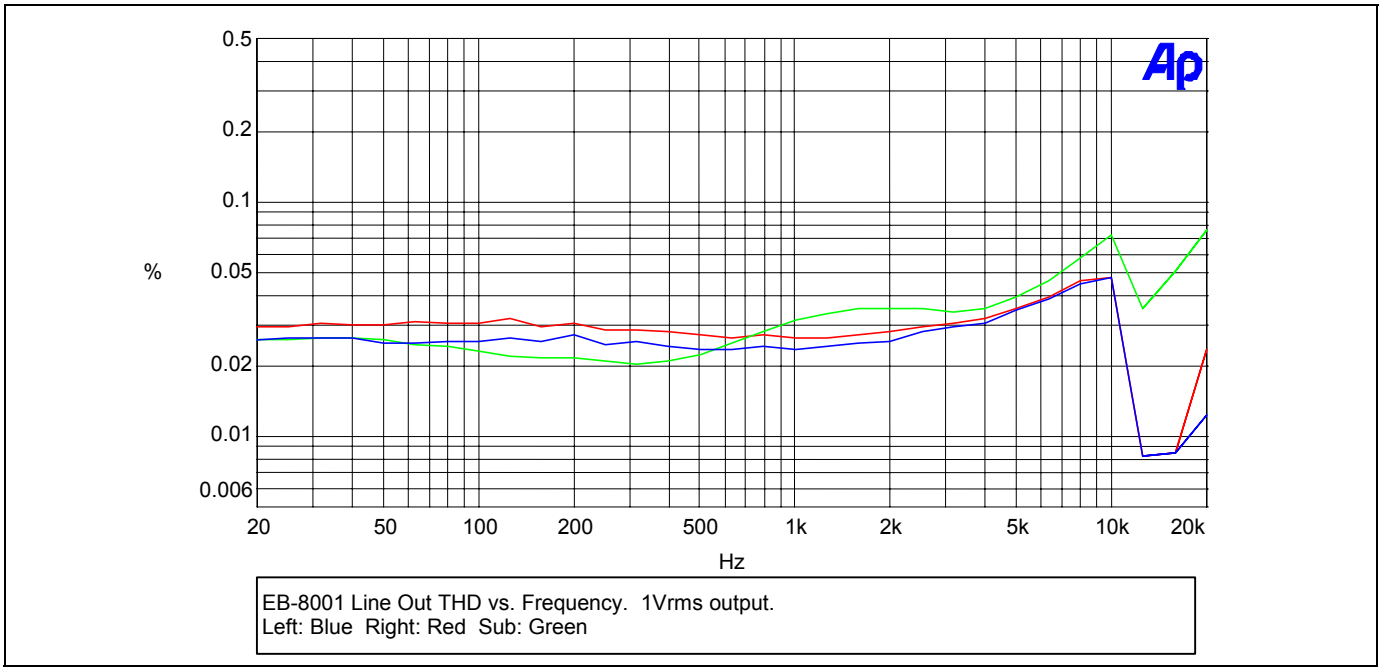


Figure 16. Line Outputs THD vs. Frequency

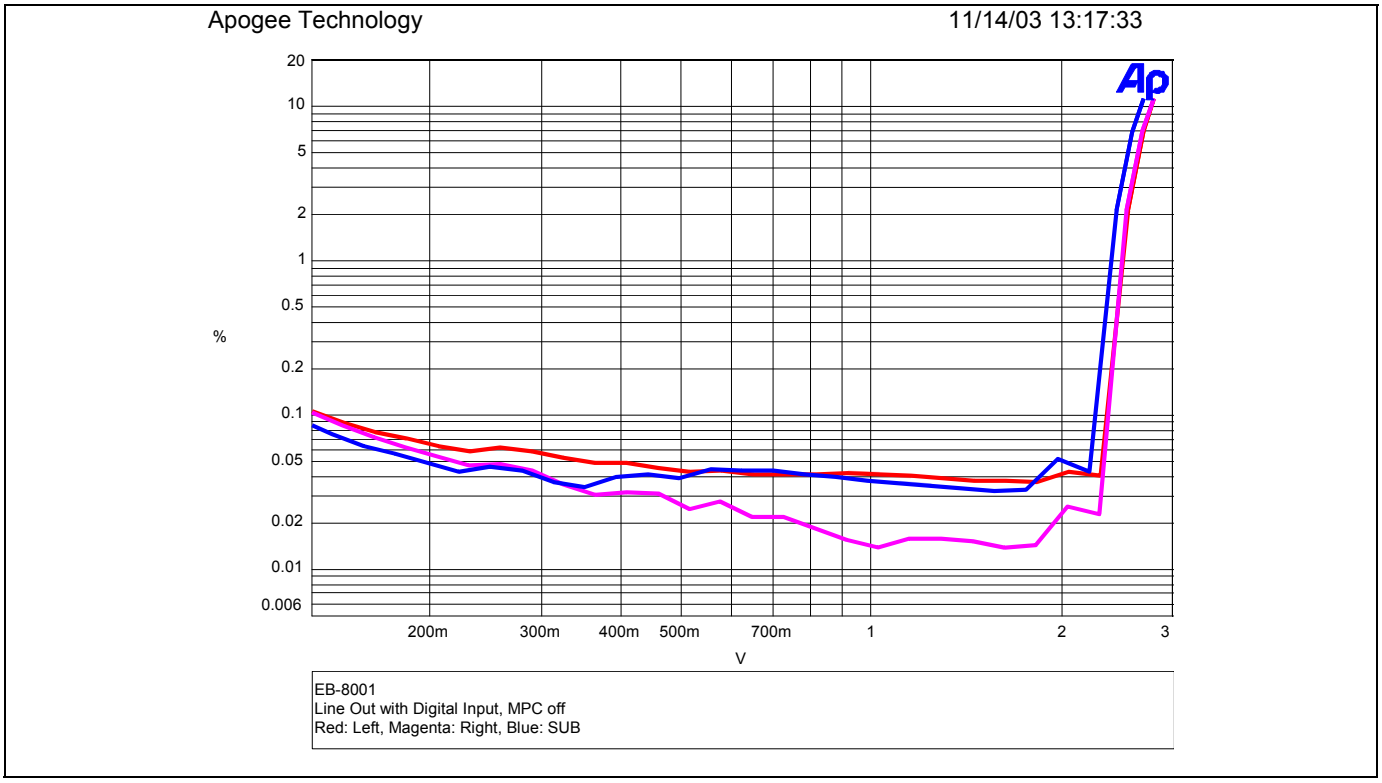


Figure 17. Line Outputs THD vs. Output Level

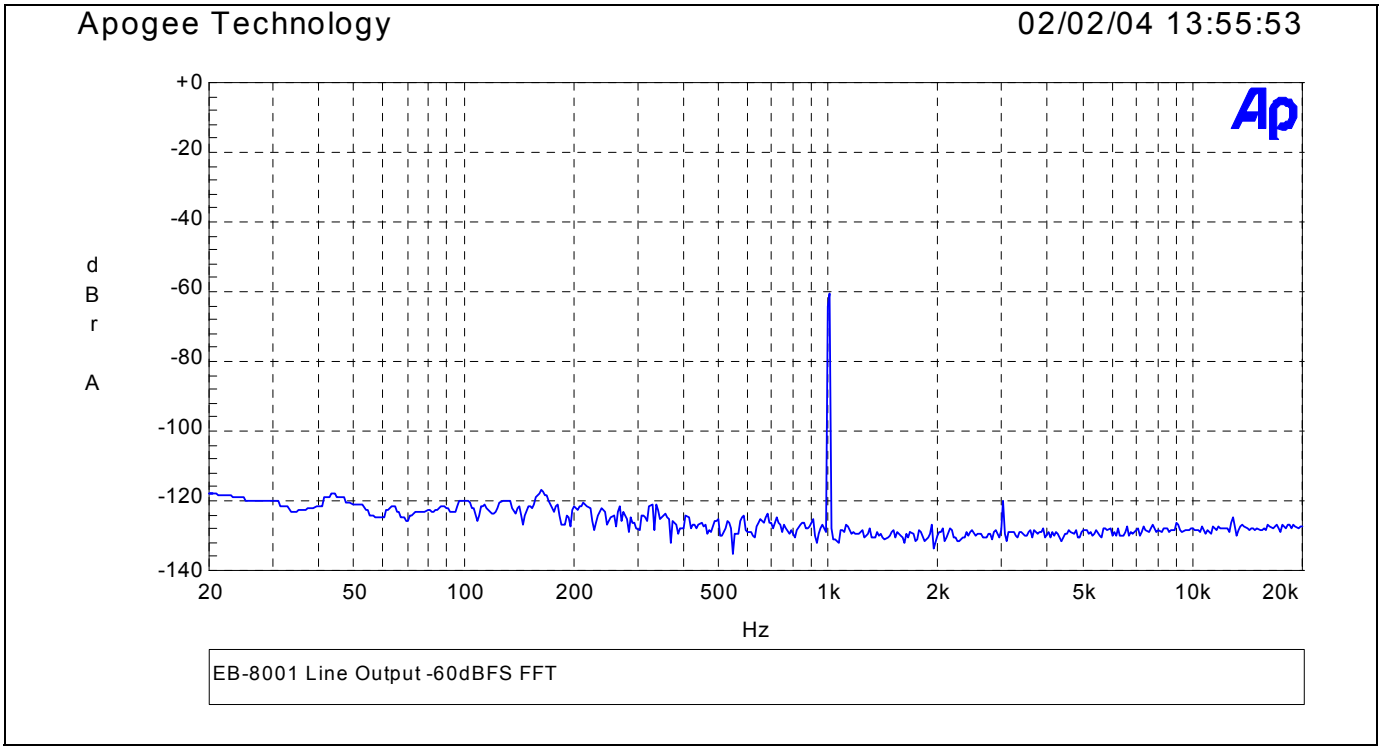


Figure 18. Line Output -60dBFS Input FFT