2W Stereo Class-D Audio Power Amplifier

BA20880

Data Sheet

Rev.1.0, 2008.09.05

Biforst Technology Inc.

2W Stereo Class-D Audio Power Amplifier

BA20880

GENERAL DESCRIPTION

The BA20880 is a 5V class-D amplifier from Biforst Technology. BA20880 provides dc volume control, lower supply current, high efficiency & few external components for driving speaker directly. BA20880 also integrates Anti-Pop, Output Short & Over-Heat Protection Circuitry to increase device reliability. The functionality makes this device ideal for LCD projectors, LCD monitors, powered speakers & other applications that demand more battery life.

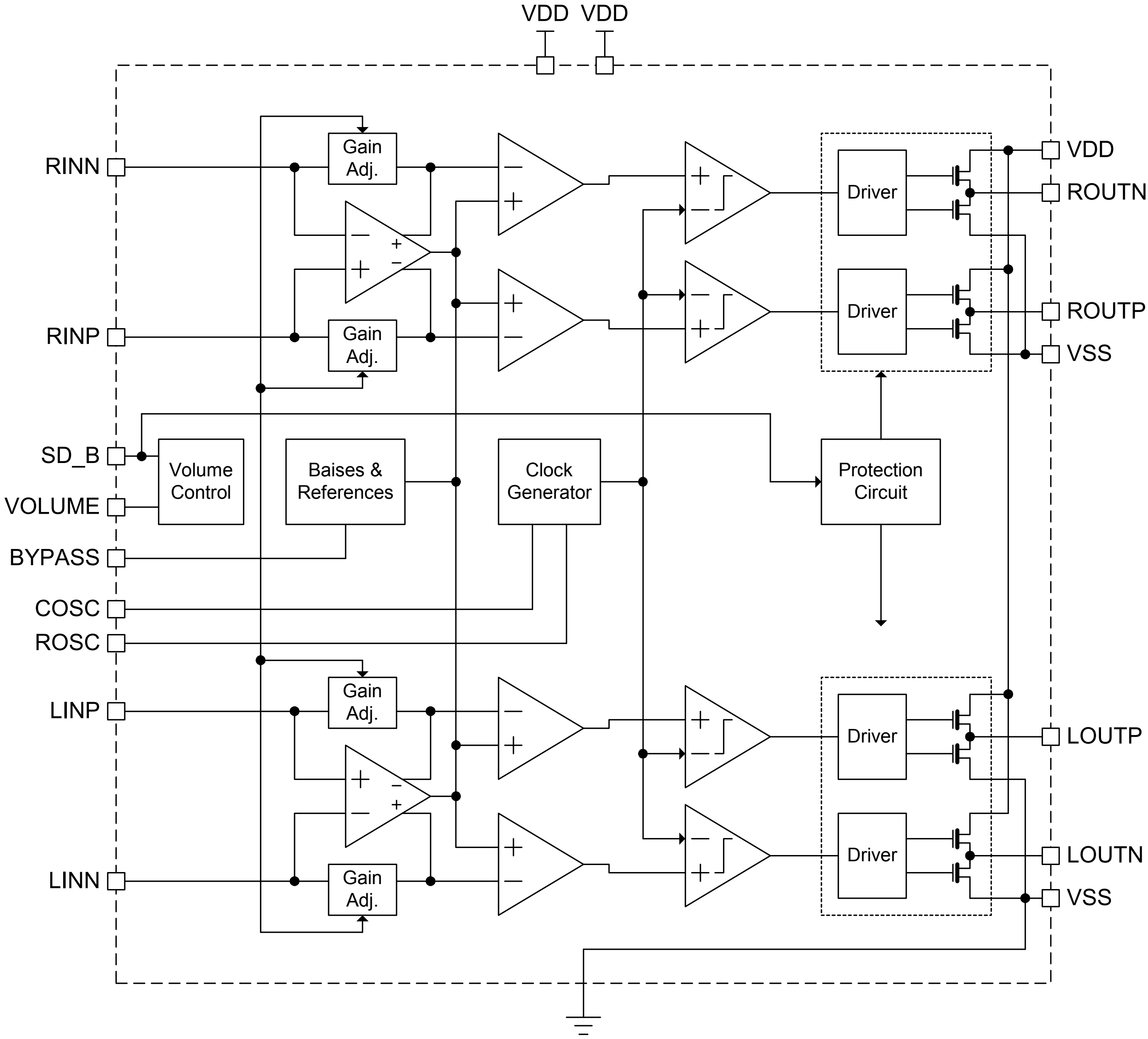
FEATURE

- 2.3W Per Channel Into 4-Ω Speakers (THD+N = 10%@5V)
- Operation Voltage From 3.3 To 5.5V
- DC Volume Control From –37dB to 20dB
- Low Shutdown Control : <10μA
- Low Noise Floor, -80dBV
- Maximum Efficiency into 3-Ω, 77%
- Maximum Efficiency into 8-Ω, 87%
- PSRR, -71dB
- Filter Free PWM Output Technology without LC Output Filter
- Integrated Anti-Pop Circuitry
- Integrated Output Short Protection Circuitry
- Integrated Over-Heat Protection Circuitry
- Provide DC Volume Control
- Package Type: DIP 18Pin

APPLICATION

- LCD Monitors
- Powered Speakers
- Cellular Phones
- PDA
- Portable DVD/CD Players
- USB Audio
- Battery Powered Application

FUNCTION BLOCK DIAGRAM



These device have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

ABSOLUTE MAXIMUM RATINGS (Note 1)

SYMBOL	PARAMETER	VALUE	UNIT
VDD, PVDD_A	Supply Voltage Range	-0.3 to 5.8	V
V_I (RLINEIN, RHPIN, RIN, LLINEIN, LHPIN, LIN)	Input Voltage Range	0 to VDD	V
V_I (VOLUME)	Input Voltage Range	0 to VDD	V
T_A	Operating Free-Air Temperature Range	-40 ~ +85	^oC
T_J	Operating Junction Temperature Range	-40 to 150	^oC
T_{STG}	Storage Temperature Range	-65 to 85	^oC

Note 1: Stress beyond those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. Exposure to absolute-maximum-rating conditions for extended periods may affect device reliability.

RECOMMENDED OPERATING CONDITIONS

SYMBOL	PARAMETER	SPECIFICATION			UNIT
		MIN	TYP	MAX	
VDD, PVDD_A	Supply Voltage	3.3		5.5	V
	Volume Terminal Voltage	0		VDD	V
V_{IH}	Input High Voltage (SD_B)	2.0			V
V_{IL}	Input Low Voltage (SD_B)			0.8	V
F_{PWM}	PWM Frequency	200		350	KHz
T_A	Operating Free-Air Temperature	-40		85	^oC
T_J	Operating Junction Temperature			125	^oC

ELECTRICAL CHARACTERISTICS (T_A=25℃, VDD=5V; unless otherwise specified)

SYMBOL	PARAMETER	TEST CONDITIONS	SPECIFICATION			UNIT
			MIN	TYP	MAX	
$\lvert V_{OS} \rvert$	Output Offset Voltage (Measured Differentially)	V_I = 0V, AV = 20dB, RL = 8Ω		15	25	mV
PSRR	Power supply rejection ratio	VDD = 4.5V to 5.5V		-70		dB

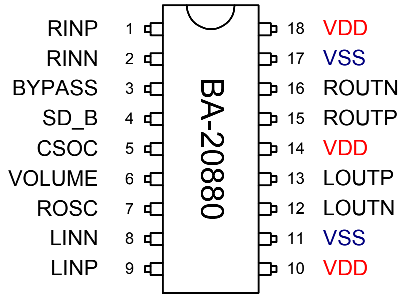
ELECTRICAL CHARACTERISTICS (T_A=25℃, VDD=5V; unless otherwise specified)

SYMBOL	PARAMETER	TEST CONDITIONS		SPECIFICATION			UNIT
$\lvert I_{IH} \rvert$	High-level input current	VDD=5.5V, V_I = VDD=0V				1	uA
$\lvert I_{IL} \rvert$	Low -level input current	VDD=5.5V, V_I = 0V				1	uA
I_{DD}	Supply Current	No Filter (No Load)			10	20	mA
$I_{DD(MAX)}$	RMS Supply Current At Max Power	RL = 3Ω, PO = 2.5W/Channel (Stereo)			1.8		A
$I_{DD(SD)}$	Supply Current In Shutdown Mode	SD_B = 0V			1	10	uA
$r_{ds(on)}$	Drain-Source On-State Resistance	VDD = 5V, I_O=500mA, T_J = 25℃	High Side		500	650	mΩ
			Low Side		500	650	

OPERATING CHARACTERISTICS (T_A=25℃, VDD=5V; R_L=4Ω;unless otherwise specified)

SYMBOL	PARAMETER	TEST CONDITIONS		SPECIFICATION MIN	TYP	MAX	UNIT
P_O	Output Power	F = 1KHz, RL = 3Ω, Stereo Operation	THD+N = 1%		2		W
			THD+N = 10%		2.5		W
		F = 1KHz, RL = 4Ω, Stereo Operation	THD+N = 1%		1.8		W
			THD+N = 10%		2.3		W
		F = 1KHz, RL = 8Ω, Stereo Operation	THD+N = 1%		1.2		W
			THD+N = 10%		1.5		W
THD+N	Total Harmonic Distortion Plus Noise	P_O = 1.5W, f= 20Hz to 20KHz			<0.7%		
BOM	Maximum Output Power Bandwidth	THD = 10%			20		KHz
SNR	Signal-to-Noise Rate	Maximum Output at THD+N < 0.5%			96		dB
T_{TP}	Thermal Trip Point				150		^oC
T_H	Thermal Hystersis				20		^oC
Vn	Integrated Noise Floor	20Hz to 20KHz, Input AC Grounded			45		uV_{rms}
					88		

PIN ASSIGNMENTS



PIN LIST & DESCRIPTION

Pin No.	Pin	Type	I/O Pad Function
1	RINP	Input	Right channel positive differential audio input
2	RINN	Input	Right channel negative differential audio input
3	BYPASS	Input	Connect a 1µF to 10µF capacitor from BYPASS to ground for internal bias reference
4	SD_B	Input	Shut down control for BA20880, Logic low is placed on this terminal for shut down mode, Logic high is placed on this terminal for normal operation (Recommend Connect 100K Ohm To VDD & Connect 0.1µF To Ground In Application Circuit)
5	COSC	Input	A capacitor connected to this terminal sets the oscillation in conjunction with COSC. For proper operation, connect a 220-pF capacitor from COSC to ground
6	VOLUME	Input	DC volume control for setting the gain on the internal amplifier. The dc voltage range is 0 to VDD
7	ROSC	Input	A resistor connected to this terminal sets the oscillation in conjunction with ROSC. For proper operation, connect a 120-kΩ resistor from ROSC to ground
8	LINN	Input	Left channel negative differential audio input
9	LINP	Input	Left channel positive differential audio input
10	VDD	Power	5V power supply
11	VSS	Power	5V ground
12	LOUTN	Output	Left channel negative output
13	LOUTP	Output	Left channel positive output
14	VDD	Power	5V power supply
15	ROUTP	Output	Right channel positive output
16	ROUTN	Output	Right channel negative output
17	VSS	Power	5V ground
18	VDD	Power	5V power supply

FUNCTION DESCRIPTION

Output Power Efficiency

The output transistors of BA20880 act as switches. The amount of power dissipated in the speaker may be estimated by first considering the overall efficiency of the system. The on-resistance of the output transistors is considered to cause the dominant loss in the system, the on-resistance of output transistors is small that the power loss is small and the power efficiency is high. When BA20880 is with 8-ohm load, the power efficiency can be better than 87%.

Shutdown Mode

The BA20880 provides a shutdown mode to reduce supply current to the absolute minimum level during periods of non-use for battery-power conservation. The SD_B input pin should be held high during normal operation when the amplifier is in use. Pulling SD_B low causes the outputs to mute and the amplifier to enter a low-current state. SD_B should never be left unconnected because the amplifier state would be unpredictable.

Recommend connecting SD_B pin with 100K Ohm To VDD & Connect 0.1μF To Ground.

Differential Input

The differential input stage of the amplifier cancels any noise that appears on both input lines of the channel. To use the BA20880 with a differential source, connect the positive lead of the audio source to the LINP/RINP input and the negative lead from the audio source to the LINN/RINN input. To use the BA20880 with a single-ended source, ac ground either input through a capacitor and apply the audio signal to the remaining input. In a single-ended input application, the un-used input should be ac-grounded at the audio source instead of at the device input for best noise performance.

Single-end stereo input application circuit shows in Figure 1. It's recommended LINN & RINN connect 0.1uμF to ground. & Left/Right analog audio signal series connect 0.1μF to LINP & RINP.

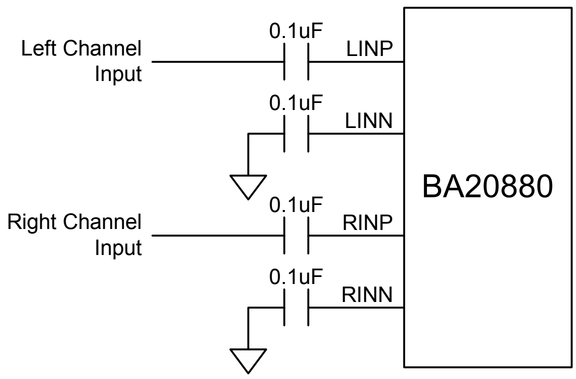


Figure 1. Single-end stereo input application circuit

Volume Control

The VOLUME pin controls the volume of the BA20880. It is controlled with a dc voltage, which should not exceed VDD. Table 1 lists the voltage on the VOLUME pin and the corresponding gain.

The volume control circuitry of the BA20880 is internally referenced to the VDD and 0V. Any common-mode noise between the VOLUME terminal and these terminals will be sensed by the volume control circuitry. If the noise exceeds the step size voltage, the gain will change. In order to minimize this effect, care must be taken to ensure the signal driving the VOLUME terminal is referenced to the VDD and 0V of the BA20880. DC volume application circuit shows in Figure 2.

Table 1. Typical DC Volume Control

Voltage On Volume Pin (V) (Increasing or Fixed Gain)	Voltage On Volume Pin (V) (Decreasing Gain)	Typical Gain Of Amplifier (dB)
0.00 ~ 0.29	0.00 ~ 0.18	-37
0.30 ~ 0.38	0.19 ~ 0.30	-36
0.39 ~ 0.50	0.31 ~ 0.42	-35
0.51 ~ 0.63	0.43 ~ 0.54	-33
0.64 ~ 0.72	0.55 ~ 0.66	-31
0.73 ~ 0.83	0.67 ~ 0.77	-29
0.84 ~ 0.95	0.78 ~ 0.86	-27
0.96 ~ 1.04	0.87 ~ 0.98	-25
1.05 ~ 1.14	0.99 ~ 1.10	-23
1.15 ~ 1.26	1.11 ~ 1.21	-21
1.27 ~ 1.38	1.22 ~ 1.31	-19
1.39 ~ 1.49	1.32 ~ 1.43	-17
1.50 ~ 1.61	1.44 ~ 1.53	-15
1.62 ~ 1.70	1.54 ~ 1.63	-13
1.71 ~ 1.80	1.64 ~ 1.74	-11
1.81 ~ 1.91	1.75 ~ 1.85	-10
1.92 ~ 2.03	1.86 ~ 1.97	-8
2.04 ~ 2.14	1.98 ~ 2.08	-6
2.15 ~ 2.24	2.09 ~ 2.18	-4
2.25 ~ 2.35	2.19 ~ 2.29	-2
2.36 ~ 2.47	2.30 ~ 2.41	0
2.48 ~ 2.59	2.42 ~ 2.55	2
2.60 ~ 2.69	2.56 ~ 2.64	4
2.70 ~ 2.81	2.65 ~ 2.76	6
2.82 ~ 2.92	2.77 ~ 2.87	7.5
2.93 ~ 3.03	2.86 ~ 2.99	9.5
3.04 ~ 3.14	3.00 ~ 3.09	11.5
3.15 ~ 3.14	3.10 ~ 3.22	13.5
3.26 ~ 3.35	3.23 ~ 3.29	15.5
3.36 ~ 3.44	3.30 ~ 3.39	17.5
3.45 ~ 3.57	3.40 ~ 3.50	19
3.58 ~ VDD	3.51 ~ VDD	20

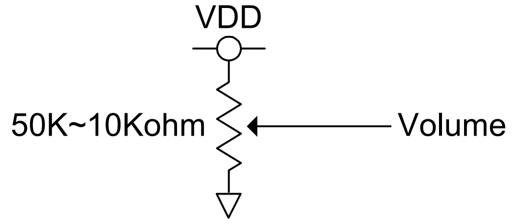


Figure 2. DC Volume Application Circuit

The trip point, where the gain actually changes, is different depending on whether the voltage on the VOLUME pin is increasing or decreasing as a result of hysteresis about each trip point. The hysteresis ensures that the gain control is monotonic and does not oscillate from one gain step to another. A pictorial representation of the volume control can be found in Figure 3. The graph focuses on three gain steps with the trip points defined in the first and second columns of Table 1. The dotted lines represent the hysteresis about each gain step.

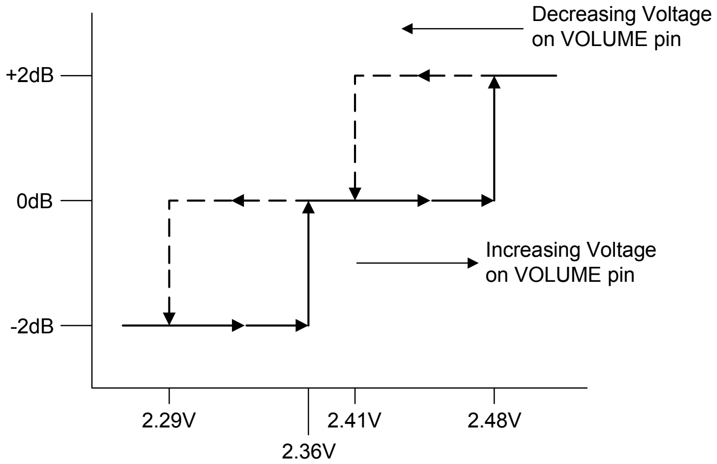


Figure 3. DC Volume Control Operation

COSC & ROSC Pin

The switching frequency is determined using the values of the components connected to ROSC and COSC. The frequency may be varied from 200 kHz to 300 kHz by adjusting the values chosen for ROSC and COSC. The recommended values are COSC = 220 pF, ROSC = 120 kΩ for a switching frequency of 250 kHz.

Over-Heat Protection

Over-Heat protection on the BA20880 prevents damage to the device when the internal die temperature exceeds 125°C. Once the die temperature exceeds the thermal set point, the device enters the shutdown state and the outputs are disabled. The device will back to normal operation when die temperature is reduced without external system interaction.

Output Short Protection

The BA20880 has output short circuit protection circuitry on the outputs that prevents damage to the device during output-to-output short, output-to-GND short, and output-to-VDD short. BA20880 enters the shutdown state and the outputs are disabled when detects output short. This is a latched fault and must be reset by cycling the voltage on the SD_B pin to a logic low and back to the logic high, or cycling the power off and then back on. This clears the short-circuit flag and allow for normal operation if the short was removed. If the short was not removed, the protection circuitry activates again.

Anti-Pop

A soft start capacitor must be added to the BYPASS pin. It recommends connecting a capacitor of 1μF from BYPASS pin to Ground. BA20880 provides fade-in function when power-on or SD_B input voltage level from 0V to VDD, and fade-out function when SD_B input voltage level from VDD to 0V. The pop noise can be eliminated by fade-in/fade-out function.

Output Filter Application Note

Design the BA20880 without the filter if the traces from amplifier to speaker are short (< 1 inch). Where the speaker is in the same enclosure as the amplifier is a typical application for class-D without a filter.

Many applications require a ferrite bead filter. The ferrite filter reduces EMI around 30 MHz. When selecting a ferrite bead, choose one with high impedance at high frequencies, but low impedance at low frequencies.

Use an LC output filter if there are low frequency (<1 MHz) EMI sensitive circuits and/or there are long wires from the amplifier to the speaker.

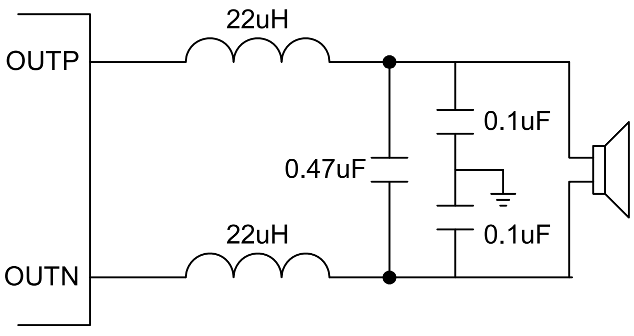


Figure 4. Typical LC Output Filter

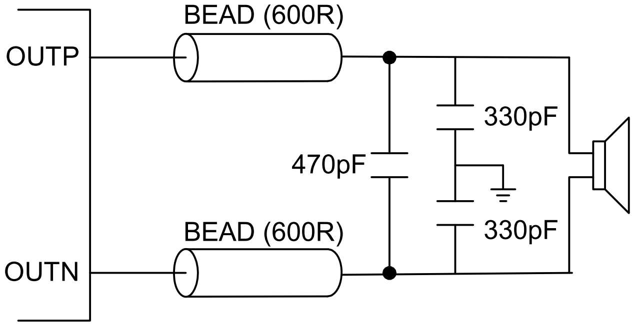


Figure 5. Typical Ferrite Chip Bead Output Filter

BYPASS Pin

It's recommended to connect a 1μF capacitor from BYPASS pin to ground for internal bias reference & provide high power supply rejection ratio (PSRR).

Typical Characteristics

Table of Graphs

Figure No.	Description		Output Load
6	Frequency Response	5V, 0.5W Output	3Ω
7		5V, 1W Output	
8		5V, 1.5W Output	
9		3.6V, 0.5W Output	
10	Frequency Response	5V, 0.5W Output	4Ω
11		5V, 1W Output	
12		5V, 1.5W Output	
13		3.6V, 0.5W Output	
14	Frequency Response	5V, 0.5W Output	8Ω
15		5V, 1W Output	
16		3.6V, 0.5W Output	
17	THD+N VS. Frequency	5V, 0.5W Output	3Ω
18		5V, 1W Output	
19		5V, 1.5W Output	
20		3.6V, 0.5W Output	
21	THD+N VS. Frequency	5V, 0.5W Output	4Ω
22		5V, 1W Output	
23		5V, 1.5W Output	
24		3.6V, 0.5W Output	
25	THD+N VS. Frequency	5V, 0.5W Output	8Ω
26		5V, 1W Output	
27		3.6V, 0.5W Output	
28	THD+N VS. Output Power	5V	3Ω
29		3.6V	
30	THD+N VS. Output Power	5V	4Ω
31		3.6V	
32	THD+N VS. Output Power	5V	8Ω
33		3.6V	
34	Crosstalk	5V	3Ω
35		3.6V	
36	Crosstalk	5V	4Ω
37		3.6V	
38	Crosstalk	5V	8Ω
39		3.6V	

Frequency Response (3Ω Load)

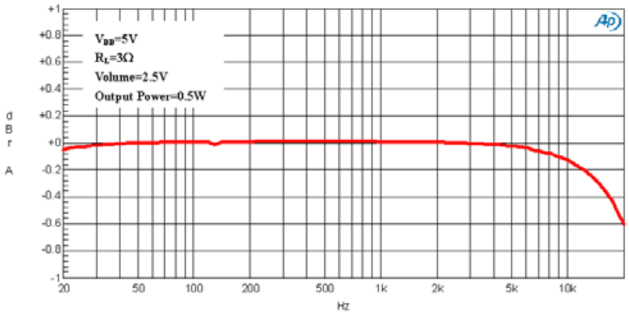


Figure 6: Frequency Response, Operate at 5V, 3Ω Load & 0.5W Output, Volume at 2.5V

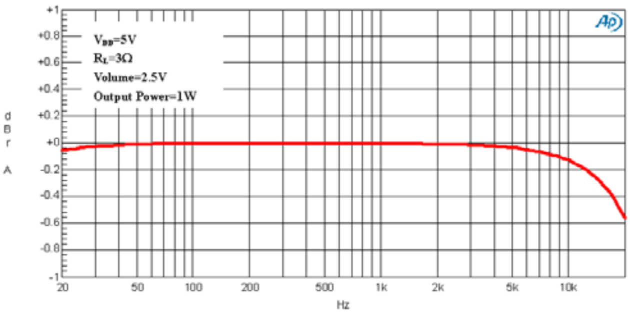


Figure 7: Frequency Response, Operate at 5V, 3Ω Load & 1W Output, Volume at 2.5V

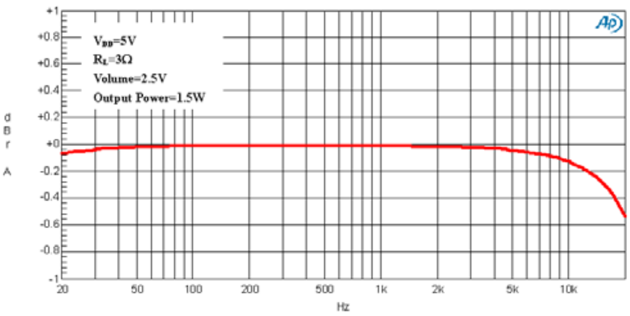


Figure 8: Frequency Response, Operate at 5V, 3Ω Load & 1.5W Output, Volume at 2.5V

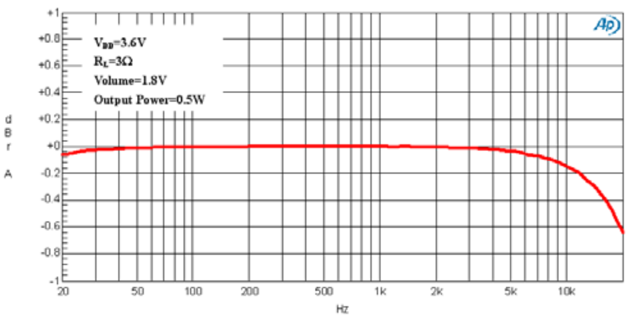


Figure 9: Frequency Response, Operate at 3.6V, 3Ω Load & 0.5W Output, Volume at 1.8V

Frequency Response (4Ω Load)

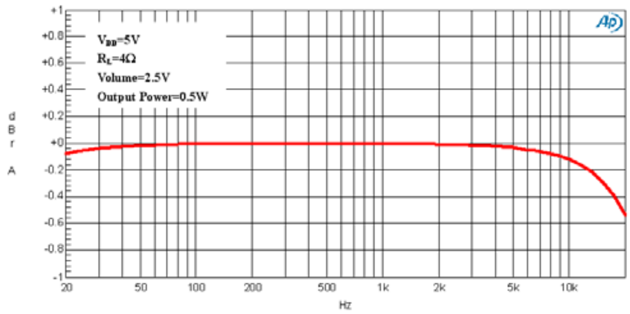


Figure 10: Frequency Response, Operate at 5V, 4Ω Load & 0.5W Output, Volume at 2.5V

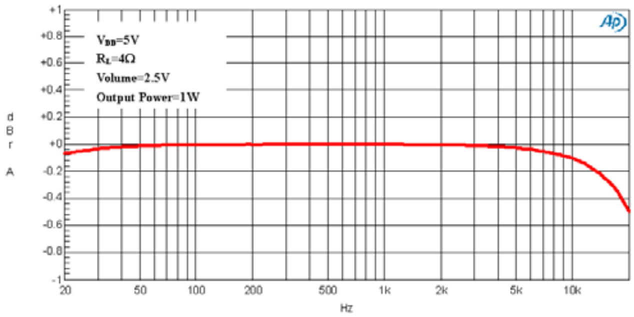


Figure 11: Frequency Response, Operate at 5V, 4Ω Load & 1W Output, Volume at 2.5V

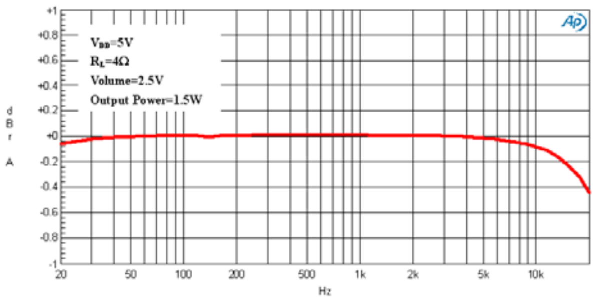


Figure 12: Frequency Response, Operate at 5V, 4Ω Load & 1.5W Output, Volume at 2.5V

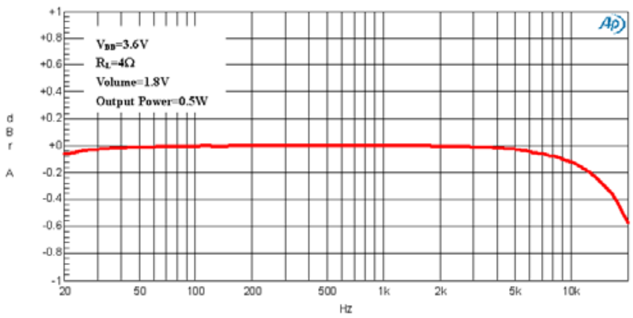


Figure 13: Frequency Response, Operate at 3.6V, 4Ω Load & 0.5W Output, Volume at 1.8V

Frequency Response (8Ω Load)

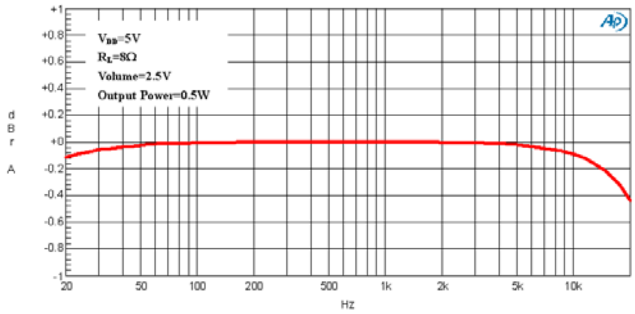


Figure 14: Frequency Response, Operate at 5V, 8Ω Load & 0.5W Output, Volume at 2.5V

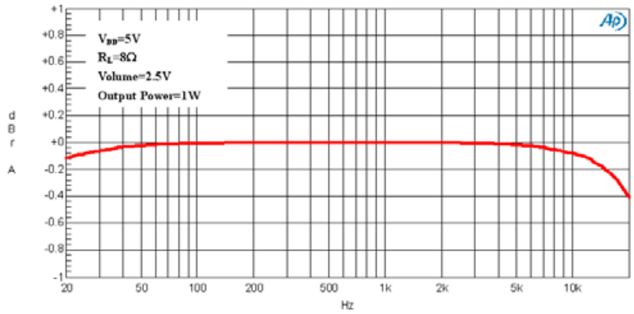


Figure 15: Frequency Response, Operate at 5V, 8Ω Load & 1W Output, Volume at 2.5V

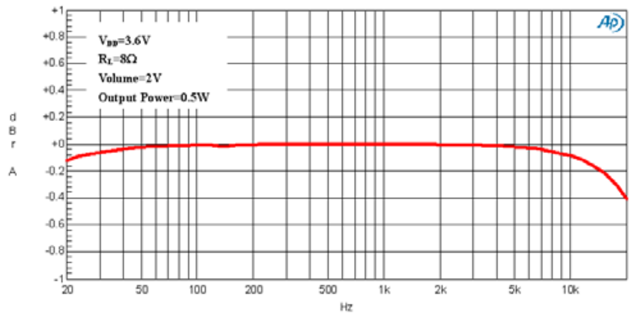


Figure 16: Frequency Response, Operate at 3.6V, 8Ω Load & 0.5W Output, Volume at 2V

THD+N VS. Frequency (3Ω Load)

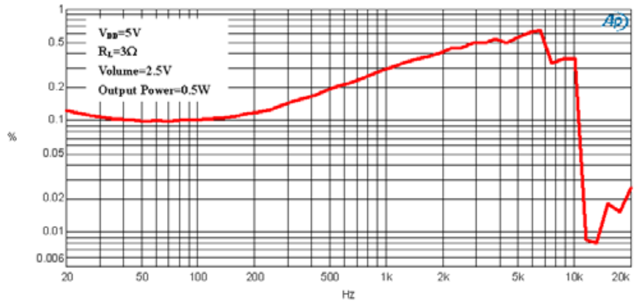


Figure 17: THD+N VS. Frequency, Operate at 5V, 3Ω Load & 0.5W Output, Volume at 2.5V

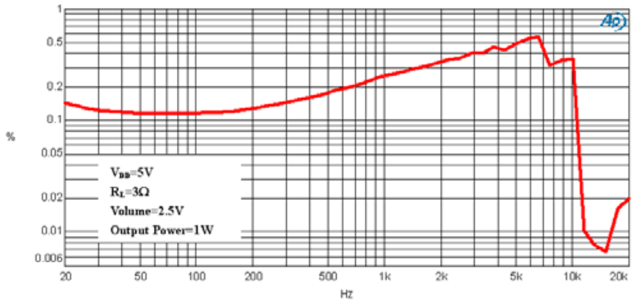


Figure 18: THD+N VS. Frequency, Operate at 5V, 3Ω Load & 1W Output, Volume at 2.5V

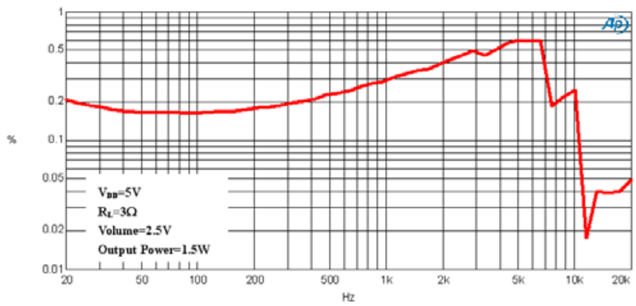


Figure 19: THD+N VS. Frequency, Operate at 5V, 3Ω Load & 1.5W Output, Volume at 2.5V

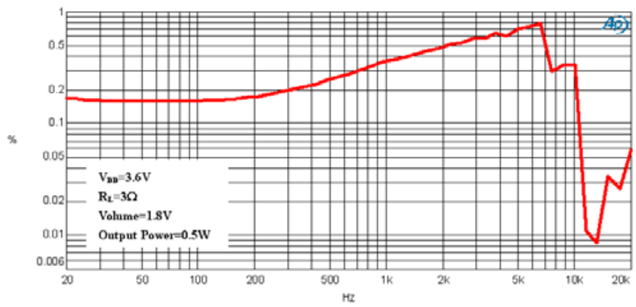


Figure 20: THD+N VS. Frequency, Operate at 3.6V, 3Ω Load & 0.5W Output, Volume at 1.8V

THD+N VS. Frequency (4Ω Load)

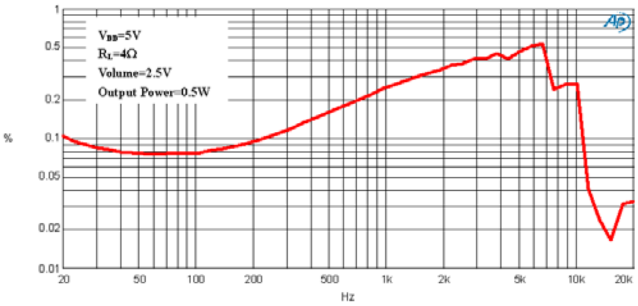


Figure 21: THD+N VS. Frequency, Operate at 5V, 4Ω Load & 0.5W Output, Volume at 2.5V

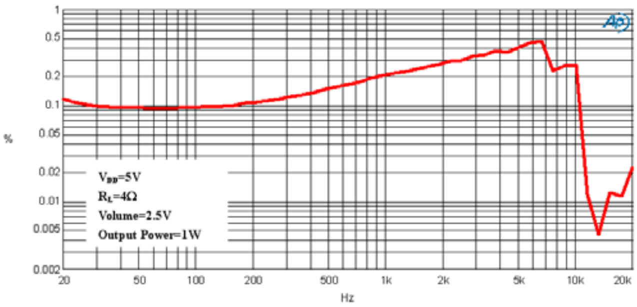


Figure 22: THD+N VS. Frequency, Operate at 5V, 4Ω Load & 1W Output, Volume at 2.5V

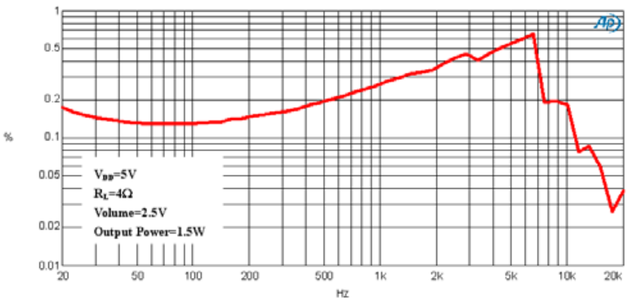


Figure 23: THD+N VS. Frequency, Operate at 5V, 4Ω Load & 1.5W Output, Volume at 2.5V

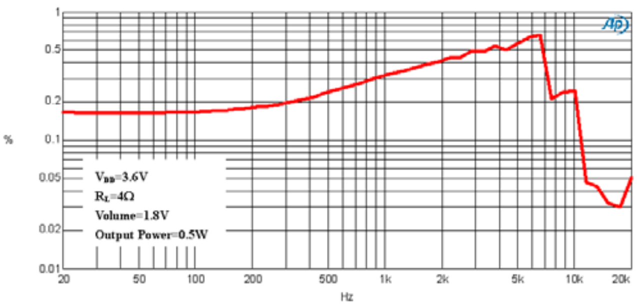


Figure 24: THD+N VS. Frequency, Operate at 3.6V, 4Ω Load & 0.5W Output, Volume at 1.8V

THD+N VS. Frequency (8Ω Load)

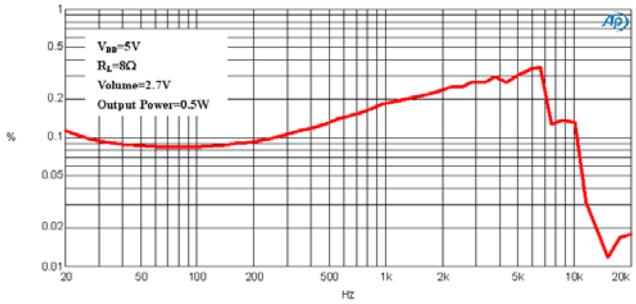


Figure 25: THD+N VS. Frequency, Operate at 5V, 8Ω Load & 0.5W Output, Volume at 2.7V

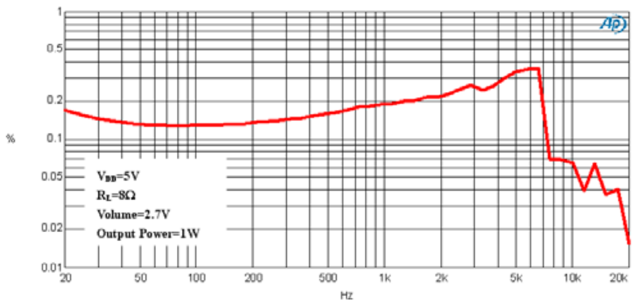


Figure 26: THD+N VS. Frequency, Operate at 5V, 8Ω Load & 1W Output, Volume at 2.7V

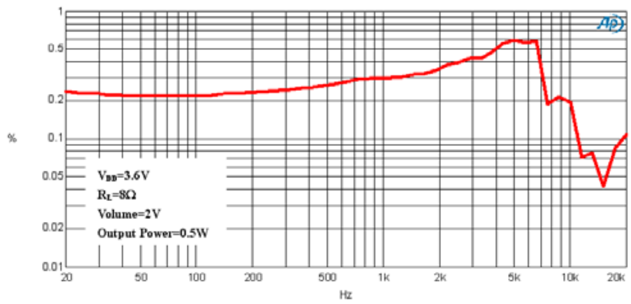


Figure 27: THD+N VS. Frequency, Operate at 3.6V, 8Ω Load & 0.5W Output, Volume at 2V

THD+N VS. Output Power (3Ω Load)

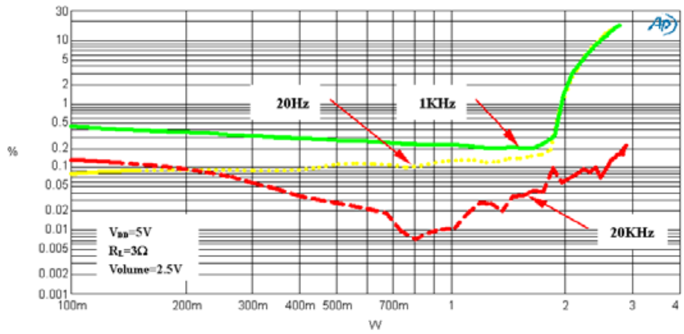


Figure 28: THD+N VS. Output Power, Operate at 5V, 3Ω Load, Volume at 2.5V

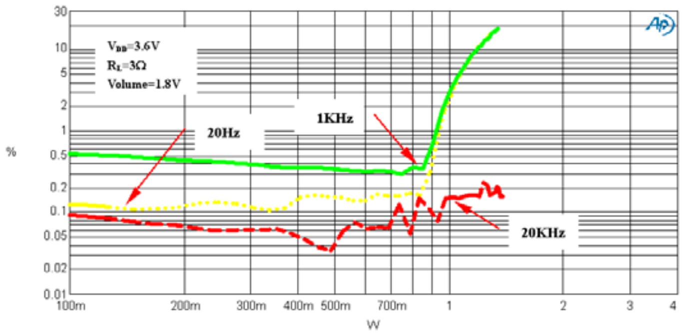


Figure 29: THD+N VS. Output Power, Operate at 3.6V, 3Ω Load, Volume at 1.8V

THD+N VS. Output Power (4Ω Load)

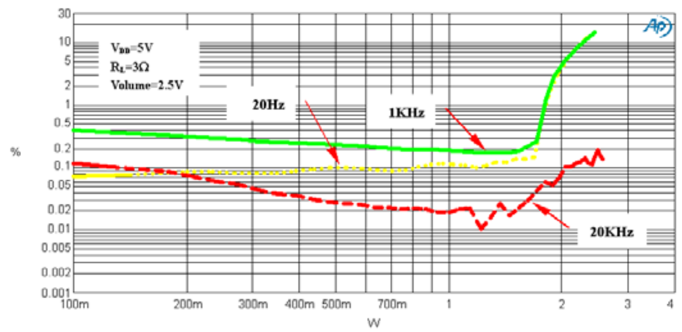


Figure 30: THD+N VS. Output Power, Operate at 5V, 4Ω Load, Volume at 2.5V

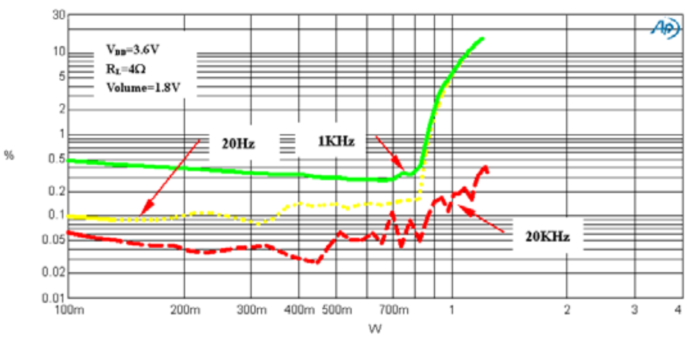


Figure 31: THD+N VS. Output Power, Operate at 3.6V, 4Ω Load, Volume at 1.8V

THD+N VS. Output Power (8Ω Load)

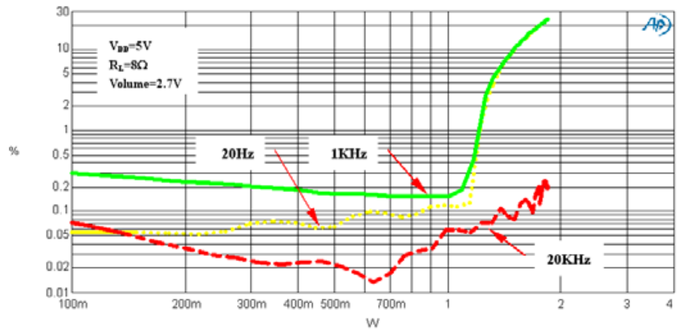


Figure 32: THD+N VS. Output Power, Operate at 5V, 8Ω Load, Volume at 2.7V

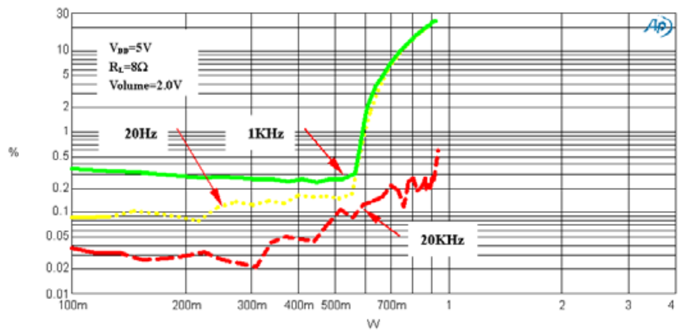


Figure 33: THD+N VS. Output Power, Operate at 3.9V, 8Ω Load, Volume at 2V

Crosstalk (3Ω Load)

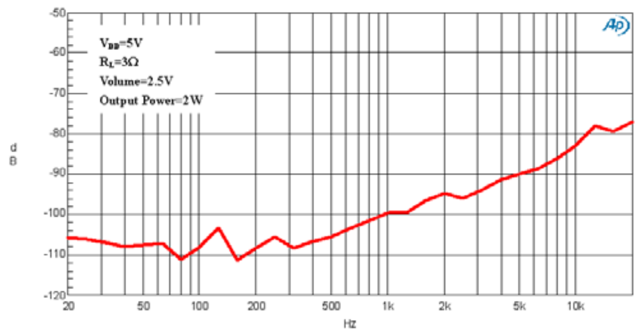


Figure 34: Classtalk, Operate at 5V, 3Ω Load, Output Power at 2W, Volume at 2.5V

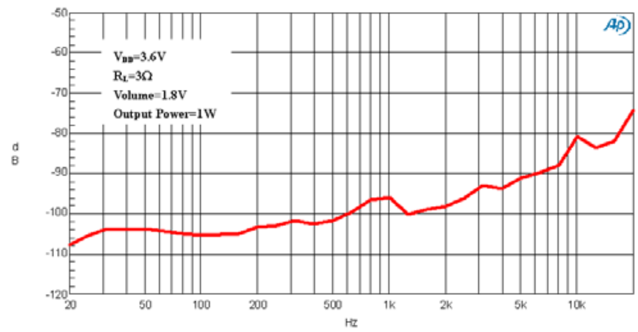


Figure 35: Classtalk, Operate at 3.6V, 3Ω Load, Output Power at 1W, Volume at 1.8V

Crosstalk (4Ω Load)

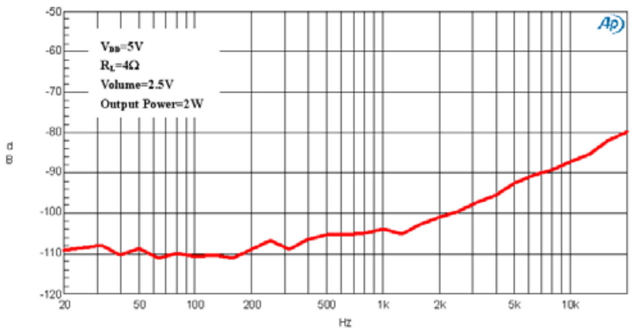


Figure 36: Classtalk, Operate at 5V, 4Ω Load, Output Power at 2W, Volume at 2.5V

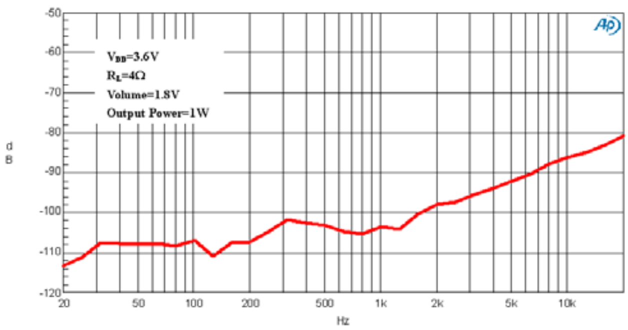


Figure 37: Classtalk, Operate at 3.6V, 4Ω Load, Output Power at 1W, Volume at 1.8V

Crosstalk (8Ω Load)

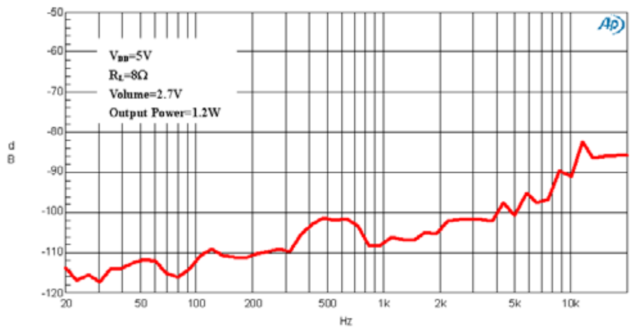


Figure 38: Classtalk, Operate at 5V, 8Ω Load, Output Power at 1.2W, Volume at 2.7V

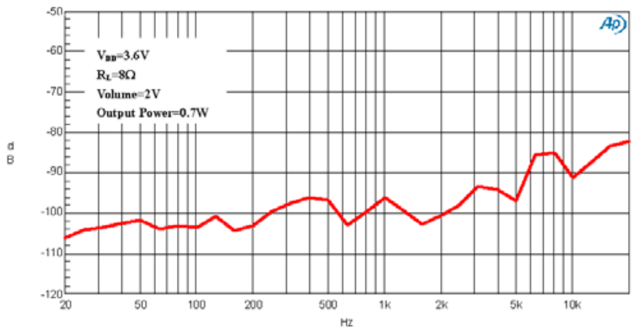
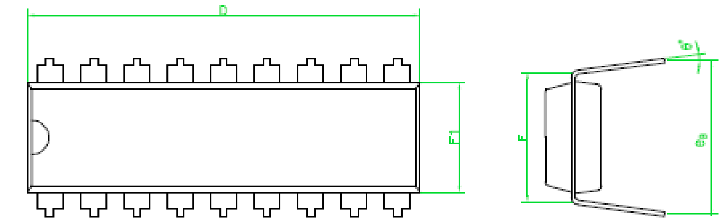
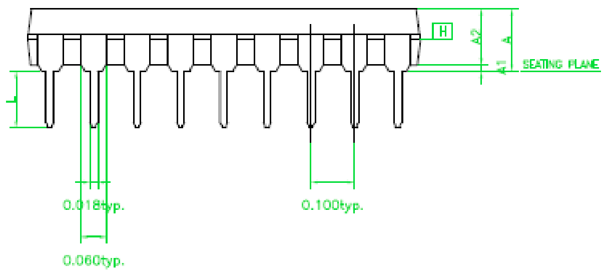


Figure 39: Classtalk, Operate at 3.6V, 8Ω Load, Output Power at 0.7W, Volume at 2V

PACKAGE DIMENSION

DIP 18Pin (300mil)





SYMBOLS	MIN.	NOR.	MAX.
A	–	–	0.210
A1	0.015	–	–
A2	0.125	0.130	0.135
D	0.880	0.900	0.920
E	0.300 BSC.		
E1	0.245	0.250	0.255
L	0.115	0.130	0.150
e_B	0.335	0.355	0.375
θ°	0	7	15

UNIT : INCH

NOTES:

1.JEDEC OUTLINE : MS–001 AC

2."D","E1" DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED .010 INCH.

3.eB IS MEASURED AT THE LEAD TIPS WITH THE LEADS UNCONSTRAINED.

4.POINTED OR ROUNDED LEAD TIPS ARE PREFERRED TO EASE INSERTION.

5.DISTANCE BETWEEN LEADS INCLUDING DAM BAR PROTRUSIONS TO BE .005 INCH MININUM.

6.DATUM PLANE [H] COINCIDENT WITH THE BOTTOM OF LEAD, WHERE LEAD EXITS BODY.

CONTACT INFORMATION

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Version History

Version	Date	Page	Description
1.0	2008.09.05		First Release