1.2 W Mono Class AB Audio Power Amplifier

General Description

The MC4996 is an audio power amplifier primarily designed for demanding applications in mobile phones and other portable communication device applications. It is capable of delivering 1 watts of continuous average power to an 8Ω BTL load with less than 1% distortion (THD+N) from a 5V DC power supply.

The MC4996 were specifically designed to provide high quality output power with a minimal amount of external components. It requires no output coupling capacitors, for this reason, it is perfectly meet the needs of mobile phone and other low voltage applications where require the consumption of power in the smallest amount.

The MC4996 can offer a low standby current and a zero shutdown current. Furthermore, the wake up time of the amplifier is fast enough to use shutdown mode as a mute function.

The MC4996 has an advanced pop & click circuitry that eliminates the noise during turning on and turning off of the device.

Features

- Po at 1% THD+N, VDD = 5V
  RL = 8Ω 1.2W
- Po at 10% THD+N, VDD = 5V
  RL = 8Ω 1.50W
- Po at 1% THD+N, VDD = 3.0V
  RL = 8Ω 0.36W (typ)
- Po at 1% THD+N, VDD = 2.6V
  RL = 8Ω 0.27W (typ)
- 2.5-5.5V operation
- 0.1μA ultra low current shutdown mode
- Less external components required
- Thermal and over current protections
- Space saving package DFN 2X2_8L
- RoHS compliant and 100% lead(Pb)-free

Applications

- Mobile Phones
- PDAs
- Portable Electronic Devices

Function Block Diagram

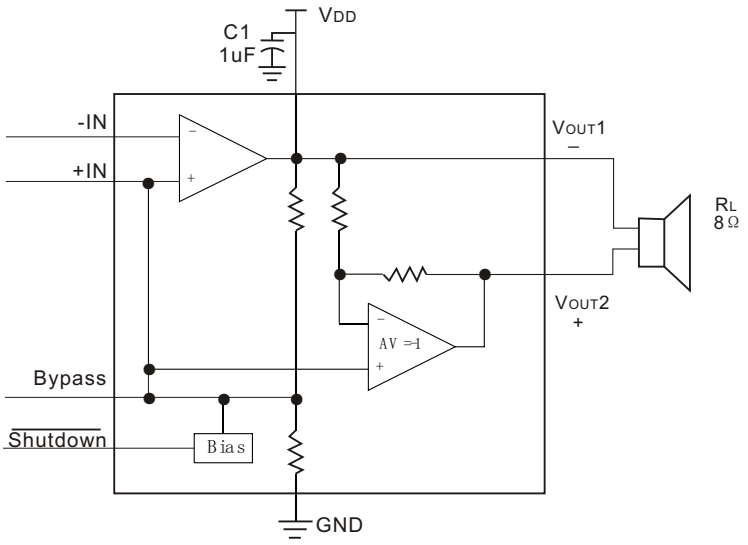
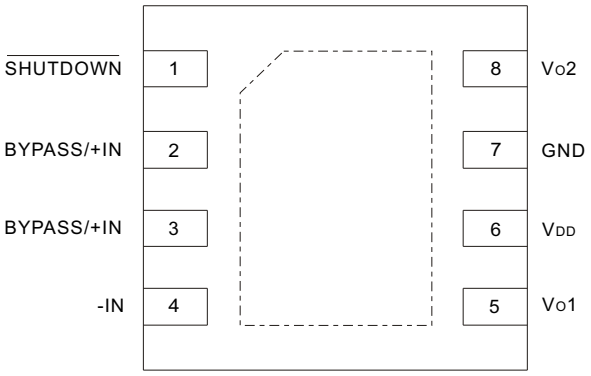


Figure1.

1.2 W Mono Class AB Audio Power Amplifier

Pin Configuration

DFN 2X2_8L



(Top View)

Pin Descriptions

Pin #	Symbol	Function
1	SHUTDOWN	Shutdown terminal active low
2,3	BYPASS/IN+	Bypass capacitor pin which provides the common mode voltage or Positive input
4	IN-	Negative input
5	Vo1	Negative output
6	VDD	Analog power supply.
7	GND	Ground
8	Vo2	Positive output

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Typical Application

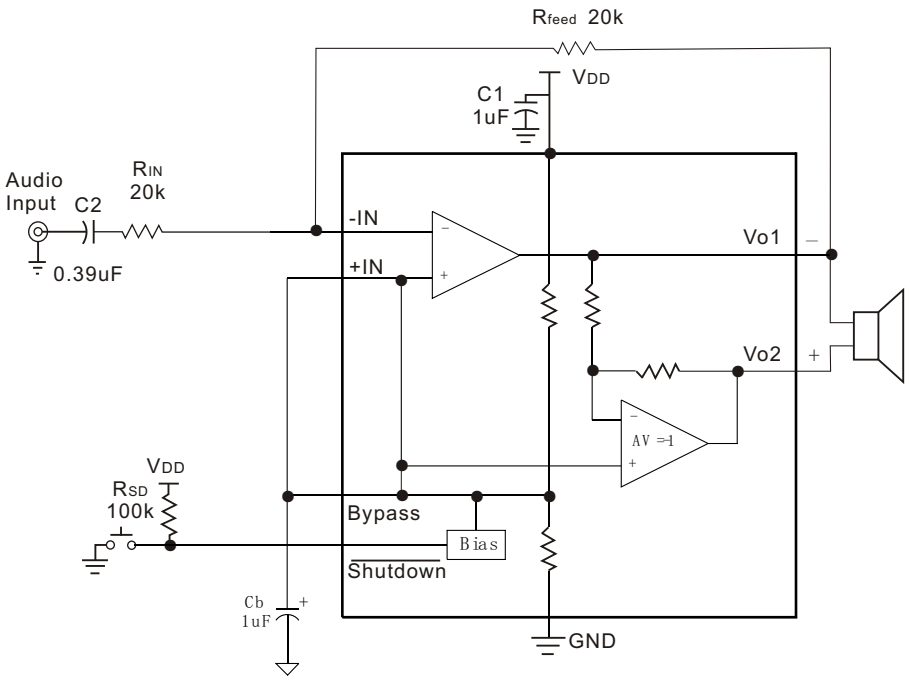

Figure2. Typical Application

1.2 W Mono Class AB Audio Power Amplifier

Absolute Maximum Ratings[1]

Symbol	Description	Value	Unit
V_{DD}	Supply Voltage at no Input Signal	6	V
V_I	Input Voltage	-0.3 to V_{DD}+0.3	V
T_J	Operating Junction Temperature Range	-40 to 150	°C
T_{SDR}	Maximum Lead Soldering Temperature , 10 Seconds	280	°C
T_{STG}	Storage Temperature Range	-65 to 150	°C

Recommended Operating Conditions

Symbol	Description	Value	Unit
V_{DD}	Supply Voltage	2. 4~5.5	V
T_A	Ambient Temperature Range	−40~85	°C
T_J	Junction Temperature Range	−40~125	°C

Thermal Information [2]

Symbol	Description	Value	Unit
θ_{JA}	Thermal Resistance-Junction to Ambient	80	°C/W
θ_{JC}	Thermal Resistance-Junction to Case	15	°C/W

Ordering and Marking Information

Device	Package Type	Marking	Reel Size	Tape Width	Quantity
MC4996	DFN 2X2_8L	4996 XXXX	7''	8mm	3000 units

ESD Susceptibility

ESD Susceptibility-HBM ---------- 2kV
ESD Susceptibility-MM ---------- 200V

1. Stresses above those listed in Absolute Maximum Ratings may cause permanent damage to the device.Functional operation at conditions other than the operating conditions specified is not implied.Only one Absolute Maximum Rating should be applied at one time.
2. The ThermalPad on the bottom of the IC should soldered directly to the PCB's ThermalPad area that with several thermal vias connect to the ground plan,and the PCB is a 2-layer,5-inch square area with 2oz copper thickness.

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Electrical Characteristics

（V_{DD} = 5V, T_A = 25°C unless otherwise specified）

Symbol	Parameter			Min.	Typ.	Max.	Unit
I_{CC}	Supply current No input signal, no load				3	6	mA
I_{SD}	Shutdown current No input signal, V_{SD} = GND, R_L = 8Ω				0.52	2	uA
V_{oo}	Output offset voltage No input signal, R_L = 8Ω				3	30	mV
P_{out}	Output power	V_{DD}=5V R_L=8Ω	THD+N = 1% (max); f = 1kHz	0.95	1.2		W
			THD+N = 10%(max); f = 1kHz		1. 5		W
		V_{DD}=4. 2V R_L=8Ω	THD+N = 1% (max); f = 1kHz		0. 83		W
			THD+N = 10%(max); f = 1kHz		1. 03		W
		V_{DD}=3. 8V R_L=8Ω	THD+N = 1% (max); f = 1kHz		0. 67		W
			THD+N = 10%(max); f = 1kHz		0. 84		W
		V_{DD}=3. 6V R_L=8Ω	THD+N = 1% (max); f = 1kHz		0. 58		W
			THD+N = 10%(max); f = 1kHz		0. 75		W
		V_{DD}=3. 0V R_L=8Ω	THD+N = 1% (max); f = 1kHz		0. 39		W
			THD+N = 10%(max); f = 1kHz		0. 49		W
THD + N	Total harmonic distortion + noise	V_{DD}=5V 20Hz ≤ F ≤ 20kHz P_{out} = 0.8Wrms, A_V = 2，R_L = 8Ω			0.03		%
		V_{DD}=3. 6V 20Hz ≤ F ≤ 20kHz P_{out} = 0.5Wrms, A_V = 2，R_L = 8Ω			0.05		%
PSRR	Power supply rejection ratio(1) R_L = 8Ω, A_V = 2, V_{ripple} = 200mVpp, input grounded f = 217Hz f = 1kHz			 55 55	 63 67		dB
t_{WU}	Wake-up time (C_b = 1μF)				100		ms
t_{SD}	Shutdown Time(C_b = 1μF)				10		μs
V_{SDH}	Shutdown Voltage level high			1.3			V
V_{SDL}	Shutdown Voltage level low					0.4	V

1. All PSRR data limits are guaranteed by production sampling tests.
   Dynamic measurements - 20*log(rms(Vout)/rms(Vripple)). Vripple is the sinusoidal signal superimposed upon Vcc.
2. The Exposed-DAP should be electrically connected to GND or an electrically isolated copper area.

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Electrical Characteristics

(V_{DD} = 3.0V, T_A = 25°C unless otherwise specified)

Symbol	Parameter		Min.	Typ.	Max.	Unit
I_{CC}	Supply current No input signal, no load			1.15	5	mA
I_{SD}	Shutdown current No input signal, V_{SD} = GND , R_L = 8Ω			0.19	2	uA
V_{oo}	Output offset voltage No input signal, R_L = 8Ω			3	30	mV
P_{out}	Output power	THD+N = 1% (max); f = 1kHz (8Ω)	0.28	0.36		mW
THD + N	Total harmonic distortion + noise P_{out} = 0.25Wrms, A_V = 2, 20Hz ≤ F ≤ 20kHz, R_L =8 Ω			0.08	0.25	%
PSRR	Power supply rejection ratio(1) R_L = 8Ω, A_V = 2, V_{ripple} = 200mVpp, input grounded f = 217Hz f = 1kHz		 55 55	 63 66		dB
t_{WU}	Wake-up time (C_b = 1μF)			80		ms
t_{SD}	Shutdown time (C_b = 1μF)			10		μs
V_{SDH}	Shutdown Voltage level high		1.2			V
V_{SDL}	Shutdown Voltage level low				0.4	V

1.2 W Mono Class AB Audio Power Amplifier

Electrical Characteristics

(V_{DD} = 2.6V, T_A = 25°C unless otherwise specified)

Symbol	Parameter	Min.	Typ.	Max.	Unit
I_{CC}	Supply current No input signal, no load		1.1	4	mA
I_{SD}	Shutdown current No input signal, V_{SD} = G_{ND}, R_L = 8Ω		0.1	2	uA
V_{oo}	Output offset voltage No input signal, R_L = 8Ω		2	30	mV
P_{out}	Output power THD+N = 1% (max); f = 1kHz (8Ω)	0.20	0.27		mW
THD + N	Total harmonic distortion + noise P_{out} = 0.15 Wrms, A_V = 2, 20Hz ≤ F ≤ 20kHz, R_L =8 Ω		0.09	0.30	%
PSRR	Power supply rejection ratio(1) R_L = 8Ω, A_V = 2, V_{ripple} = 200mVpp, input grounded f = 217Hz f = 1 kHz	 55 55	 60 62		dB
t_{WU}	Wake-up time (C_b = 1μF)		70		ms
t_{SD}	Shutdown time (C_b = 1μF)		10		μs
V_{SDH}	Shutdown Voltage level high	1.2			V
V_{SDL}	Shutdown Voltage level low			0.4	V

1.2 W Mono Class AB Audio Power Amplifier

Typical Operating Characteristics

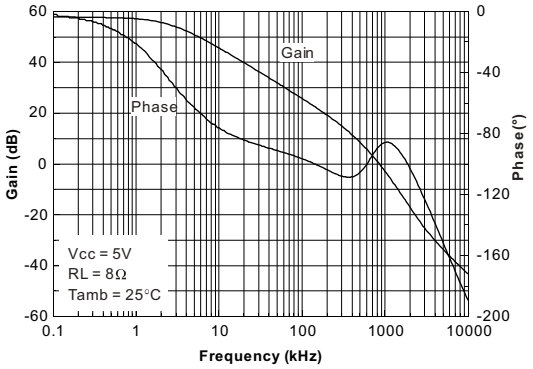


Figure 4. Open loop frequency response

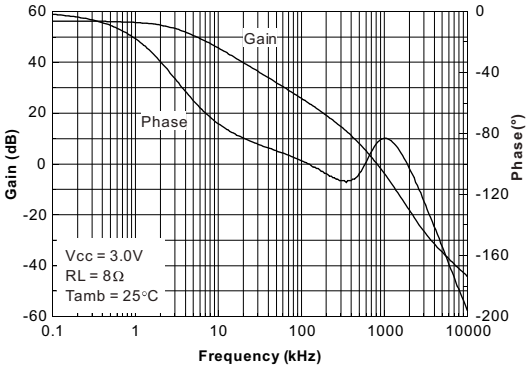


Figure 5. Open loop frequency response

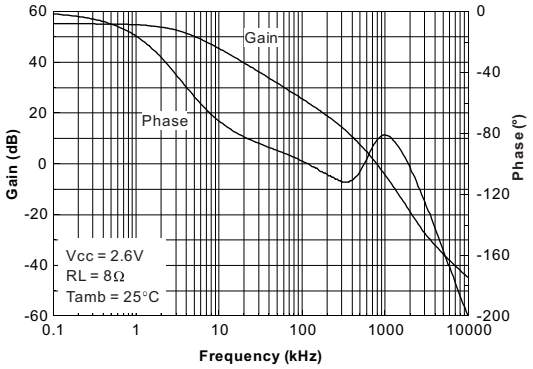


Figure 6. Open loop frequency response

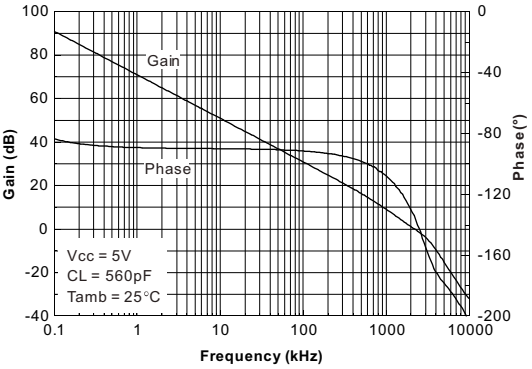


Figure 7. Open loop frequency response

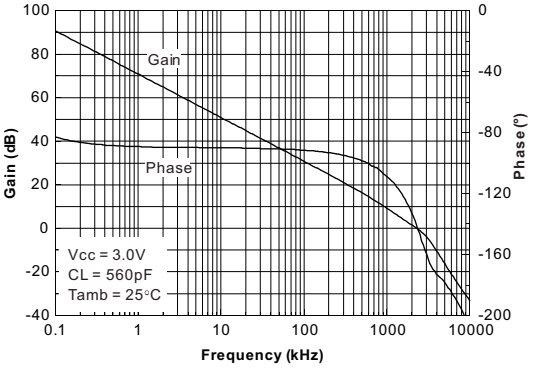


Figure 8. Open loop frequency response

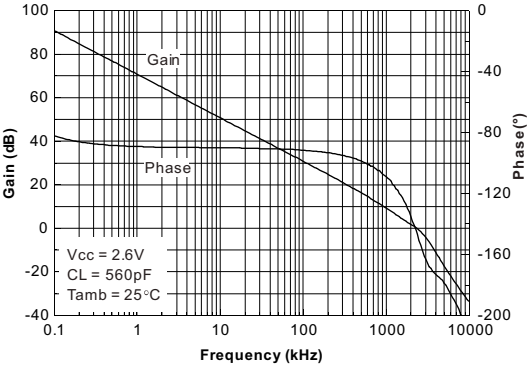


Figure 9. Open loop frequency response

1.2 W Mono Class AB Audio Power Amplifier

Typical Operating Characteristics (Continued)

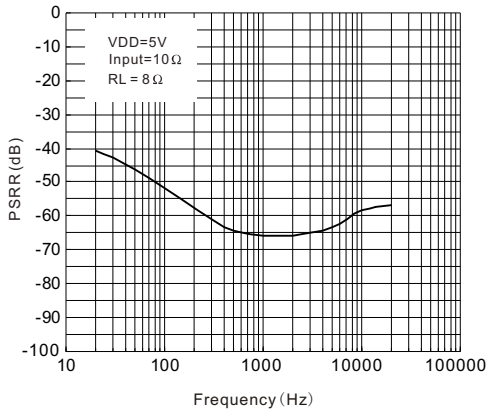


Figure 10. PSRR vs.power supply

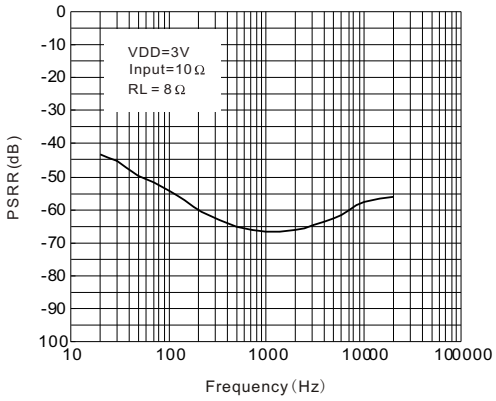


Figure 11. PSRR vs.power supply

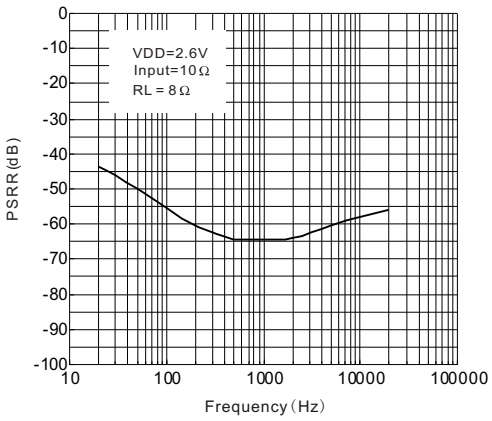


Figure 12. PSRR vs.power supply

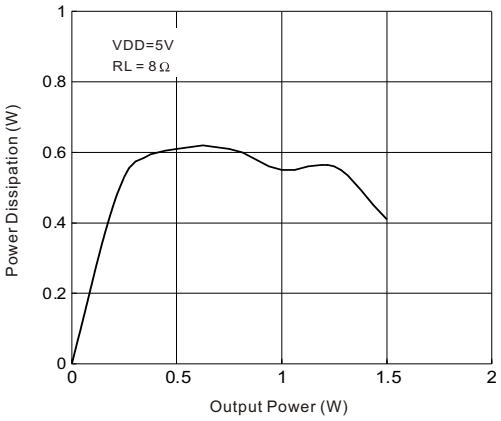


Figure 13.Power Dissipation vs Output Power

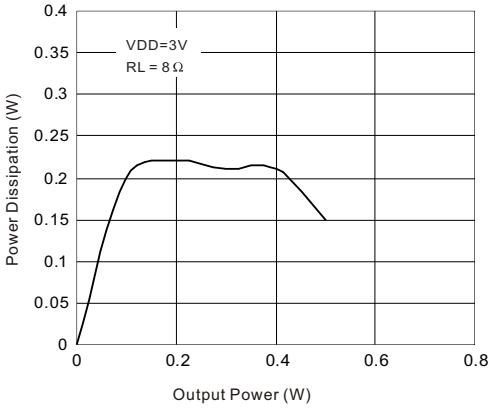


Figure 14.Power Dissipation vs Output Power

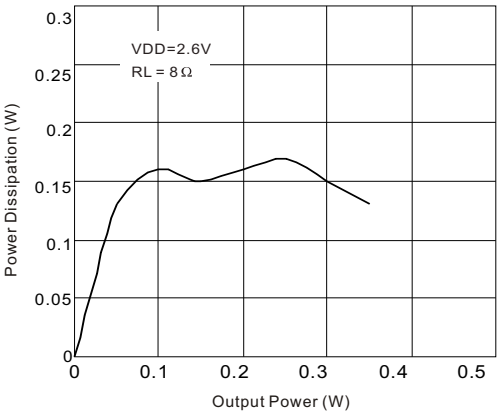


Figure 15.Power Dissipation vs Output Power

1.2 W Mono Class AB Audio Power Amplifier

Typical Operating Characteristics (Continued)

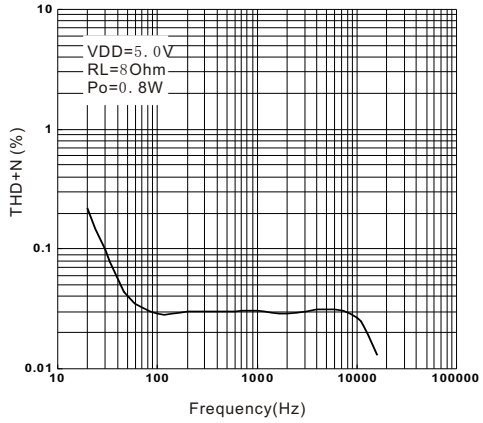


Figure 16.THD+N vs Frequency

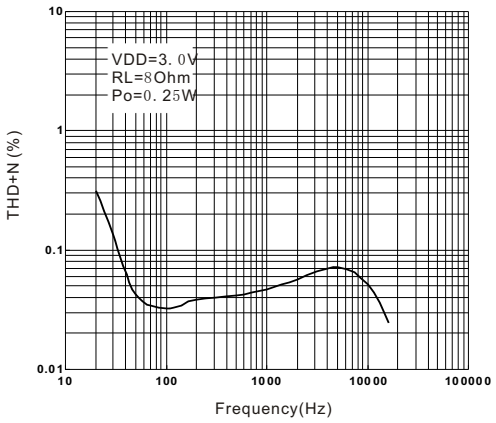


Figure 17.THD+N vs Frequency

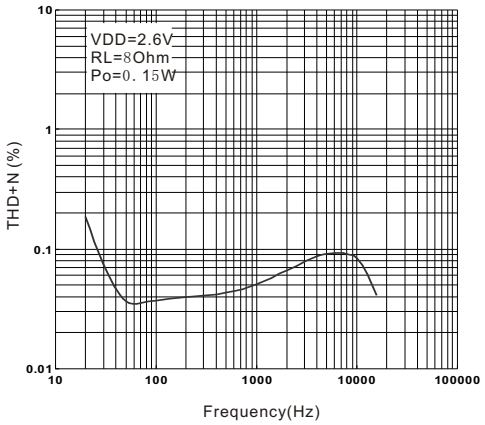


Figure 18.THD+N vs Frequency

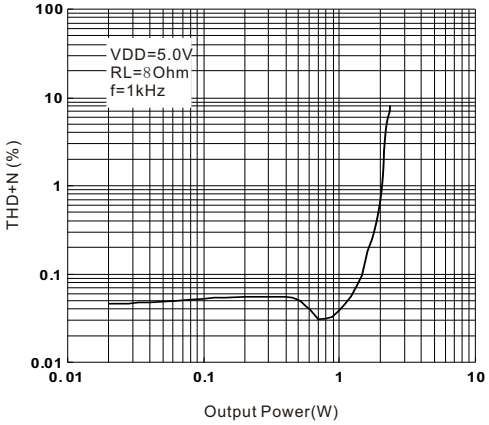


Figure 19.THD+N vs Output Power

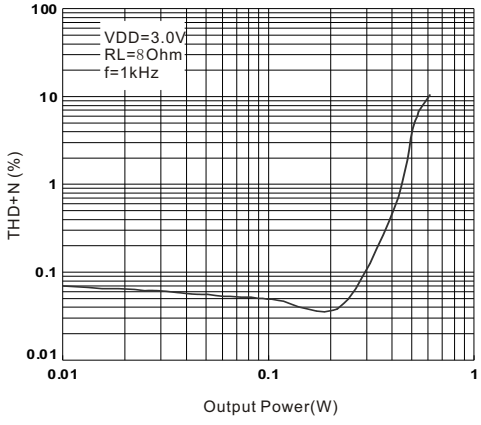


Figure 20.THD+N vs Output Power

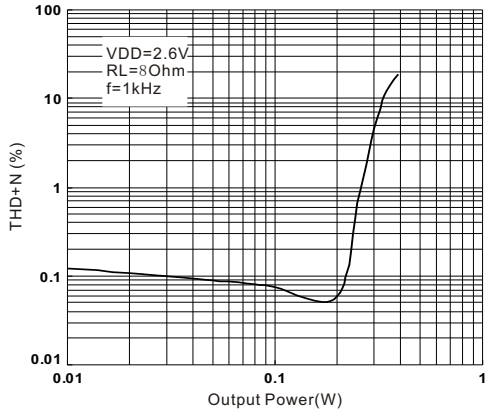


Figure 21.THD+N vs Output Power

1.2 W Mono Class AB Audio Power Amplifier

Typical Operating Characteristics (Continued)

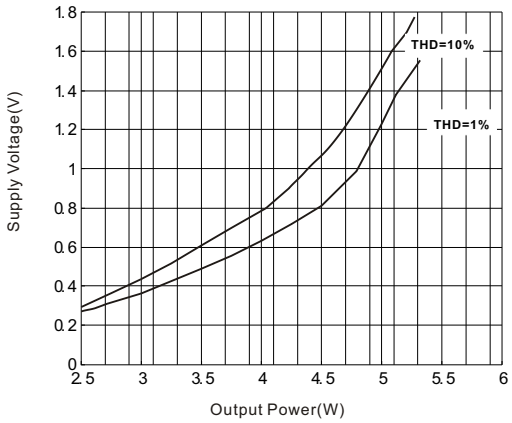


Figure 22.Output Power vs Supply Voltage

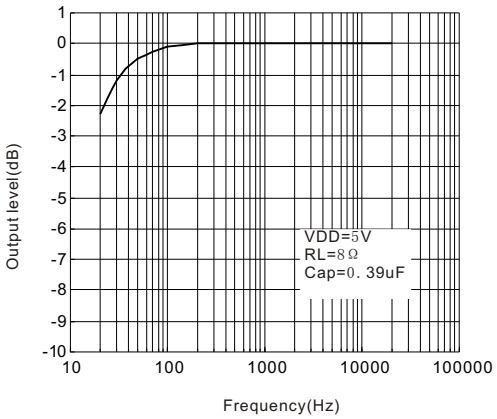


Figure 23.Frequency Response vs Input Capacitor Size

1.2 W Mono Class AB Audio Power Amplifier

Applications Information

Bridged Configuration principle

The MC4996 is a monolithic power amplifier with a BTL output type. BTL (bridge tied load) means that each end of the load is connected to two single-ended output amplifiers. Thus,we have:

Single-ended output 1 = Vout1 = Vout (V)
Single ended output 2 = Vout2 = -Vout (V)
and Vout1 - Vout2 = 2Vout (V)

The output power is:

$$P_{out} = \frac{(2V_{out_{RMS}})^2}{R_L}$$

For the same power supply voltage, the output power in BTL configuration is four times higher than the output power in single ended con-figuration.

Gain in a typical application schematic

The typical application schematic is shown in *Figure 2* . In the flat region (no Cin effect), the output voltage of the first stage is (in Volts):

$$V_{out1} = (-V_{in})\frac{R_{feed}}{R_{in}}$$

For the second stage: Vout2 = -Vout1 (V)
The differential output voltage is (in Volts):

$$V_{out2} - V_{out1} = 2V_{in}\frac{R_{feed}}{R_{in}}$$

The differential gain named gain (Gv) for more convenient usage is:

$$G_v = \frac{V_{out2} - V_{out1}}{V_{in}} = 2\frac{R_{feed}}{R_{in}}$$

Vout2 is in phase with Vin and Vout1 is phased 180° with Vin. This means that the positive terminal of the loudspeaker should be connected to Vout2 and the negative to Vout1.

Power Dissipation and Efficiency

Hypotheses:

- Load voltage(Vout) and current (Iout) are sinusoidal.
- Supply voltage is a pure DC source (Vcc).

Regarding the load we have:

$$V_{out} = V_{PEAK}\sin\omega t \ (V) \ ;$$

$$I_{out} = \frac{V_{out}}{R_L} \quad (A) \ ;$$

$$P_{out} = \frac{V_{PEAK}^2}{2R_L} \quad (W)$$

Therefore, the average current delivered by the supply voltage is:

$$I_{CC_{AVG}} = 2\frac{V_{PEAK}}{\pi R_L} \quad (A)$$

The power delivered by the supply voltage is:

$$P_{supply} = V_{CC} \cdot I_{CC_{AVG}} \quad (W)$$

Then, the *power dissipated by each amplifier* is:

$$P_{diss} = P_{supply} - P_{out} \quad (W)$$

$$P_{diss} = \frac{2\sqrt{2}V_{CC}}{\pi\sqrt{R_L}}\sqrt{P_{out}} - P_{out}$$

and the maximum value is obtained when:

$$\frac{\delta P_{diss}}{\delta P_{out}} = 0$$

and its value is:

$$P_{diss_{max}} = \frac{2V_{CC}^2}{\pi^2 R_L} \quad (W)$$

Note: This maximum value is only dependent on power supply voltage and load values. The efficiency is the ratio between the output power and the power supply:

$$\eta = \frac{P_{out}}{P_{supply}} = \frac{\pi V_{PEAK}}{4V_{CC}}$$

The maximum theoretical value is reached when $V_{PEAK} = VCC$, so:

$$\frac{\pi}{4} = 78.5\%$$

1.2 W Mono Class AB Audio Power Amplifier

Shutdown time

When the shutdown command is set, the time required to put the two output stages in high impedance and the internal circuitry in shutdown mode is a few microseconds.
In shutdown mode, Bypass pin and Vin- pin are short circuited to ground by internal switches. This allows a quick discharge of Cb and Cin capacitors.

POP performance

Pop performance is intimately linked with the size of the input capacitor Cin and the bias voltage bypass capacitor Cb.
The size of Cin is dependent on the lower cut-off frequency and PSRR values requested. The size of Cb is dependent on THD+N and PSRR values requested at lower frequencies.
Moreover, Cb determines the speed with which the amplifier turns ON. In order to reach near zero pop and click, the equivalent input constant time,

$$\tau_{in} = (R_{in} + 2K\Omega)xC_{in} \quad (s) \text{ with } R_{in} \geq 5k\Omega$$

By following the previous rules, the MC4996 can reach near zero pop and click even with high gains such as 20 dB.

Wake-up time(t_{WU})

When the shutdown is released to put the device ON, the bypass capacitor Cb will not be charged immediately. As Cb is directly linked to the bias of the amplifier, the bias will not work properly until the Cb voltage is correct. The time to reach this voltage is called wake-up time or t_{WU} and specified in the electrical characteristics table with Cb = 1µF.

Decoupling of the circuit

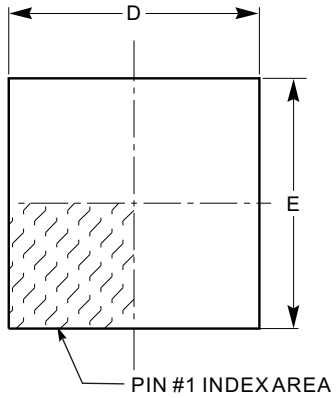
Two capacitors are needed to correctly bypass the MC4996: a power supply bypass capacitor Cs and a bias voltage bypass capacitor Cb.

C_s has particular influence on the THD+N in the high frequency region (above 7kHz) and an indirect influence on power supply disturbances. With a value for C_s of 1µF, you can expect THD+N levels similar to those shown in the datasheet.
In the high frequency region, if C_s is lower than 1µF, it increases THD+N and disturbances on the power supply rail are less filtered.
On the other hand, if Cs is higher than 1µF, those disturbances on the power supply rail are more filtered.
C_b has an influence on THD+N at lower frequencies, but its function is critical to the final result of PSR (with input grounded and in the lower frequency region).
If C_b is lower than 1µF, THD+N increases at lower frequencies and PSRR worsens. If C_b is higher than 1µF, the benefit on THD+N at lower frequencies is small, but the benefit to PSRR is substantial.
Note that C_{in} has a non-negligible effect on PSRR at lower frequencies. The lower the value of Cin, the higher the PSRR.

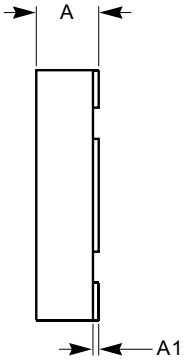
1.2 W Mono Class AB Audio Power Amplifier

Package Information

DFN 2X2_8L

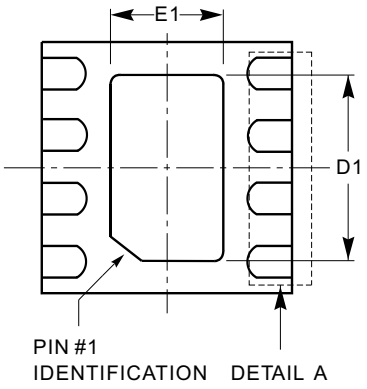


TOP VIEW

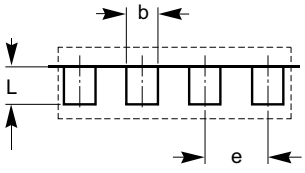


SIDE VIEW

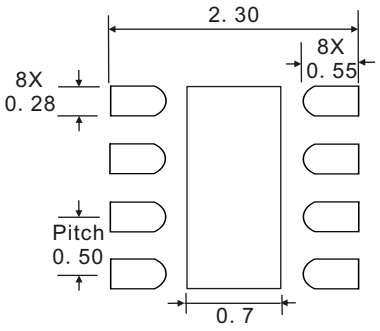
SYMBOL	MIN	NOM	MAX
A	0.70	0.75	0.80
A1	0.00	0.02	0.05
b	0.18	0.25	0.30
D		2.00BSC	
D1	1.10	1.20	1.30
E		2.00BSC	
E1	0.50	0.60	0.70
e		0.50 BSC	
L	0.30	0.35	0.40



BOTTOM VIEW



DETAIL A



UNIT:mm

Recommended Land Pattern

Notes:

(1) All dimensions are in millimeters.

(2) Complies with JEDEC MO-229.