PT5306

2.5W Filter-free Class D Audio Power Amplifier

GENERAL DESCRIPTION

The PT5306 is a single supply, high efficiency 2.5W class D audio amplifier. A low noise, filterless PWM architecture eliminates the output filter, reducing external component count, board area consumption, system cost, and simplifying design.

The PT5306 is designed to meet the demands of mobile phones and other portable communication devices. Operating on a single 5V supply, it is capable of driving a 4Ω speaker load at a continuous average output of 2.5W with less than 10% THD+N. Its flexible power supply requirements allow operation from 2.5V to 5.5V.

The PT5306 has high efficiency with speaker loads compared to a typical Class AB amplifier. With a 5V supply driving an 8Ω speaker, the IC's efficiency for a 100mW power level is 82%, and reaching 90% at 400mW output power.

FEATURES

- 2.5W Into 4 Ω from a 5V Supply at THD=10% (Typ)
- High Efficiency: 90% at 400mW, 5V power supply and 8Ω Speaker,
- 4mA Quiescent Current
- 0.5uA Shutdown Current
- 70dB PSRR at 217Hz
- Advanced pop & click circuitry
- Thermal overload protection
- Low power shutdown mode
- Only Three External Components
- Wide Supply Voltage (2.5V to 5.5V)
- Space Saving Packages: 9 Bump SMD package and 3mm×3mm DFN8 package

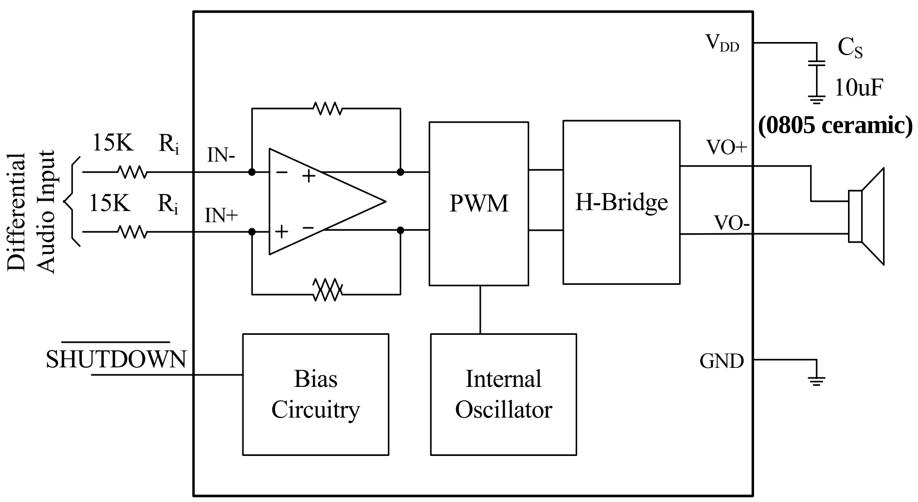
APPLICATIONS

- Cell Phones
- Handheld Computers and PDAs
- Portable electronic device

ORDERING INFORMATION

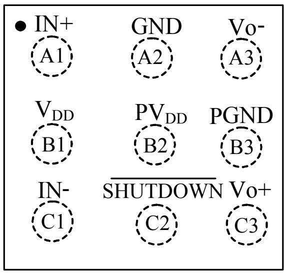
PACKAGE	TEMPERATURE RANGE	ORDERING PART NUMBER	TRANSPORT MEDIA	MARKING
DFN-8	-40 °C to 85 °C	PT5306EQFN	Tape and Reel 5000units	PT5306 xxxxxX
SMD-9	-40 °C to 85 °C	PT5306ESMD	Tape and Reel 3000units	P5306 xxxxX

TYPICAL APPLICATIONS

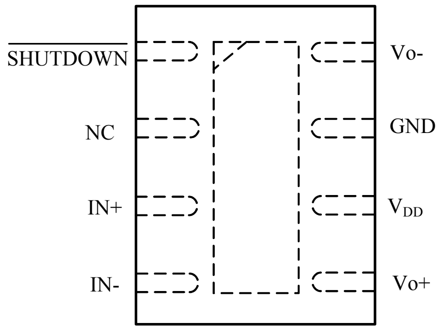


PIN ASSIGNMENT

9 Bump micro SMD Package
(Top View of PCB)



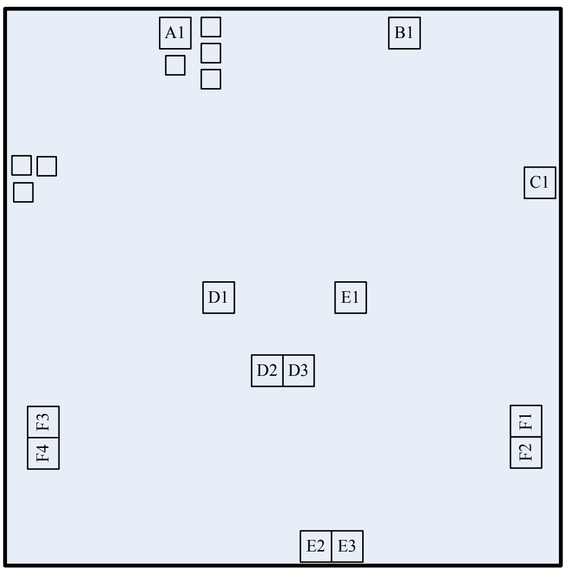
DFN-8
(Top View of PCB)



PIN DESCRIPTIONS

SMD9	DFN8	PIN NAME	DESCRIPTION
C2	1	$\overline{ShoutDown}$	Shutdown terminal (active low logic)
A1	3	IN+	Positive differential input
C1	4	IN-	Negative differential input
C3	5	V_O+	Positive BTL output
B1	6	V_{DD}	Power supply
A2	7	GND	Ground
A3	8	V_O-	Negative BTL output
B3		PGND	High current ground
B2		PV_{DD}	High current power supply

PAD ASSIGNMENT



PAD DESCRIPTIONS

PADS	NAMES	POSITION	DESCRIPTION
A1	INP	(-315.7,616.1)	Positive differential input
B1	INN	(340.2,616.6)	Negative differential input
C1	SD	(620.5,179.1)	Shutdown terminal (active low logic)
D1	VDDA	(-216.5,-22.9)	Power supply
D2,D3	VDDP	(-39.1,-189.1),(40.9,-189.1)	Power supply
E1	GNDA	(213.9,-22.9)	Ground
E2,E3	GNDP	(54.5,-637.6),(134.5,-637.6)	Ground
F1,F2	VOP	(607.6,-335.6),(607.6,-415.6)	Positive BTL output
F3,F4	VON	(-607.6,-335.6),(-607.6,-415.6)	Negative BTL output

ABSOLUTE MAXIMUM RATINGS (Note 1)

SYMBOL	ITEMS	VALUE	UNIT
V_{DD}	Supply Voltage	-0.3～6	V
V_{IN}	Input Voltage	-0.3～V_{DD} +0.3	V
P_{DMAX}	Power Dissipation (Note 2)	Internally Limited	W
P_{TR1}	Thermal Resistance, DFN8: θ_{JA}	63	℃/W
P_{TR2}	Thermal Resistance, SMD9: θ_{JA} (Note 3)	180	℃/W
T_A	Operating free-air temperature	-40 to 85	℃
T_J	Operating junction temperature	-40 to 150	℃
Tstg	Storage Temperature	-55 to 150	℃
Tsolder	Package Lead Soldering Temperature	260℃, 10s	
	ESD Susceptibility (Note 4)	2500	V

RECOMMENDED OPERATING RANGE (Note 5)

SYMBOL	ITEMS	VALUE	UNIT
V_{DD}	Supply voltage	2.5 ~ 5.5	V
V_{IH}	$\overline{ShoutDown}$	2 ~ V_{DD}	V
V_{IL}	$\overline{ShoutDown}$	0 ~ 0.8	V
R_I	Input resistor ($A_V \leq 20$ V/V)	15	KΩ
V_{IC}	Common mode input voltage range	0.5 ~ V_{DD}-0.8	V
T_A	Operating free-air temperature	-40 to 85	℃

Note 1: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur.
Note 2: The maximum power dissipation must be derated at elevated temperatures and is dictated by T_{JMAX}, θ_{JA}, and

the ambient temperature T_A. The maximum allowable power dissipation is $P_{DMAX} = (T_{JMAX}–T_A)/\theta_{JA}$ or the number given in Absolute Maximum Ratings, whichever is lower.

Note 3: All bumps have the thermal resistance and contribute equally when used to lower thermal resistance. All bumps must connected to achieve specified thermal resistance

Note 4: Human body model, 100pF discharged through a 1.5kΩ resistor.

Note 5: Operating Ratings indicate conditions for which the device is functional, but do not guarantee specific performance limits.

ELECTRICAL CHARACTERISTICS (Note 6, 7)

The following specifications apply for 8Ω load, and A_V=2 V/V, T_A=25 °C, unless specified otherwise.

SYMBOL	ITEMS	CONDITIONS		MIN.	TYP.	MAX.	UNIT
$\lvert V_{OS} \rvert$	Output offset voltage	V_I=0, V_{DD} =2.5 to 5.5V, A_V = 2V/V				25	mV
I_Q	Quiescent current	V_{DD} =5.5V, no load			4	7.5	mA
		V_{DD} =3.6V, no load			3.8	7.0	mA
		V_{DD} =2.5V, no load			2.3	6.5	mA
I_{SD}	Shutdown current	V($\overline{ShoutDown}$)=0.8V, V_{DD} =2.5 to 5.5V			0.2	1	uA
Rout	Output impedance in shutdown mode	V($\overline{ShoutDown}$)=0.8V			>1		KΩ
f_{SW}	Switching frequency	V_{DD} =2.5 to 5.5V		400	500	600	KHz
A_V	Gain			$2\times\frac{142\,K\Omega}{R_I}$	$2\times\frac{150\,K\Omega}{R_I}$	$2\times\frac{158\,K\Omega}{R_I}$	V/V
P_O	Output power	THD+N=10%, f=1KHz, R_L=4Ω	V_{DD} =5V		2.50		W
			V_{DD} =3.6V		1.20		
			V_{DD} =2.5V		0.50		
		THD+N=1%, f=1KHz, R_L=4Ω	V_{DD} =5V		2.00		
			V_{DD} =3.6V		1.00		
			V_{DD} =2.5V		0.32		
		THD+N=10%, f=1KHz, R_L=8Ω	V_{DD} =5V		1.40		
			V_{DD} =3.6V		0.65		
			V_{DD} =2.5V		0.50		
		THD+N=1%, f=1KHz, R_L=8Ω	V_{DD} =5V		1.16		
			V_{DD} =3.6V		0.60		
			V_{DD} =2.5V		0.27		
THD+N	Total harmonic distortion plus noise	P_O=1W, f=1KHz, R_L=8Ω	V_{DD} =5V		0.2%		
		P_O=0.5W, f=1KHz, R_L=8Ω	V_{DD} =3.6V		0.1%		
		P_O=0.2W, f=1KHz, R_L=8Ω	V_{DD} =2.5V		0.1%		

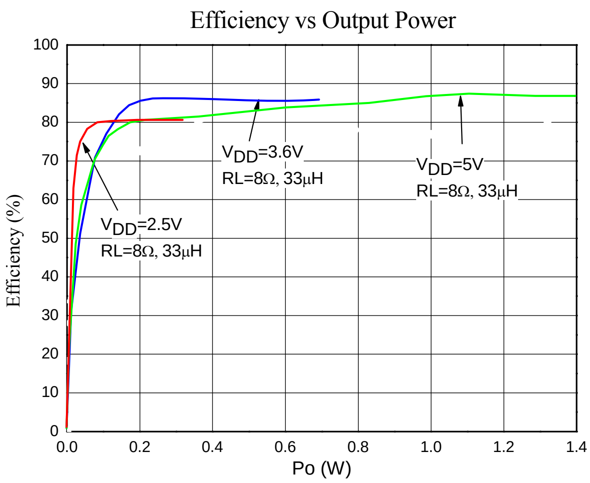
ELECTRICAL CHARACTERISTICS (Continued) (Note 6, 7)

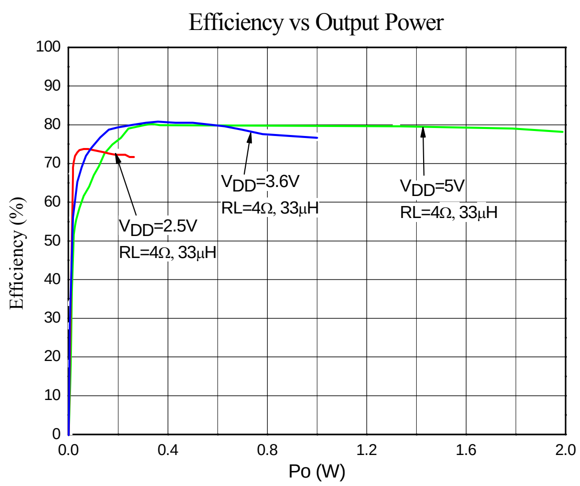
SYMBOL	ITEMS	CONDITIONS		MIN.	TYP.	MAX.	UNIT
PSRR	Power supply rejection ratio	V_{DD} =2.5 to 5.5V			-70	-55	dB
CMRR	Common mode rejection ratio	V_{DD} =2.5 to 5.5V, V_{IC}=0.5 to V_{DD} -0.8V			-60	-49	dB
SNR	Signal-to-noise ratio	V_{DD} =5V, R_L=8Ω, P_O = 1W			95		dB
V_n	Output voltage noise	VDD=3.6V, BW = 20Hz to 20kHz, Inputs ac-grounded with Ci = 2uF	No Weighting		50		uV
			A Weighting		40		uV
Tsu	Start-up time from shutdown				650		us

Note 6: Typicals are measured at 25˚C and represent the parametric norm.

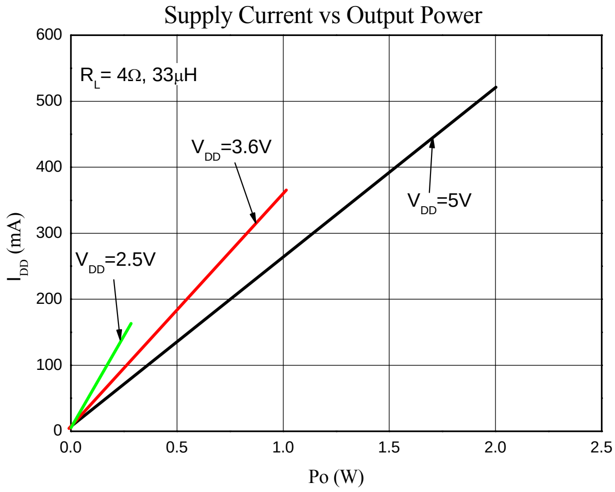
Note 7: Datasheet min/max specification limits are guaranteed by design, test, or statistical analysis.

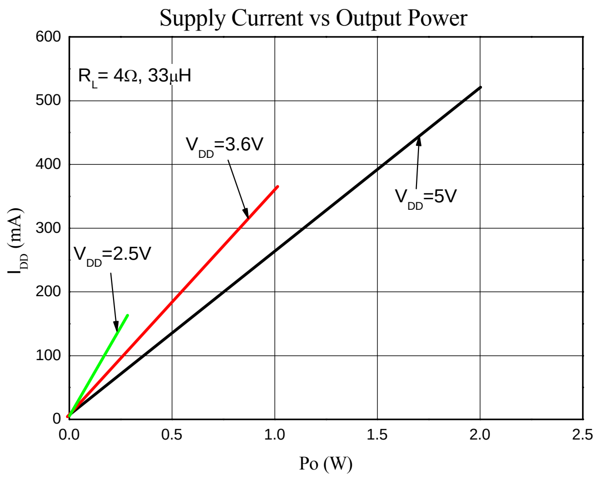
TYPICAL PERFORMANCE CHARACTERISTICS

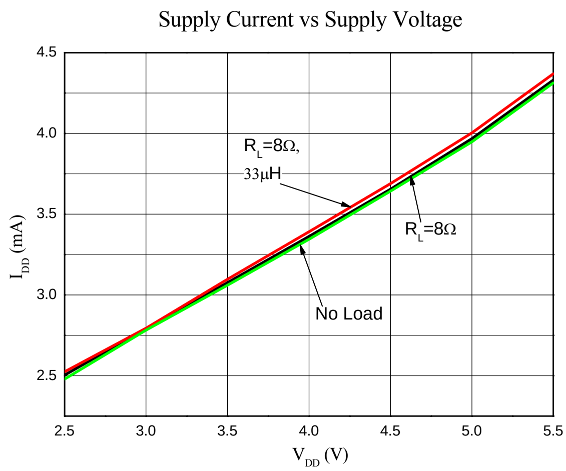


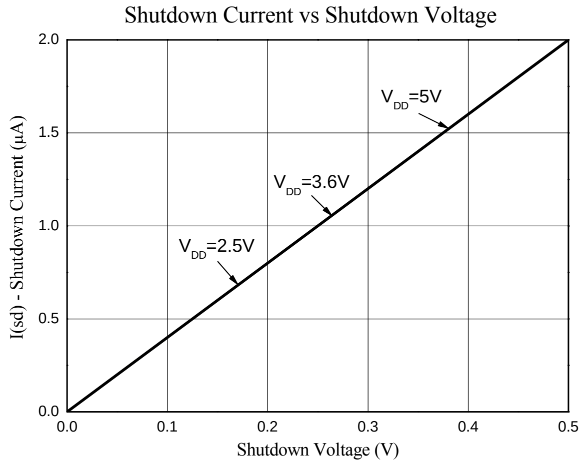


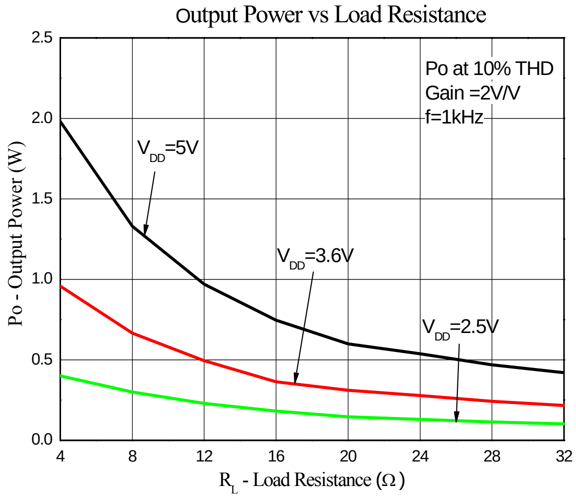
TYPICAL PERFORMANCE CHARACTERISTICS

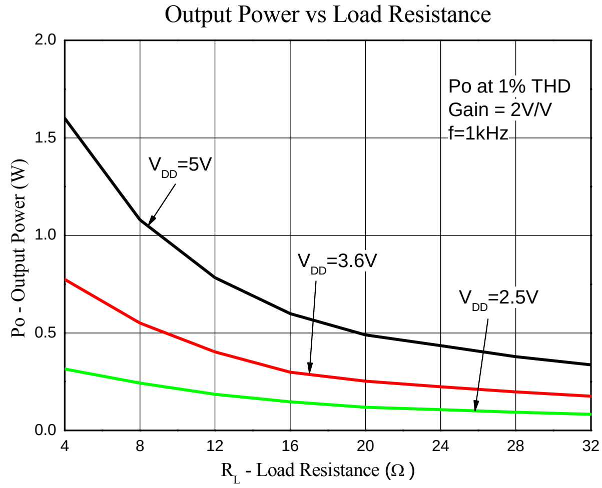






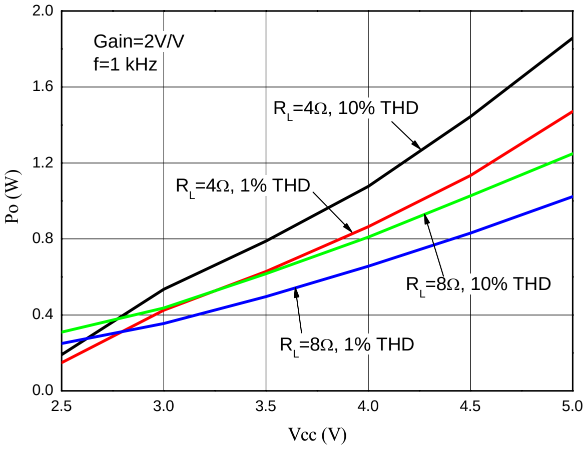




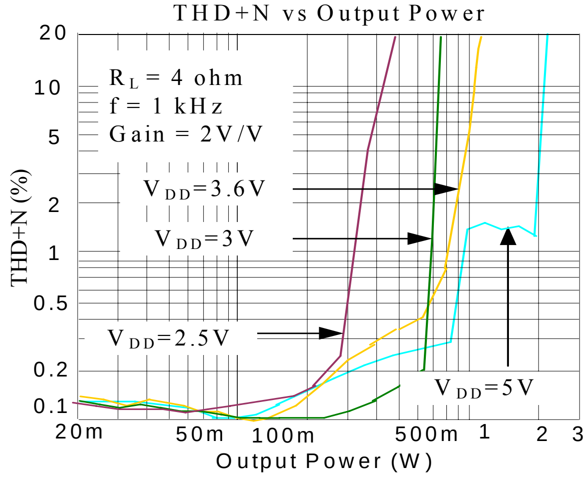


TYPICAL PERFORMANCE CHARACTERISTICS

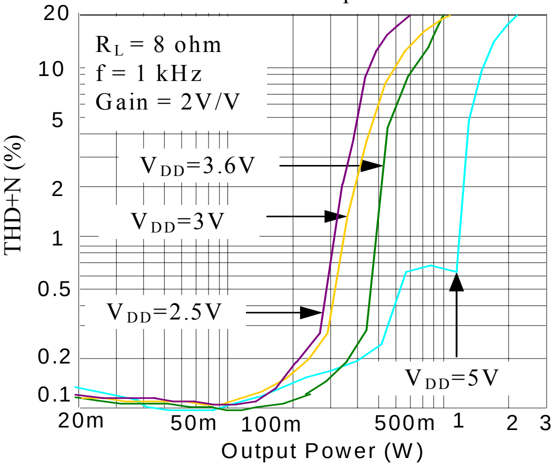
Output Power vs Supply Voltage



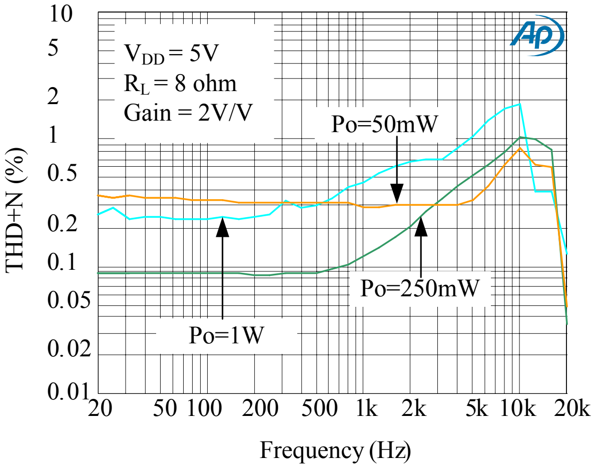
THD+N vs Output Power



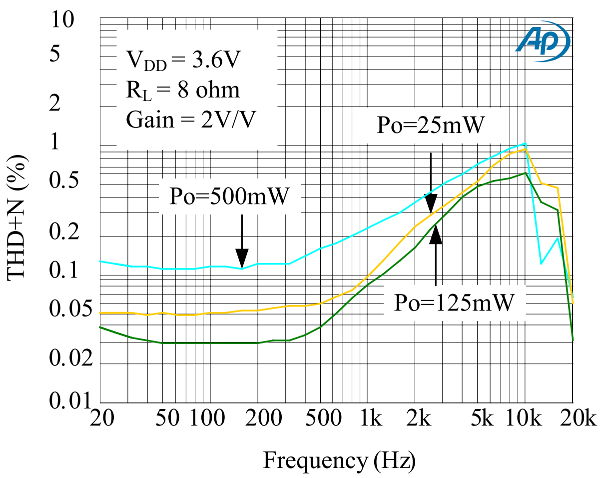
THD+N vs Output Power



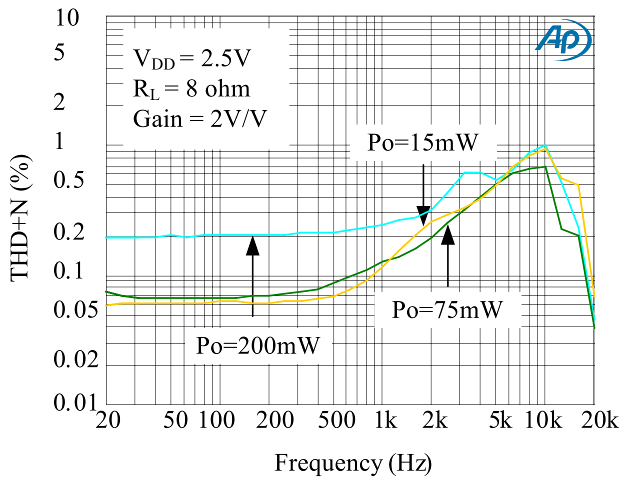
THD+N vs Frequency



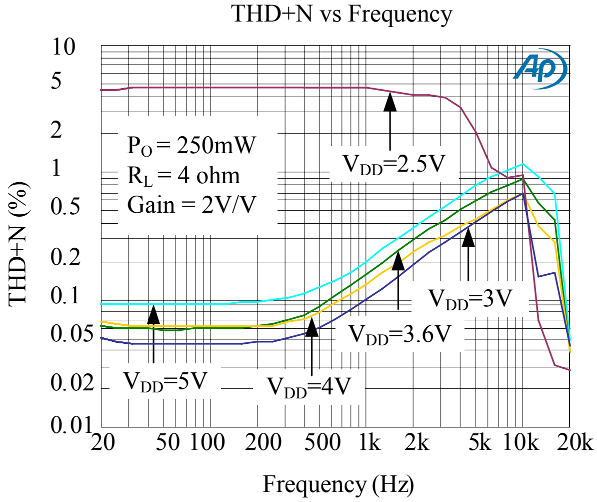
THD+N vs Frequency

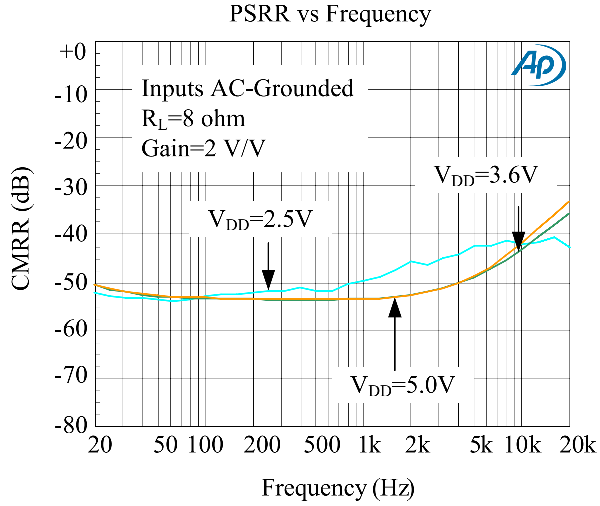


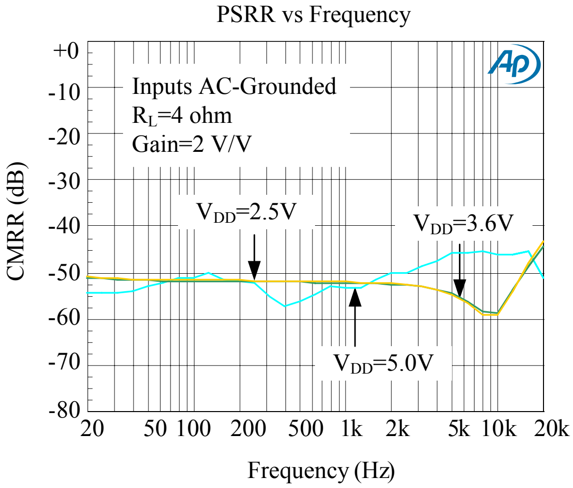
THD+N vs Frequency

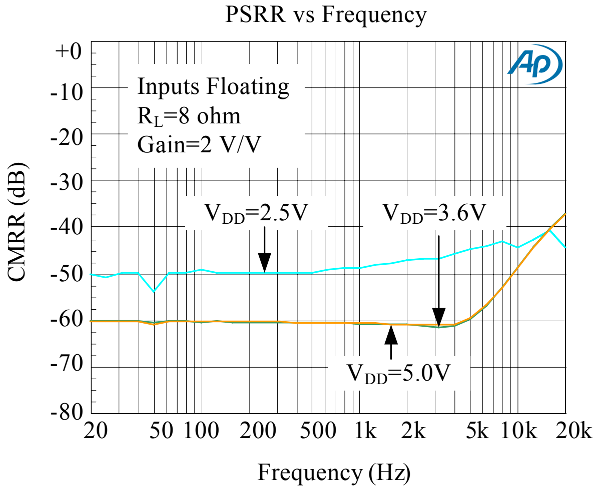


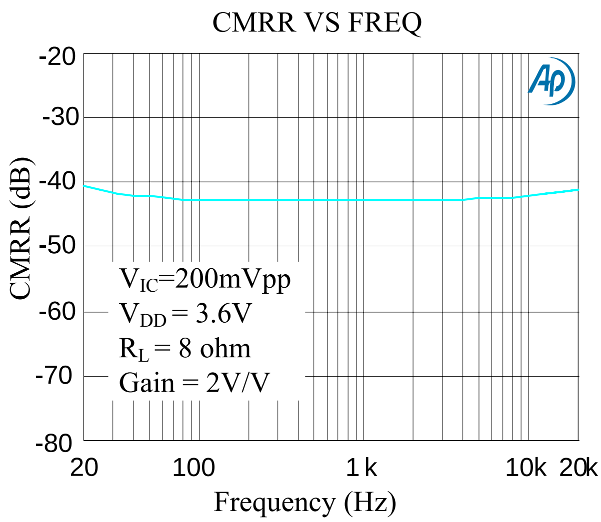
TYPICAL PERFORMANCE CHARACTERISTICS

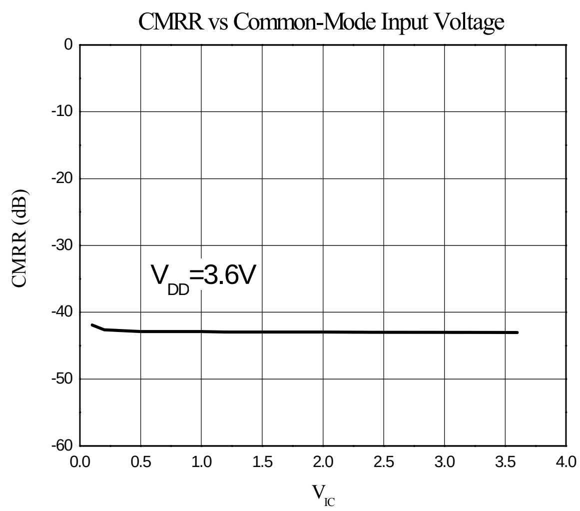




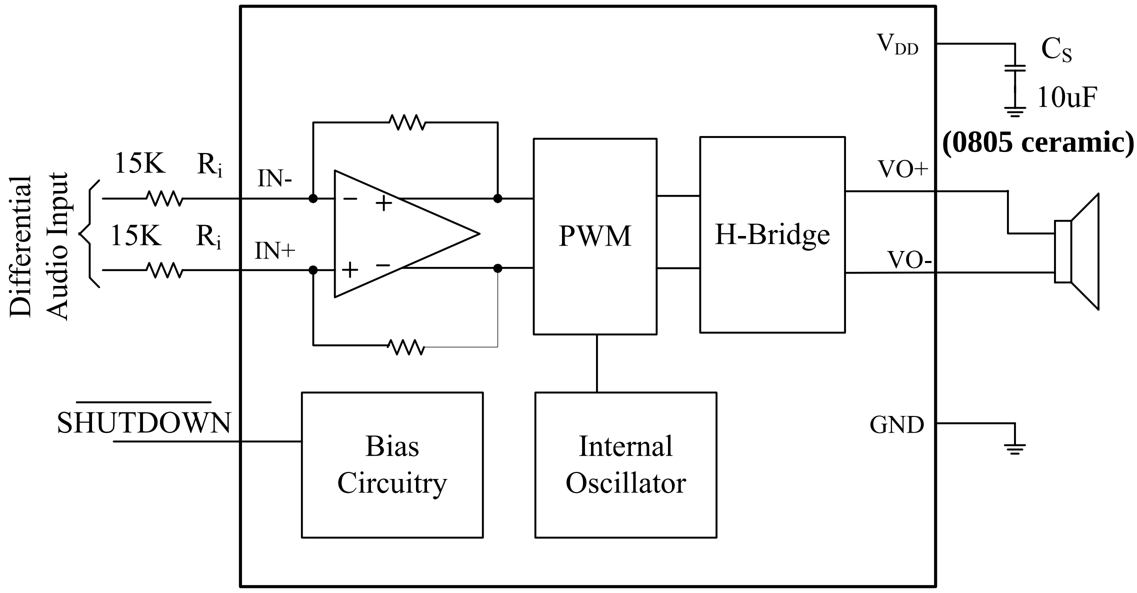




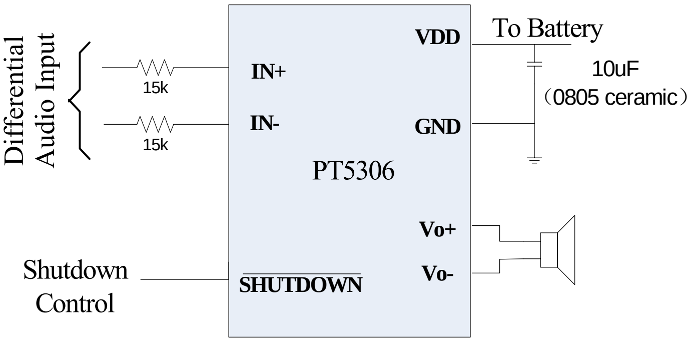




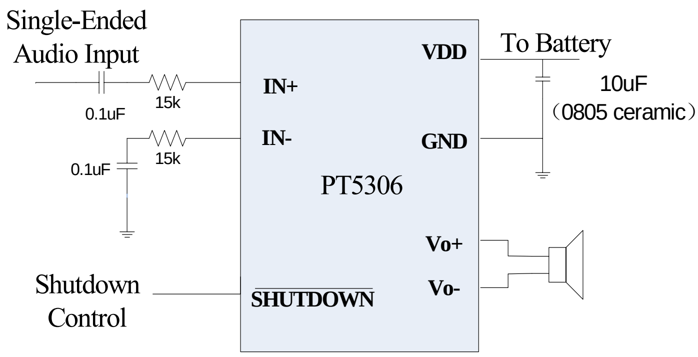
SIMPLIFIED BLOCK DIAGRAM



APPLICATION INFORMATION



PT 5306 Application Schematic with Differential input



PT 5306 Application Schematic with Single Ended input Capacitors

DECOUPLING CAPACITOR (C_S)

The PT5306 is a high-performance Class-D audio amplifier that requires adequate power supply decoupling to ensure the efficiency is high and total harmonic distortion (THD) is low. For higher frequency transients, spikes, or digital hash on the line a good low equivalent-series-resistance (ESR) ceramic capacitor or tantalum capacitor, typically 10µF, placed as close as possible to the device V_{DD} lead works best. Placing this decoupling capacitor close to the PT5306 is important for the efficiency of the Class-D amplifier, because any resistance or inductance in the trace between the device and the capacitor can cause a loss in efficiency. For filtering lower-frequency noise signals, a 10µF or greater 0805 capacitor placed near the audio power amplifier would also help.

INPUT CAPACITORS (CI)

The PT5306 does not require input coupling capacitors if the design uses a differential source that is biased from 0.5 V to VDD -0.8 V. If the input signal is not biased within the recommended common-mode input range, if high pass filtering is needed (see Figure above), or if using a single-ended source (see Figure above), input coupling capacitors CI are required.

The input capacitors and input resistors R_I form a high-pass filter with the corner frequency, fc, determined in Equation1.

$$f_c = \frac{1}{2\pi R_I C_I} \qquad (1)$$

The value of the input capacitor is important to consider as it directly affects the bass (low frequency) performance of the circuit. Speakers in wireless phones cannot usually respond well to low frequencies, so the corner frequency can be set to block low frequencies in this application. Not using input capacitors can increase output offset.

Equation 2 is used to solve for the input coupling capacitance.

$$C_I = \frac{1}{2\pi R_I f_c} \qquad (2)$$

If the corner frequency is within the audio band, the capacitors should have a tolerance of ±10% or better, because any mismatch in capacitance causes an impedance mismatch at the corner frequency and below.

COMPONENT LOCATION

Place all the external components very close to the PT5306. Placing the decoupling capacitor, C_S, close to the PT5306 is important for the efficiency of the Class-D amplifier. Any resistance or inductance in the trace between the device and the capacitor can cause a loss in efficiency.

PCB LAYOUT CONSIDERATIONS

As output power increases, interconnect resistance (PCB traces and wires) between the amplifier, load and power supply create a voltage drop. The voltage loss on the traces between the PT5306 and the load results is lower output power and decreased efficiency. Higher trace resistance between the supply and the PT5306 has the same effect as a poorly regulated supply, increase ripple on the supply line also reducing the peak output power. The effects of residual trace resistance increases as output current increases due to higher output power, decreased load impedance or both. To maintain the highest output voltage swing and corresponding peak output power, the PCB traces that connect the output pins to the load and the supply pins to the power supply should be as wide as possible to minimize trace resistance.

The use of power and ground planes will give the best THD+N performance. While reducing trace resistance, the use of power planes also creates parasite capacitors that help to filter the power supply line.

The inductive nature of the transducer load can also result in overshoot on one or both edges, clamped by the parasitic diodes to GND and V_{DD} in each case. From an EMI standpoint, this is an aggressive waveform that can radiate or conduct to other components in the system and cause interference. It is essential to keep the power and output traces short and well shielded if possible. Use of ground planes, beads, and micro-strip layout techniques are all useful in preventing unwanted interference.

As the distance from the PT5306 and the speaker increase, the amount of EMI radiation will increase since the output wires or traces acting as antenna become more efficient with length. What is acceptable EMI is highly application specific.

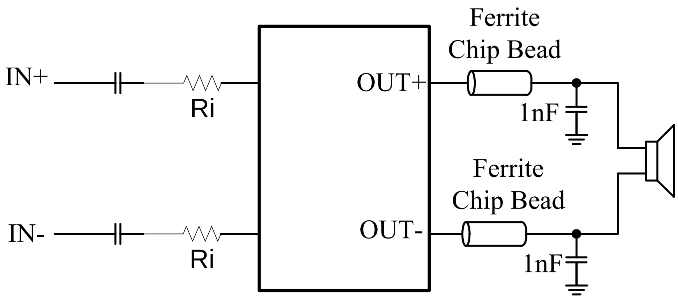
Ferrite chip inductors placed close to the PT5306 may be needed to reduce EMI radiation. The value of the ferrite chip is very application specific.

WHEN TO USE AN OUTPUT FILTER

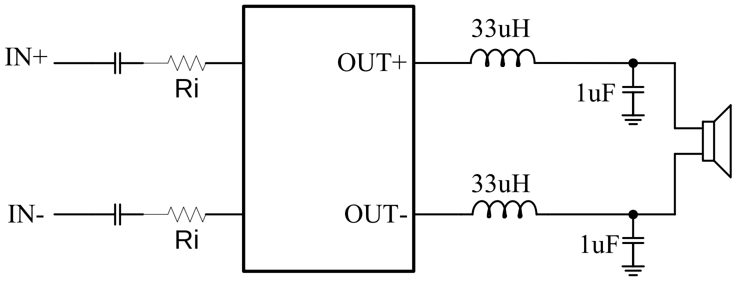
Design the PT5306 without an output filter if the traces from amplifier to speaker are short. Wireless handsets and PDAs are great applications for class-D without a filter.

A ferrite bead filter often can be used if the design is failing radiated emissions without an LC filter, and the frequency-sensitive circuit is greater than 1 MHz. This is good for circuits that just have to pass FCC and CE because FCC and CE only test radiated emissions greater than 30 MHz. If choosing a ferrite bead, choose one with high impedance at high frequencies, but very 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 leads from amplifier to speaker.



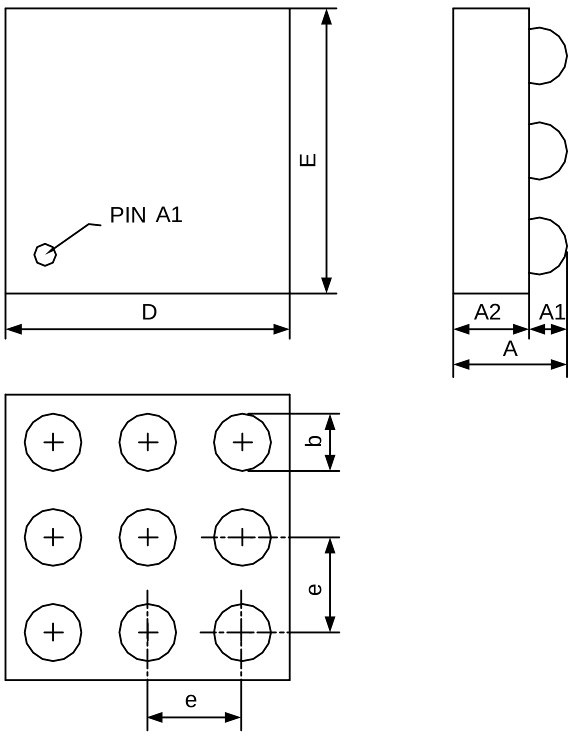
Ferrite Chip Bead Filter



Typical LC Output Filter, Cut-Off Frequency of 27k Hz

PACKAGE INFORMATION

SMD9 Package



SYMBOL	MILLIMETERS	
	MIN	MAX
A	0.635	0.735
A1	0.209	0.249
A2	0.426	0.486
b	0.25	0.35
D	1.47	1.53
E	1.47	1.53
e	0.50 BSC	

PACKAGE INFORMATION

DFN-8 Package