Lyontek Inc.

LY8006

1.4 W Mono Filterless Class D Audio power Amplifier (MSOP / DFN)
－Compatible with LY8890/8891/8891B Single-Ended Input

Rev. 1.7

FEATURES

- 1.4 W Into 8Ω from 5V power supply at THD = 10% (Typ).
- 2.5V~5.5V power supply.
- Low shutdown current.
- Low quiescent current.
- Minimum external components.
- No output filter required for inductive loads.
- Output Pin Short-Circuit Protection (Short to Output Pin, Short to GND, Short to VCC)
- Low noise during turn-on and turn-off transitions.
- **Easy upgrade Class AB (LY8990/LY8891) to Class D (Pin to Pin Replace).**
- Lead free and green package available. (RoHS Compliant)
- Space Saving Package
  - 8-pin MSOP package.
  - 8-pin DFN package

GENERAL DESCRIPTION

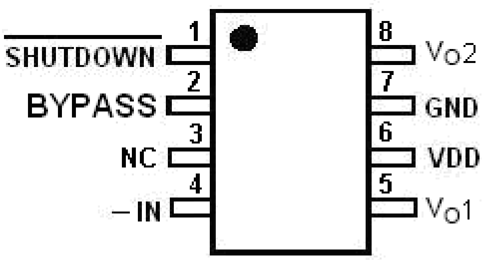
The LY8006 is a high efficiency, 1.4 W mono class D audio power amplifier. It is a low noise, filterless PWM architecture eliminates the output filter, reducing external component count, system cost, and simplify design.
The LY8006 is designed to meet of portable electronic devices. The LY8006 is a single 5V supply, it is capable of driving 8Ω speaker load at a continuous average output of 1.4 W with 10% THD+N. The LY8006 has high efficiency with speaker loads compared to a typical Class AB amplifier. With a 3.6V supply driving an 8Ω speaker, the LY8006 efficiency for a 400mW power level is 88%.
In cellular handsets, the earpiece, speaker phone, and melody ringer can each be driven by the LY8006.The gain of the LY8006 is externally configurable which allows independent gain control from multiple sources by summing the signals.
Output pin short circuit (short to output pin, short to ground and short to VDD) protection prevent the device from damage during fault conditions.

APPLICATION

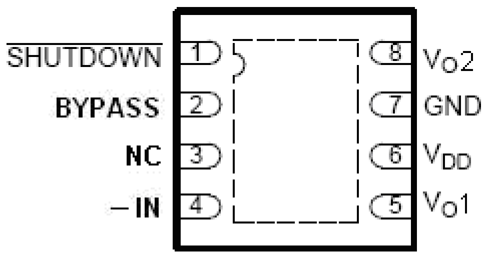
- Portable electronic devices
- Mobile Phones
- PDAs

PIN CONFIGURATION

8-PIN MSOP PACKAGE
(TOP VIEW)



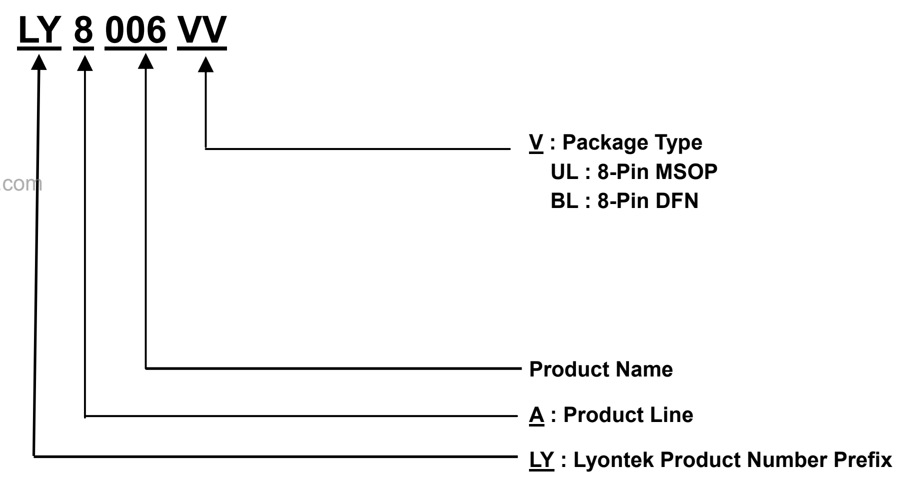
8-PIN DFN PACKAGE
(TOP VIEW)



PIN DESCRIPTION

SYMBOL	Pin No.		DESCRIPTION
	MSOP	DFN	
SHUTDOWN	1	1	Shutdown the device.(when low level is active the pin)
BYPASS	2	2	Bypass pin
NC	3	3	No Internal connection
-IN	4	4	Negative input
Vo1	5	5	Positive BTL output
V_{DD}	6	6	Power supply
GND	7	7	Ground
Vo2	8	8	Negative BTL output

ORDERING INFORMATION



APPLICATION CIRCULT

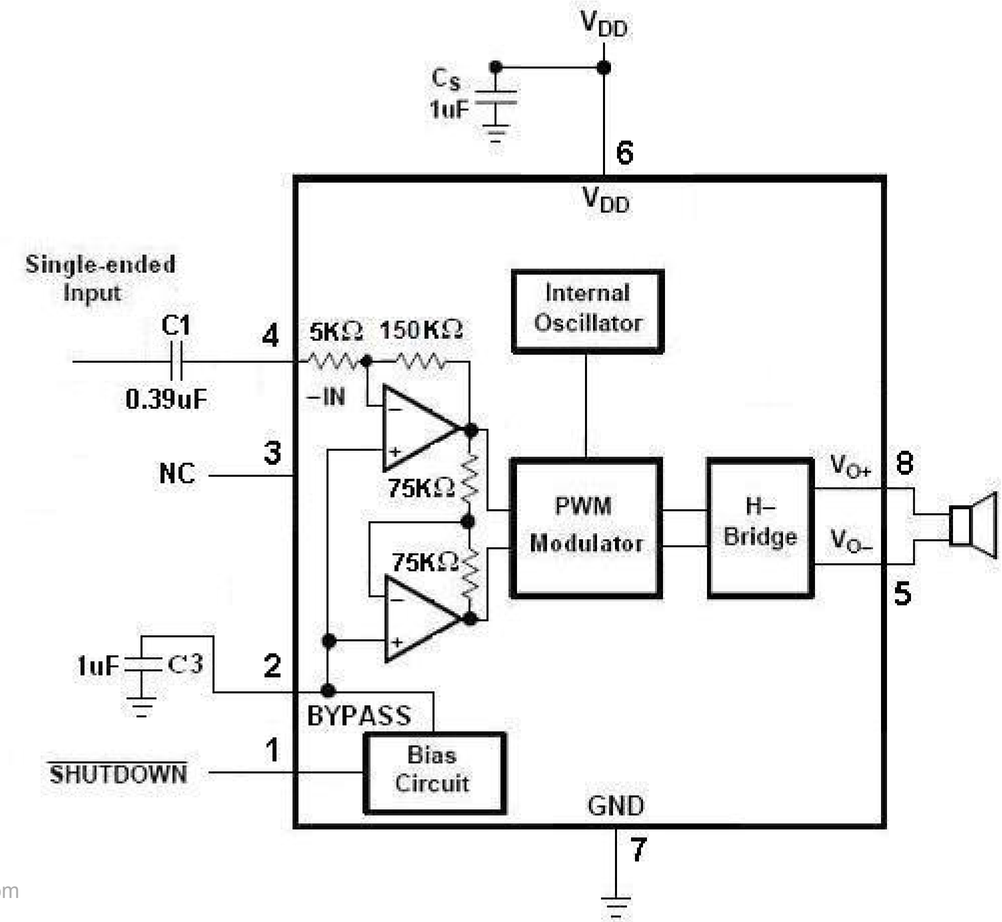


Figure 1. Application Schematic With Single-Ended Input Configuration
Single-End Input With Pre-Amplifier Gain = (150 KΩ / 5 KΩ) * 2 = 60

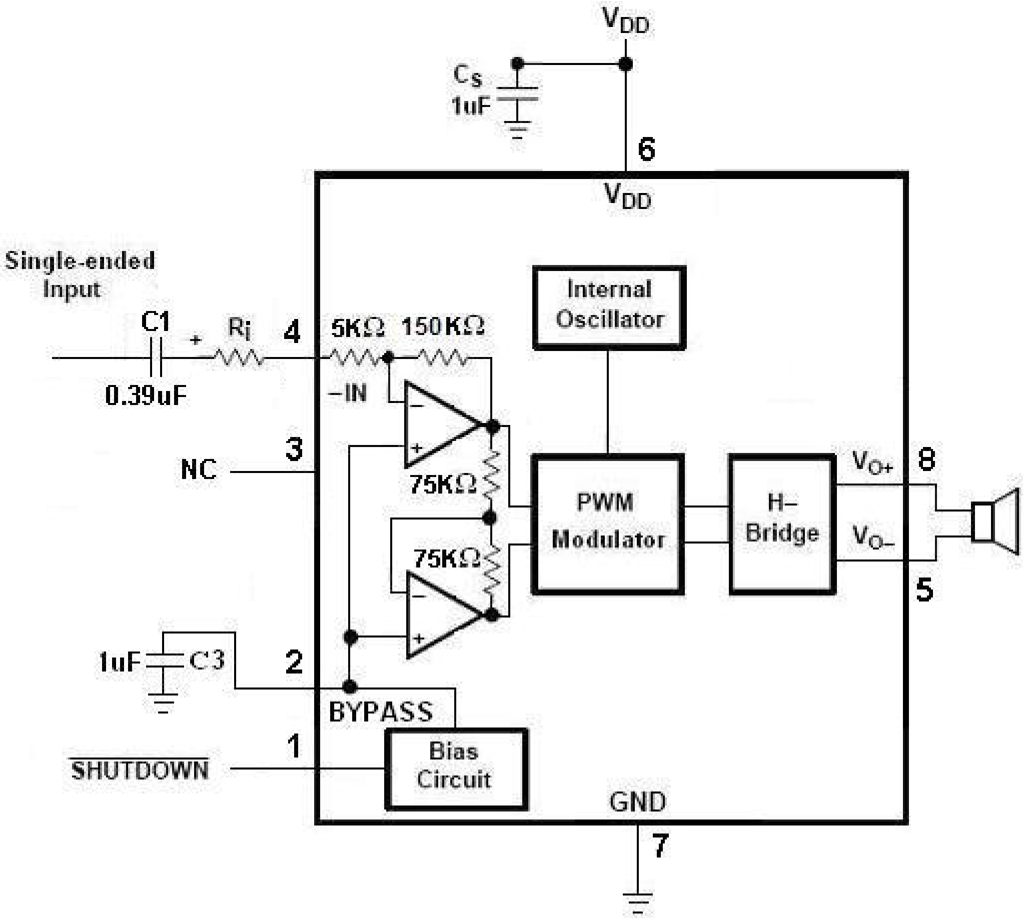


Figure 2. Application Schematic With Single-Ended Input Configuration
Single-End Input With Pre-Amplifier Gain = [150 KΩ / (5 KΩ+ Ri)] * 2

ABSOLUTE MAXIMUN RATINGS

PARAMETER	SYMBOL	RATING	UNIT
Supply Voltage	V_{DD}	6.0	V
Operating Temperature	T_A	-40 to 85 (I grade)	℃
Input Voltage	V_I	-0.3V to V_{DD} +0.3V	V
Storage Temperature	T_{STG}	-65 to 150	℃
Power Dissipation	P_D	Internally Limited	W
ESD Susceptibility	V_{ESD}	2000	V
Junction Temperature	T_{JMAX}	150	℃
Soldering Temperature (under 10 sec)	T_{SOLDER}	260	℃

ELECTRICAL CHARACTERISTICS (T_A = 25℃,Unless otherwise noted)

PARAMETER	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Output offset voltage (measured differentially)	$\lvert V_{OS} \rvert$	V_I = 0 V, Av = 2 V/V, V_{DD} = 2.5 V to 5.5 V	-	-	25	mV
High-level input current	$\lvert I_{IH} \rvert$	V_{DD} = 5.5 V, V_I = 5.8 V	-	-	100	uA
Low-level input current	$\lvert I_{IL} \rvert$	V_{DD} = 5.5 V, V_I = 0.3 V	-	-	5	uA
Power supply rejection ratio	PSRR	V_{DD} = 2.5 V to 5.5 V		-75	-55	dB
Quiescent Current	I_Q	V_{DD} = 5.5V, No Load	-	3.4	4.5	mA
		V_{DD} = 3.6V, No Load	-	2.8	-	
		V_{DD} = 2.5V, No Load	-	2.2	3.2	
Shutdown Current	I_{SD}	$V_{SHUTDOWN} \leqq 0.8V$, V_{DD} = 2.5V to 5.5V	-	0.3	2	μA
Total Gain (*)		V_{DD}= 2.5V to 5.5V R_L = 8Ω	[300KΩ / (5KΩ+Ri)] x2 (TYP.)			V/V

(*)The audio amplifier's gain is determined by：

Pre-Amplifier Gain = [150KΩ / (5KΩ＋Ri)] x 2

Total Gain = {[150KΩ / (5KΩ＋Ri)] x 2} x 2

where Ri is the external serial resistance at the input pin.

OPERATING CHARACTERISTICS (TA = 25℃, Gain = 2V/V, RL = 8Ω, Unless otherwise noted)

PARAMETER	SYMBOL	TEST CONDITION		MIN.	TYP.	MAX.	UNIT
Out Power	Po	THD+N= 10%, f = 1 kHz, R_L= 8Ω	VDD=5.0V	-	1.55	-	W
			VDD=3.6V	-	0.79	-	
			VDD=2.5V	-	0.36	-	
		THD+N= 1%, f = 1 kHz, R_L= 8Ω	VDD=5.0V	-	1.2	-	
			VDD=3.6V	-	0.6	-	
			VDD=2.5V	-	0.3	-	
Total harmonic distortion + noise	THD+N	P_O = 1 W, f = 1 kHz, R_L = 8Ω	VDD=5V	-	0.2	-	%
		P_O = 0.5 W, f = 1 kHz, R_L = 8Ω	VDD=3.6V	-	0.18	-	
		P_O = 0.2 W, f = 1 kHz, R_L = 8Ω	VDD=2.5V	-	0.15	-	
Supply ripple rejection ratio	K_{SVR}	f = 217 Hz, V(RIPPLE) = 200mVpp, inputs ac-grounded with Ci = 2uF	VDD=3.6V	-	-56	-	dB
Signal-to-noise ratio	SNR	P_O= 1 W, R_L = 8Ω	VDD=5V	-	97	-	dB
Output voltage noise	Vn	V_{DD} = 3.6 V, f = 20 Hz to 20 kHz, Inputs ac-grounded with Ci = 2 μF	No weighting	-	48	-	uV_{RMS}
			A weighting	-	36	-	
Start-up time from shutdown	Z_I	V_{DD} = 3.6 V		-	110	-	ms

TYPICAL PERFORMANCE CHARACTERISTICS

Figure 3
Total Harmonic Distortion + Noise vs Output Power

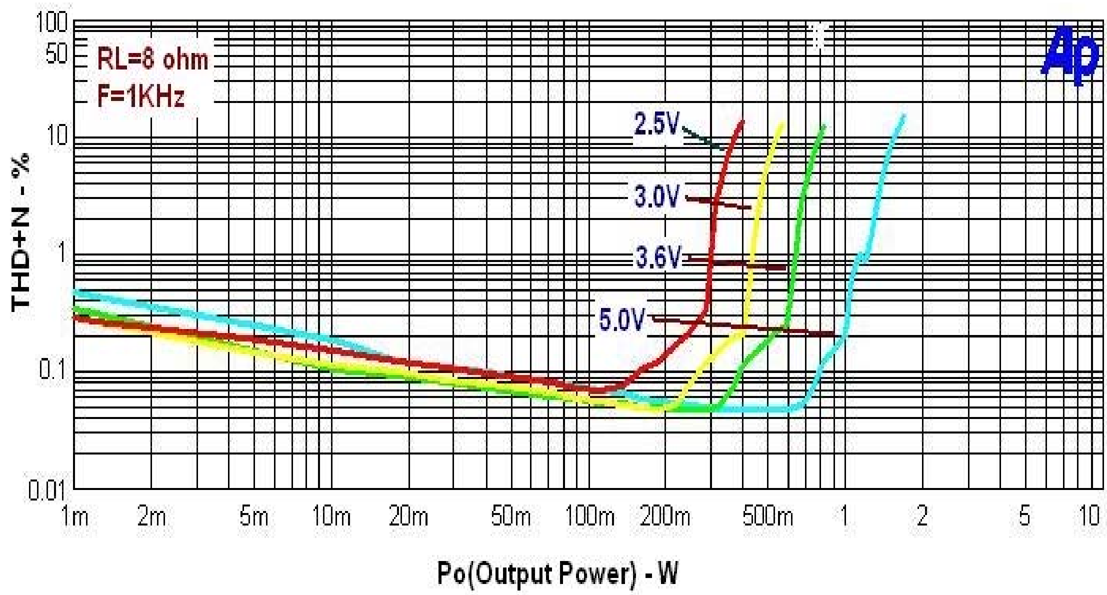


Figure 4
Total Harmonic Distortion + Noise vs Frequency

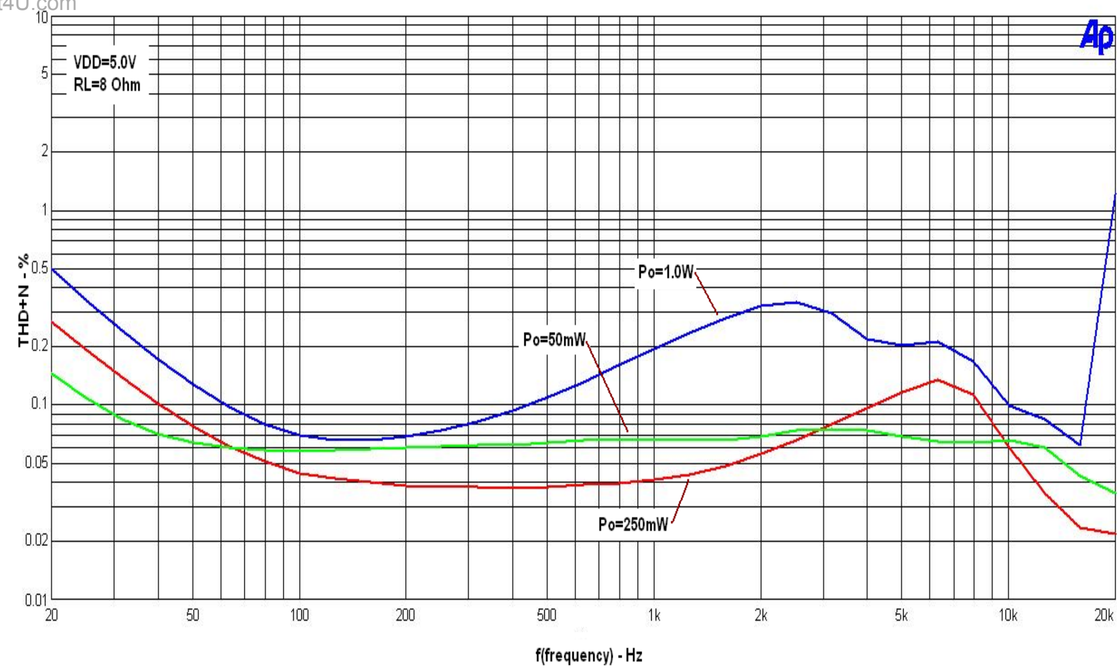


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Figure 5
Efficiency vs Output power (RL=8Ω, 33μH)

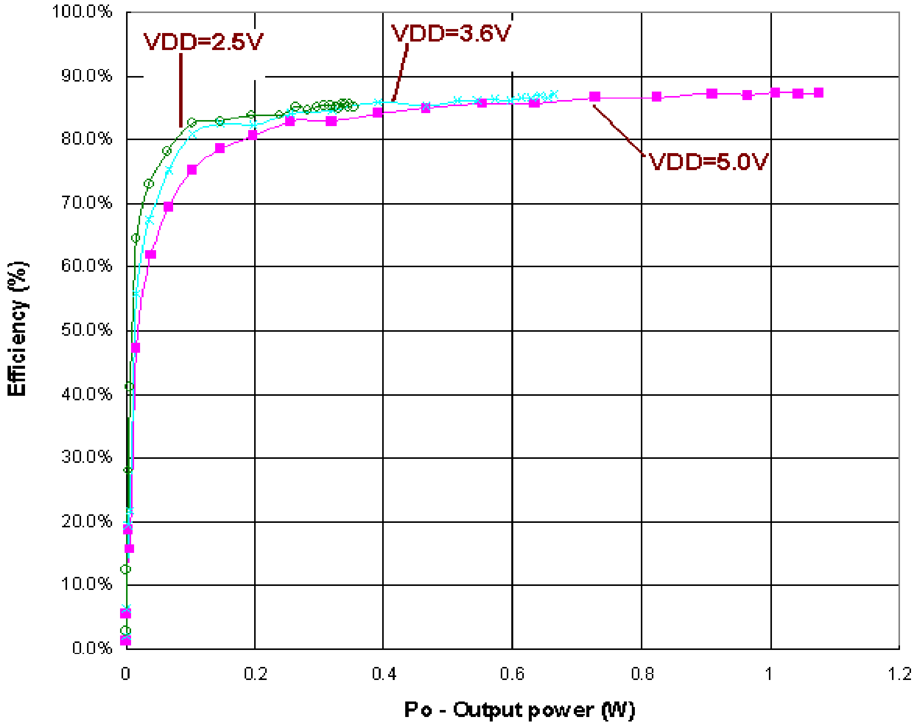


Figure 6
Power dissipation vs Output power (RL=8Ω, 33μH)

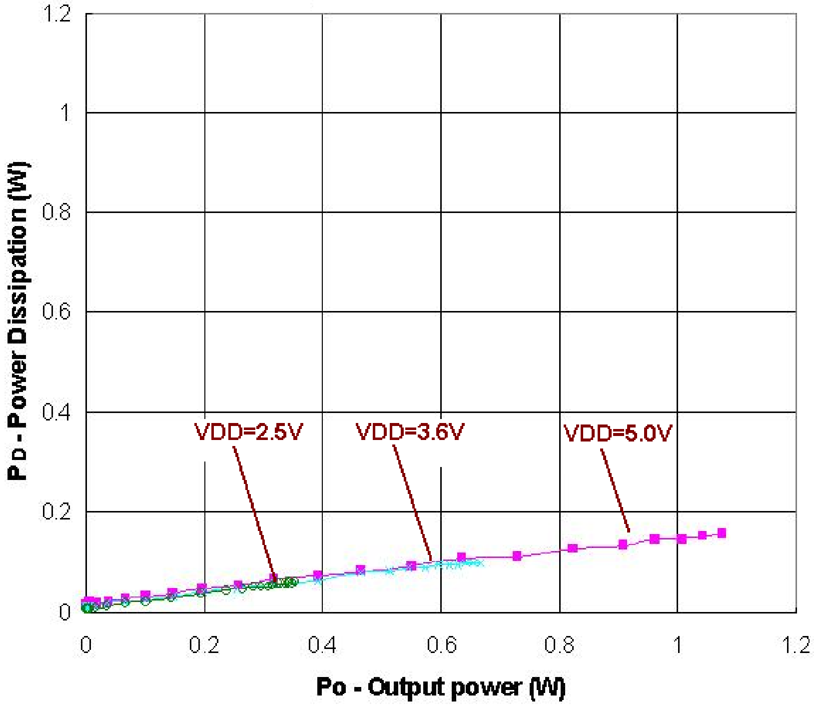


Figure 7
Supply Current vs Output Power (RL=8Ω, 33μH)

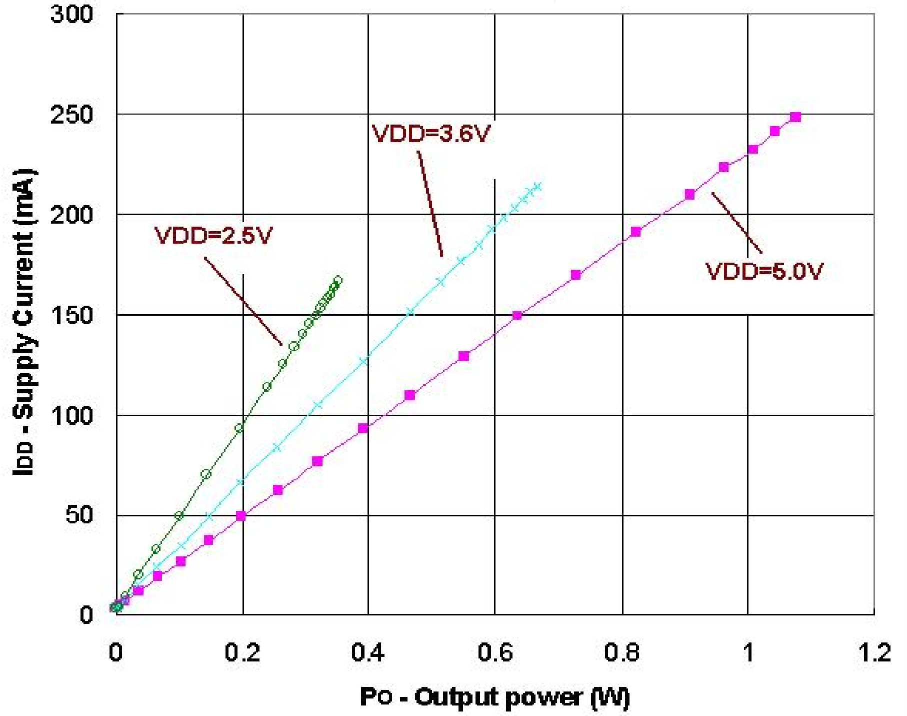


Figure 8
Output Power vs Load Resistance (Po at 10 % THD with f = 1 kHz)

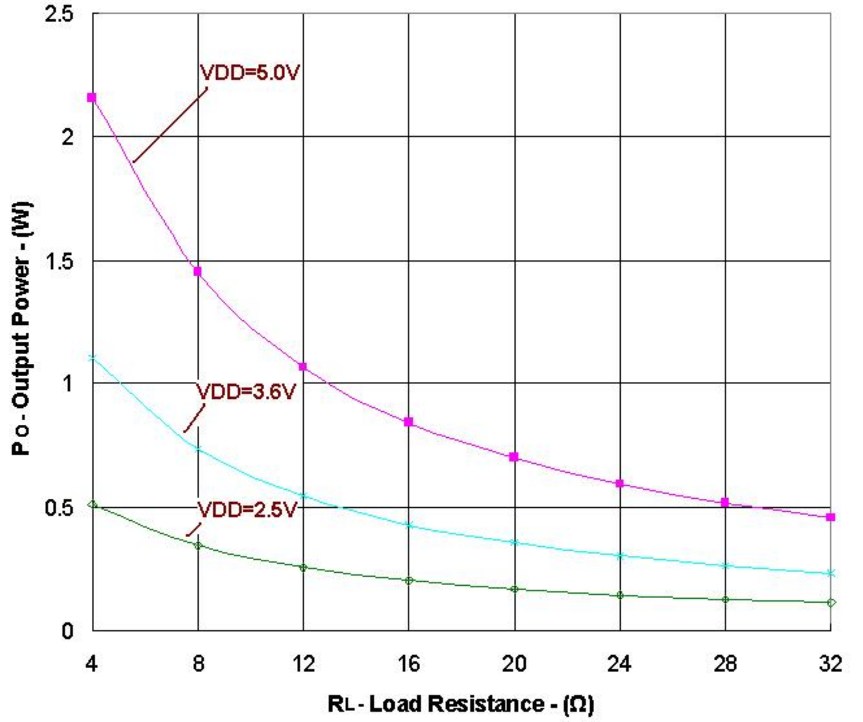


Figure 9
Output Power vs Load Resistance (Po at 1 % THD with f = 1 kHz)

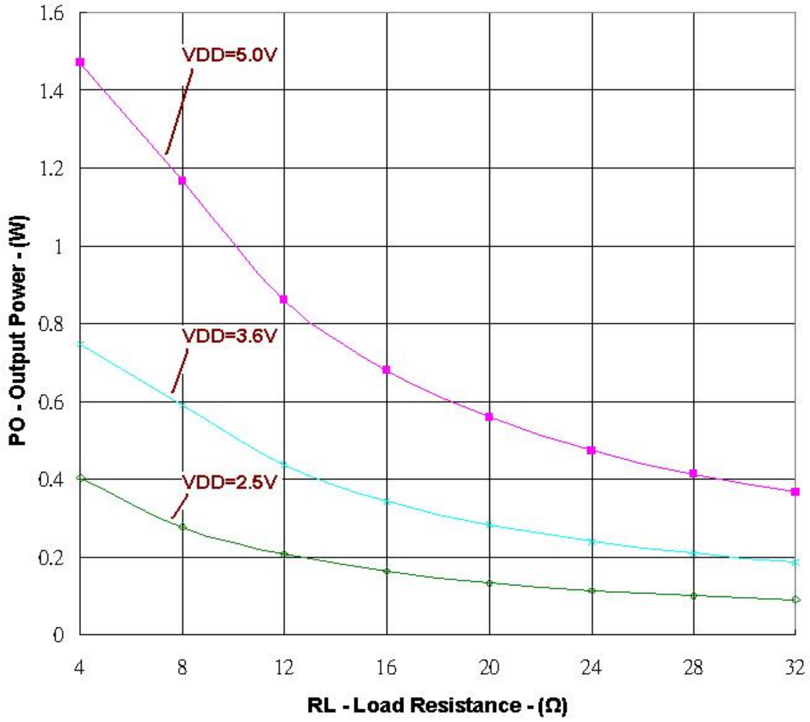


Figure 10
THD+N & Output Power vs Temperature (VDD=3V, RL=8Ω)

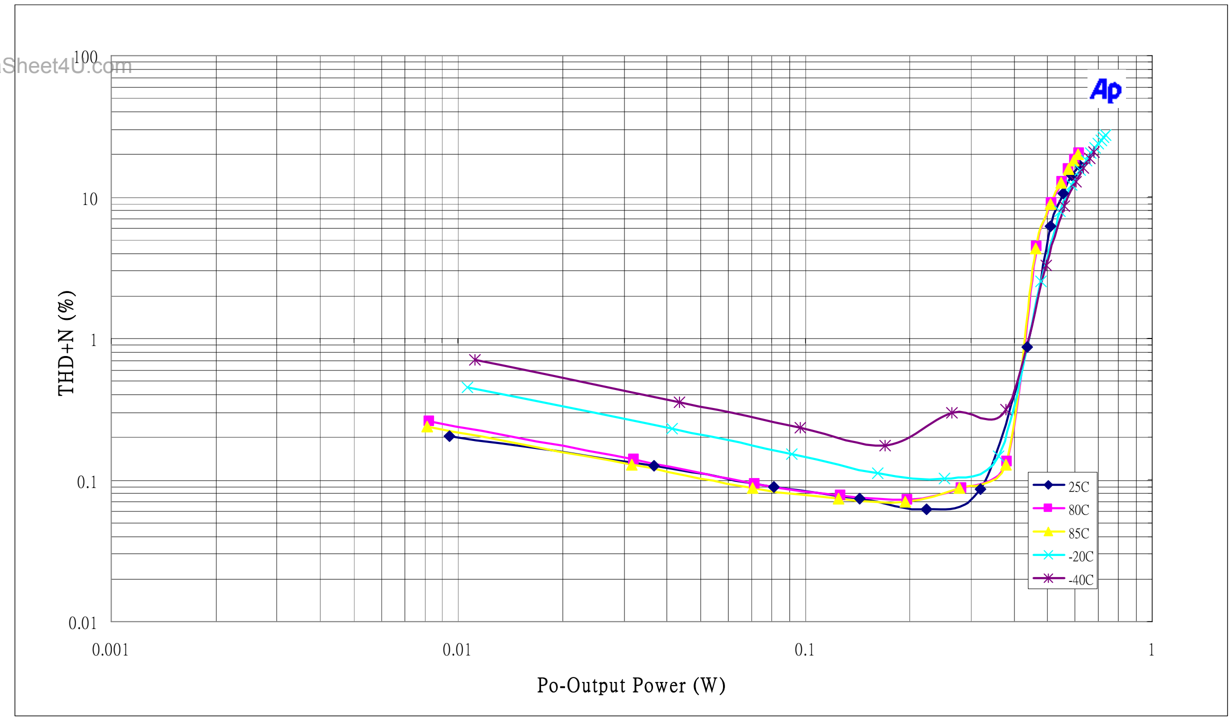


Figure 11
THD+N & Output Power vs Temperature (VDD=4.5V, RL=8Ω)

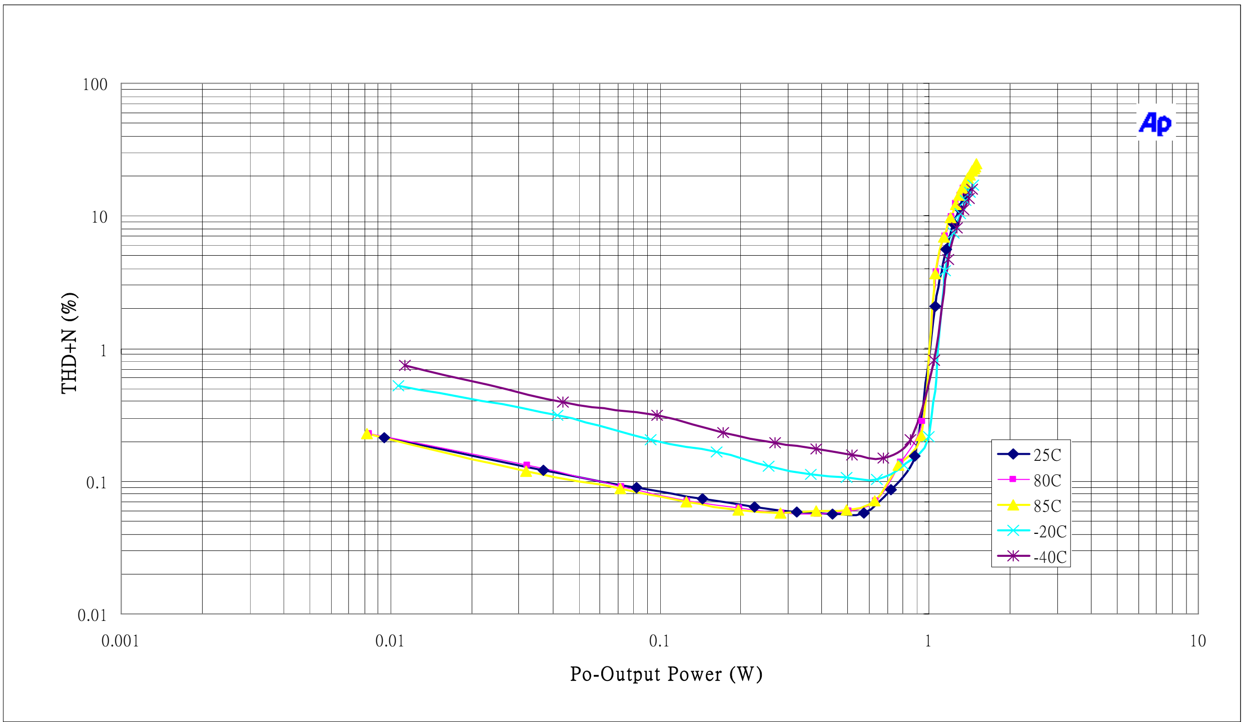
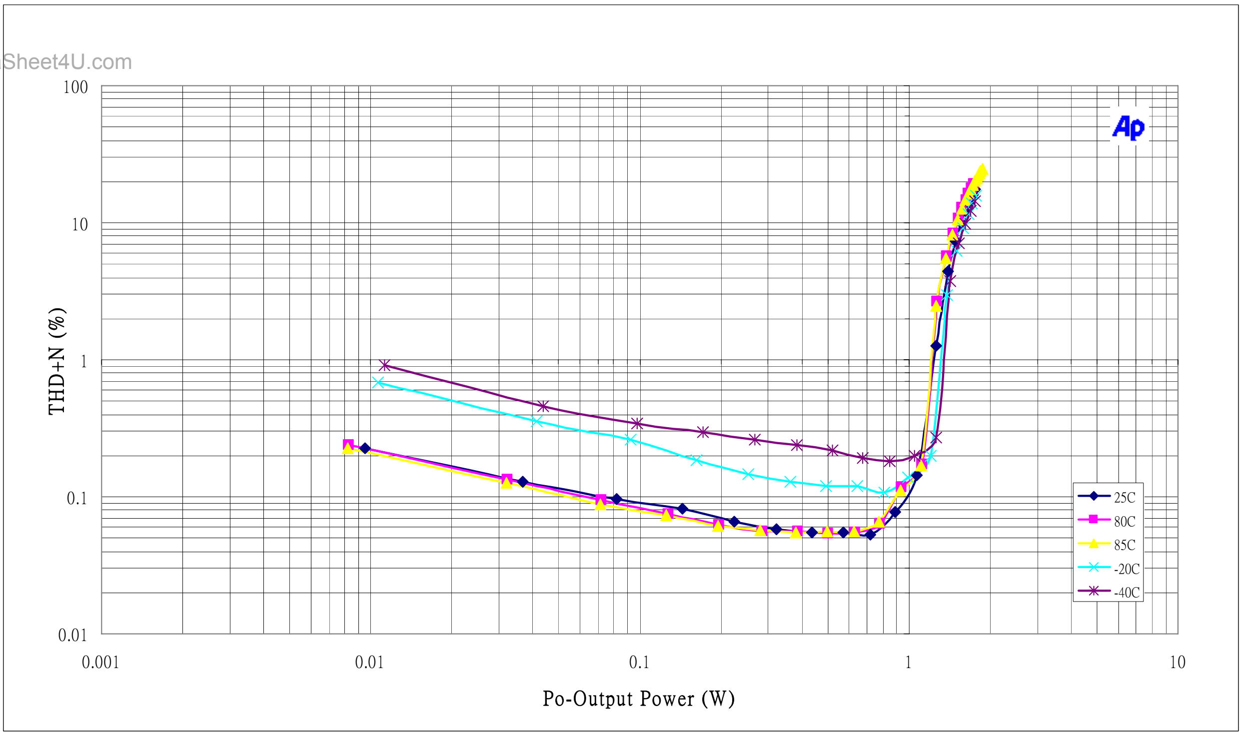


Figure 12
THD+N & Output Power vs Temperature (VDD=5.0V, RL=8Ω)



APPLICATION INFORMATION

Input Resistors (Ri) and Gain

The input resistors (Ri) set the gain of the amplifier according to the equation.

Pre-Amplifier Gain = (Rf / Ri) x 2 = [150KΩ / (5KΩ + Ri)] x 2

Total Gain = [(Rf / Ri) x 2] x 2 = {[150KΩ / (5KΩ + Ri)] x 2} x 2

A_{VD} = 20 x log {2 x [(Rf /Ri) x2]}

The resistor matching is very important in the amplifiers. Balance of the output on the reference voltage depends on matched ratio of the resistors. CMRR, PSRR, and cancellation of the second harmonic distortion if resistor mismatch occurs. Therefore, it is recommended to use 1% tolerance resistors or better to keep the performance optimized. Matching is more important than overall tolerance.
Resistor arrays with 1% matching can be used with a tolerance greater than 1%.Place the input resistors very close to the LY8006 to limit noise injection on the high-impedance nodes. For optimal performance the gain should be set to 2 V/V or lower. Lower gain allows the LY8006 to operate at its best,

For example

Table 1. Typical Total Gain and A_{VD} Values

Rf (KΩ)	150	150	150	150	150	150
Ri (KΩ)	300	150	100	75	50	37.5
Pre AMP. Gain	1	2	3	4	6	8
Total Gain	2	4	6	8	12	16
A_{VD} (db)	6.02	12.04	15.56	18.06	21.58	24.08

Input Capacitors (Ci)

The LY8006 using a single-ended source, So the input coupling capacitors are required. The input capacitors and input resistors form a high-pass filter with the corner frequency(f_c), determined in the equation.

$f_c = 1 / (2\pi R_i C_i)$

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. Equation is reconfigured to solve for the input coupling capacitance.

$C_i = 1 / (2\pi R_i f_c)$

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.

For example

In the table 2 shows the external components. Rin in connect with Cin to create a high-pass filter.

Table 2. Typical Component Values

Reference	Description	Note
Ri	150KΩ	1% tolerance resistors
Ci	0.22uF	80%/–20%

Ci = 1 / (2π Ri fc)

Ci = 1 / (2π *150KΩ*4.8Hz)=0.221uF，Use 0.22uF

Two Single-Ended Input Signals

Two resistors and two capacitors are needed for summing single-ended input signals. The gain and corner frequencies (f_{c1} and f_{c2}) for each input source can be set independently.

Pre-Amplifier Gain 1 = [150KΩ / (5KΩ + Ri1)] x 2

Pre-Amplifier Gain 2 = [150KΩ / (5KΩ + Ri2)] x 2

Ci1 = 1 / (2π Ri1 fc1)

Ci2 = 1 / (2π Ri2 fc2)

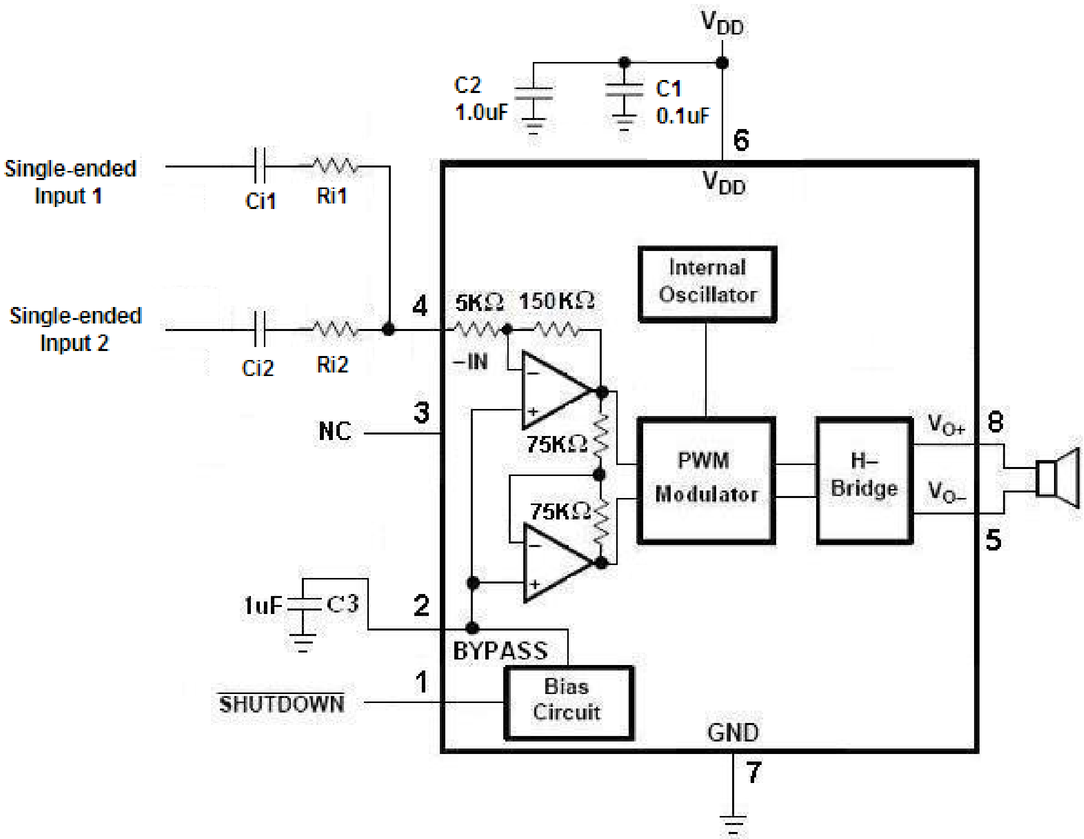


Figure 7. Application Schematic With Two Single-Ended Inputs Configuration

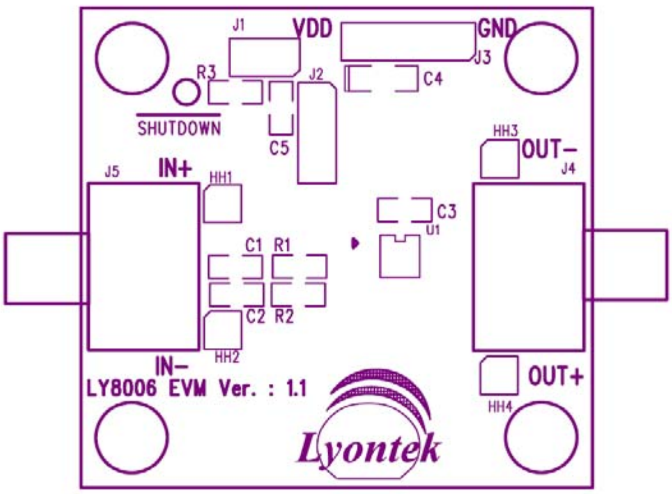
PCB Layout

All the external components must place very close to the LY8006. The input resistors need to be very close to the LY8006 input pins so noise does not couple on the high impedance nodes between the input resistors and the input amplifier of the LY8006. Then place the decoupling capacitor Cs, close to the LY8006 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.

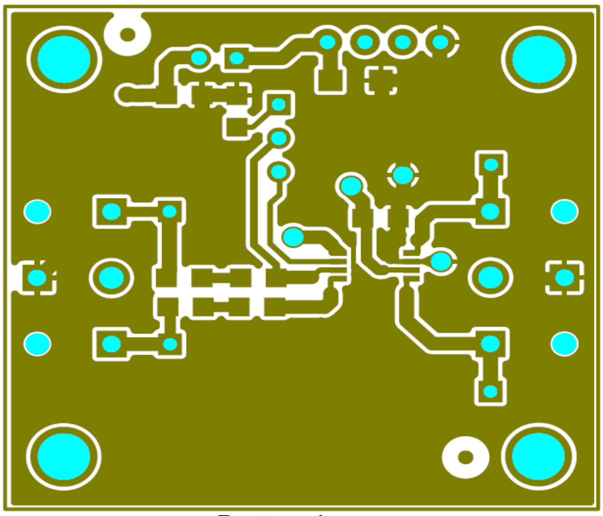
Making the high current traces going to VDD, GND, V_{O+} and V_{O-} pins of the LY8006 should be as wide as possible to minimize trace resistance. If these traces are too thin, the LY8006's performance and output power will decrease. The input traces do not need to be wide, but do need to run side-by-side to enable common-mode noise cancellation.

LY8006UL/LY8006BL Demo Board Artwork

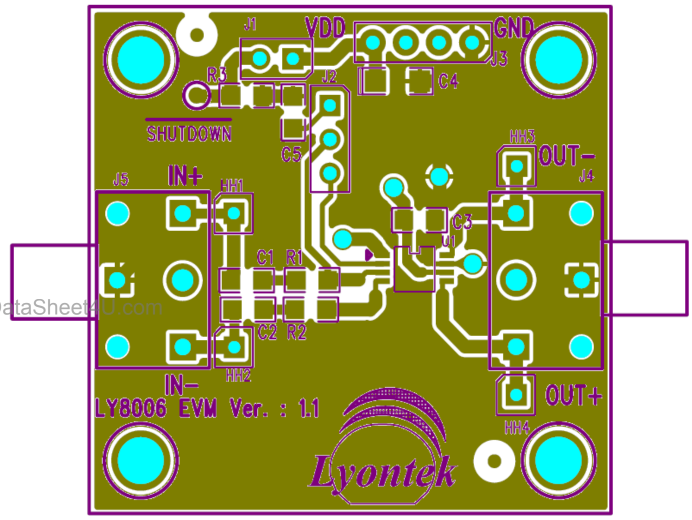
Top Silkscreen



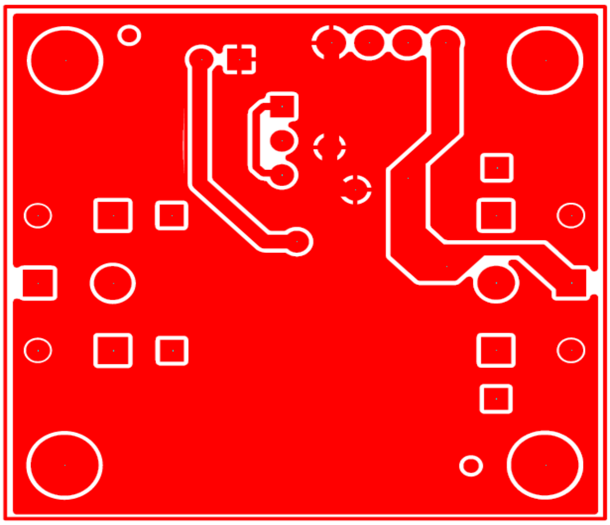
Top Layer



Composite view



Bottom Layer



LY8006 V1.1 BOM List

No.	Description	Reference	Note
1	Resistor, 100KΩ	R2,R3	
2	Capacitor, 0.39uF	C2	
3	Capacitor, 0.1uF	C3	
4	Capacitor, 10.0uF	C4	
5	Capacitor, 1.0uF	C5	
6	1*2 Pin Header	J1	Close → Active
7	NC	R1,C1,J2	

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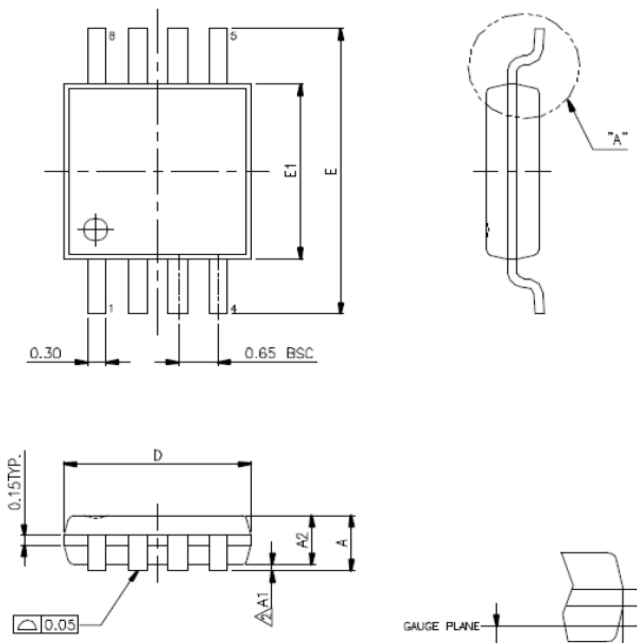
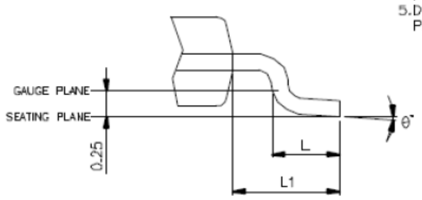
PACKAGE OUTLINE DIMENSION

8 Pin MSOP Package Outline Dimension





SYMBOLS	MIN.	NOM.	MAX.
A	–	–	1.10
A1	0.00	–	0.15
A2	0.75	0.85	0.95
D		3.00 BSC	
E		4.90 BSC	
E1		3.00 BSC	
L	0.40	0.60	0.80
L1		0.95 REF	
θ°	0	–	8

UNIT : MM

NOTES:
1. JEDEC OUTLINE : MO-187 AA
2. DIMENSION 'D' DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS. MOLD FLASH, PROTRUSIONS OR GATE BURRS SHALL NOT EXCEED 0.15 PER SIDE.
3. DIMENSION 'E1' DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION. INTERLEAD FLASH OR PROTRUSION SHALL NOT EXCEED 0.25 PER SIDE.
4. DIMENSION '0.22' DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.08 MM TOTAL IN EXCESS OF THE '0.22' DIMENSION AT MAXIMUM MATERIAL CONDITION. DAMBAR CANNOT BE LOCATED ON THE LOWER RADIUS OF THE FOOT. MINIMUM SPAC BETWEEN PROTRUSION AND ADJACENT LEAD IS 0.07 MM.
5. DIMENSIONS 'D' AND 'E1' TO BE DETERMINED AT DATUM PLANE ⊞ .

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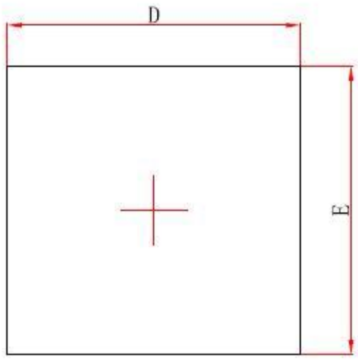
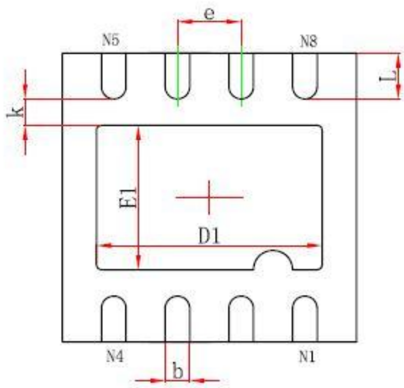
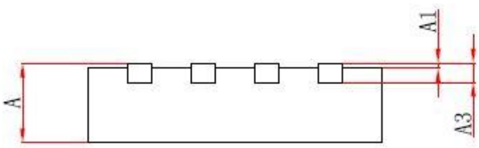
8 Pin DFN Package Outline Dimension



Top View



Bottom View



Side View

Symbol	Dimensions In Millimeters	
	Min.	Max.
A	0.700/0.800	0.800/0.900
A1	0.000	0.050
A3	0.203REF.	
D	2.900	3.100
E	2.900	3.100
D1	2.200	2.400
E1	1.400	1.600
k	0.200MIN.	
b	0.180	0.300
e	0.650TYP.	
L	0.375	0.575