2.7W Mono Filter-free Class-D Audio Power Amplifier

General Description

The DL3097 is a 2.7W high efficiency filter-free classD audio power amplifier. The DL3097 can operate from 2.7
to 5.5V supply. When powered with 5V voltage, the DL3097 can deliver 2.7W to a 4Ω load at 10% THD+N.

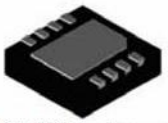
As a Class D audio power amplifier, the DL3097 features 90% high efficiency and -75dB PSRR at 217Hz which make the device ideal for battery-supplied, high quality audio applications. The IA2010 also features the minimized click-and-pop noise during the turn-on and shutdown.

The DL3097 is manufactured inspace-saving WCSP9 1.46X1.46、DFN8 3X3、MSOP8 packages.

Features

- Output power at 5V supply
  - 2.7W (4Ω load, 10% THD+N)
  - 1.65W (8Ω load, 10% THD+N)
- Quiescent current: 3.0mA @ 3.6V supply (8Ω load)
- Shutdown current: 0.1μA (typical)
- PSRR: -75dB (typical)
- CMRR: -65dB (typical)
- Efficiency up to 90%
- Short circuit protection
- Packaging: 1.46mmx1.46mm WCSP9, MSOP-8, DFN 3x3

CSP9 Package
1.46mmX1.46mm
-40℃～85℃



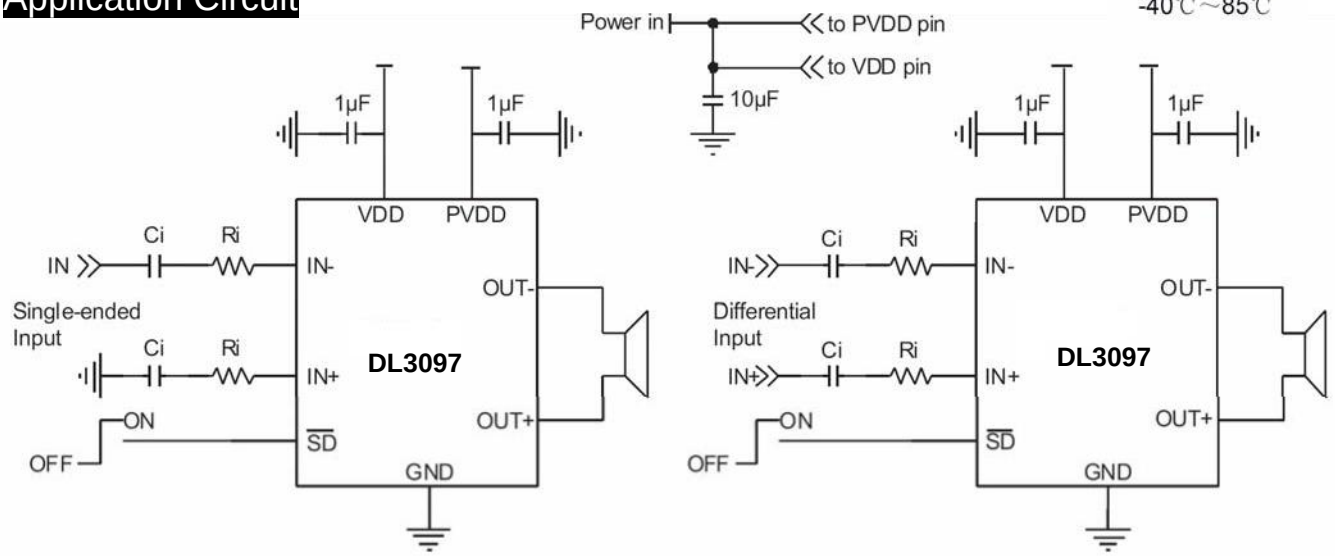
DFN8 Package
3mm x 3mm
-40℃～85℃

Applications

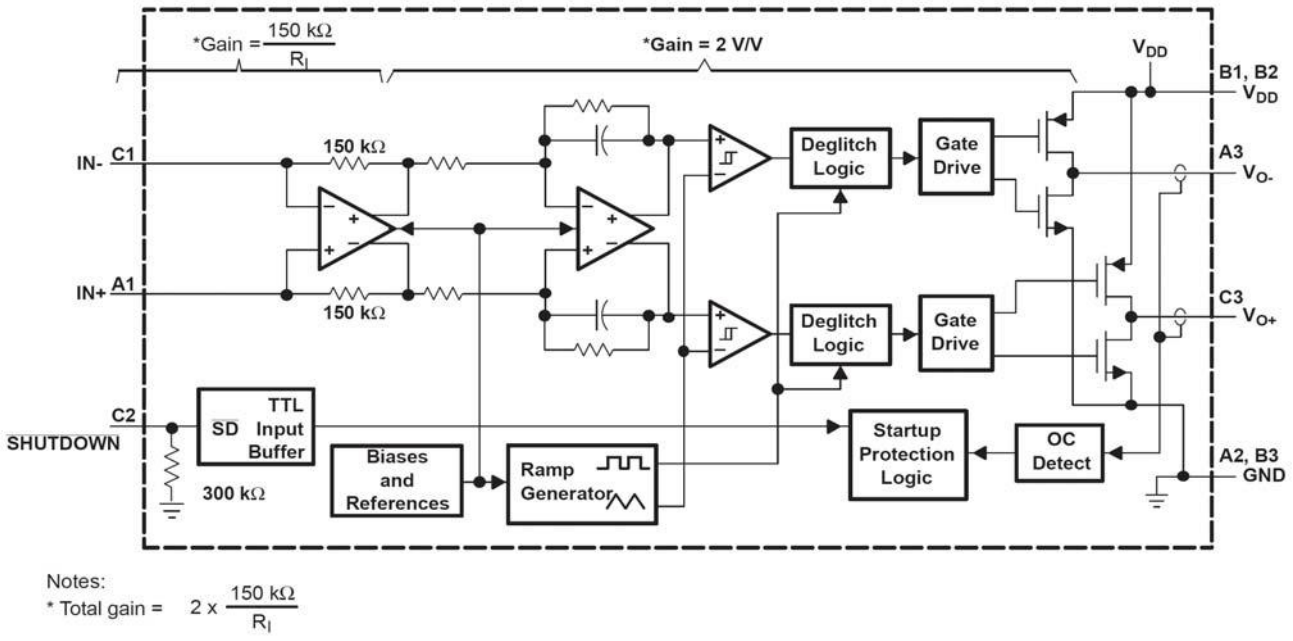
- Mobile phone
- Personal Digital Assistant (PDA)
- Portable gaming device
- Powered speakers
- Notebook computer

MSOP8 Package
-40℃～85℃

Application Circuit

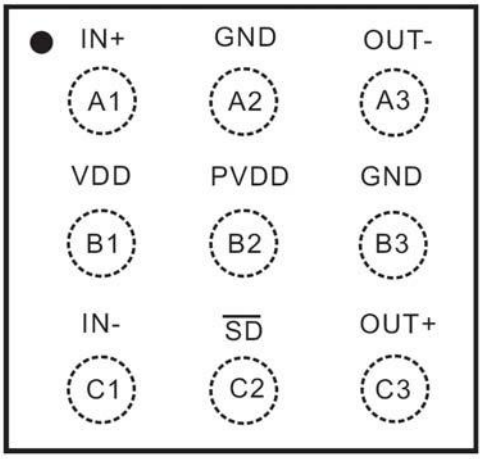


Functional Block Diagram



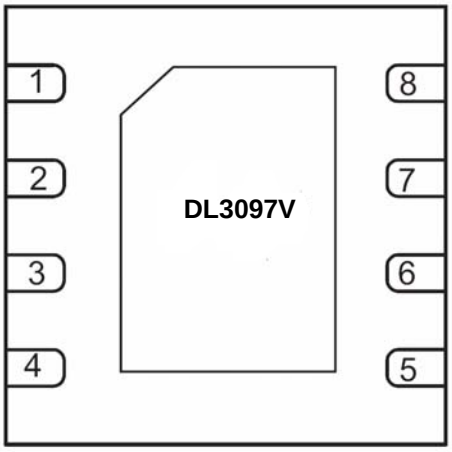
Pin Configuration and Pin Description

9 Ball WCSP
Top View

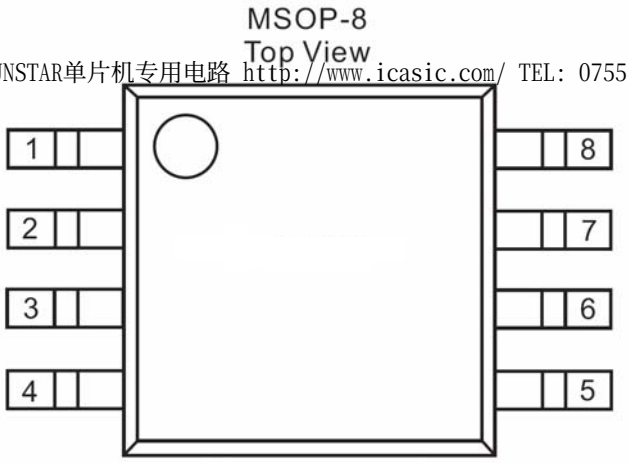


Order Number DL3097W

DFN -8
Top View



Order Number DL3097V



Order Number DL3097M

PIN	MSOP-8	DFN-8	WCSP-9	I/O	DESCRIPTION
SHUTDOWN	1	1	C2	I	Shutdown terminal (active low logic)
PVDD	7	-	B2	I	Power Supply
+IN	3	3	A1	I	Positive differential input
-IN	2	4	C1	I	Negative differential input
VO	5	8	A3	O	Negative BTL output
VDD	-	6	B1	I	Power supply
GND	4/6	7	A2/B3	I	High-current ground
VO+	8	5	C3	O	Positive BTL output
NC	-	2	-		No internal connection

Absolute Maximum Ratings

Operating Junction Temperature (T_J)

-40°C to +125°C

Storage Temperature (T_{STG})

-65°C to +150°C

Lead Temperature (Solding, 10sec.)

260° C

ESD Susceptibility

2KV

Operation Ratings

Supply Voltage (V_{DD})

2.7V to 5.5V

High Level Input Voltage (V_{IH})

1.5V to VDD

Low Level Input Voltage (V_{IL})

0 to 0.35V

Operating Temperature (T_A)

-40°C to 85°

Thermal Information

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Parameter	Symbol	Package	Maximum	Unit
Thermal Resistance (Junction to ambient)	Θ_{JA}	WCSP1.46x1.46	90-220	°C/W
		MSOP	180	°C/W
		DFN3x3	47.9	°C/W
Thermal Resistance (Junction to case)	Θ_{JC}	MSOP	40	°C/W
		DFN 3x3	NA	°C/W

Note: For the 9-pin CSP package, the thermal resistance is highly dependent on the PCB heat sink area. For example, the Θ_{JA} can equal to 195 °C/W with 50mm total area or 135 °C/W with 500mm area. When using ground and power planes, the value is around 90 °C/W.

Electrical Characteristics

Note: The following electrical characteristics state DC and AC electrical specifications under particular test conditions which guarantee specific performance limits. But note that specifications are not guaranteed for parameters where no limit is given. The typical value however, is a good indication of device performance.All voltages in the following tables are specified at 25°C which is generally taken as parametric norm.

T_A=25°C

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
$\lvert V_{OS} \rvert$	Output offset voltage (measured differentially)	V_I=0V, A_V=2V/V, V_{DD}=2.7V to 5.5V		1	25	mV
PSRR	Power supply rejection ratio	V_{DD}=2.7V to 5.5V		-75	-55	dB
CMRR	Common mode rejection ratio	V_{DD}=2.7V to 5.5V		-65	-50	dB
$\lvert I_{IH} \rvert$	High-level input current	V_{DD}=5.5V, V_I=5.5V			50	μA
$\lvert I_{IL} \rvert$	Low-level input current	V_{DD}=5.5V, V_I=-0.3V			5	μA
$I_{(Q)}$	Quiescent current	V_{DD}=5.5V, no load		3.8	5	mA
		V_{DD}=3.6V, no load		3.0		
$I_{(SD)}$	Shutdown current	$V_{(\overline{SHOUTDOWN})}$=0.35V, V_{DD}=2.7V to 5.5V		0.1	2	μA
$r_{DS(ON)}$	Static Drain-source On-state Resistance	V_{DD}=3.6V		400		mΩ
		V_{DD}=5.5V		350		
	Output impedance in $\overline{SHUTDOWN}$	$V_{(\overline{SHOUTDOWN})}$=0.35V		2		kΩ
$f_{(SW)}$	Switching frequency	V_{DD}=2.7V to 5.5V	200	250	300	kHZ
	Gain	V_{DD}=2.7V to 5.5V	$\frac{280k\Omega}{RI}$	$\frac{300k\Omega}{R_I}$	$\frac{320k\Omega}{R_I}$	$\frac{V}{V}$
	Resistance from shutdown to GND			300		kΩ

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Operating Characteristics

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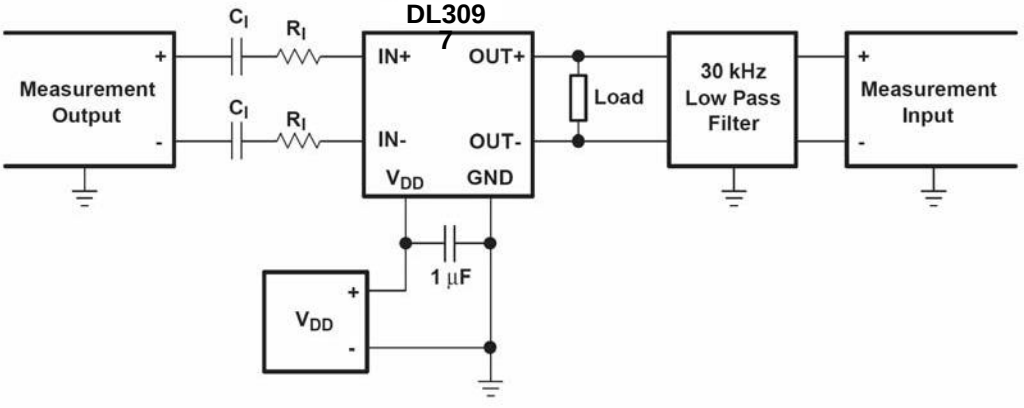
Note: The following electrical characteristics state DC and AC electrical specifications under particular test conditions which guarantee specific performance limits. But note that specifications are not guaranteed for parameters where no limit is given. The typical value however, is a good indication of device performance.All voltages in the following tables are specified at 25°C which is generally taken as parametric norm.

T_A=25°C, R_L=8Ω

Symbol	Parameter	Test Conditions		Min	Typ	Max	Unit
P_O	Output power	THD+N=10%, f=1kHz, R_L=4Ω	V_{DD}=5V		2.7		W
			V_{DD}=3.6V		1.35		
		THD+N=1%, f=1kHz, R_L=4Ω	V_{DD}=5V		2.2		W
			V_{DD}=3.6V		1.10		
		THD+N=10%, f=1kHz, R_L=8Ω	V_{DD}=5V		1.65		W
			V_{DD}=3.6V		0.83		
		THD+N=1%, f=1kHz, R_L=8Ω	V_{DD}=5V		1.32		W
			V_{DD}=3.6V		0.68		
THD+N	Total harmonic distortion plus noise	V_{DD}=5V, P_O=1W, R_L=8Ω, f=1kHz			0.15%		
		V_{DD}=3.6V, P_O=0.5W, R_L=8Ω, f=1kHz			0.12%		
k_{SVR}	Supply ripple rejection ratio	V_{DD}=3.6V, Inputs ac-grounded with C_i=2μF	f=217Hz, $V_{(RIPPLE)}$= 200mV_{pp}		-65		dB
SNR	Signal-to-noise ration	V_{DD}=5V, P_O=1W, R_L=8Ω			95		dB
Vn	Output voltage noise	V_{DD}=5V, Inputs ac-grounded with C_i=1μF	No weighting		46		μV RMS
CMRR	Common mode rejection ratio	V_{DD}=3.6V, V_{IC}=1V_{pp}	f=217Hz		-65		dB
Z_I	Input impedance			142	150	158	kΩ
	Start-up time from shutdown	V_{DD}=3.6V			32		ms

Test Setup for Performance Testing



Notes:(1) C_I was Shorted for any Common-Mode input voltage measurement;(2) A 33-uH inductor was placed in series with the load resistor to emulate a small speaker for efficiency measurements;(3) The 30-kHz low-pass filter is required even if the analyzer has an internal low-pass filter. An RC low pass filter (100 W, 47 nF) isused on each output for the data sheet graphs.

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Typical Operating Characteristics

T =25°C, VDD =5V, f=1kHz, Gain=2V/V, unless otherwise noted

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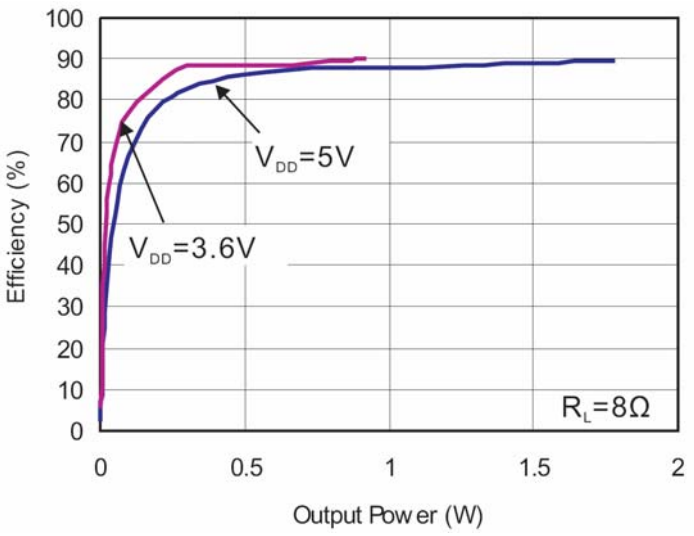
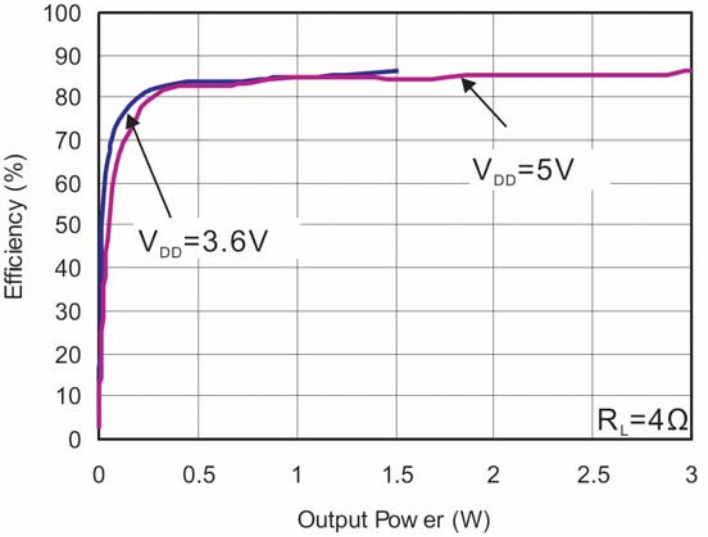
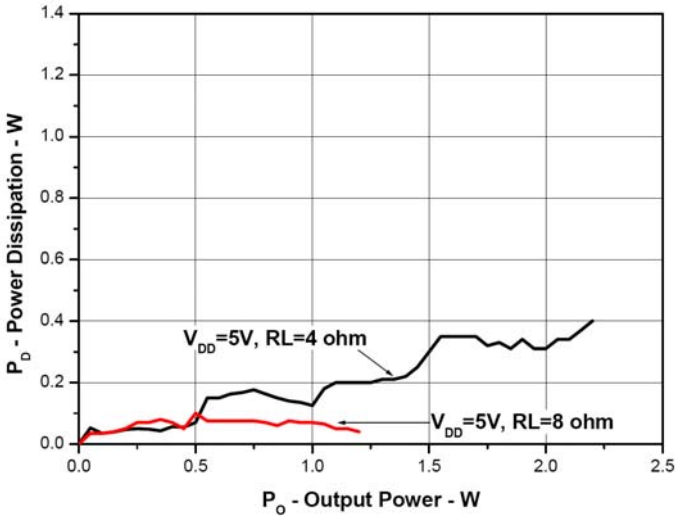
1. Efficiency VS Output Power



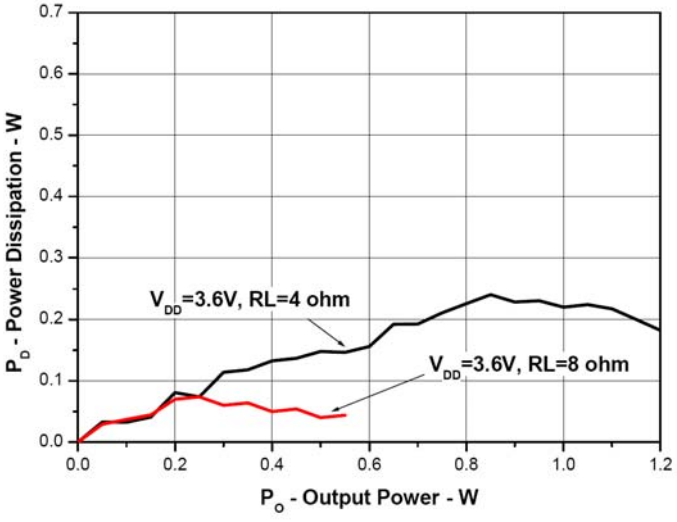
2. Efficiency VS Output Power



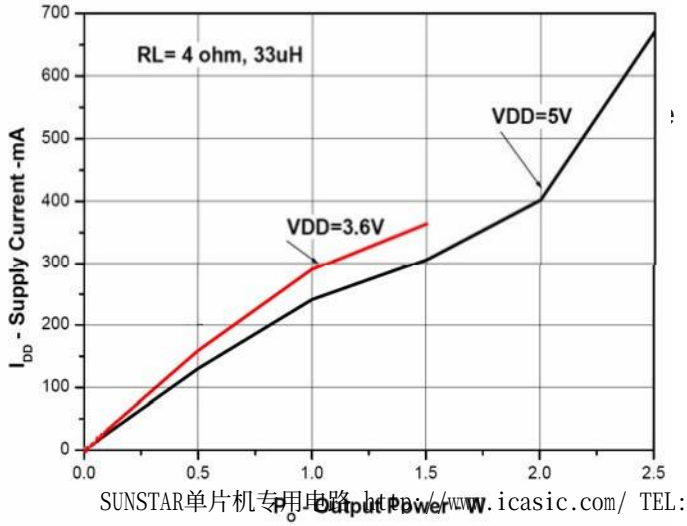
3. Power Dissipation VS Output Power



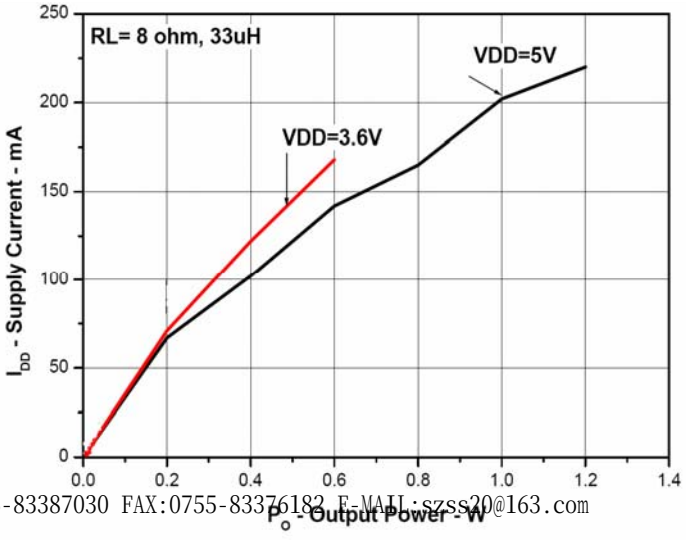
4. Power Dissipation VS Output Power



5. Supply Current VS Output Power



6. Supply Current VS Output Power



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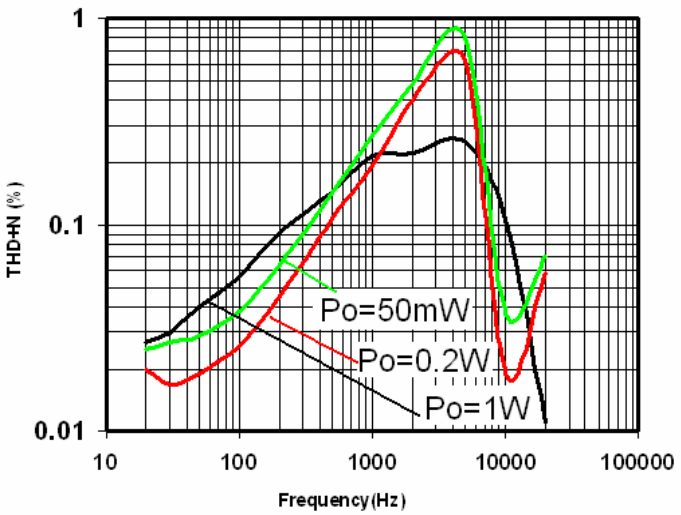
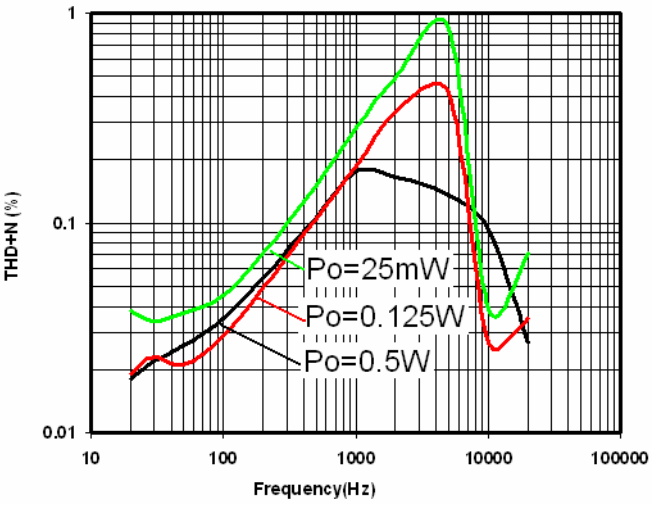
7. THD+N VS Frequency

VDD=5V, RL=8Ω, Ci=2uF, Av=2V/V

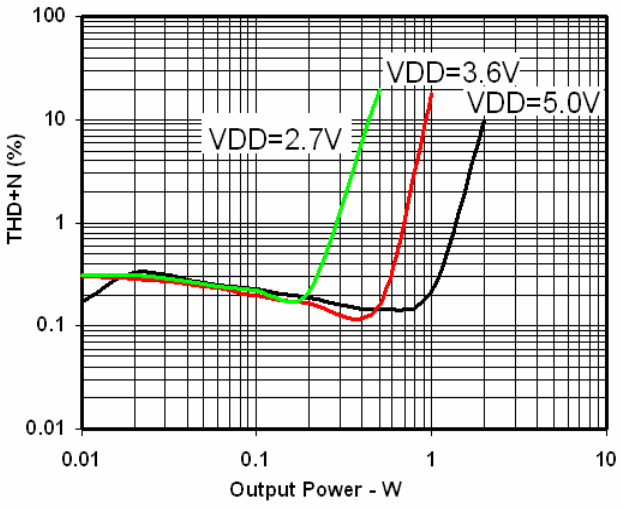


8. THD+N VS Frequency

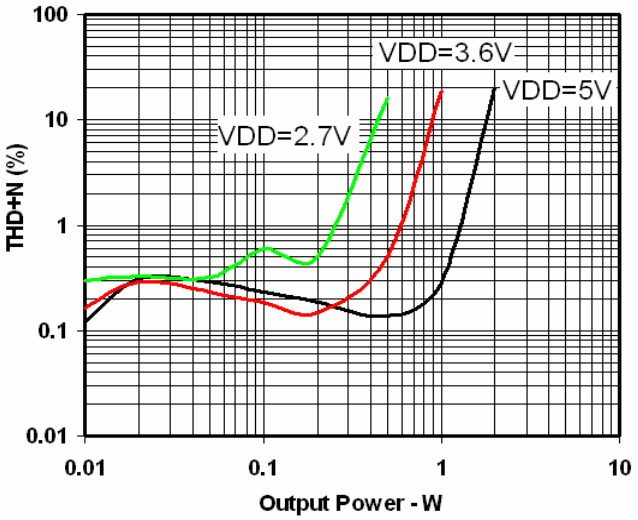
VDD=3.6V, RL=8Ω, Ci=2uF, Av=2V/2V



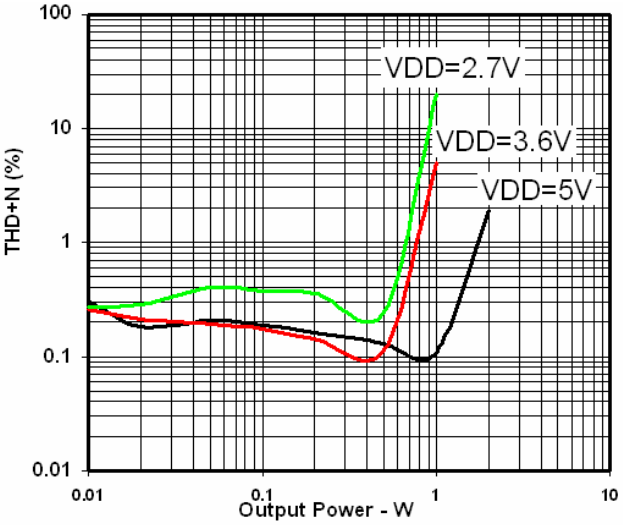
9. THD+N VS Output Power, RL=8Ω, Av=24dB



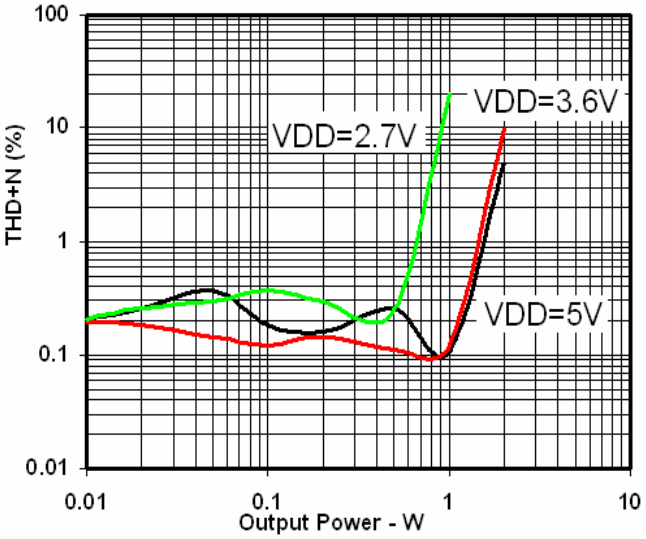
10. THD+N VS Output Power, RL=8Ω, Av=6dB



11. THD+N VS Output Power, RL=4Ω, Av=24dB



12. THD+N VS Output Power, RL=4Ω, Av=6dB



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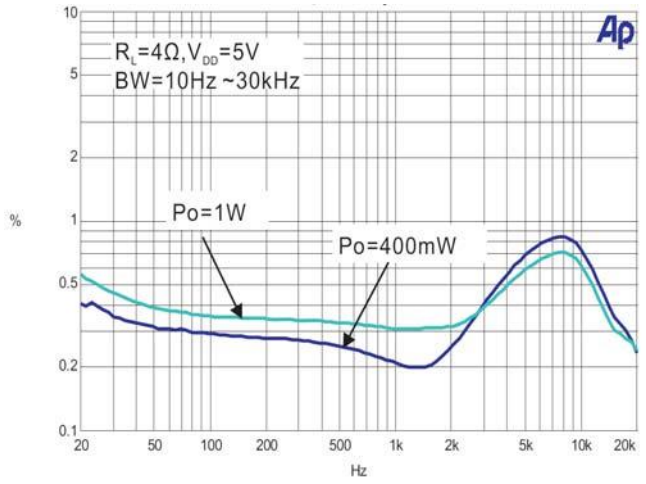
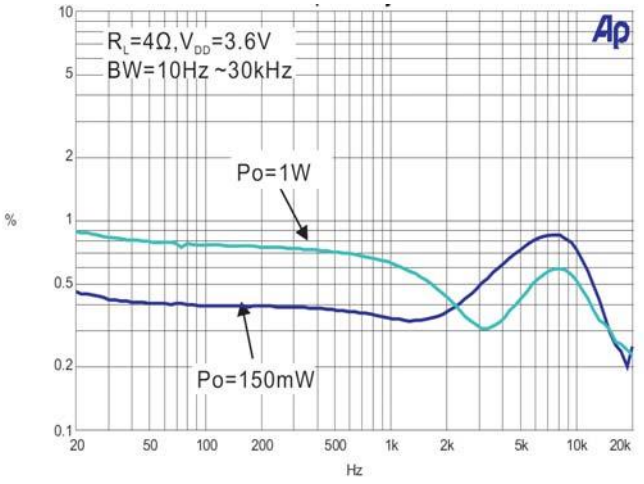
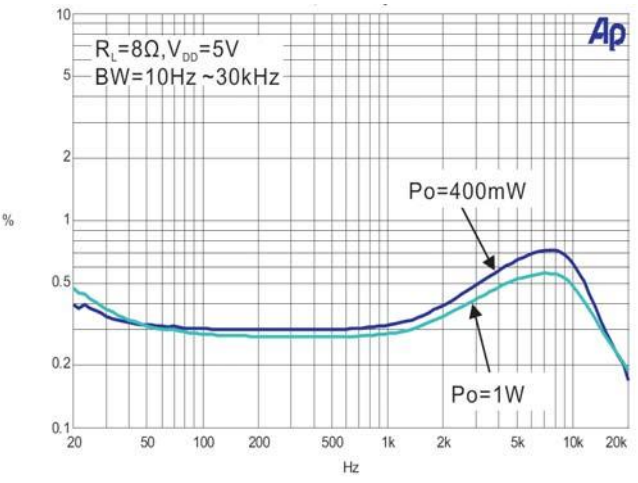
13. THD+N VS Frequency



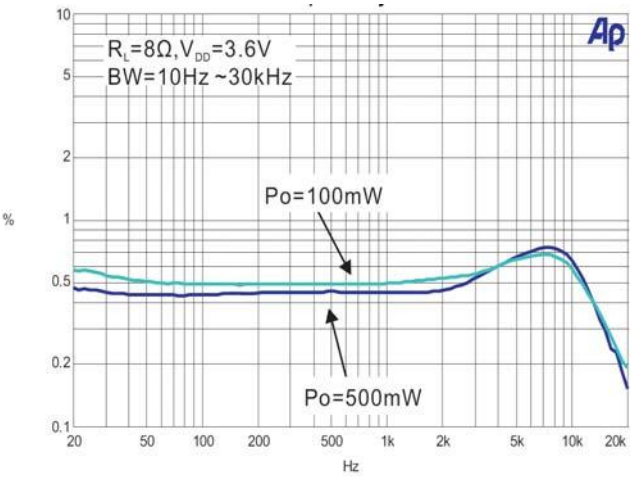
14. THD+N VS Frequency



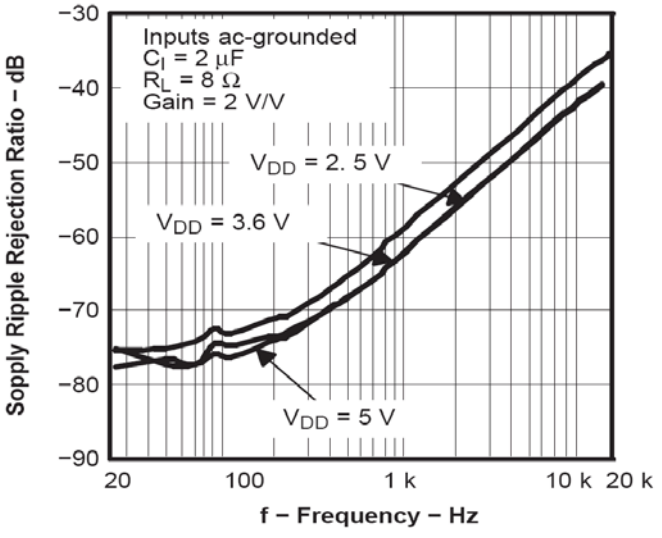
15. THD+N VS Frequency



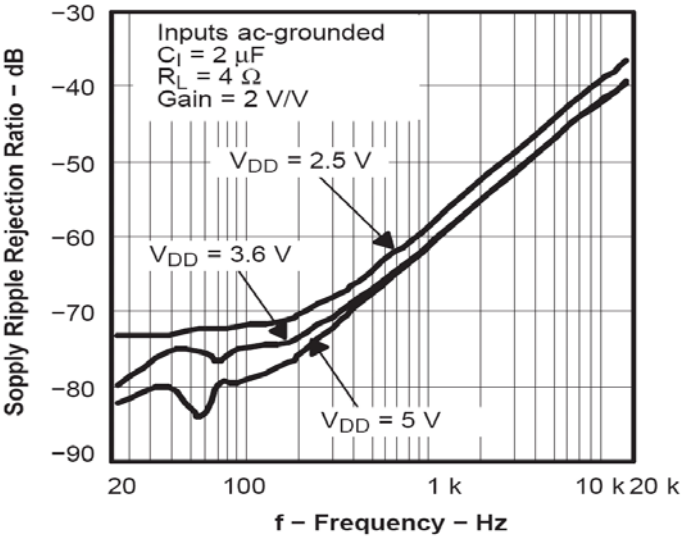
16. THD+N VS Frequency



17. PSRR VS Frequency



18. PSRR VS Frequency



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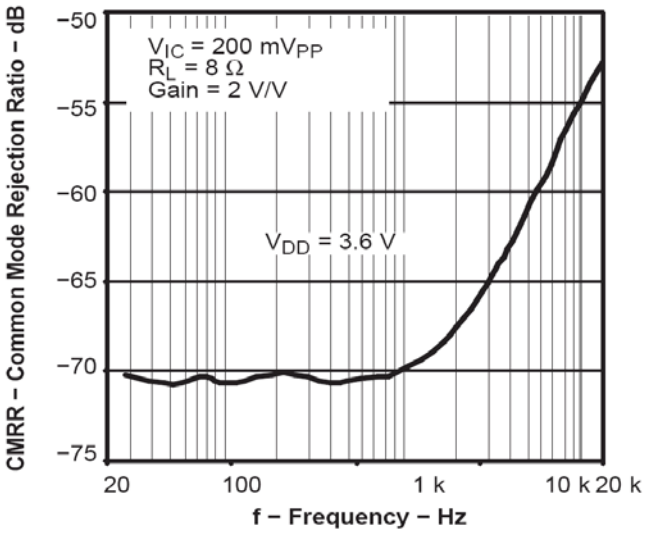
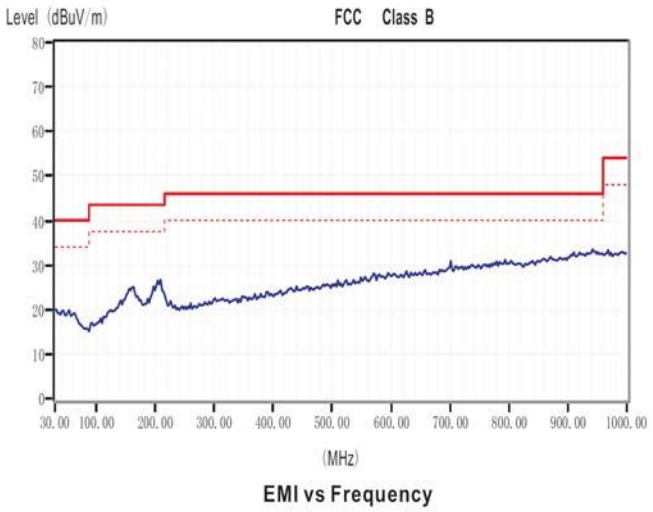
19. CMRR VS Frequency



20. FCC Level



EMI vs Frequency

Application **Information**

Fully Differential Amplifier

The DL3097 is a fully differential amplifier with different ial inputs and outputs. The fully differential amplifier consists of a differential amplifier and a common-mode amplifier. The differential amplifier ensures that the amplifier outputs a differential voltage on the output that is equal to the differential input times the gain. The common-mode feedback ensures that the common-mode voltage at the output is biased around VDD/2 regardless of the common-mode voltage at the input. The fully differential DL3097 can still be used with a single-ended input; however, the DL3097 should be used with differential inputs when in a noisy environment,

like a wireless handset, to ensure maximum noise rejection.

Advantages of Fully Differential Amplifiers

·Input-coupling capacitors not required:

– The fully differential amplifier allows the inputs to be biased at voltage other than mid-supply. For example, if a codec has a mid-supply lower than the mid-supply of the DL3097, thecommon-mode feedback circuit will adjust, and the DL3097 outputswill still be biased at mid-supply of the DL3097. The inputs ofthe ft2010 can be biased from 0.5 V to VDD– 0.8 V. If the inputs are biased outside of that range, input-coupling capacitors are required.

· Mid-supply bypass capacitor, C (BYPASS), not required:

– The fully differential amplifier does not require a bypass capacitor. This is because any shift in the mid-supply affects both positive and negative channels equally and cancels at the differential output.

· Better RF-immunity:

– GSM handsets save power by turning on and shutting off the RF transmitter at a rate of 217 Hz. The transmitted signal is picked-up on input and output traces. The fully differential amplifier cancels the signal much better than the typical audio amplifier.

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Filter-less Design

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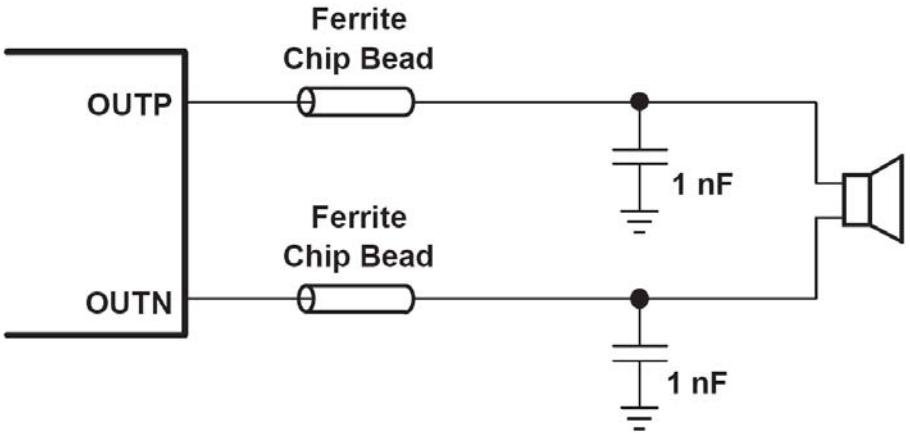
In traditional Class D amplifier design, the differential outputs changes from ground to supply voltage and are in anti-phase. Therefore, the voltage at the load (speaker) varies between positive and negative supply voltage. Thus, even a duty cycle of 50% yields 0V voltage across the load, the current on the load is quite high which results in high power loss and low efficiency. In this case, LC filter is introduced at the output ends to store the ripple current.

The DL3097 outputs switch from ground to supply voltage but are in phase with each other. That is to say, when the duty cycle is 50%, there will be almost no voltage across the load. When the positive output duty cycle is greater than 50% and the negative less than 50%, the voltage across the load equals OUT+ minus OUT-, which switches from 0V to V_{DD} and mostly sits at 0V. This greatly reduces the switching current, reduces the power loss over the load resistance and save the LC filter.

However, LC filter is required when the trace between the DL3097 and the speaker exceeds 50mm. Long trace acts like tiny antenna and causes EMI emissions which may result in FCC and CE certification failure.

How to Reduce EMI

Most applications require a ferrite bead filter for EMI elimination. The ferrite filter reduces EMI around 1MHz and higher. When selecting a ferrite bead, choose one with high-impedance at high frequencies, but low impedance at low frequencies.



Ferrite Bead Filter to Reduce EMI

Components Select

Input Resistors (R_I)

The input resistors (R_I) set the gain of the amplifier according to equation (1).

$$\text{Gain} = \frac{2 \cdot 150\text{k}\Omega}{R_I} \frac{\text{V}}{\text{V}} \quad (1)$$

Resistor matching is very important in fully differential amplifiers. The balance of the output on the reference voltage depends on matched ratios of the resistors. CMRR, PSRR, and cancellation of the second harmonic distortion diminish 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 DL3097 to limit noise in jection on the high-impedance nodes.

For optimal performance the gain should be set to 2X (Ri=150k) or lower. Lower gain allows the DL3097 to operate at its best, and keeps a high voltage at the input making the inputs less susceptible to noise. In addition to these features, higher value of Ri minimizes pop noise.

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Decoupling Capacitor (C_S)

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Decoupling capacitor helps to stabilize voltage of power supply and thus reduce the total harmonic distortion (THD). It can also be applied to prevent oscillations over long leads. A Low Equivalent Series Resistance (ESR) capacitor of 1μF is required for decoupling and should be placed close to the DL3097 to reduce the resistance and inductance on the trace between the amplifier and the capacitor.

For filtering lower-frequency noise signals, a 10μF capacitor could be placed near the audio power amplifier.

Input Capacitors (C_I)

The input capacitor and input resistor determine the corner frequency of the high pass filter. The corner frequency (fC) is calculated with the Equation (2) below.

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

The corner frequency directly influences the low frequency signals and consequently determines output bass quality.

Under Voltage Lock-out (UVLO)

The DL3097 incorporates circuitry designed to detect low supply voltage. When the supply voltage drops to 2.3V or below, the DL3097 goes into a state of shutdown, and the device comes out of its shutdown state and restore to normal function only when reset the power supply or SD pin.

Short Circuit Protection

The DL3097 has short circuit protection circuitry on the outputs to prevent the device from damage when output-to-output shorts or output-to-GND shorts occur. When a short circuit occurs, the device immediately goes into shutdown state. Once the short is removed, the device will be reactivated.

Over Temperature Protection

Thermal protection on the DL3097prevents the device from damage when the internal die temperature exceeds 135°C. There is a 15°C tolerance on this trip point from device to device. Once the die temperature exceeds the set point, the device will enter the shutdown state and the outputs are disabled. This is not a latched fault. The thermal fault is cleared once the temperature of the die decreased by 30 °C. This large hysteresis will prevent motor boating sound well and the device begins normal operation at this point with no external system interaction.

POP and Click Circuitry

The DL3097 contains circuitry to minimize turn-on and turn-off transients or “click and pops”, where turn-on refers to either power supply turn-on or device recover from shutdown mode. When the device is turned on, the amplifiers are internally muted. An internal current source ramps up the internal reference voltage. The device will remain in mute mode until the reference voltage reach half supply voltage, 1/2 VDD. As soon as the reference voltage is stable, the device will begin full operation .For the best power-off pop performance, the amplifier should be set in shutdown mode prior to removing the power supply voltage.

PCB Layout

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 DL3097 and the load results is lower output power and decreased efficiency. Higher trace resistance between the supply and the DL3097has 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.

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The inductive nature of the transducer load can also result in overshoot on one of both edges, clamped by the parasitic diodes to GND and V_{DD} in each case. From an EMI stand- point, 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.

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As the distance from the DL3097 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 DL3097 may be needed to reduceEMI radiation. The value of the ferrite chip is very application specific.

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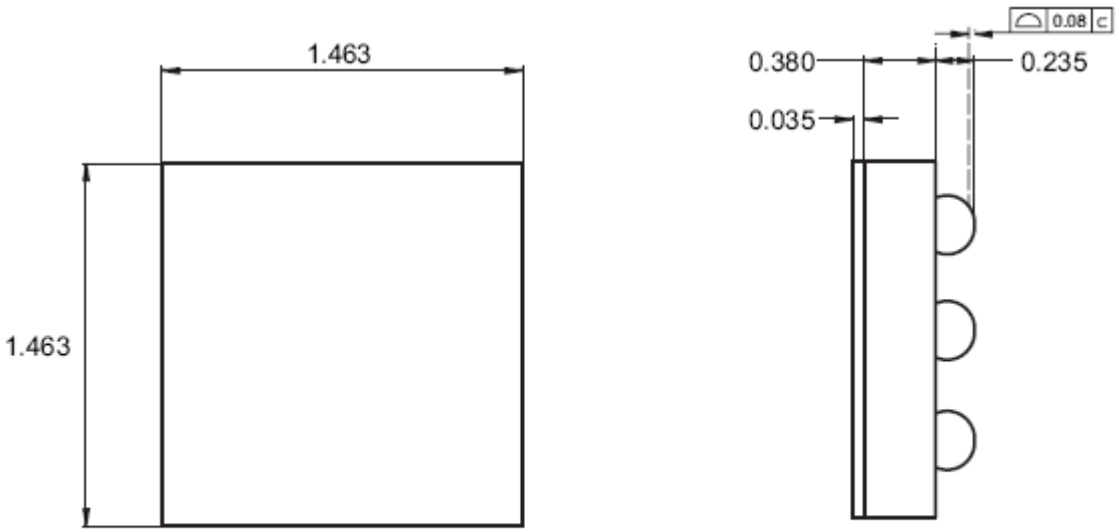
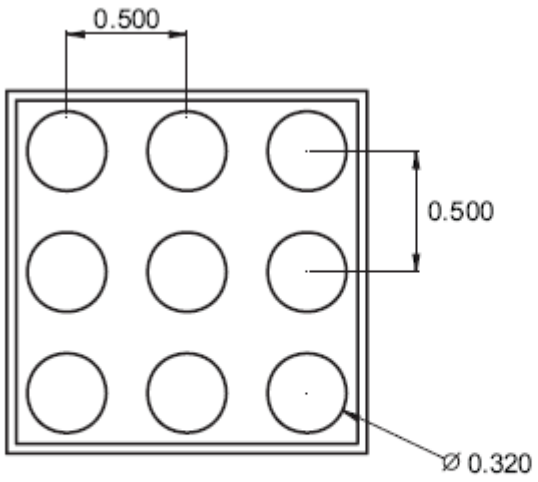
WCSP-9 1.46mmX1.46mm

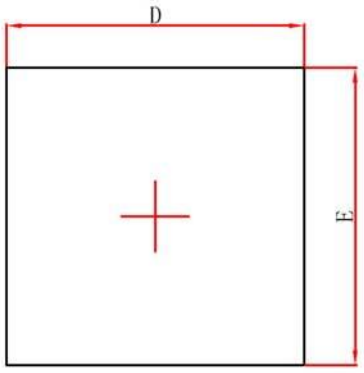


TOP VIEW

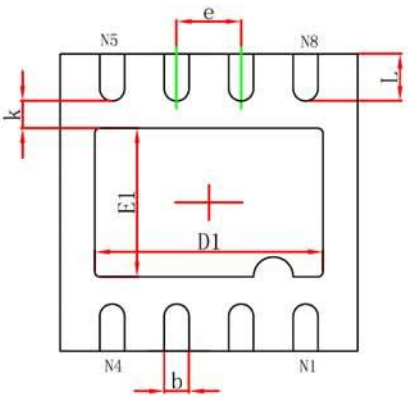


BOTTOM VIEW

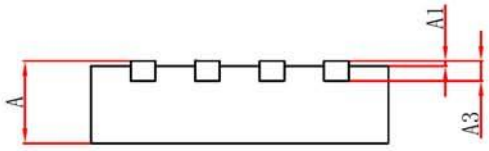
Note: All Dimensions Are in Millimeters.



Top View



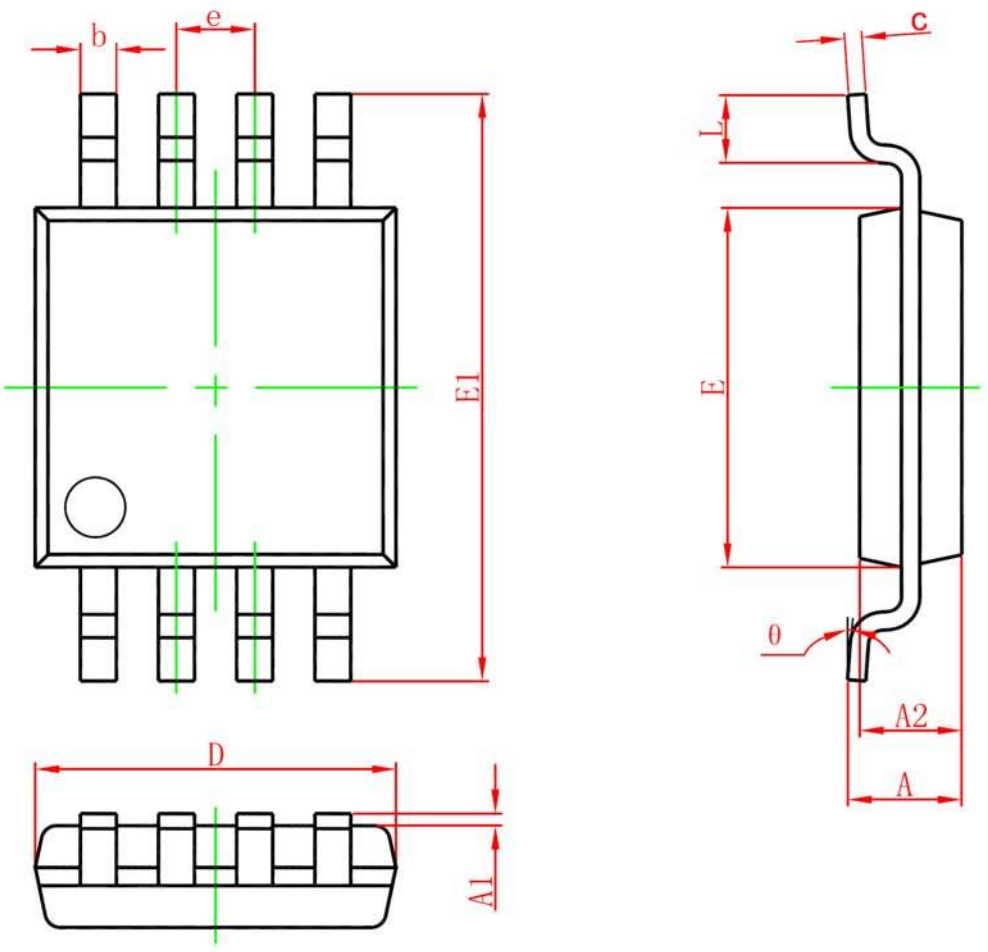
Bottom View



Side View

Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	0.700/0.800	0.800/0.900	0.028/0.031	0.031/0.035
A1	0.000	0.050	0.000	0.002
A3	0.203REF.		0.008REF.	
D	2.900	3.100	0.114	0.122
E	2.900	3.100	0.114	0.122
D1	2.200	2.400	0.087	0.094
E1	1.400	1.600	0.055	0.063
k	0.200MIN.		0.008MIN.	
b	0.180	0.300	0.007	0.012
e	0.650TYP.		0.026TYP.	
L	0.375	0.575	0.015	0.023

MSOP-8 3mmX4.8mm



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.820	1.100	0.032	0.043
A1	0.020	0.150	0.001	0.006
A2	0.750	0.950	0.030	0.037
b	0.250	0.380	0.010	0.015
c	0.090	0.230	0.004	0.009
D	2.900	3.100	0.114	0.122
e	0.650(BSC)		0.026(BSC)	
E	2.900	3.100	0.114	0.122
E1	4.750	5.050	0.187	0.199
L	0.400	0.800	0.016	0.031
θ	0°	6°	0°	6°