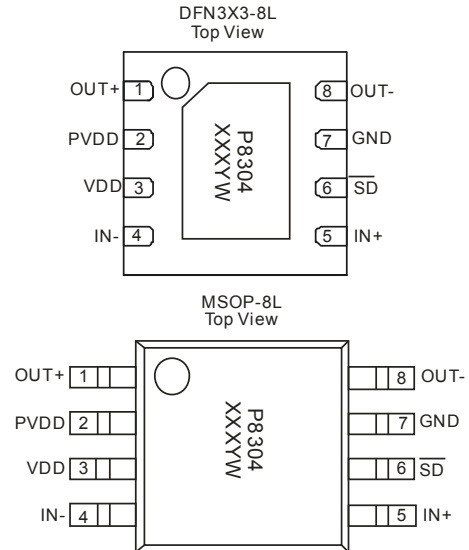## Description

The PAM8304 is a mono, filter-less, Class-D amplifier with high SNR and differential input that helps eliminate noise. The PAM8304 supports 2.8V to 6V operation, which makes it ideal for up to 4-cell alkaline battery applications. The PAM8304 is capable of driving speaker loads as low as 3Ω with a 5V supply, maximizing the output power.

The device's over 90% efficiency and small PCB area make the PAM8304 Class-D amplifier ideal for portable applications. The output uses a filter-less architecture, minimizing the number of external components in the PCB area whilst providing a high-performance, simple, and lower cost system.

The PAM8304 features short circuit protection, thermal shutdown, and undervoltage lock-out.

The PAM8304 is available in the U-DFN3030-8 and MSOP-8 packages.

Pin Assignments

DFN3X3-8L
Top View

OUT+	1			8	OUT-
PVDD	2	P8304		7	GND
VDD	3	XXXYW		6	SD
IN-	4			5	IN+

MSOP-8L
Top View

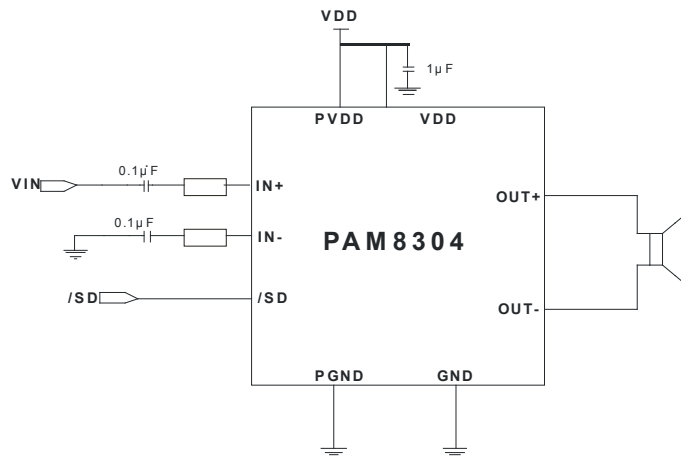| OUT+ | 1 | | | 8 | OUT- |
PVDD	2	P8304		7	GND
VDD	3	XXXYW		6	SD
IN-	4			5	IN+

Features

- Supply Voltage from 2.8V to 6.0 V
- 3Ω Driving Capability
- 3.0W@10% THD Output with a 4Ω Load and 5V Supply
- High Efficiency up to 90% @1W with an 8Ω Load
- Shutdown Current <1µA
- Superior Low Noise without Input
- Short Circuit Protection
- Thermal Shutdown
- Available in Space-Saving U-DFN3030-8 and MSOP-8L Packages
- Pb-Free Package
- **For automotive applications requiring specific change control (i.e. parts qualified to AEC-Q100/101/200, PPAP capable, and manufactured in IATF 16949 certified facilities), please contact us or your local Diodes representative. https://www.diodes.com/quality/product-definitions/**

Applications

- MP4/MP3
- GPS
- Set-Top-Box
- Tablets/Digital Photo Frame
- Electronic Dictionary
- Portable Game Machines

## Typical Applications Circuit

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Pin Descriptions

Pin Name	MSOP-8/ U-DFN3030-8	Function
OUT+	1	Positive BTL Output
PVDD	2	Power Supply
VDD	3	Analog Power Supply
IN-	4	Negative Differential Input
IN+	5	Positive Differential Input
/SD	6	Shutdown Terminal, Active Low
GND	7	Ground
OUT-	8	Negative BTL Output
Exposed Pad	—	NC

Functional Block Diagram
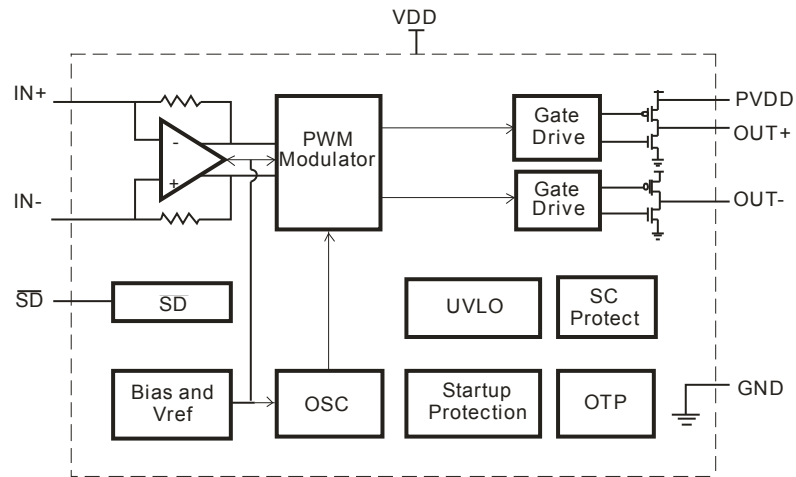
Absolute Maximum Ratings (@ T_A = +25°C, unless otherwise specified.)

Parameter	Rating	Unit
Supply Voltage (VDD)	6.5	V
Input Voltage (IN+, IN-, /SD)	-0.3 to V_{DD} +0.3	V
Storage Temperature	-65 to +150	°C
Maximum Junction Temperature	150	°C

Recommended Operating Conditions (@ T_A = +25°C, unless otherwise specified.)

Symbol	Parameter	Min	Max	Unit
V_{DD}	Supply Voltage	2.8	6.0	V
T_A	Operating Ambient Temperature Range	-40	+85	°C
T_J	Junction Temperature Range	-40	+125	°C

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Electrical Characteristics (@ T_A = +25°C, V_{DD} = 5V, Gain = 18dB, R_L = L(33μH) + R + L(33μH), unless otherwise noted.)

Symbol	Parameter	Test Conditions		Min	Typ	Max	Unit
VDD	Supply Voltage	—		2.8	—	6.0	V
Po	Output Power	THD+N = 10%, f = 1kHz, R = 4Ω	VDD = 5.0V	—	3.0	—	W
			VDD = 3.6V	—	1.5	—	
			VDD = 3.2V	—	1.2	—	
		THD+N = 1%, f = 1kHz, R = 4Ω	VDD = 5.0V	—	2.4	—	W
			VDD = 3.6V	—	1.25	—	
			VDD = 3.2V	—	1.0	—	
		THD+N = 10%, f = 1kHz, R = 8Ω	VDD = 5.0V	—	1.75	—	W
			VDD = 3.6V	—	0.90	—	
			VDD = 3.2V	—	0.70	—	
		THD+N = 1%, f = 1kHz, R = 8Ω	VDD = 5.0V	—	1.40	—	W
			VDD = 3.6V	—	0.72	—	
			VDD = 3.2V	—	0.60	—	
THD+N	Total Harmonic Distortion Plus Noise	VDD = 5.0V, Po = 1W, R = 8Ω	f = 1kHz	—	0.17	—	%
		VDD = 3.6V, Po = 0.1W, R = 8Ω		—	0.16	—	
		VDD = 3.2V, Po =0.1W, R = 8Ω		—	0.14	—	
		VDD = 5.0V, Po = 0.5W, R = 4Ω	f = 1kHz	—	0.14	—	%
		VDD = 3.6V, Po = 0.2W, R = 4Ω		—	0.16	—	
		VDD = 3.2V, Po = 0.1W, R = 4Ω		—	0.17	—	
PSRR	Power Supply Ripple Rejection	VDD = 3.6V, Inputs ac-grounded with C = 1μF	f=217Hz	—	-68	—	dB
			f=1kHz	—	-70	—	
			f=10kHz	—	-67	—	
Dyn	Dynamic Range	VDD = 5V,THD = %, R = 8Ω	f=1kHz	—	95	—	dB
Vn	Output Noise	Inputs ac-grounded	No A weighting	—	170	—	μV
			A-weighting	—	130		
η	Efficiency	RL = 8Ω,THD = 10%	f=1kHz	—	93	—	%
		RL = 4Ω,THD = 10%		—	86	—	
IQ	Quiescent Current	VDD = 5V	No Load	—	5	—	mA
Isd	Shutdown Current	VDD = 2.8V to 5V	/SD=0V	—	—	1	μA
Rdson	Static Drain-to Source On-state Resistor	High-Side PMOS, I = 500mA	VDD=5.0V	—	325	—	mΩ
		Low-Side NMOS, I = 500mA	VDD=5.0V	—	200	—	mΩ
fsw	Switching Frequency	VDD = 2.8V to 5V	—	—	400	—	kHz
Gv	Closed-Loop Gain	VDD = 2.8V to 5V	—	—	300K/Rin	—	V/V
Vos	Output Offset Voltage	Input ac-ground, VDD = 5V	—	—	—	50	mV
VIH	SD Input High Voltage	VDD = 5V	—	1.4	—	—	V
VIL	SD Input Low Voltage	VDD = 5V	—	—	—	0.4	

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Performance Characteristics (continued) (@ T_A = +25°C, V_{DD} = 5V, Gain = 18dB, R_L = L(33μH) + R + L(33μH), unless otherwise noted.)
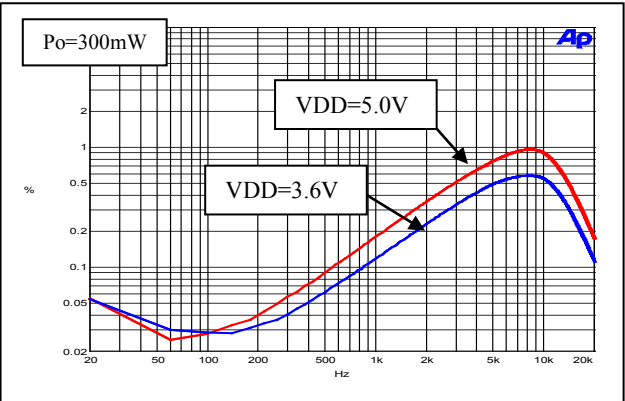
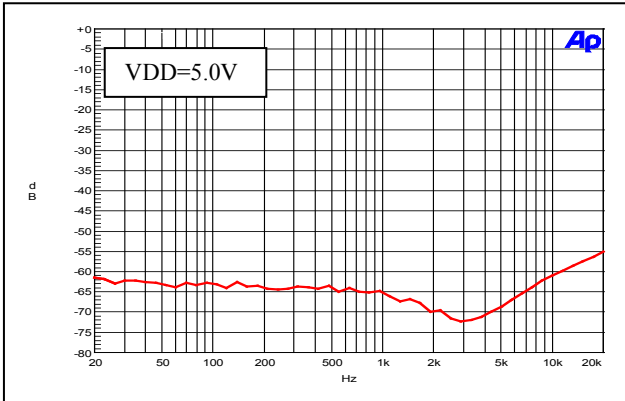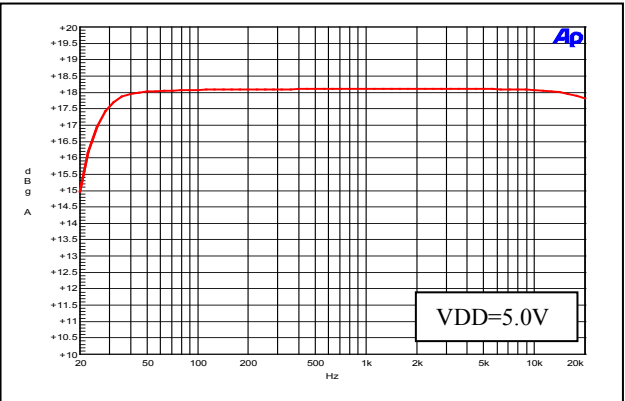### THD+N Vs. Output Power (RL=4Ω)
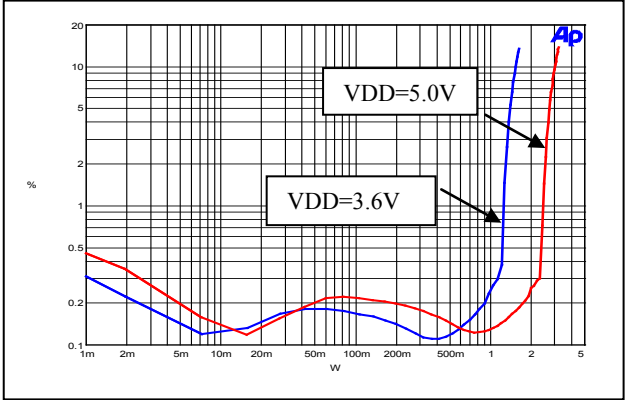
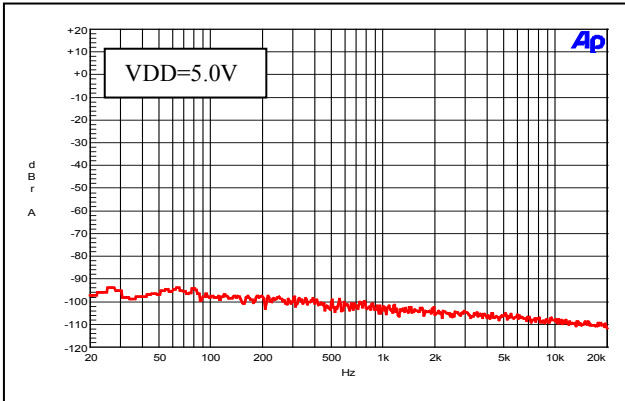### THD+N Vs. Output Power (RL=8Ω)
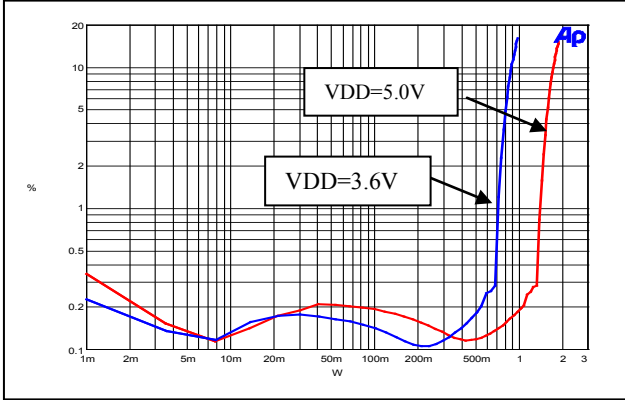
THD+N Vs. Frequency
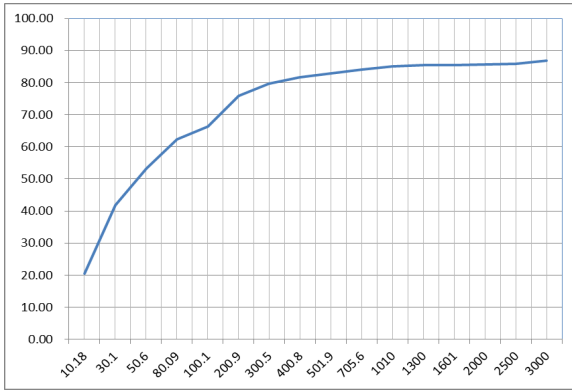

PSRR Vs. Frequency

Frequency Response

Noise Floor

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Performance Characteristics (@ T_A = +25°C, V_{DD} = 5V, Gain = 18dB, R_L = L(33µH) + R + L(33µH), unless otherwise noted.)
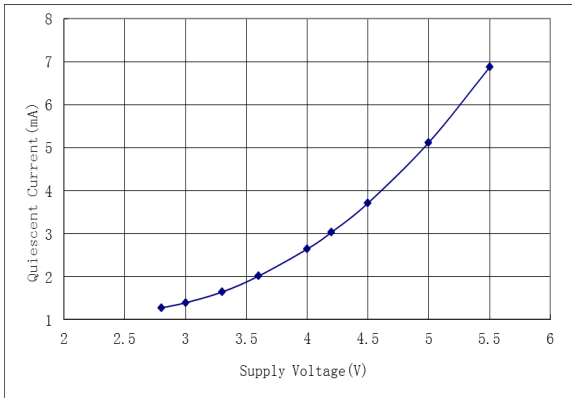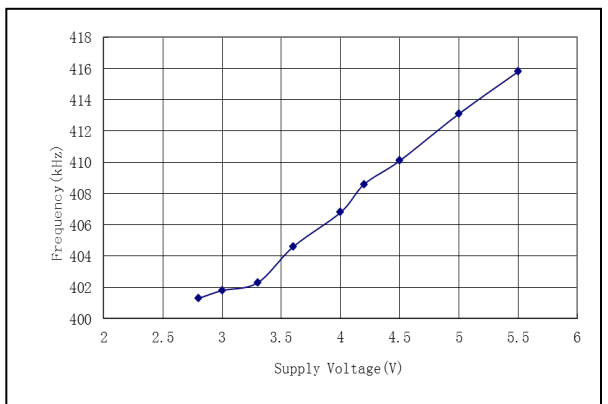
Efficiency Vs. Output Power (RL=4Ω)

Efficiency Vs. Output Power (RL=8Ω)
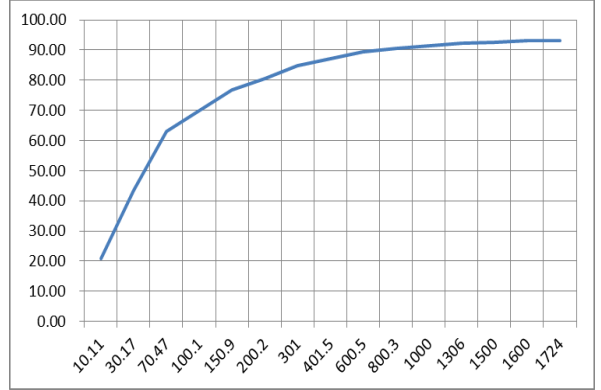
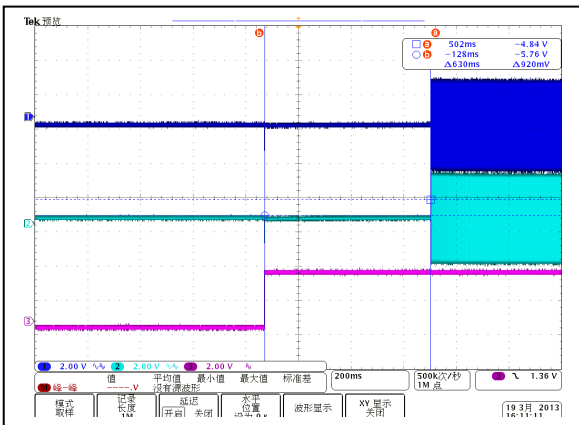Quiescent Current Vs. Supply Voltage

OSC Frequency Vs. Supply Voltage

Start-up Response

Shutdown Response

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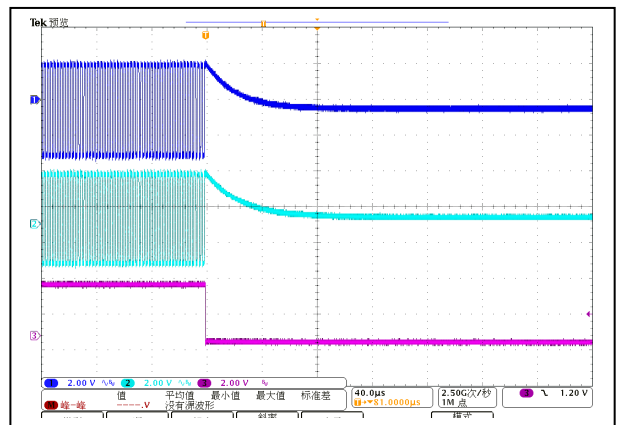
Application Information

Input Capacitors (Ci)

In typical application, an input capacitor Ci is required to allow the amplifier to bias the input signal to the proper DC level for optimum operation. In this case, Ci and the minimum input impedance Ri form a high-pass filter with the corner frequency determined in the follow equation:

$$f_C = \frac{1}{\left(2\pi RiCi\right)}$$

It is important to consider the value of Ci as it directly affects the low frequency performance of the circuit. For example, when Ri is 150kΩ and the specification calls for a flat bass response down to 150Hz. The equation is reconfigured as followed to determine the value of Ci:

$$Ci = \frac{1}{\left(2\pi Ri f_c\right)}$$

When input resistance variation is considered, if Ci is 7nF, one would likely choose a value of 10nF. A further consideration for this capacitor is the leakage path from the input source through the input network (Ci, Ri, and Rf) to the load. This leakage current creates a DC offset voltage at the input to the amplifier and reduces useful headroom, especially in high-gain applications. For this reason, a low-leakage tantalum or ceramic capacitor is recommended. When polarized capacitors are used, the positive side of the capacitor should face the amplifier input in most applications as the DC level is held at VDD/2, which is likely higher than the source DC level. Please note that it is important to confirm the capacitor polarity in the application.

Decoupling Capacitor (CS)

The PAM8304 is a high-performance CMOS audio amplifier that requires adequate power supply decoupling to ensure the output total harmonic distortion (THD) is as low as possible. Power supply decoupling also prevents oscillations caused by long lead length between the amplifier and the speaker.

Optimum decoupling is achieved by using two different types of capacitors that target different types of noise on the power supply leads. Higher frequency transients, spikes, or digital hashes should be filtered with a good low equivalent-series-resistance (ESR) ceramic capacitor with a value of typically 1µF. This capacitor should be placed as close as possible to the VDD pin of the device. Lower frequency noise signals should be filtered with a large ceramic capacitor of 10µF or greater. It is recommended to place this capacitor near the audio power amplifier.

How to Reduce EMI

Most applications require a ferrite bead filter for EMI elimination, as shown in Figure 1. The ferrite filter reduces EMI around 1MHz and higher. When selecting a ferrite bead, it should be chosen with consideration to high impedance at high frequencies and low impedance at low frequencies.
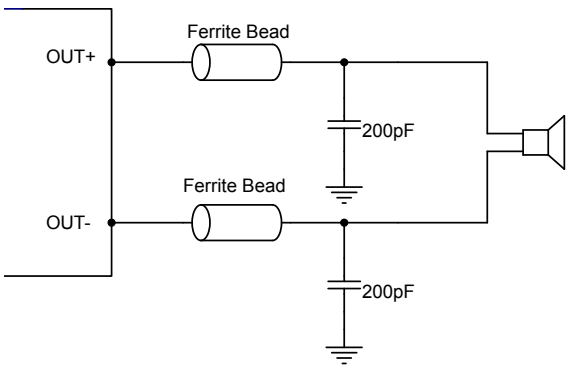

Figure 1 Ferrite Bead Filter to Reduce EMI

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Application Information (continued)

Shutdown Operation

The PAM8304 contains amplifier shutdown circuitry in order to reduce power consumption while not in use. When a logic low or ground is applied to the /SD pin, the PAM8304 will enter a standby mode and supply current drawn will be minimized.

Undervoltage Lock-Out (UVLO)

The PAM8304 incorporates circuitry designed to detect low supply voltage. When the supply voltage drops to 2.5V or below, the PAM8304 goes into a state of shutdown. The device returns to normal operation only when VDD is higher than 2.8V.

Short Circuit Protection (SCP)

The PAM8304 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.
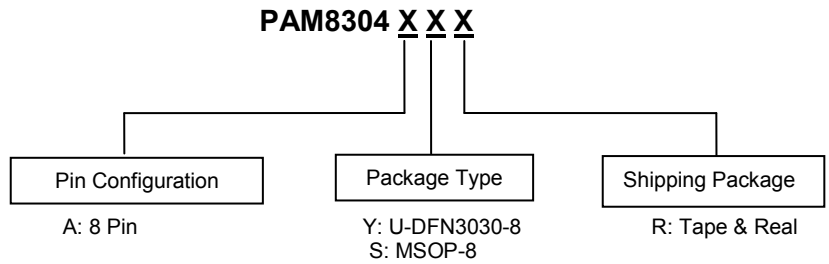
Overtemperature Protection (OTP)

Thermal protection prevents the device from damage. When the internal die temperature exceeds a typical of 150°C the device will enter a shutdown state and the outputs are disabled. This is not a latched fault, once the thermal fault is cleared and the temperature of the die decreases by 40°C, the device will restart with no external system interaction.

Anti-Pop and Anti-Click Circuitry

The PAM8304 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 recovery 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 reaches half-supply voltage. 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.

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Ordering Information

PAM8304 X X X

Pin Configuration	Package Type	Shipping Package
A: 8 Pin	Y: U-DFN3030-8 S: MSOP-8	R: Tape & Real

Part Number	Package	Standard Package
PAM8304AYR	U-DFN3030-8	3,000Units/Tape&Real
PAM8304ASR	MSOP-8	2,500Units/Tape&Real

Marking Information
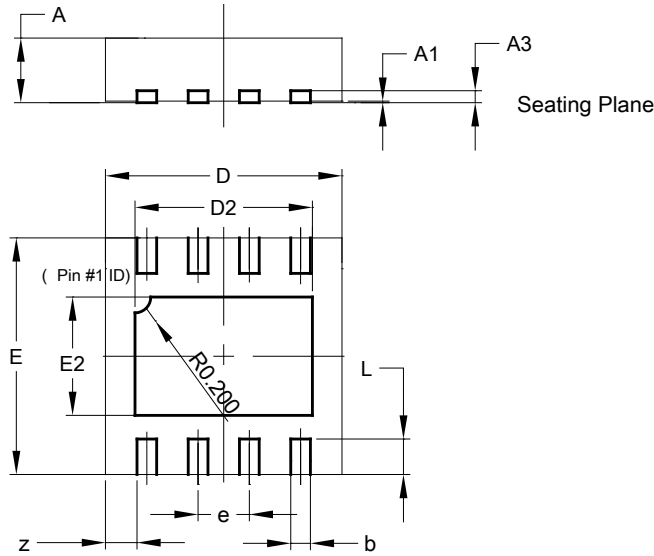
U-DFN3030-8

P8304
XXXYW
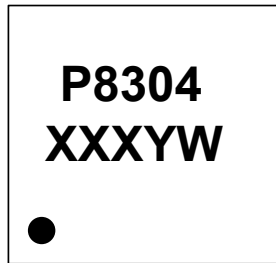
MSOP-8
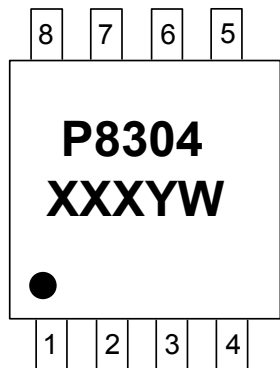
P8304
XXXYW

P8304: Product Code

X : Internal Code

Y : Year : 0 to 9

W : Week : A to Z : 1 to 26 week;
a to z : 27 to 52 week; z represents
52 and 53 week

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Package Outline Dimensions

Please see http://www.diodes.com/package-outlines.html for the latest version.

U-DFN3030-8 (Type E)

U-DFN3030-8 (Type E)			
Dim	Min	Max	Typ
A	0.57	0.63	0.60
A1	0.00	0.05	0.02
A3	-	-	0.15
b	0.20	0.30	0.25
D	2.95	3.05	3.00
D2	2.15	2.35	2.25
E	2.95	3.05	3.00
E2	1.40	1.60	1.50
e	-	-	0.65
L	0.30	0.60	0.45
z	-	-	0.40
All Dimensions in mm			

MSOP-8

Detail C

See Detail C
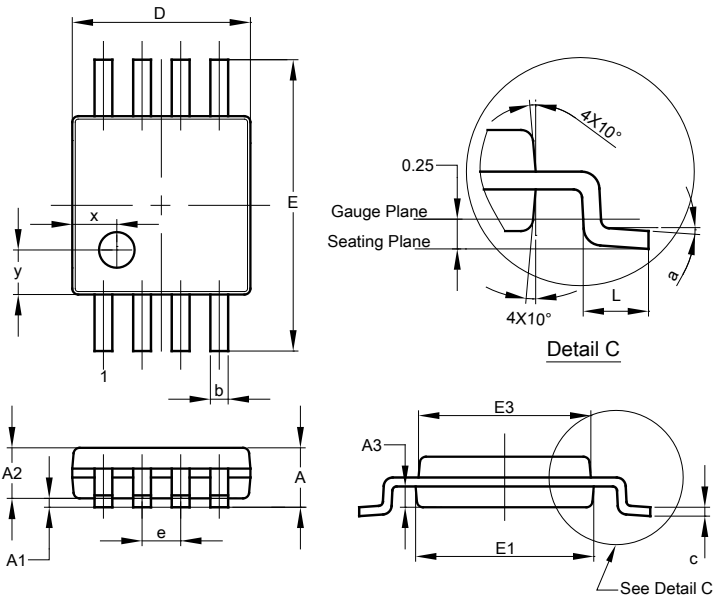
MSOP-8			
Dim	Min	Max	Typ
A	-	1.10	-
A1	0.05	0.15	0.10
A2	0.75	0.95	0.86
A3	0.29	0.49	0.39
b	0.22	0.38	0.30
c	0.08	0.23	0.15
D	2.90	3.10	3.00
E	4.70	5.10	4.90
E1	2.90	3.10	3.00
E3	2.85	3.05	2.95
e	-	-	0.65
L	0.40	0.80	0.60
a	0°	8°	4°
x	-	-	0.750
y	-	-	0.750
All Dimensions in mm			

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Suggested Pad Layout

Please see http://www.diodes.com/package-outlines.html for the latest version.

U-DFN3030-8 (Type E)
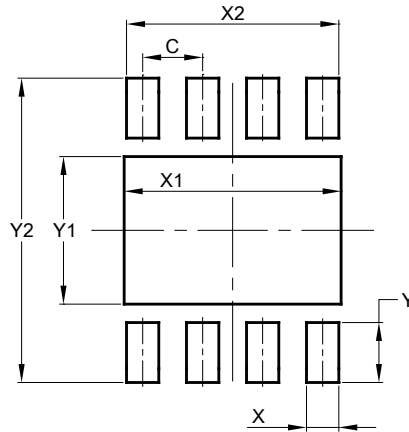
Dimensions	Value (in mm)
C	0.650
X	0.350
X1	2.350
X2	2.300
Y	0.650
Y1	1.600
Y2	3.300

MSOP-8
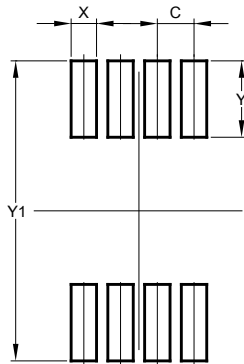
Dimensions	Value (in mm)
C	0.650
X	0.450
Y	1.350
Y1	5.300

Mechanical Data

MSOP-8

- Moisture Sensitivity: Level 3 per J-STD-020
- Terminals: Finish – Matte Tin Plated Leads, Solderable per MIL-STD-202, Method 208 ⓔ3
- Weight: 0.027 grams (Approximate)

U-DFN3030-8 (Type E)

- Moisture Sensitivity: Level 1 per J-STD-020
- Terminals: Finish – NiPdAu, Solderable per J-STD-002, Test B1 ⓔ4
- Weight: 0.018 grams (Approximate)

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