EUTECH
MICROELECTRONICS

EUA2014

2.5W Stereo Class-D Audio Power Amplifier with 3D Enhancement

DESCRIPTION

The EUA2014 is a high efficiency, 2.5W/channel stereo class-D audio power amplifier. A low noise, filterless PWM architecture eliminates the output filter.

Operating from a single 5V supply, EUA2014 is capable of delivering 2.5W/ channel of continuous output power to a 4Ω load with 10% THD+N.

The EUA2014 features independent shutdown controls for each channel. The gain can be selected to 6, 12, 18, or 24 dB utilizing the G0 and G1 gain select pins. High PSRR and differential architecture provide increased immunity to noise and RF rectification.

The EUA2014 also includes 3D audio enhancement that improves stereo sound quality. In devices where the left and right speakers are in close proximity, 3D enhancement affects channel specialization, widening the perceived soundstage.

The EUA2014 is available in space-saving TQFN package, is an idea choice for mobile phones and other portable communication devices.

Typical Application Circuit

FEATURES

- Unique Modulation Scheme Reduces EMI Emission
- Output Power By TQFN Package
  - 2.5W/Ch Into 4Ω at 5V
  - 1.5W/Ch Into 8Ω at 5V
  - 750mW/Ch Into 8Ω at 3.6V
- Wide Supply Voltage: 2.5V to 5.5V
- Independent Shutdown Control for Each Channel
- Selectable Gain of 6,12,18 and 24 dB
- Internal Pulldown Resistor On Shutdown Pins
- High PSRR :70dB at 217Hz
- Fast 10ms Startup Time
- Low 4.7mA Quiescent Current at 3.6V Supply and 1.5μA Shutdown Current
- Short-Circuit and Thermal Protection
- 3D Enhancement
- Space Saving Packages
  - 4mm × 4mm TQFN-24 package
- RoHS Compliant and 100% Lead(Pb)-Free

APPLICATIONS

- Wireless or Cellular Handsets and PDAs
- Portable Audios
- Notebook PC

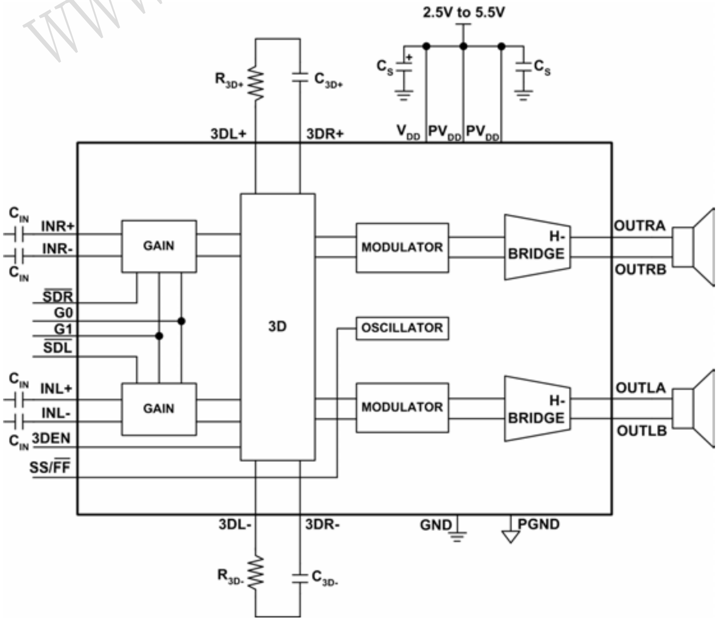
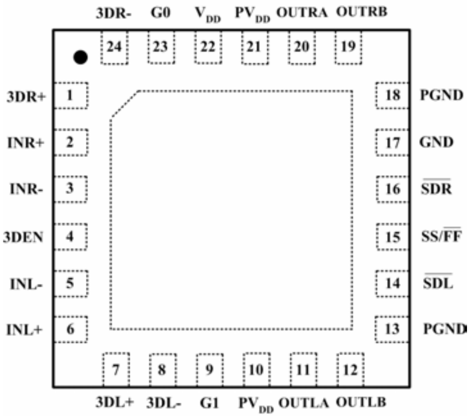


Figure1.

Pin Configurations

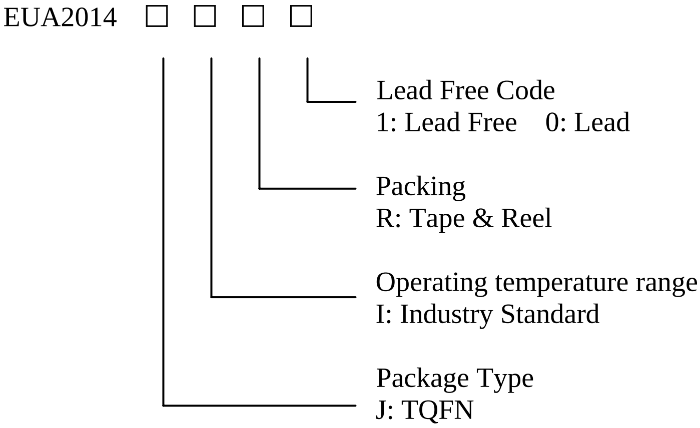
Package Type	Pin Configurations
TQFN-24	

Pin Description

PIN	NAME	DESCRIPTION
1	3DR+	Right Channel non-inverting 3D connection. Connect to 3DL+ through C_{3D+} and R_{3D+}
2	INR+	Right Channel Non-Inverting Input
3	INR-	Right Channel Inverting Input
4	3DEN	3D Enable Input
5	INL-	Left Channel Inverting Input
6	INL+	Left Channel Non-Inverting Input
7	3DL+	Left Channel non-inverting 3D connection. Connect to 3DR+ through C_{3D+} and R_{3D+}
8	3DL-	Left Channel non-inverting 3D connection. Connect to 3DR+ through C_{3D-} and R_{3D-}
9	G1	Gain Select Input 1
10,21	PV_{DD}	Speaker Power Supply
11	OUTLA	Left Channel Inverting Output
12	OUTLB	Left Channel Non-Inverting Output
13,18	PGND	Power Ground
14	$\overline{SDL}$	Left Channel Active Low Shutdown. Connect to VDD for normal operation. Connect to GND to disable the left channel.
15	SS/$\overline{FF}$	Modulation Mode Select. Connect to VDD for spread spectrum mode. Connect to GND for fixed frequency mode.
16	$\overline{SDR}$	SDR Right Channel Active Low Shutdown. Connect to VDD for normal operation. Connect to GND to disable the right channel.
17	GND	Ground
19	OUTRB	Right Channel Non-Inverting Output
20	OUTRA	Right Channel Inverting Output
22	V_{DD}	Power Supply
23	G0	Gain Select Input 0
24	3DR-	Right Channel muting 3D connection. Connect to 3DL- through $C_{3D-}$and R_{3D-}

Ordering Information

Order Number	Package Type	Marking	Operating Temperature range
EUA2014JIR1	TQFN-24	xxxxx A2014	-40 °C to 85°C



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Lead Free Code
1: Lead Free 0: Lead

Packing
R: Tape & Reel

Operating temperature range
I: Industry Standard

Package Type
J: TQFN

Absolute Maximum Ratings

- Supply Voltage -- 6V
- Input Voltage -- -0.3 V to V_{DD} +0.3V
- Junction Temperature, T_J -- 150°C
- Storage Temperature Rang, T_{stg} -- -65°C to 150°C
- ESD Susceptibility -- 2kV
- Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds -------------------------------------- 260°C
- Thermal Resistance
  - θ_{JA} (TQFN) -- 47°C/W

Recommended Operating Conditions

	Min	Max	Unit
Supply voltage, V_{DD},PV_{DD}	2.5	5.5	V
High-level input voltage, $\overline{SDL}$, $\overline{SDR}$, G0,G1, SS/$\overline{FF}$, 3DEN	1.3		V
Low-level input voltage, $\overline{SDL}$, $\overline{SDR}$, G0,G1, SS/$\overline{FF}$, 3DEN		0.2	V
Operating free-air temperature, T_A	-40	85	°C

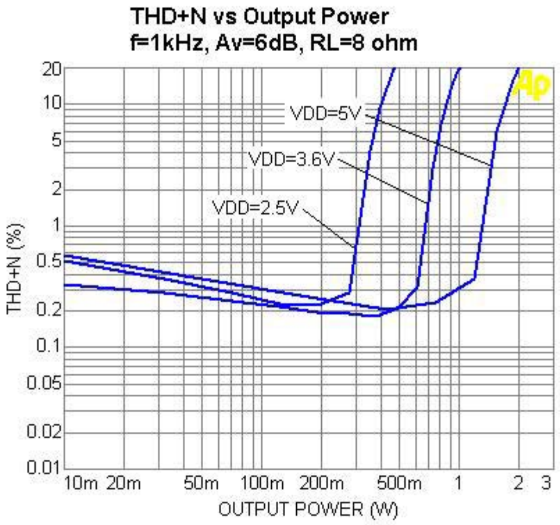
Electrical Characteristics V_{DD}=PV_{DD}=3.6V The following specifications apply for A_V = 6dB, R_L = 15µH + 8Ω + 15µH, SS/$\overline{FF}$ = V_{DD} = (Spread Spectrum mode), f = 1kHz, unless otherwise specified. Limits apply for T_A = 25°C.

Symbol	Parameter	Conditions	EUA2014			Unit
			Min	Typ	Max.	
V_{OS}	Differential Output Offset Voltage	V_{IN}=0, VDD=2.5V to 5.5V		5	25	mV
I_{DD}	Quiescent Power Supply Current (Both channels active)	V_{DD}= 3.6V, no load or output filter		4.7	6.5	mA
		V_{DD}= 5V, no load or output filter		7.3	9.5	
I_{SD}	Shutdown Current	V_{SDL}=V_{SDR}=GND		0.8	1.5	µA
T_{WU}	Wake Up Time	V_{DD}= 3.6V		10		ms
f_{SW}	Switching Frequency	SS/$\overline{FF}$ =V_{DD} (Spread Spectrum)		300	330	kHz
		SS/$\overline{FF}$ =GND (Fixed Frequency)		300		kHz
A_V	Gain	G0,G1=GND	5.5	6	6.5	dB
		G0=V_{DD} ,G1=GND	11.5	12	12.5	
		G0=GND, G1= V_{DD}	17.5	18	18.5	
		G0,G1= V_{DD}	23.5	24	24.5	
R_{IN}	Input Resistance	A_V=6dB		160		kΩ
		A_V=12dB		80		
		A_V=18dB		40		
		A_V=24dB		20		

Electrical Characteristics $V_{DD}=PV_{DD}=3.6V$ The following specifications apply for A_V = 6dB, R_L = 15μH + 8Ω + 15μH, $SS/\overline{FF}$ = V_{DD} = (Spread Spectrum mode), f = 1kHz, unless otherwise specified. Limits apply for T_A = 25°C.

Symbol	Parameter	Conditions	EUA2014			Unit
			Min	Typ	Max.	
P_O	Output Power (Per Channel)	R_L=15uH + 4Ω + 15uH, THD≤10% f=1kHz, 22kHz BW				
		V_{DD}=5V		2.5		W
		V_{DD}=3.6V		1.2		W
		V_{DD}=2.5V		0.5		W
		R_L=15uH + 8Ω + 15uH, THD≤10% f=1kHz, 22kHz BW				
		V_{DD}=5V		1.5		W
		V_{DD}=3.6V		0.75		W
		V_{DD}=2.5V		0.35		W
		R_L=15uH + 4Ω + 15uH, THD≤1% f=1kHz, 22kHz BW				
		V_{DD}=5V		1.85		W
		V_{DD}=3.6V		1		W
		V_{DD}=2.5V		0.45		W
		R_L=15uH + 8Ω + 15uH, THD≤1% f=1kHz, 22kHz BW				
		V_{DD}=5V		1.2		W
		V_{DD}=3.6V		0.6		W
		V_{DD}=2.5V		0.27		W
THD+N	Total Harmonic Distortion	P_o=500mW/Ch, f=1kHz, R_L=8Ω		0.2		%
		P_o=300mW/Ch, f=1kHz, R_L=8Ω		0.22		%
PSRR	Power Supply Rejection Ratio	V_{RIPPLE}=200mV_{p-p} Sine, Inputs AC GND, C_{IN}=1uF, input referred f_{Ripple}=217Hz		70		dB
		f_{Ripple}=1kHz		68		dB
CMRR	Common Mode Rejection Ration	V_{RIPPLE}=1V_{p-p}, f_{RIPPLE}=217Hz		60		dB
η	Efficiency	Po=1W/Ch, f=1kHz, R_L=8Ω, V_{DD}=5V		86		%
X_{talk}	Crosstalk	Po=500mW/Ch, f=1kHz		82		dB
SNR	Signal to Noise Ratio	V_{DD}=5V, Po=1W, Fixed Frequency Mode		88		dB
ε_{OS}	Output Noise	Input referred, Fixed Frequency Mode No Weighted Filter		66		μV
		A-Weighted Filter		48		μV

Typical Operating Characteristics



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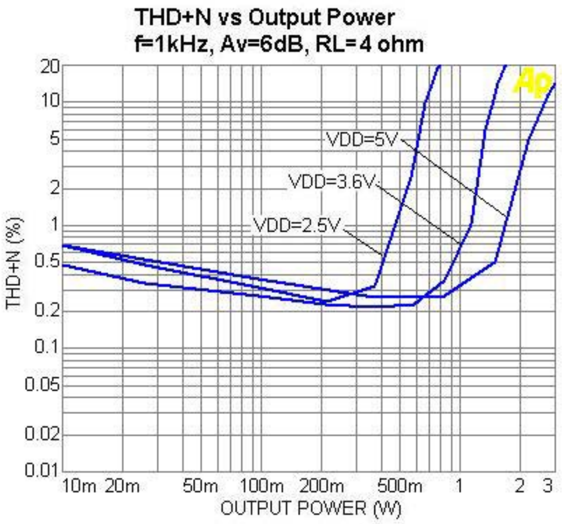

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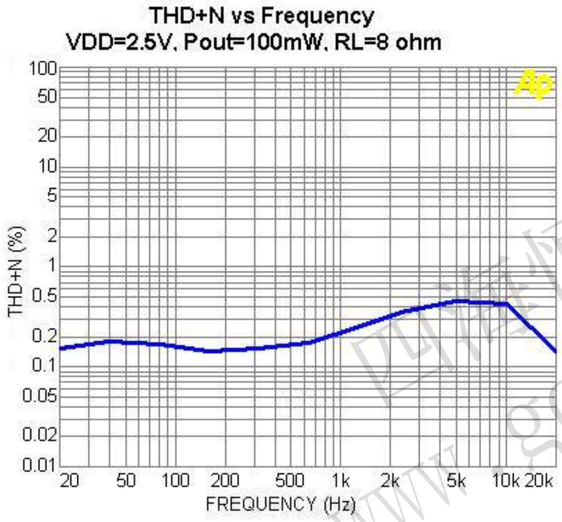

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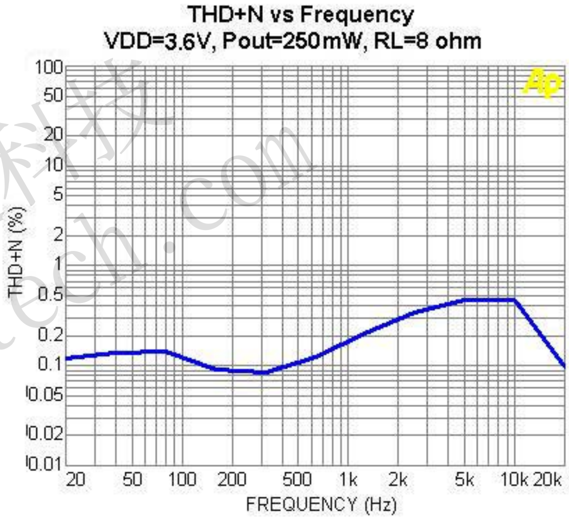

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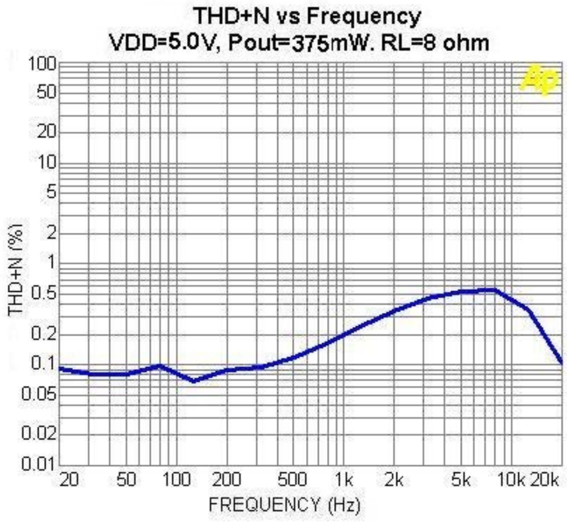

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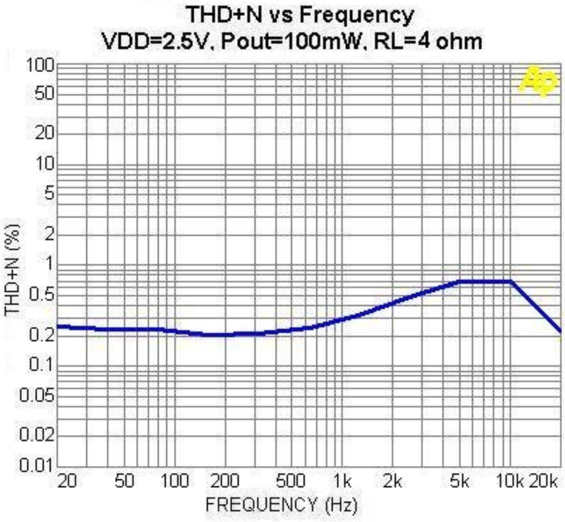

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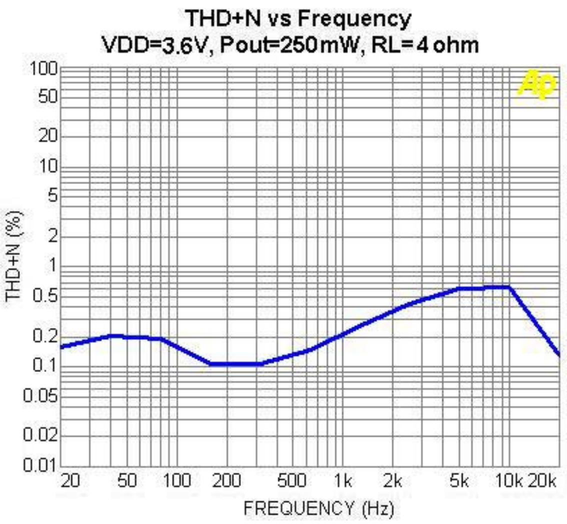

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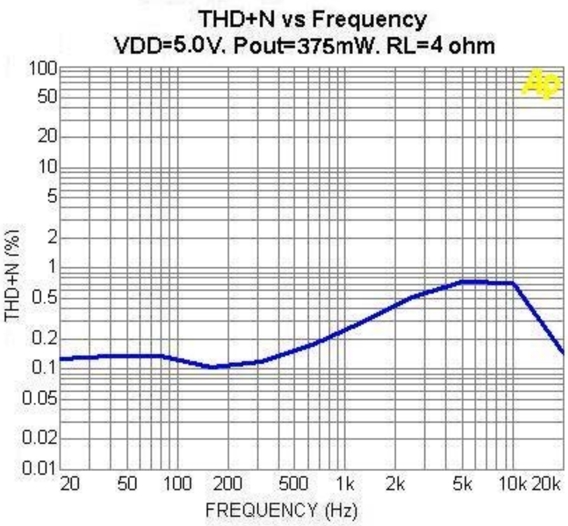

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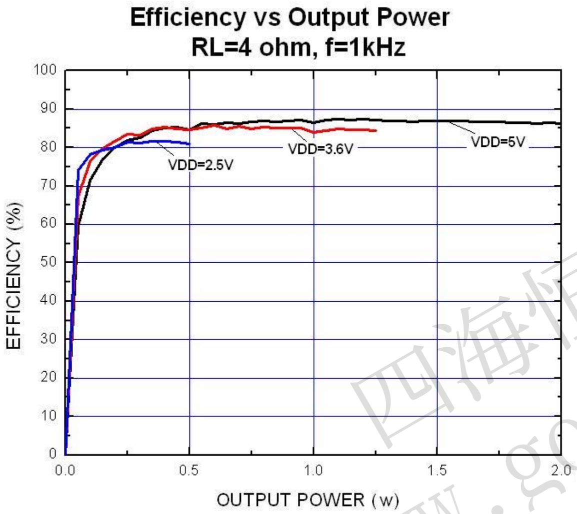

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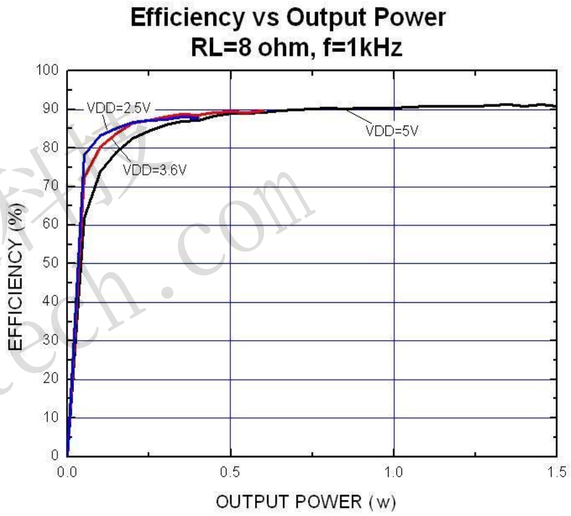

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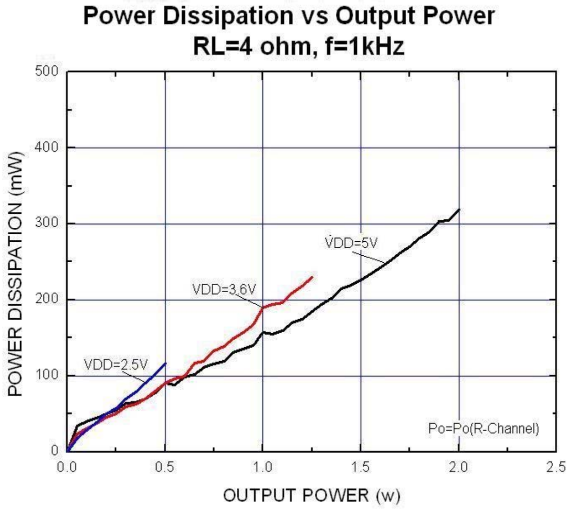

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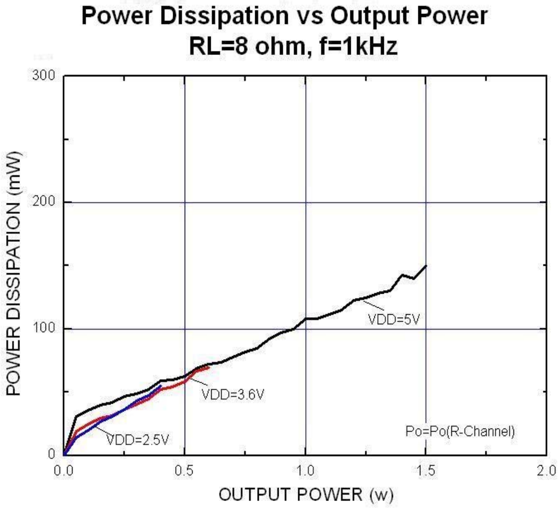

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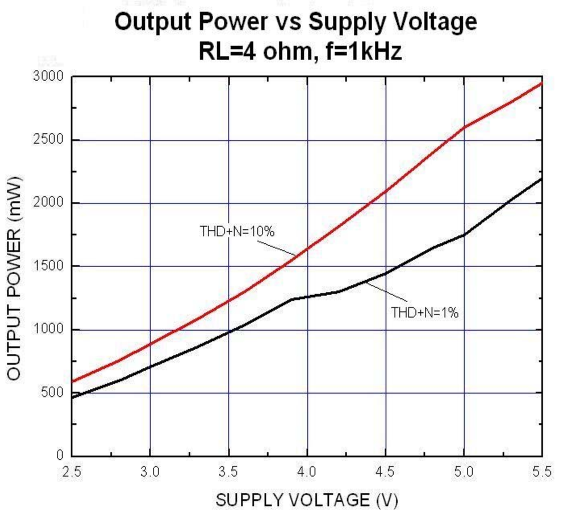

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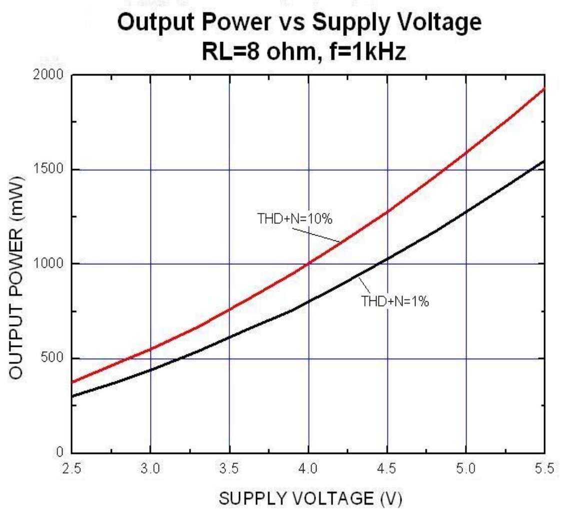

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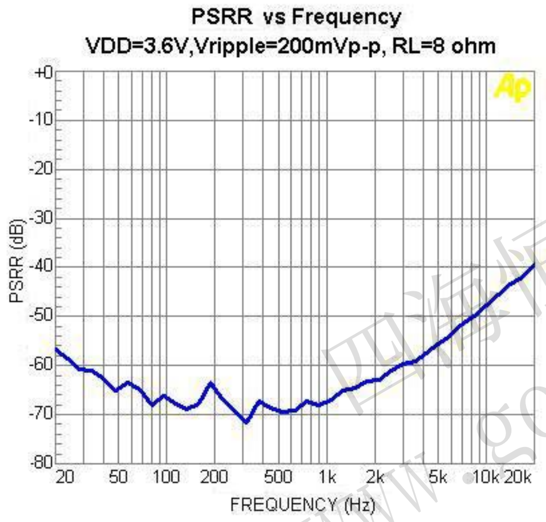

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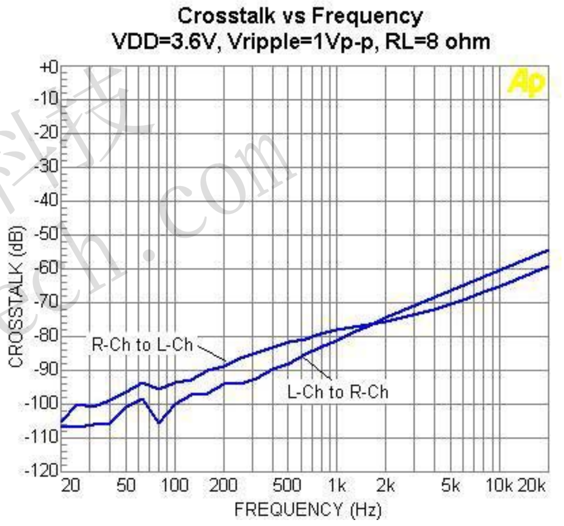

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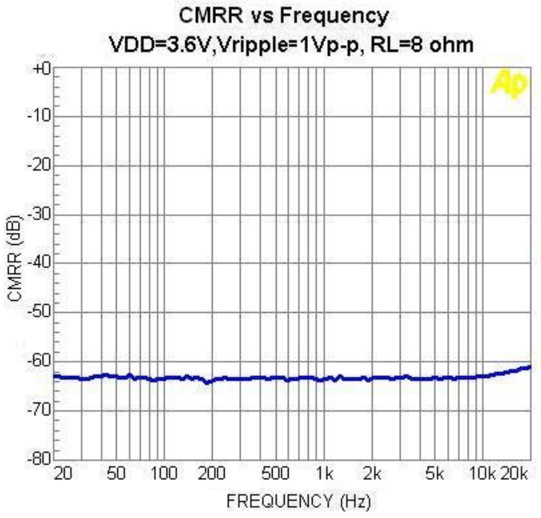

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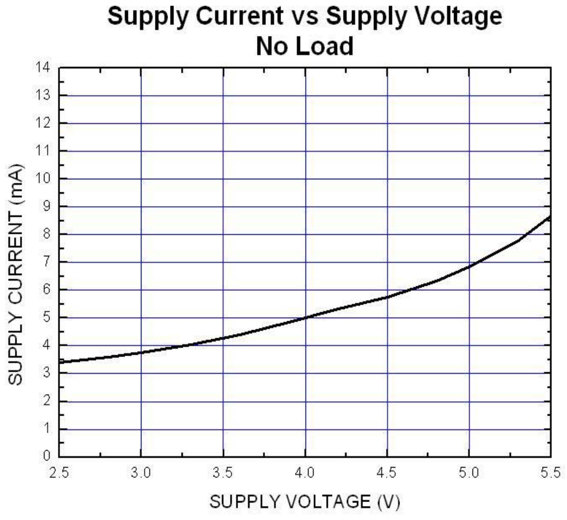


Figure19.

Application Information

Decoupling Capacitor (C_S)

The EUA2014 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, typically 1μF, placed as close as possible to the device PV_{DD} lead works best. Placing this decoupling capacitor close to the EUA2014 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 4.7μF or greater capacitor placed near the audio power amplifier would also help, but it is not required in most applications because of the high PSRR of this device.

Table 1. Gain Setting

G1	G0	GAIN (V/V)	GAIN (dB)	Input Impedance (R_{IN})(KΩ)
0	0	2	6	160
0	1	4	12	80
1	0	8	18	40
1	1	16	24	20

Input Capacitors (C_I)

The EUA2014 does not require input coupling capacitors if the design uses a differential source that is biased from 0.5 V to V_{DD} – 0.8 V. If the input signal is not biased within the recommended common −mode input range, if high pass filter (shown in Figure 1), input coupling capacitors are required.

The input capacitors and input resistors form a high-pass filter with the corner frequency, fc, determined in equation (1).

$$f_c = \frac{1}{(2\pi R_I C_I)} \quad \text{--(1)}$$

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.

$$C_I = \frac{1}{(2\pi R_I f_c)} \quad \text{--(2)}$$

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 EUA2014. Placing the decoupling capacitor, CS, close to the EUA2014 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.

Filter Free Operation and Ferrite Bead Filters

A ferrite bead filter can often be used if the design is failing radiated emissions without an LC filter and the frequency sensitive circuit is greater than 1 MHz. This filter functions well for circuits that just have to pass FCC and CE because FCC and CE only test radiated emissions greater than 30 MHz. When choosing a ferrite bead, choose one with high impedance at high frequencies, and very low impedance at low frequencies. In addition, select a ferrite bead with adequate current rating to prevent distortion of the output signal.

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.

Figure 20 shows typical ferrite bead and LC output filters.

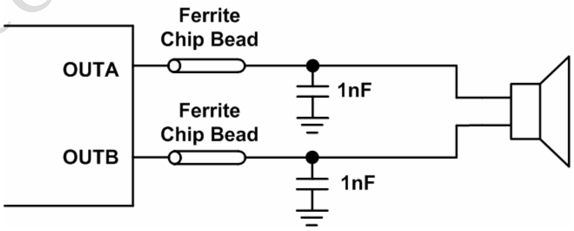


Figure20. Typical Ferrite Chip Bead Filter

3D Enhancement

The EUA2014 features 3D enhancement effect that widens the perceived soundstage of a stereo audio signal. The 3D enhancement increases the apparent stereo channel separation, improving audio reproduction whenever the left and right speakers are too close to one another.

An external RC network shown in Figure 1 is required to enable the 3D effect. Because the EUA2014 is a fully differential amplifier, there are two separate RC networks, one for each stereo input pair (INL+ and INR+, and INL- and INR-). Set 3DEN high to enable the 3D effect. Set 3DEN low to disable the 3D effect.

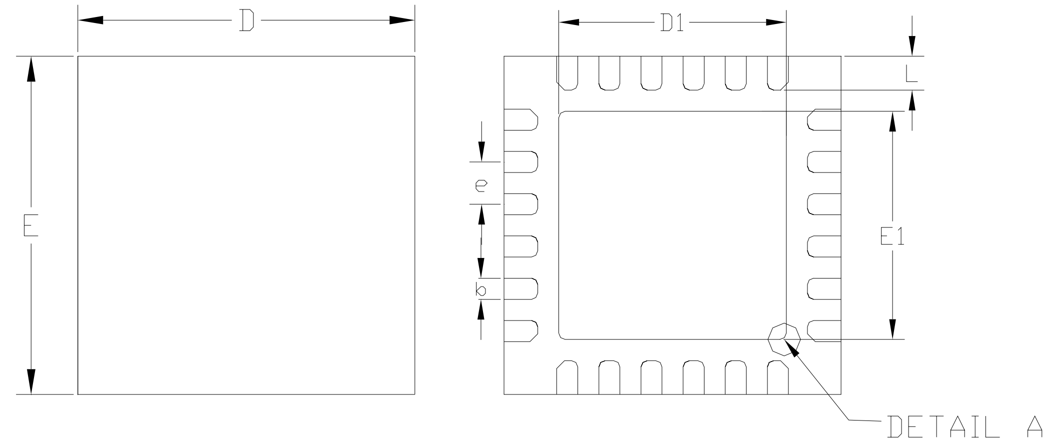
The 3D RC network acts as a high pass filter. The amount of the 3D effect is set by the R_{3D} resistor. Decreasing the value of R_{3D} increases the 3D effect. The C_{3D} capacitor sets the frequency at which the 3D effect occurs. Increasing the value of C_{3D} decreases the low frequency cutoff point, extending the 3D effect over a wider bandwidth. The low frequency cutoff point is given by:

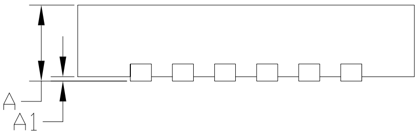
$$f_{3D(-3dB)} = 1/2\pi(R_{3D})(C_{3D})$$

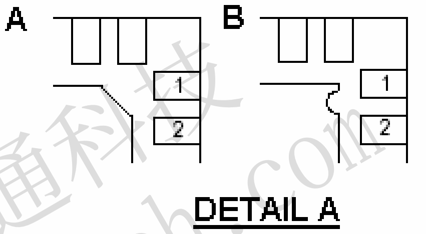
Enabling the 3D effect increase the gain by a factor of (1 +20kΩ/R_{3D}). Setting R_{3D} to 20kΩ results in a gain increase of 6dB whenever the 3D effect is enabled. In fully differential configuration, the component values of the two RC networks must be identical. Any component variations can affect the sound quality of the 3D effect. In single-ended configuration, only the RC network of the input pairs being driven by the audio source needs to be connected. For instance, if audio is applied to INR+ and INL+, then a 3D network must be connected between 3DL+ and 3DR+. 3DL- and 3DR- can be left unconnected.

Packaging Information

TQFN-24







DETAIL A

Thermal Pad Option

SYMBOLS	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A	0.70	0.80	0.028	0.031
A1	0.00	0.05	0.000	0.002
b	0.18	0.30	0.007	0.012
E	3.90	4.10	0.154	0.161
D	3.90	4.10	0.154	0.161
D1	2.70		0.106	
E1	2.70		0.106	
e	0.50		0.020	
L	0.30	0.50	0.012	0.020