

## 2.5W/CH Stereo Filter-less Class-D Audio Amplifier

### Features

- Supply voltage range: 2.8 V to 5.5 V
- Support single-ended or differential analog input
- Low static operation current
- Low shut-down current
- Short power-on transient time (1ms)
- Internal pull-low resistor on shut-down pins
- Independent shut-down control for left or right channel
- Short-circuit protection
- Over-temperature protection
- Loudspeaker power within 10% THD+N
  - 1.5W/ch into 8Ω loudspeaker
  - 2.5W/ch into 4Ω loudspeaker
- Loudspeaker efficiency
  - 89% @ 8Ω, THD+N=10%
  - 82% @ 4Ω, THD+N=10%

### Applications

- Monitor audio

- PDA
- Portable multimedia devices
- Notebook computer
- Mobile phone

### Description

The EMA2016 is a stereo, filter-less class-D audio amplifier. Operating with 5.0V loudspeaker driver supply, it can deliver 1.5W/ch output power into 8 Ω loudspeaker and 2.5W/ch output power into 4 Ω loudspeaker within 10% THD+N.

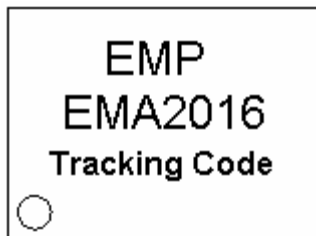
The EMA2016 packaged as SOP 16L is a stereo audio amplifier with high efficiency and proper thermal resistance, which leads to longer battery life and less heat sink requirement. It's suitable for the notebook computer, and portable multimedia devices. EMA2016 with the independent shut-down control for left or right channel, That's a better solution for low cost Class-D system.

### Ordering Information

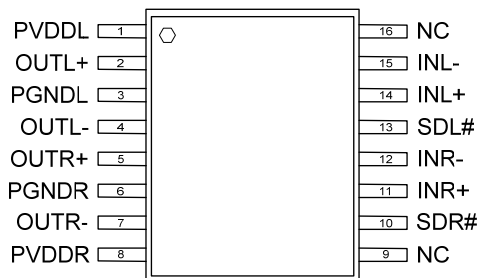
Product ID	Package	Comments	Packing
EMA2016-50SA16NRR	SOP 16L	Green	Tape & Reel 2.5K units

### Marking Information

- Line 1 : LOGO
- Line 2 : Product No
- Line 3 : Tracking Code



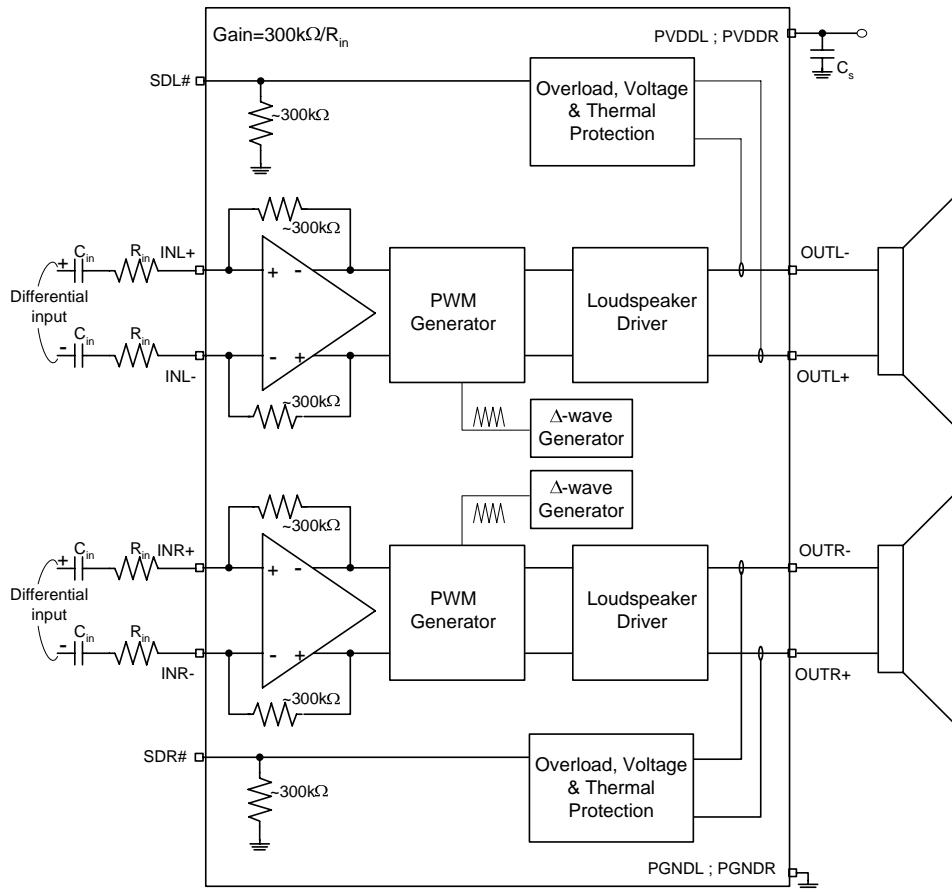
## Pin Assignments



## Pin Description

NAME		TYP	DESCRIPTION	CHARACTERISTIC
1	PVDDL	P	Left channel power supply	
2	OUTL+	O	Left channel output (+)	
3	PGNDL	G	Left channel ground	
4	OUTL-	O	Left channel output (-)	
5	OUTR+	O	Right channel output (+)	
6	PGNDR	G	Right channel ground	
7	OUTR-	O	Right channel output (-)	
8	PVDDR	P	Right channel power supply	
9	NC		NC	
10	SDR#	I	Shut-down right channel (Low active)	with 300 kΩ pull-low resistor
11	INR+	I	Right channel Input (+)	
12	INR-	I	Right channel Input (-)	
13	SDL#	I	Shut-down left channel (Low active)	with 300 kΩ pull-low resistor
14	INL+	I	Left channel Input (+)	
15	INL-	I	Left channel Input (-)	
16	NC		NC	

## Functional Block Diagram



## Available Package

Package	Product No.	$\theta_{JA}$ ( $^{\circ}\text{C}/\text{W}$ )	Exposed Thermal Pad
SOP 16L	EMA2016	57.3	No

## Absolute Maximum Ratings

SYMBOL	PARAMETER	MIN	MAX	UNIT
PVDD	Supply for analog cells & loudspeaker	2.8	5.5	V
	Input voltage	-0.3	AVDD	V
$T_{stg}$	Storage temperature	-65	150	$^{\circ}\text{C}$
$T_a$	Ambient operating temperature	0	70	$^{\circ}\text{C}$

## Recommended Operating Conditions

SYMBOL	PARAMETER	TYP	UNIT
PVDD	Supply for analog cells & loudspeaker driver	2.8~5.5	V
V <sub>IH</sub>	High-Level Input Voltage	At 5V	1.8
		At 3.6V	1.4
V <sub>IL</sub>	Low-Level Input Voltage	0.8	V
T <sub>a</sub>	Ambient Operating Temperature	0~70	°C

## General Electrical Characteristics

SYMBOL	PARAMETER	CONDITION	MIN	TYP	MAX	UNIT
I <sub>SD</sub>	Supply current during shut-down mode	PVDD=5.0V; SDL#=SDR#=0V		0.7	1	μA
I <sub>Q</sub>	Quiescent current	PVDD=5.0V; SDL#=SDR#=5.0V; no load		10		mA
		PVDD=3.6V; SDL#=SDR#=3.6V; no load		8.8		
V <sub>offset</sub>	Output offset voltage	Input ac grounded, PVDD=5.0V		14	25	mV
	Junction temperature for driver shutdown		145	150	155	°C
	Temperature hysteresis for recovery from shutdown		115	120	125	°C
f <sub>sw</sub>	Switching rate of loudspeakers driver		300	450	600	kHz
R <sub>SC</sub>	Loudspeaker short-circuit detect resistance	PVDD=5.0V		2.2	2.8	Ω
r <sub>DS(on)</sub>	Static drain-source on-state resistance	PVDD=5.0V		400		mΩ
		PVDD=3.6V		500		

## Electrical Characteristics and Specifications of Loudspeaker Driver

- Gain= 2 V/V, Load=8Ω,  $f_{in}$ =1 kHz,  $T_A$ =25°C (unless otherwise noted)

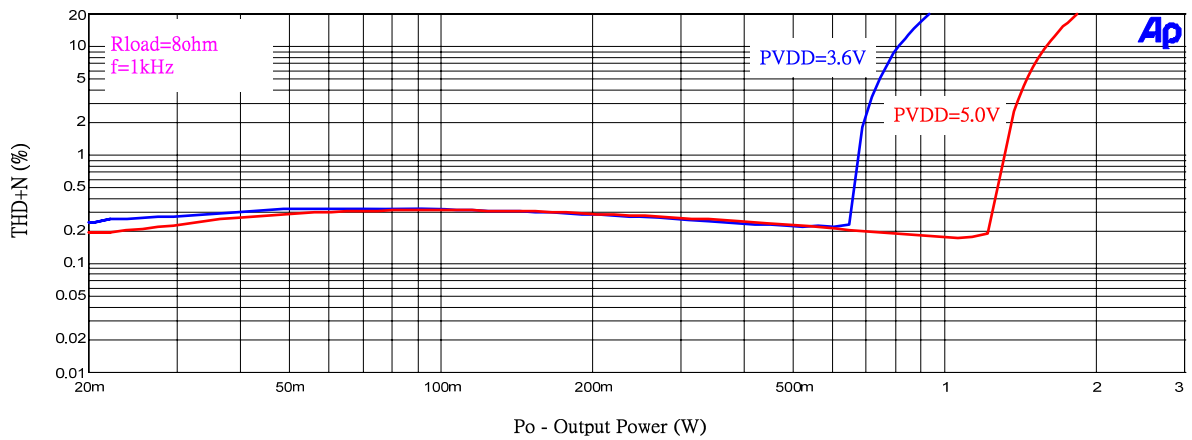
SYMBOL	PARAMETER	CONDITION	MIN	TYP	MAX	UNIT
P <sub>O</sub>	RMS Output Power per Channel	PVDD=5.0V	THD+N = 10 %	1.6		W
			THD+N = 1 %	1.3		W
		PVDD=3.6V	THD+N = 10 %	0.82		W
			THD+N = 1 %	0.66		W
THD+N	Total Harmonic Distortion plus Noise	PVDD=5.0V, P <sub>O</sub> =1.0W		0.2		%
		PVDD=3.6V, P <sub>O</sub> =0.5W		0.23		%
SNR	Signal to Noise Ratio	PVDD=5.0V, P <sub>O</sub> =1.0W		93		dB
PSRR	Power Supply Rejection Ratio	PVDD=3.6V, V <sub>ripple</sub> =200mVpp Inputs ac grounded with C <sub>i</sub> =2μF f=217 Hz		-56		dB
CMRR	Common-Mode Rejection Ratio	PVDD=3.6V, V <sub>IC</sub> =0.1Vpp, f=217Hz		-50		dB
Crosstalk	Crosstalk	PVDD=5V, $f_{in}$ =1kHz V <sub>o</sub> =2Vpp		-91		dB
V <sub>n</sub>	Output integrated noise (A-weighted)	PVDD=3.6V $f_{in}$ =20Hz ~ 20kHz		80		μV
η	Efficiency	PVDD=5V, THD+N=10%		89		%

- Gain= 2 V/V, Load=4Ω,  $f_{in}$ =1 kHz,  $T_A$ =25°C (unless otherwise noted)

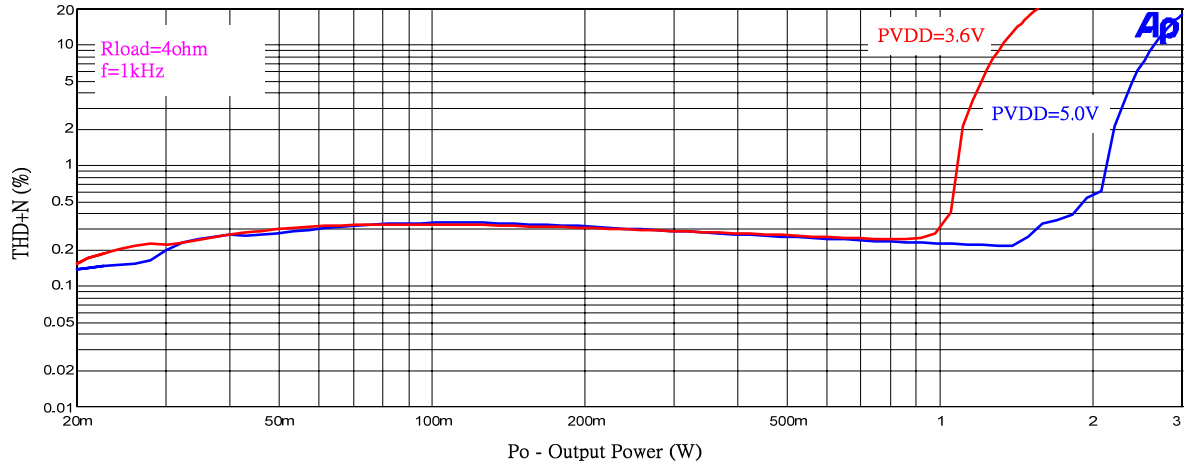
SYMBOL	PARAMETER	CONDITION	MIN	TYP	MAX	UNIT
P <sub>O</sub>	RMS Output Power per Channel	PVDD=5.0V	THD+N = 10 %	2.6		W
			THD+N = 1 %	2.05		W
		PVDD=3.6V	THD+N = 10 %	1.3		W
			THD+N = 1 %	1.05		W
THD+N	Total Harmonic Distortion plus Noise	PVDD=5.0V, P <sub>O</sub> =1.8W		0.18		%
		PVDD=3.6V, P <sub>O</sub> =1.0W		0.22		%
SNR	Signal to Noise Ratio	PVDD=5.0V, P <sub>O</sub> =1.5W		91		dB
PSRR	Power Supply Rejection Ratio	PVDD=3.6V, V <sub>ripple</sub> =200mVpp Inputs ac grounded with C <sub>i</sub> =2μF f=217 Hz		-55		dB
CMRR	Common-Mode Rejection Ratio	PVDD=3.6V, V <sub>IC</sub> =0.1Vpp, f=217Hz		-50		dB
Crosstalk	Crosstalk	PVDD=5V, $f_{in}$ =1kHz, V <sub>o</sub> =2Vpp		-92		dB
V <sub>n</sub>	Output integrated noise (A-weighted)	PVDD=3.6V $f_{in}$ =20Hz ~ 20kHz		73		μV
η	Efficiency	PVDD=5V, THD+N=10%		82		%

## Typical Characteristics (Gain=2 V/V, unless otherwise noted)

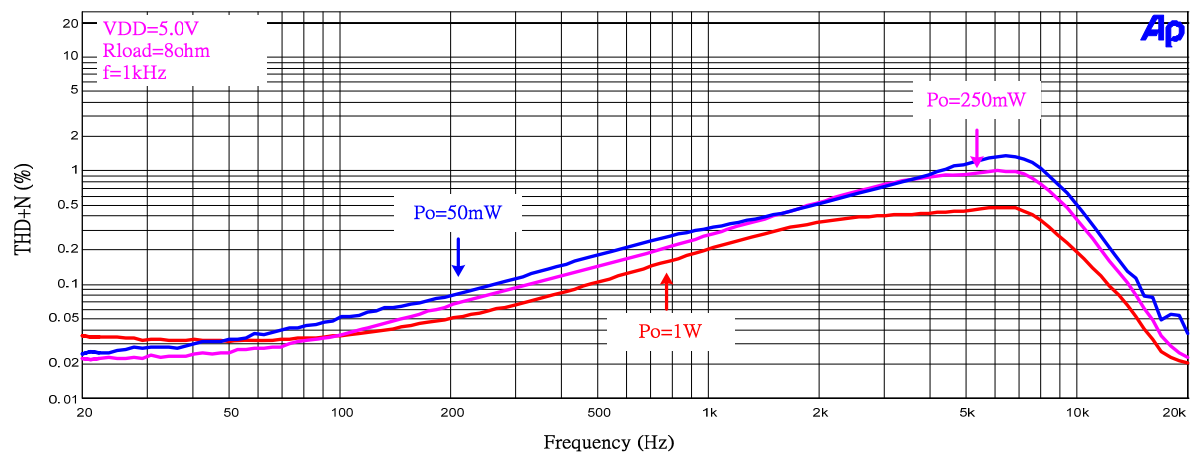
- Total Harmonic Distortion + Noise (THD+N) vs. Output Power (8Ω)



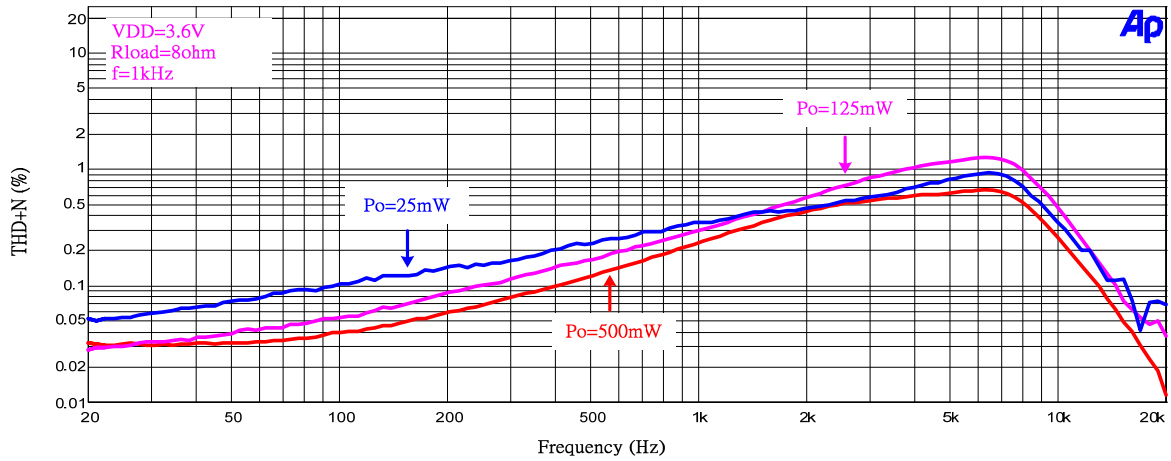
- Total Harmonic Distortion + Noise (THD+N) vs. Output Power (4Ω)



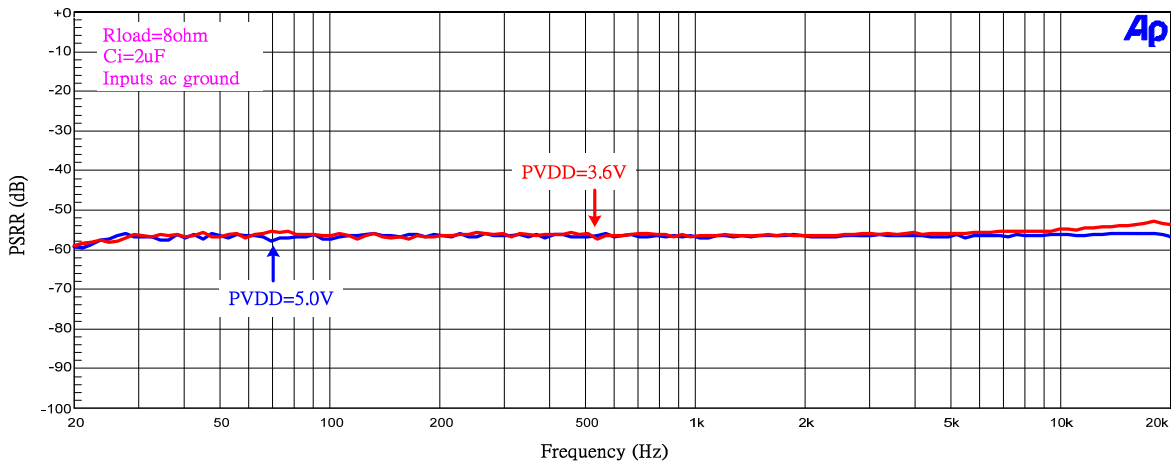
- Total Harmonic Distortion + Noise (THD+N) vs. Signal Frequency (5.0V/8Ω)



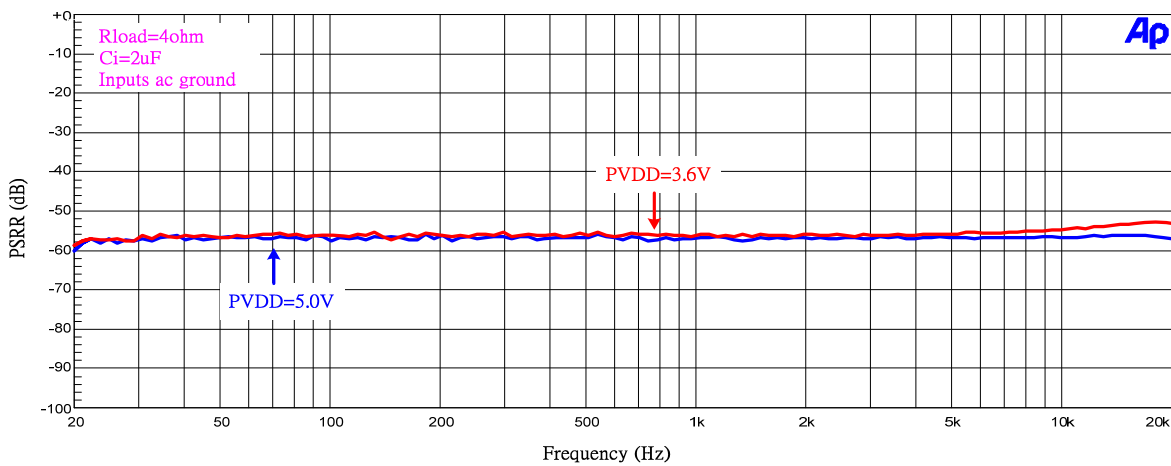
● Total Harmonic Distortion + Noise (THD+N) vs. Signal Frequency (3.6V/8Ω)



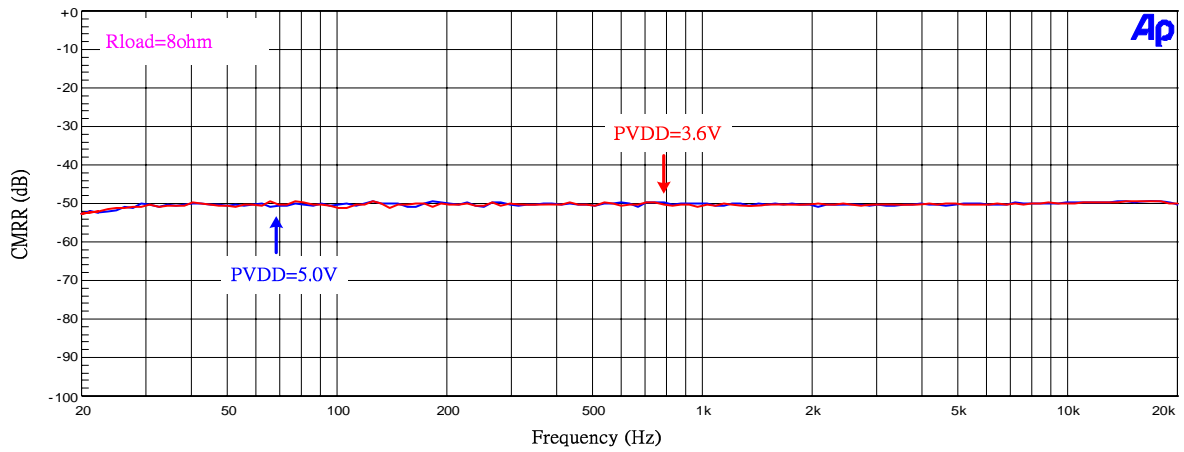
● Power Supply Rejection Ratio vs. Frequency (8Ω)



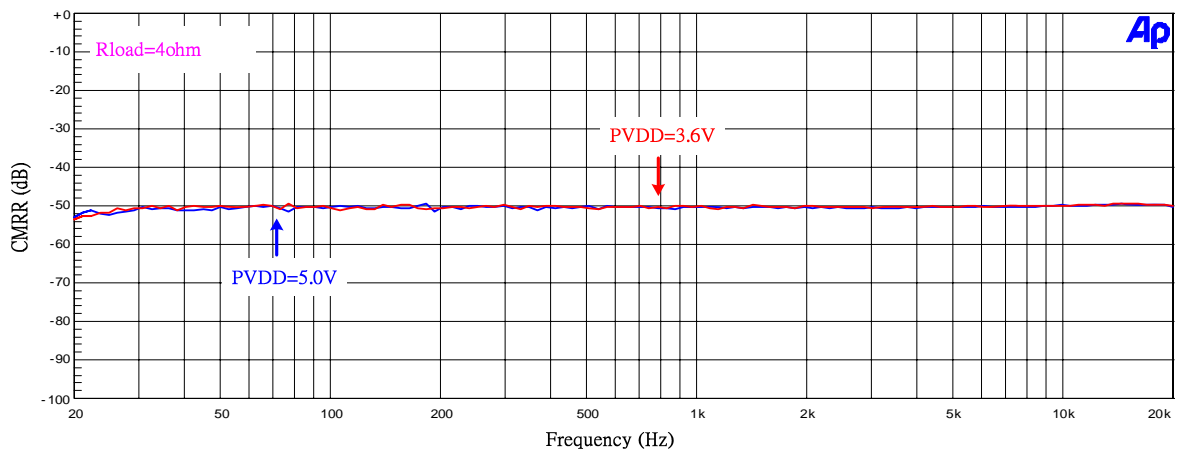
● Power Supply Rejection Ratio vs. Frequency (4Ω)



- Common Mode Rejection Ratio vs. Frequency (8Ω)

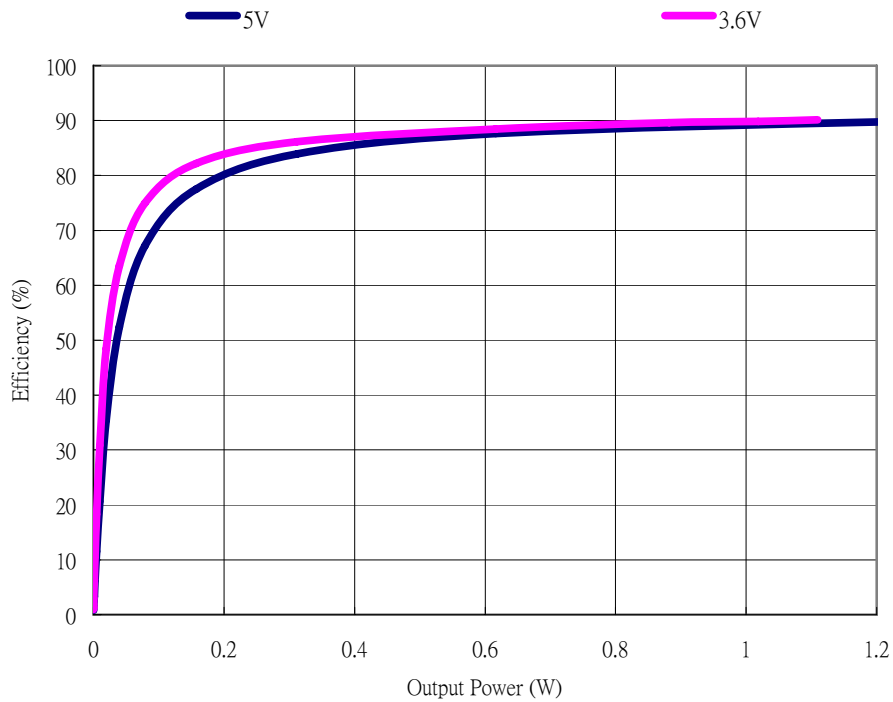


- Common Mode Rejection Ratio vs. Frequency (4Ω)

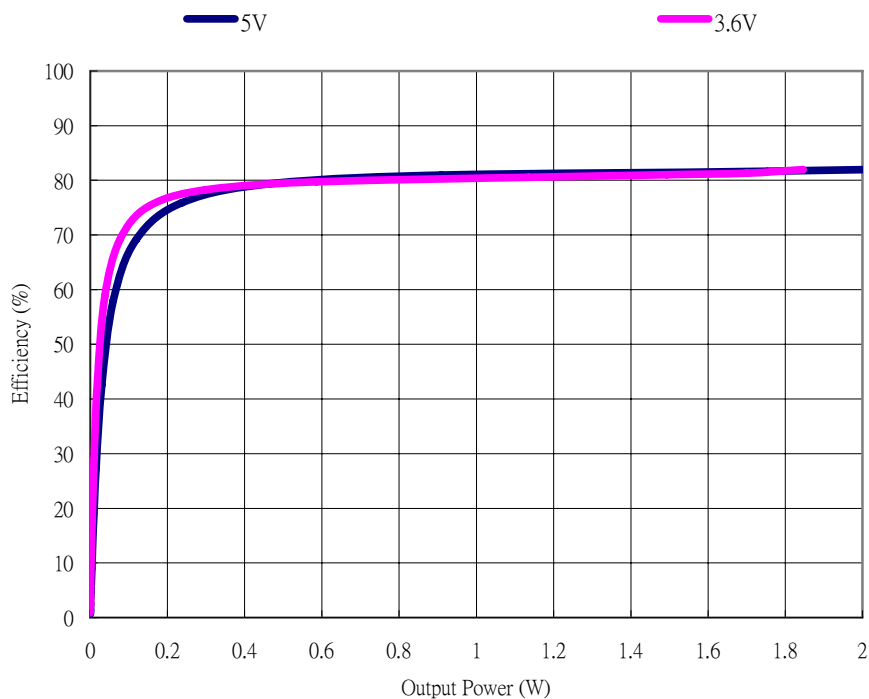




- Efficiency vs. Output Power (8Ω)



- Efficiency vs. Output Power (4Ω)



## Operation Descriptions

- Self-protection circuits (Typical values are used below.)

EMA2016 has built-in over-temperature, overload and voltage detectors.

  - (i) If the internal junction temperature is higher than 150°C, the outputs of loudspeaker drivers will be disabled and at low state. The temperature hysteresis for EMA2016 to return to normal operation is about 30°C. The variation of protected temperature is around 10%.
  - (ii) EMA2016 has built-in independent short-circuit protection for right and left channel. To protect loudspeaker drivers from over-current damage when the wires connected to loudspeakers are shorted to one another or shorted to GND, circuits for the detection of output loading are built in the EMA2016. For normal operation, loudspeaker resistance is larger than 3.2Ω is required. Otherwise, overload detectors may activate. Once one of right and left channel overload detectors is active, loudspeaker drivers of right/left channel will be disabled and at low state. And, EMA2016 will be recovery from short-circuit fault by pulling SDR#/SDL# pin down to low and back to high after removing the short. EMA2016 will be burnt if the lines connected to loudspeakers are shorted to PVDD.
  - (iii) Once the PVDD voltage is lower than 2.5V, EMA2016 will disable and loudspeaker drivers are disabled and at low state, cease EMA2016 beside this circuit. When PVDD becomes larger than 2.6V, EMA2016 will return to normal operation.
- Anti-pop design

EMA2016 is with anti-pop design. Annoying pop sounds during initial power on and power down/up are suppressed. When one of the operations mentioned above is applied, EMA2016 will internally generate appropriate control signals to suppress pop sounds.

## Application information

- Input resistors ( $R_{in}$ ) and input capacitors ( $C_{in}$ )

The total gain of the audio amplifier (EMA2016) is set by input resistor ( $R_{in}$ ) according to the following equation (a). The performance at low frequency (bass) is affected by the corner frequency ( $f_c$ ) of the high-pass filter composed of input resistors ( $R_{in}$ ) and input capacitors ( $C_{in}$ ), determined in equation (b).

$$Gain = \frac{300k\Omega}{R_{in}} \left( \frac{V}{V} \right) \dots\dots\dots (a)$$

$$f_c = \frac{1}{2\pi R_{in} C_{in}} \text{ (Hz)} \dots\dots\dots (b)$$

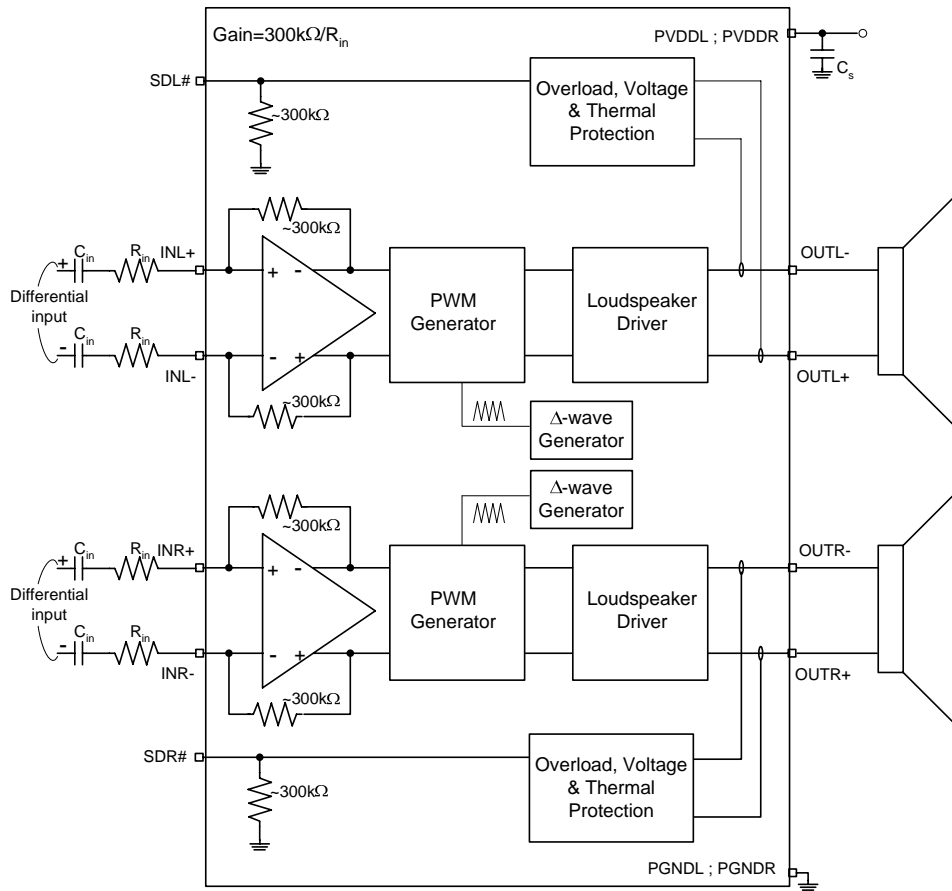
For differential audio signal application, the input capacitors ( $C_{in}$ ), for DC decoupling, are not required. When single-ended audio source is used, the input capacitors ( $C_{in}$ ) are required.

- Decoupling capacitor ( $C_s$ )

Because of the power loss on the trace, which is between the device and decoupling capacitor, the decoupling capacitor should be placed as close as to the device PVDD and PGND to reduce any parasitic resistor or inductor between them. And, a low ESR ceramic capacitor, typically  $1\mu\text{F}$ , is suggested for high frequency transients. For filtering audio band noise signal, a  $10\mu\text{F}$  or greater capacitor (tantalum or electrolytic type) is suggested, but it is not required for most applications because of the high PSRR of this device.

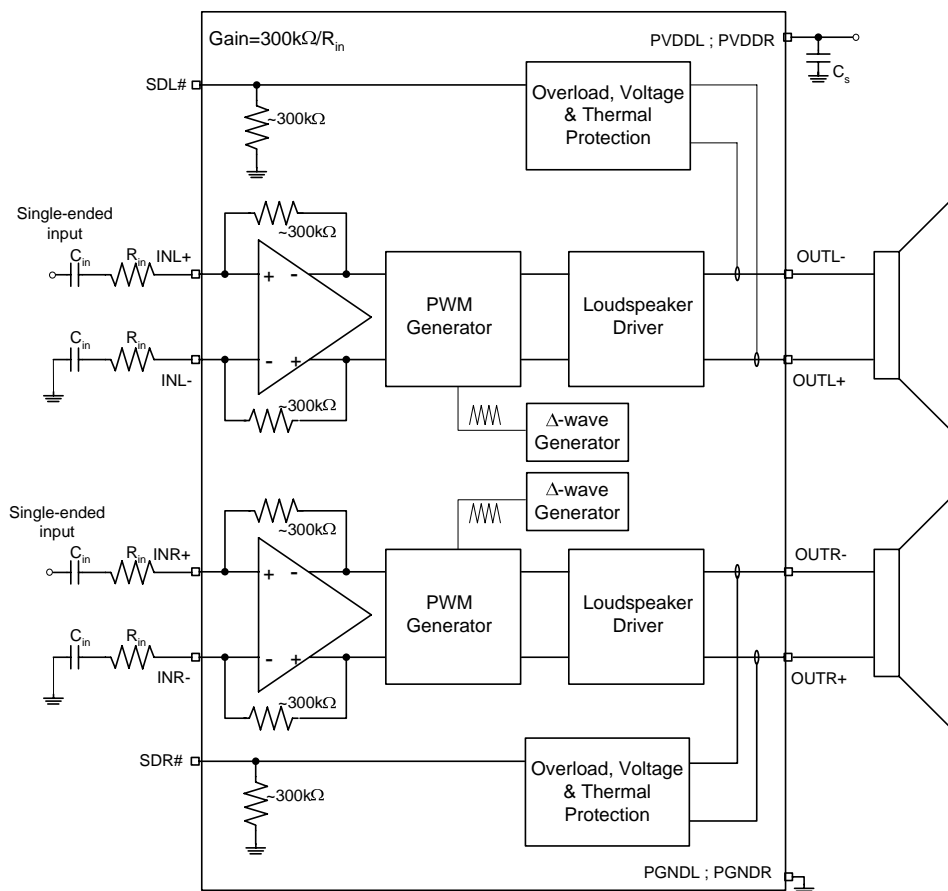
## Application Circuit Example (Filter-less with fully differential input)

- Application circuit for fully differential input



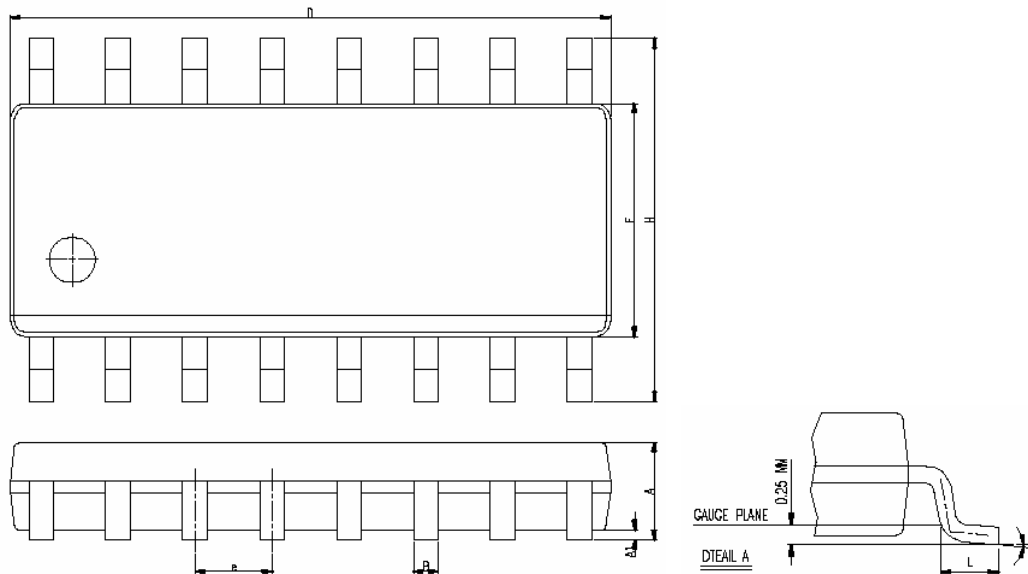
## Application Circuit Example (Filter-less with single-ended input)

- Application circuit for single-ended input



## Package Dimensions

- SOP 16L



SYMBOLS	DIMENSION IN MILLIMETER			DIMENSION IN INCH		
	MIN	NOM	MAX	MIN	NOM	MAX
A	1.35	---	1.75	0.0532	---	0.0688
A1	0.10	---	0.25	0.0040	---	0.0098
B	0.33	---	0.51	0.013	---	0.020
C	0.19	---	0.25	0.0075	---	0.0098
e	1.27 BSC			0.050 BSC		
D	9.80	---	10.00	0.3859	---	0.3937
H	5.80	---	6.20	0.2284	---	0.2440
E	3.80	---	4.00	0.1497	---	0.1574
L	0.40	---	1.27	0.016	---	0.050
h	0.25	---	0.50	0.0099	---	0.0196
θ	0°	---	8°	0°	---	8°

## Revision History

Revision	Date	Description
0.1	2009.03.30	Original
1.0	2009.10.30	Removed the letters of "Preliminary"

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