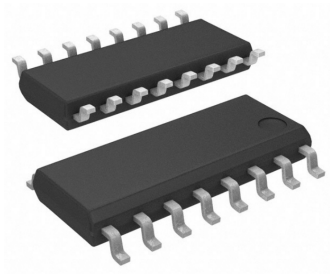
Filterless 3W Class-D Stereo Audio Amplifier

Features

- 3W Output at 10% THD with a 4Ω Load and 5V Power Supply
- Filterless, Low Quiescent Current and Low EMI
- Low THD+N
- Low Noise
- Efficiency up to 90%
- Short Circuit Protection
- Thermal Shutdown
- Less External Components to Save the Space and Cost
- Single End Inputs

SOP-16



Description

The AM3820A is a 3W, class-D audio amplifier. It offers low THD+N, allowing it to achieve high- quality sound reproduction. The new filterless architecture allows the device to drive the speaker directly, requiring no low-pass output filters, thus to save the system cost and PCB area.

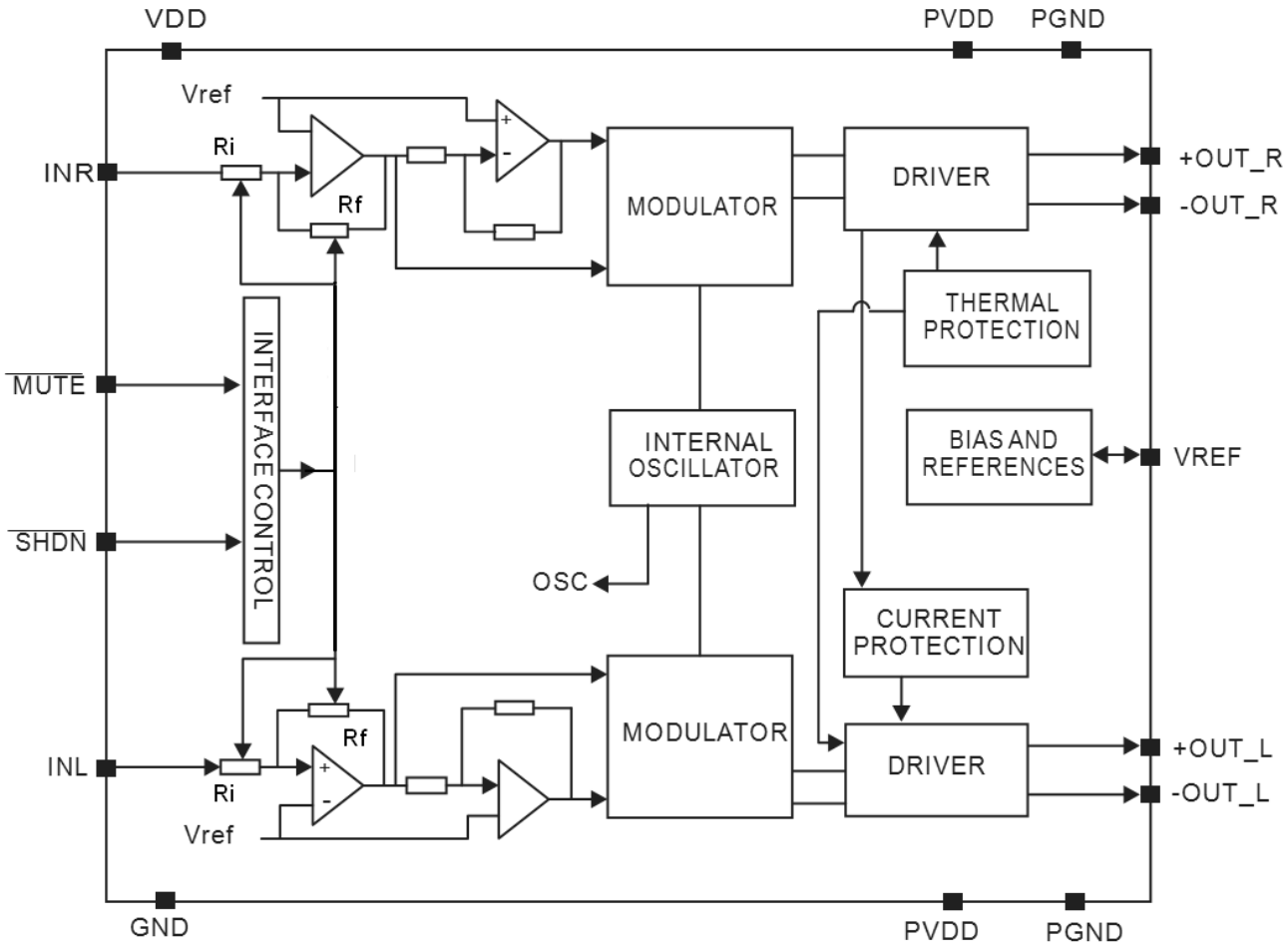
With similar number of external components, the efficiency of the AM3820A is much better than that of its class-AB cousins. It extends the battery life, which is ideal for portable applications.

The AM3820A is available in SOP-16 package.

Applications

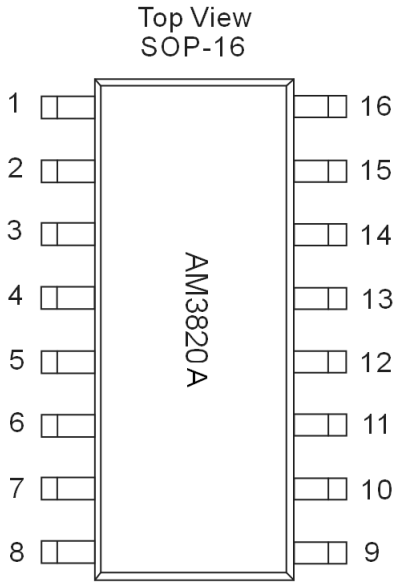
- LCD Monitors / TV Projectors
- Notebook Computers
- Portable Speakers
- Portable DVD Players, Game Machines
- Cellular Phones/Speaker Phones

1 Block diagram



2 Pin description

2.1 Pin out



2.2 Pin out

PIN		I/O/P	DESCRIPTION
NAME	NO		
+OUT_L	1	O	Left Channel Positive Output
PGND	2	P	Power GND
-OUT_L	3	O	Left Channel Negative Output
PVDD	4	P	Power VDD
$\overline{\text{MUTE}}$	5	I	Mute Control Input（active low）
VDD	6	P	Analog VDD
INL	7	I	Left Channel Input
VREF	8	O	Internal analog reference, connect a bypass capacitor from VREF to GND
NC	9	I	No connect
INR	10	I	Right Channel Input
GND	11	P	Analog GND
$\overline{\text{SHDN}}$	12	I	Shutdown Control Input (active low)
PVDD	13	P	Power VDD
-OUT_R	14	O	Right Channel Negative Output
PGND	15	P	Power GND
+OUT_R	16	O	Right Channel Positive Output

3 Electrical specifications

3.1 Absolute maximum ratings

			UNIT
Supply voltage		VDD, PVDD	–0.3 V to 6 V
Input voltage		$\overline{SHDN}$, $\overline{MUTE}$	–0.3 V to VDD + 0.3 V
T_A	Operating free-air temperature range		–40°C to 85°C
T_J	Operating junction temperature range		–40°C to 125°C
T_{Jmax}	Maximum junction temperature		150°C
T_{stg}	Storage temperature range		–65°C to 150°C
T_{solder}	Soldering temperature		300°C, 5 sec
ESD	Electrostatic discharge	Human body model	2000 V
		Machine model	200 V

3.2 Thermal information

THERMAL METRIC		SOP-16	UNITS
θ_{JA}	Junction-to-ambient thermal resistance	110	°C/W
θ_{JC}	Junction-to-case thermal resistance	23	

3.3 Recommended operating conditions

PARAME		TEST CONDITIONS	MIN	MAX	UNIT
V_{DD}	Supply voltage	PVDD, VDD	2.5	5.5	V
T_A	Operating free-air temperature		–40	85	°C
T_J	Operating junction temperature		–40	125	°C

3.4 Electrical specifications

V_{DD}=5V, Gain=24dB, R_L=8Ω, T_A=25°C, unless otherwise noted.

Symbol	Paramet	Test Conditions		MIN	TYP	MAX	UNIT
VIN	Supply Power			2.5		5.5	V
Po	Output Power	THD+N=10%,f=1kHz, R_L=4 Ω	VDD=5.0V		3.2		W
			V_{DD}=3.6V		1.6		
			V_{DD}=3.0V		1.3		
		THD+N=1%,f=1kHz, R_L=4 Ω	VDD=5.0V		2.5		W
			VDD=3.6V		1.3		
			VDD=3.0V		0.85		
		THD+N=10%,f=1kHz, R_L=8 Ω	V_{DD}=5.0V		1.8		W
			V_{DD}=3.6V		0.9		
			VDD=3.0V		0.6		
		THD+N=1%,f=1kHz, RL=8 Ω	V_{DD}=5.0V		1.4		W
			V_{DD}=3.6V		0.72		
			V_{DD}=3.0V		0.45		
THD+N	Total Harmonic Distortion Plus Noise	V_{DD}=5.0V,Po=0.5W,R_L=8 Ω	f=1kHz		0.15		%
		VDD=3.6V,Po=0.5W,RL=8 Ω			0.11		
		V_{DD}=5.0V,Po=1W,R_L=4 Ω	f=1kHz		0.15		%
		V_{DD}=3.6V,Po=1W,R_L=4 Ω			0.11		
Gv	Gain				24		dB
PSRR	Power Supply Ripple Rejection	V_{DD}=5.0V, Inputs ac-grounded with C_{IN} =0.47μF	f=100Hz		-59		dB
			f=1kHz		-58		
Cs	Cross talk	V_{DD}=5V,Po=0.5W,R_L=8Ω,Gv=20d	F=1kHz		-95		dB
SNR	Signal-to-noise ratio	V_{DD}=5V, Vorms=1V,Gv=20dB	f=1kHz		80		dB
Vn	Output noise	V_{DD}=5V, Inputs ac-grounded with C_{IN} =0.47μF	A-weighted		120		μV
			Non A-weighted		180		
Dyn	Dynamic range	V_{DD}=5.0V, THD=1%	f=1kHz		90		dB
η	Efficiency	R_L=8Ω, THD=10%	f=1kHz		87		%
		R_L=4Ω, THD=10%			83		
IQ	Quiescent Current	VDD=5.0	No load		7.2		mA
		V_{DD}=3.6			5.7		
		VDD=3.0			5.		

3.4 Electrical specifications (Continued)

V_{DD}=5V Gain=24dB, R_L=8Ω, T_A=25°C, unless otherwise noted.

Symbol	Parameter	Test Conditions		MIN	TYP	MAX	UNIT
IMUT	Muting Current	VDD=5.0	VMUTE		3.0		mA
IS	Shutdown Current	VDD=2.5V to 5.5V	Vsd=0.3V		0.7		μA
Rdson	Static Drain-to-source On-state Resistor	IDS=500mA,Vgs=5V	PMOS		300		mΩ
			NMOS		150		
fsw	Switching Frequency	VDD=3V to 5V			275		kHz
Vos	Output Offset Voltage	Vin=0V, VDD=5V			10		mV
V_{IH}	Enable Input High Voltage	V_{DD}=5.0		1.5	1.4		V
V_{IL}	Enable Input Low Voltage	V_{DD}=5.0			0.7	0.4	
V_{IH}	$\overline{MUTE}$ Input High Voltage	V_{DD}=5.0		1.5	1.4		V
V_{IL}	$\overline{MUTE}$ Input Low Voltage	V_{DD}=5.0			0.7	0.4	
OTP	Over Temperature Protection	No Load, Junction Temperature	VDD=5V		140		°C
OTH	Over Temperature Hysteresis				30		

4 APPLICATION INFORMATION

Maximum Gain

As shown in block diagram (page 2), AM3820A has two internal amplifier stages. The first stage's gain is externally configurable, while the second stage's is internally fixed. The closed-loop gain of the first stage is set by selecting the ratio of Rf to Ri. The second stage's gain is 2.33x. The output of amplifier 1 serves as the input to amplifier 2, thus the two amplifiers produce signals identical in magnitude, but different in phase by 180°. Consequently, the differential gain for the IC is

$$A_{VD}=20*\log [2*(Rf/Ri+R1)*2.33]$$

Where Rf and Ri are the internal gain setting resistors as shown in the block diagram.
R1 is the external resistor shown in the application circuit (section 6) to reduce the overall gain of the system.

The maximum Rf on the chip is 86k Ω and minimum Ri is 25kΩ, so the maximum closed-loop gain is 24dB when external gain setting resistor, R1, is shorted circuit. However, to allow adequate dynamic range for the input signal, R1 should be less than 100kΩ.

$\overline{\text{Mute}}$ Operation

The $\overline{\text{MUTE}}$ pin is an input for controlling the output state of the AM3820A. A logic low on this pin disables the outputs, and a logic high on this pin enables the outputs. This pin may be used as a quick disable or enable of the outputs without a volume fade out. Quiescent current is listed in the electrical characteristic table. The $\overline{\text{MUTE}}$ pin can be left floating as it is internally pulled up.

Shutdown operation

In order to reduce power consumption while not in use, the AM3820A contains shutdown circuitry to turn off the amplifier's bias circuitry. This shutdown feature turns the amplifier off when logic low is applied to the $\overline{\text{SHDN}}$ pin. By switching the $\overline{\text{SHDN}}$ pin connected to GND, the AM3820A supply current draw will be minimized in idle mode. The $\overline{\text{SHDN}}$ pin can also be left floating because of the internal pull-up.

Power supply decoupling

The AM3820A is a high performance CMOS audio amplifier that requires adequate power supply decoupling to keep the output THD and PSRR low. Power supply decoupling affects low frequency response. Optimum decoupling is achieved by using two capacitors of different types targeting at different types of noise on the power supply rails. For higher frequency transients, spikes, or digital harsh on the line, a good low equivalent-series-resistance (ESR) ceramic capacitor, typically 1.0μF, being placed as close as possible to the device VDD terminal, will do the job. For filtering of lower-frequency noise, a large capacitor of 20μF (ceramic) or greater is recommended. Also, it should be placed near the audio power amplifier.

Input Capacitor (Ci)

Large input capacitors are both expensive and bulky for portable designs. However, a certain sized capacitor is needed to couple in low frequencies without severe attenuation. In many cases the speakers used in portable systems, whether internal or external, have little ability to perfectly reproduce signals below 100Hz to 150Hz. Thus, using a large input capacitor may not increase actual system performance. In this case, input capacitor (Ci) and input resistance (Ri) of the amplifier form a high-pass filter with the corner frequency determined by equation below,

$$f_C = 1 / (2\pi RiCi)$$

In addition to system cost and size, click and pop performance is affected by the size of the input coupling capacitor, Ci. A larger input coupling capacitor requires more charge to reach its quiescent DC voltage. This charge comes from the internal circuit via the feedback and is apt to create pops upon device enable. Thus, by minimizing the capacitor size based on necessary low frequency response, turn-on pops can be minimized.

Analog Reference Bypass Capacitor (C_{BYP})

The Analog Reference Bypass Capacitor (C_{BYP}) is the most critical capacitor and serves several important functions. During start-up or recovery from shutdown mode, C_{BYP} determines the rate at which the amplifier starts up. The second function is to reduce noise caused by the power supply coupling into the output drive signal. This noise is from the internal analog reference to the amplifier, which appears as degraded PSRR and THD+N.

A ceramic bypass capacitor (C_{BYP}) with values of 0.47μF to 1.0μF is recommended for the best THD and noise performance. Increasing the bypass capacitor reduces clicking and popping noise from power on/off and entering and leaving shutdown.

Under Voltage Lock-out (UVLO)

The AM3820A incorporates circuitry designed to detect low supply voltage. When the supply voltage drops to 2.0V or below, the AM3820A outputs are disabled. The device will come out of this state and resumes normal operation when VDD rises above 2.2V.

Short Circuit Protection (SCP)

The AM3820A has short circuit protection circuitry on the outputs to prevent damage to the device when output-to-output, output-to-GND or output-to-VDD short occurs. When a short circuit is detected on the outputs, the outputs are disabled immediately. If the short-circuit condition is removed, the device activates again.

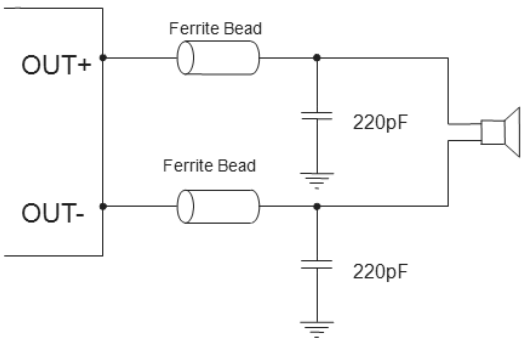
Over Temperature Protection

Thermal protection on the AM3820A prevents the device from damage when the internal die temperature exceeds 140°C. There is a 15 degree tolerance on this trip point from device to device. Once the die temperature exceeds the thermal set point, the device outputs are disabled. This is not a permanently latched fault state. The thermal fault condition is cleared once the temperature of the die is reduced by 30°C.

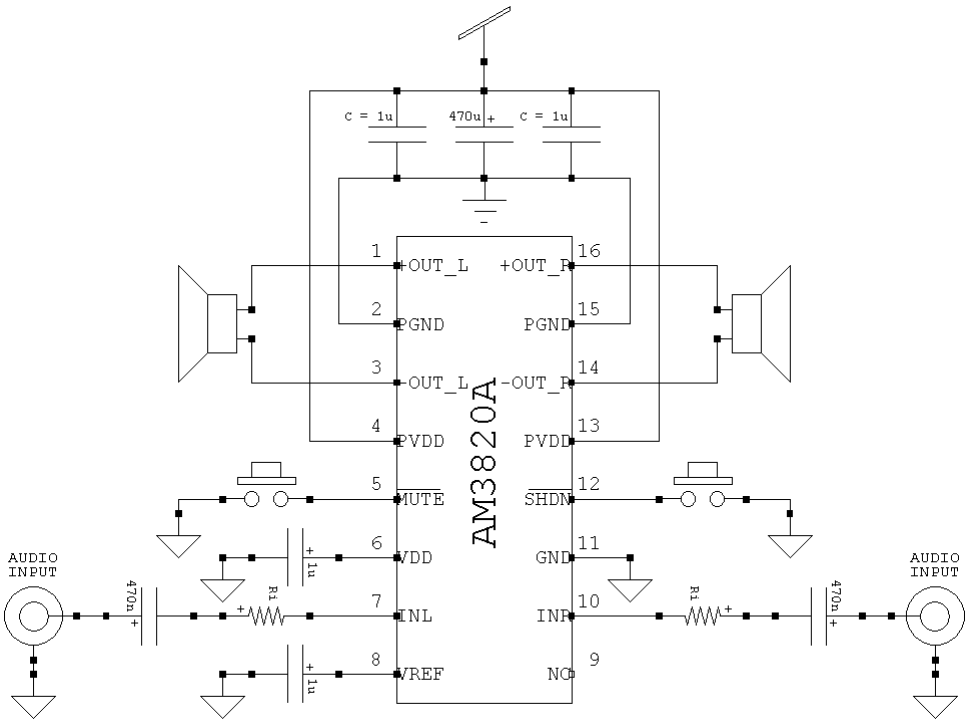
How to Reduce EMI (Electro Magnetic Interference)

A simple solution is to put an additional capacitor 1000μF at power supply terminal for power line coupling if the traces from amplifier to speakers are short (<20cm).

Most applications require a ferrite bead filter as shown in following circuit. The ferrite filter reduces EMI of around 1 MHz and higher. When selecting a ferrite bead, choose one with high impedance at high frequencies, and low impedance at low frequencies.

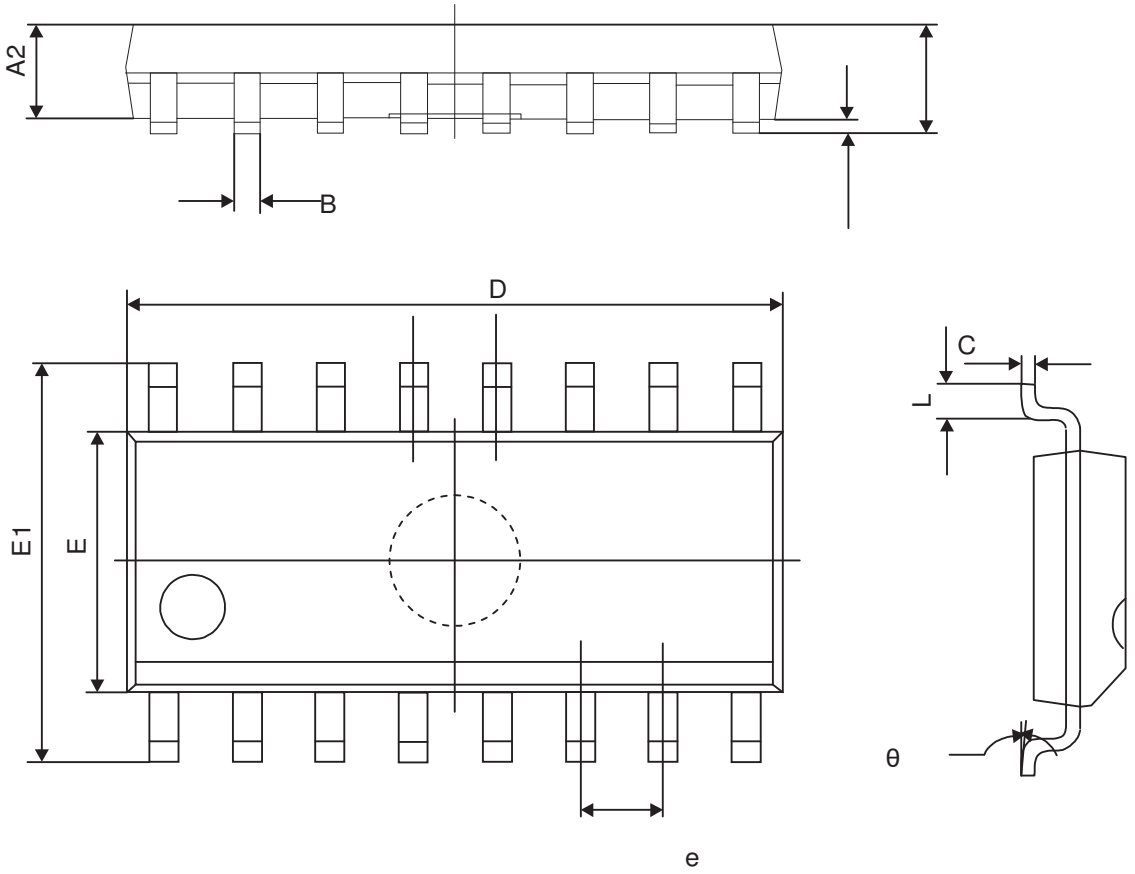


5 Application circuit



6 Package Information

SOP-16



Symbol	Dimensions Millimeters	
	Min	Max
A	1.350	1.750
A1	0.100	0.250
A2	1.350	1.550
B	0.330	0.510
C	0.190	0.250
D	9.800	10.000
E	3.800	4.000
E1	5.800	6.300
e	1.270(TYP)	
L	0.400	1.270
θ	0º	8º