VA2110

30W Mono Class D Audio Amplifier

General Description

The VA2110 is a low cost/high power Class D mono audio power amplifier that operates in wide range of various power supplies. VA2110 is designed with 36dB fixed gain setting. VA2110 can output 30W into 4Ω load with lower supply current and fewer external components for driving bridged-tied mono speaker directly.

VA2110 operates with high efficiency energy conversion up to 88% (8Ω Load) so that the external heat sink can be minimized while playing music.

VA2110 also integrates Anti-Pop, Output Short & Over-Heat Protection Circuitry to ensure device reliability. This device also provides the DC detect and protection scheme to prevent the damage of speaker voice coils.

The VA2110 is available in small SO-10P green package with exposed pad.

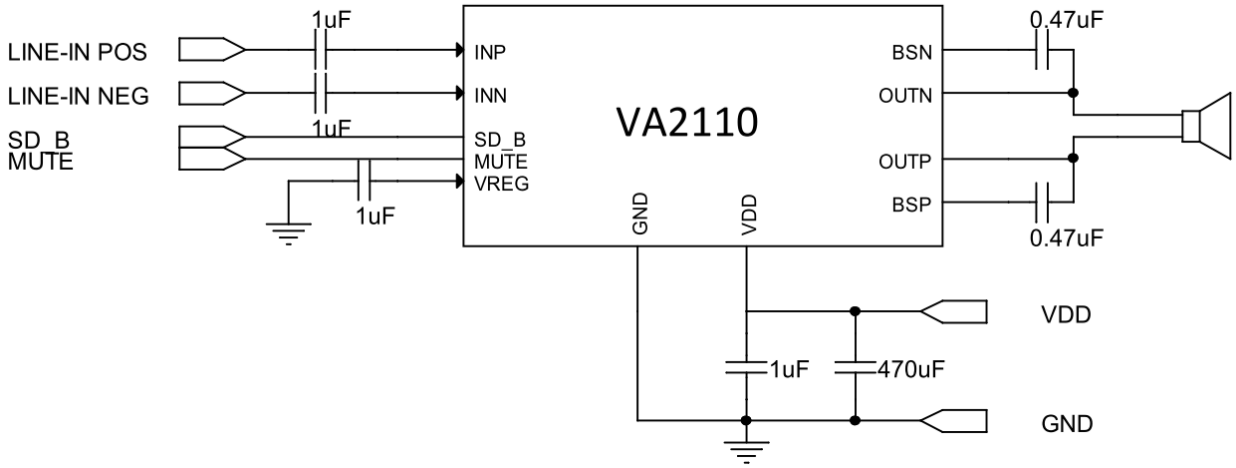
Features

- Operation Voltage from 6.0V to 26V
- Maximum 88% Efficiency with an 8Ω Speaker
- 18W@4Ω Load with THD+N =10% at 12V
- 30W@4Ω Load with THD+N =1% at 18V
- Fixed 36dB Gain Setting
- Mute Control for Less CODEC Pop-up Noise
- Speaker DC Detection and Protection
- Thermal Protection with Auto-Recovery
- Short Circuit and Thermal Protection
- RoHS 2.0 compliant SO-10P Green Package with Exposed Pad

Applications

- Woofers
- Boom-Box

Typical Application



Absolutely Maximum Ratings

Over operating free-air temperature range, unless otherwise specified (* 1)

Symbol	Parameter	Limit	Unit
V_{DD}(VDD)	Supply voltage	-0.3 to 30	V
LV_{DD}(VREG)	Low Voltage Input	-0.3 to 6	V
V_I (INP, INN, SD_B, MUTE)	Input voltage	-0.3 to 6.5	V
T_A	Operating free-air temperature range	-40 ~ +85	°C
T_J	Operating junction temperature range(* 2)	-40 to +150	°C
T_{STG}	Storage temperature range	-65 to 150	°C
$R_{(LOAD)}$	Minimum load resistance	4	Ω
θ_{JC}	Thermal Resistance (Junction to Case)	10	°C/W
θ_{JA}	Thermal Resistance (Junction to Air)	50	°C/W
Electrostatic discharge	Human body model	±2	kV
Electrostatic discharge	Machine model	±200	V

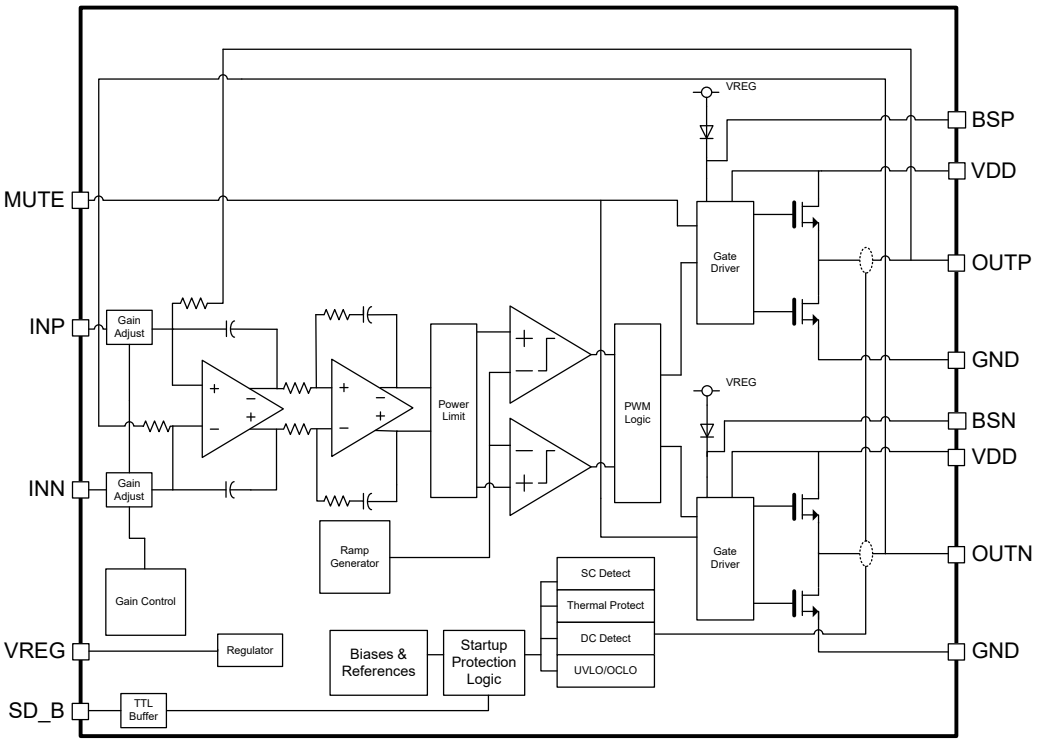
(*1): Stress beyond those listed at "absolute maximum rating" table may cause permanent damage to the device. These are stress rating ONLY. For

Recommended Operating Conditions

Over operating free-air temperature range, unless otherwise specified.

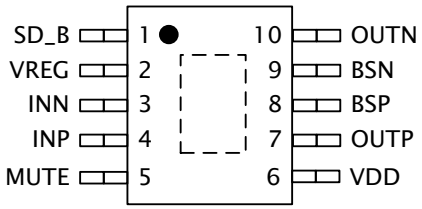
Symbol	Parameter	Test Condition	Specification		Unit
			Min	Max	
V_{DD}	Supply voltage	VDD	6.0	26	V
T_A	Operating free-air temperature		-40	85	°C

Functional Block Diagram



Pin Assignments And Descriptions

SO-10P
Top View



Pin No.	Pin	I/O/P	Function Description
1	SD_B	O	Shutdown control terminal. Low active. TTL Logic levels with compliance to VDD.
2	VREG	O	Internal regulator output.
3	INN	O	Negative audio signal input.
4	INP	O	Positive audio signal input.
5	MUTE	P	Mute signal for fast disable/enable of outputs (HIGH = outputs Hi-Z, LOW = outputs enabled). TTL logic levels with compliance to VREG.
6	VDD	P	Power Supply.
7	OUTP	I	Output positive PWM output.
8	BSP	O	Bootstrap I/O for positive high-side switch.
9	BSN	O	Bootstrap I/O for negative high-side switch.
10	OUTN	O	Output negative PWM output.
EP	GND	P	Ground.

Electrical Characteristics

T_A = 25℃, V_{DD} = 12V, R_L=8Ω, unless otherwise noted.

Symbol	Parameter	Test Condition		Specification			Unit
				Min	Typ.	Max	
$\|V_{OS}\|$	Output offset voltage (measured differentially)	V_I=0V			2	20	mV
I_Q	Quiescent current	No load, Without L/C filter			24	45	mA
I_{SD}	Shutdown current	No load			300	500	μA
t_{ON}	Turn-on time					30	ms
f_{OSC}	Internal oscillation frequency				260		kHz
A	Amplifier gain	VDD=12V			36		dB
$R_{DS(ON)}$	Drain-Source ON resistance[1]	V_{DD}=12V, I_{OUT}=500mA	High Side		120		mΩ
			Low Side		120		
V_{REG}	Regulator output	I_{VREG} = 100μA, V_{DD}=6~26V		5.25	5.75	6.25	V
t_{DC-DET}	DC detect time				450		ms

(1) Design center value.

Operating Characteristics

V_{DD}=12V, T_A = 25℃ unless otherwise noted.

Symbol	Parameter	Test Condition		Specification			Unit
				Min	Typ.	Max	
P_O	Output power	THD+N=1%, f=1kHz, R_L=4Ω	V_{DD} = 18V		30		W
		THD+N=10%, f=1kHz, R_L=4Ω	V_{DD} = 12V		17.8		W
THD+N	Total harmonic distortion plus noise	V_{DD}=12V, P_O=5W, R_L=4Ω, f=1kHz			0.05		%
$\|V_{OS}\|$	Offset voltage					20	mV
$\|K_{SVR}\|$	Supply ripple rejection ration	Input AC-Grounded, C_i=1μF, f=1kHz			68		dB
|SNR|	Signal-to-Noise ratio	A-weighted, THD+N=1%, R_L=8Ω			94		dB
V_n	Output voltage noise	V_{DD}=12V, f=20Hz to 20kHz, Input AC-Grounded, C_i=1μF	No Weight		330		μV_{RMS}
			A-Weighted		160		
|CMRR|	Common mode rejection ratio	V_{DD}=12V, V_{IC}=1V_{PP}	f=120Hz		66		dB
Z_I	Input impedance				9		kΩ

Functional Descriptions

Fixed Gain Setting And Input Impedance

The gain of the VA2110 is fixed at 36dB. The input resistance is depended on the gain setting. Since the gain setting is determined by the ratio of the internal feedback resistive network, the variation of the gain is small. But the absolute value of the input resistance may shift by ±20% at the same gain. In actual design cases, 80% of nominal value should be assumed as the input resistance of VA2110 in the input network of whole amplifier. The value of VA2110 input resistance is typically 9kΩ, from 10.8kΩ to 7.2kΩ.

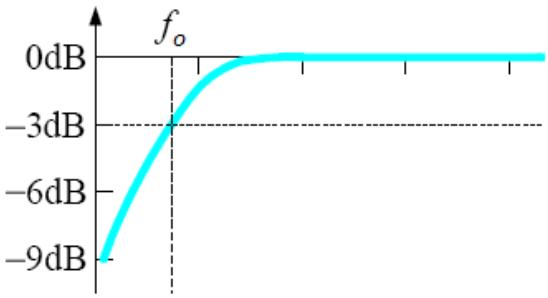


Figure 1. Cut-off point of high-pass filter

In most cases, no extra resistor needs to be added on the input of VA2110. The actual input resistor is already determined with the gain. If a single capacitor is used in the input high-pass filter, the cut-off frequency fo may vary with the change of gain setting. The -3dB point of the cut-off frequency can be calculated by the following equation,

$$fo = \frac{1}{2\pi \times R_I \times C_I} \quad \text{(Hz)} \quad \text{Equation (1)}$$

,where the R_I values is the typical input resistance 9kΩ.

VREG Supply

The V_{REG} Supply is used to bias the gates of the output full-bridge upper half MOSFETs. Add at least 1μF capacitor to ground at this pin.

Speaker Protection

Due to the nature of Class D amplifiers, the speaker may have DC current if the audio inputs get DC voltage in any case. An output DC fault will shut down the audio amplifier and change the state of output into high impedance.

To resolve the case of DC input, it is good to treat it as very low frequency sine wave much lower than audio band such as 2Hz. Based on this criteria, a DC detect fault shall be issued when the output differential duty-cycle of either channel exceeds 14% for more than 450ms at the same polarity. This feature protects the speaker away from large currents.

The minimum differential input DC voltages required to trigger the DC detection fault are 17mV, since the gain is fixed at 36dB.

To resume the normal operation, it is necessary to power off the amplifier and then power on again.

Short Circuit Protection

VA2110 has protection from over-current conditions caused by a short circuit on the output stage. And short circuit protection is latch with auto recovery. The short latch will be release after a short period about every 450ms.

Thermal Protection

Thermal protection on the VA2110 prevents damage to the device when the internal die temperature exceeds 150°C. There is a ±20°C tolerance on this trip point from device to device. Once the die temperature exceeds the thermal set point, the

Functional Descriptions (cont.)

device enters into 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 is reduced by 20°C. VA2110 will be back to normal operation at this point with no external system interaction.

Shutdown Operation

The VA2110 employs a state of shutdown mode to reduce supply current to the absolute minimum level during periods of nonuse for power conservation. This terminal should be held high during normal operation when the amplifier is in normal operating. Pulling low causes the output drivers shutdown and the amplifier to enter a low-current state. Do not leave it unconnected, because there is no weakly pulling resistor inside the amplifier.

Remember that to place the amplifier in the shutdown state prior to removing the power supply voltage so that power-off pop noise can be eliminated.

Mute Operation

The MUTE pin is an input for controlling the output state of the VA2110. A logic high on this terminal disables the outputs. A logic low on this pin enables the outputs. This terminal may be used as a quick disable/enable of outputs when transitioning between different audio sources, or turning off output stage to eliminate the charging noise from upstream CODEC capacitor. The MUTE terminal is recommended not to be left floating. For power conservation, the SD_B terminal should be used to reduce the quiescent current to the absolute minimum level.

Please note that MUTE is 5V level TTL compliant, do not connect it to VDD or any other source which is higher than 5V.

Application Information

Output Filter

Design the VA2110 without the filter if the traces from amplifier to speaker are short (< 10cm), where the speaker is in the same enclosure as the amplifier is a typical application for class D without a filter. Many applications require a ferrite bead filter at least. The ferrite filter reduces EMI above 30MHz. When selecting a ferrite bead, choose one with high impedance at high frequencies, but low impedance at low frequencies, be aware of its maximum current limitation.

Use an LC output filter if there are low frequency (<1 MHz) EMI sensitive circuits and there are long wires from the amplifier to the speaker.

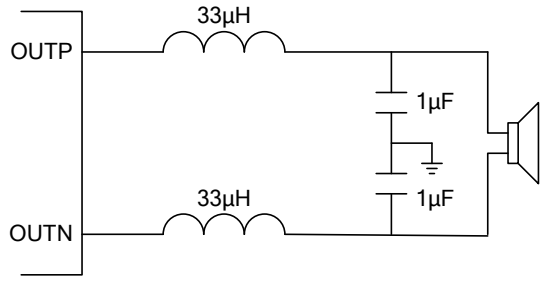


Figure 2. Typical LC Output Filter, Speaker Impedance=8Ω

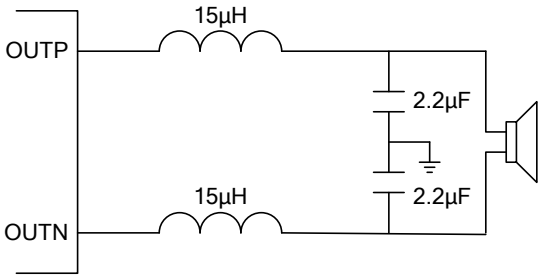


Figure 3. Typical LC Output Filter, Speaker Impedance=4Ω

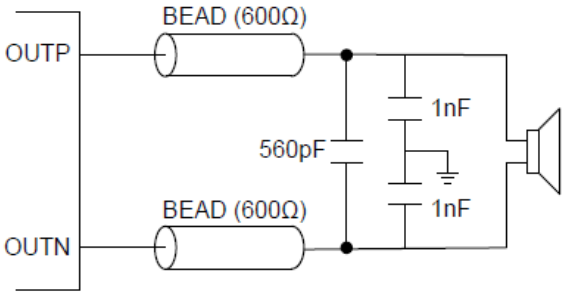


Figure 4. Typical Ferrite Chip Bead Output Filter

Inductors used in LC filters must be selected carefully. A significant change in inductance at the peak output current of the VA2110 will cause increased distortion. The change of inductance at currents up to the peak output current must be less than 0.1µH per amp to avoid this. Also note that smaller inductors than 15µH may cause an increase in distortion above what is shown in preceding graphs of THD versus frequency and output power.

Like the selection of the inductor in LC filters, the capacitor must be selected carefully, too. A significant change in capacitance at the peak output voltage of the VA2110 will cause increased distortion. LC filter capacitors should be double of DC voltage ratings of the peak application voltage (the power supply voltage) at least. In general, it is strongly recommended using capacitors with good temperature performance like X5R series.

Output Snubbers

In Figure 5, the 330pF capacitors in series with 10Ω resistors connected with the outputs of the VA2110 are snubber circuits. They smooth switching transitions and reduce overshoot and ringing. With these networks, THD+N can be improved at lower power levels and EMC can be reduced 2~4 dB at middle frequencies. They increase quiescent current by 3mA~11mA depending on supply voltage.

Application Information (cont.)

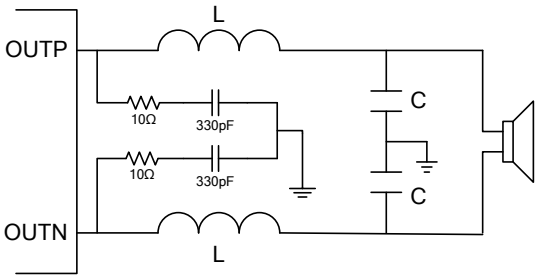


Figure 5. Output Snubber Circuits

Low ESR Capacitors

Low ESR capacitors are high recommended for this application. In general, a practical capacitor can be modeled simply as a resistor in series with an ideal capacitor. The voltage drop across this unwanted resistor can eliminate the effects of the ideal capacitor. Place low ESR capacitors on supply circuitry can improve THD+N performance.

Boot-Strap Capacitors

The full H-bridge output stages use only MOS transistors. Therefore, they require bootstrap capacitors for the high side of each output to turn on correctly. A 0.47μF ceramic capacitor, rated for at least 25V, must be connected from each output to its corresponding boot-strap input. Specifically, one 0.47μF capacitor must be connected from OUTP to BSP, and one 0.47μF capacitor must be connected from OUTN to BSN.

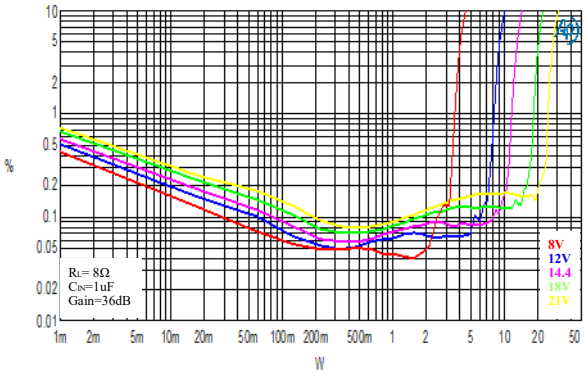
The bootstrap capacitors connected between the BSP or BSN pins and corresponding output function as a floating power supply for the high side N-channel power MOSFET gate drive circuitry. During each high side switching cycle, the bootstrap capacitors hold the gate-to-source voltage high enough to keep the high-side MOSFETs turned on.

Decoupling Capacitors

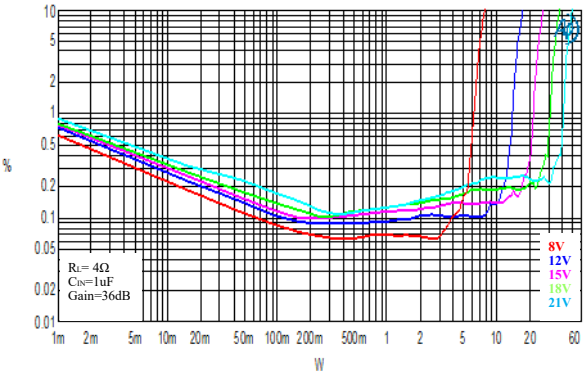
VA2110 requires appropriate power decoupling to minimize the output total harmonic distortion (THD) and improves EMC performance. Power supply decoupling also prevents intrinsic oscillations for long lead lengths between the amplifier and the speaker. The optimum decoupling can be achieved by using two different types of capacitors which target different types of noise on the power supply lines. For higher frequency spikes, or digital hash on the rail, a good low ESR ceramic capacitor, for example 0.1μF to 10μF, placed as close as possible to VDD pin works best. For filtering lower frequency noise, a larger low ESR aluminum electrolytic capacitor of 470μF or greater placed near the audio power amplifier is suggested. The 470μF capacitor also serves as local storage capacitor for supplying current during heavy power output on the amplifier outputs. The VDD terminal provide the power to the output transistors, so a 470μF or larger capacitor should be placed by VDD terminal as near as possible. A 10μF ceramic capacitor on VDD terminal is also recommended.

Typical Characteristic (cont.)

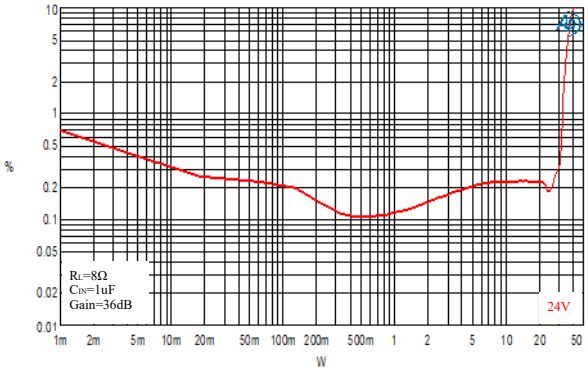
THD+N vs. Output Power, 8Ω load



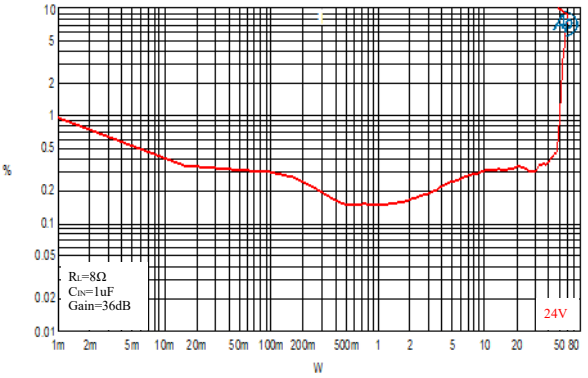
THD+N vs. Output Power, 4Ω load



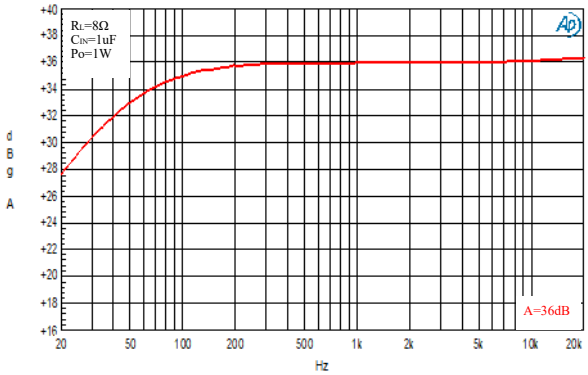
THD+N vs. Output Power, 24V, 8Ω load



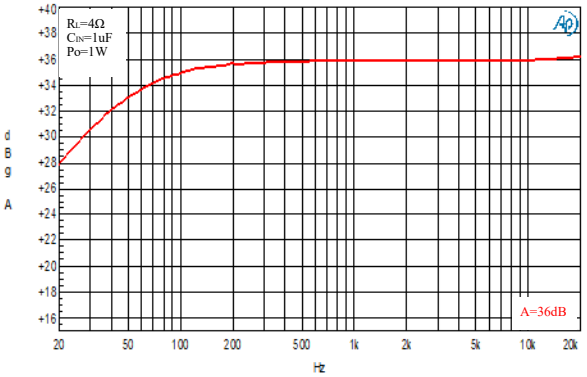
THD+N vs. Output Power, 24V, 8Ω load



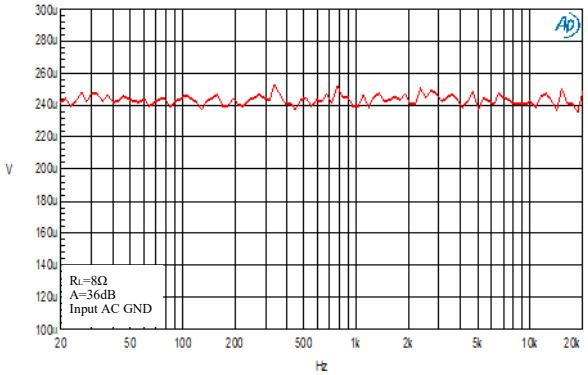
Frequency Response, 24V, 8Ω load



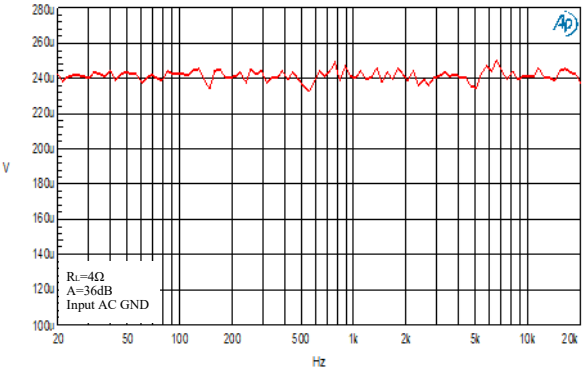
Frequency Response, 24V, 4Ω load



Noise, 24V, 8Ω load

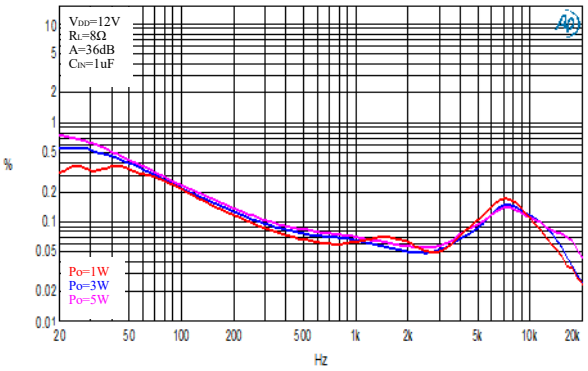


Noise, 24V, 4Ω load

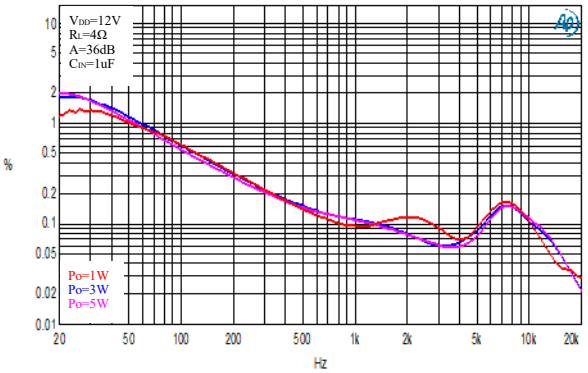


Typical Characteristic (cont.)

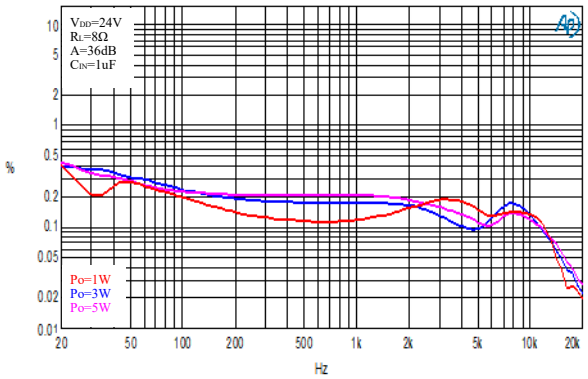
THD + N (%) vs. Frequency, 12V, 8Ω load



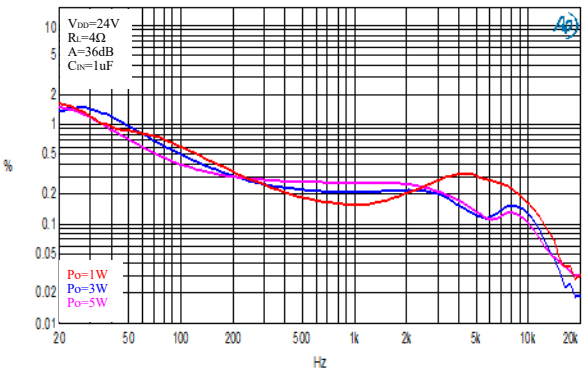
THD + N (%) vs. Frequency, 12V, 4Ω load



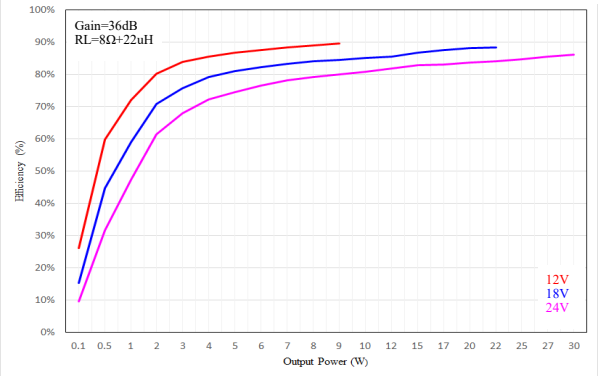
THD + N (%) vs. Frequency, 24V, 8Ω load



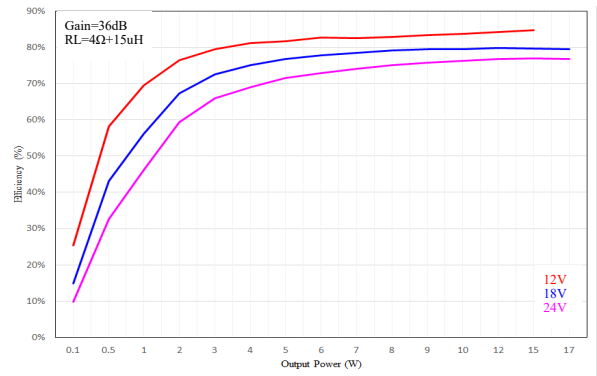
THD + N (%) vs. Frequency, 24V, 4Ω load



Efficiency, 8Ω load



Efficiency, 4Ω load



Application Circuit

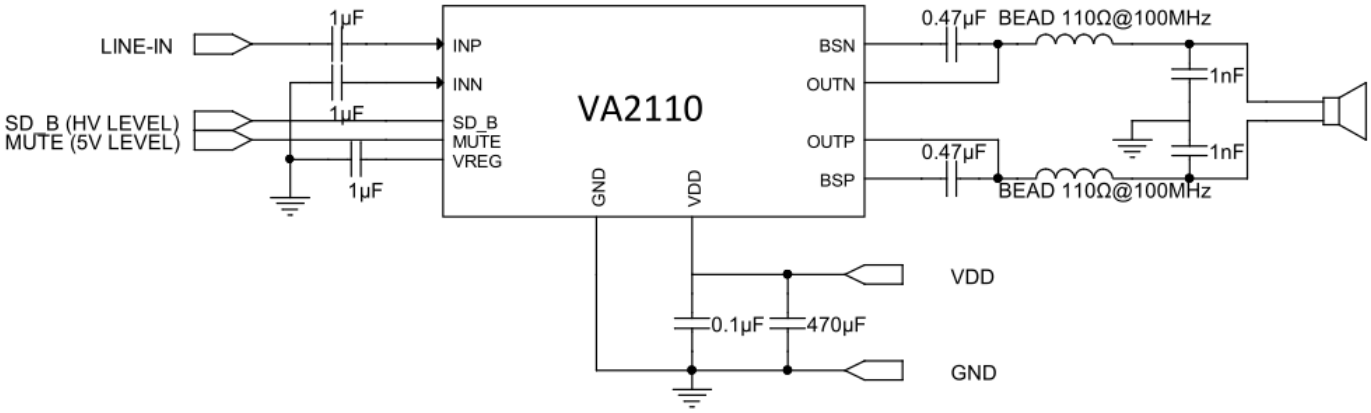


Figure 6. VA2110 Reference Application Circuit (BEAD Filter)

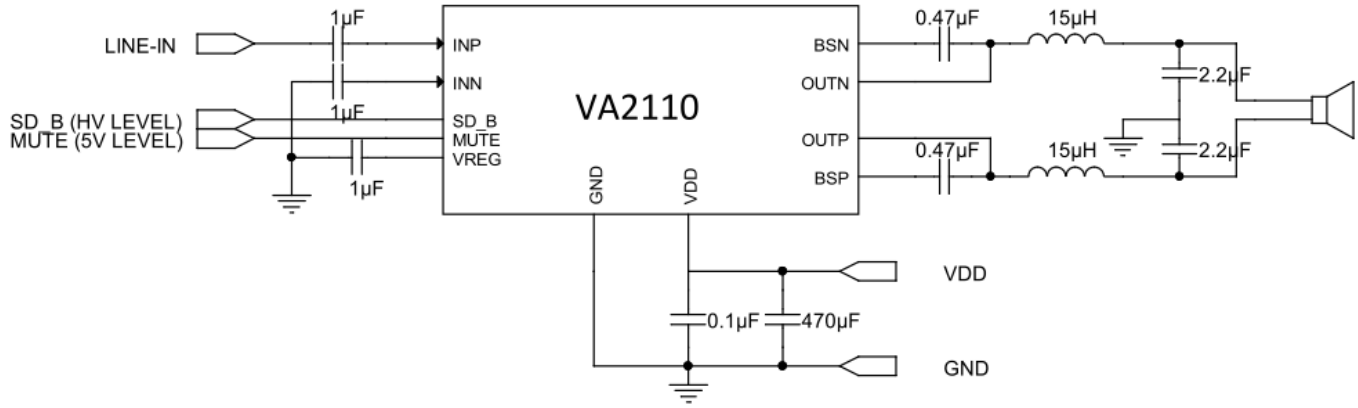
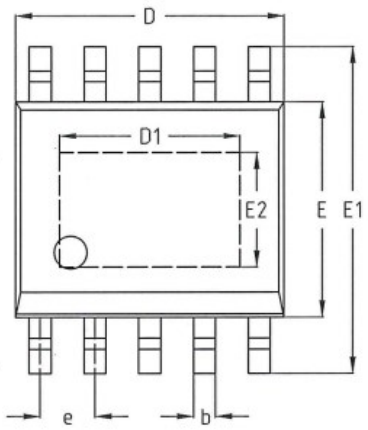


Figure 7. VA2110 Reference Application Circuit (LC Filter)

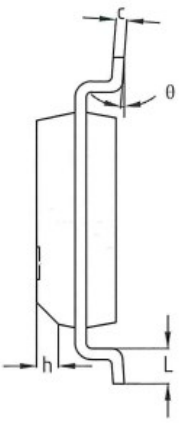
Package Information

SO-10P

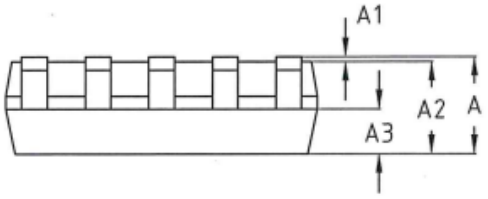
TOP VIEW
正视图



SIDE VIEW
侧视图



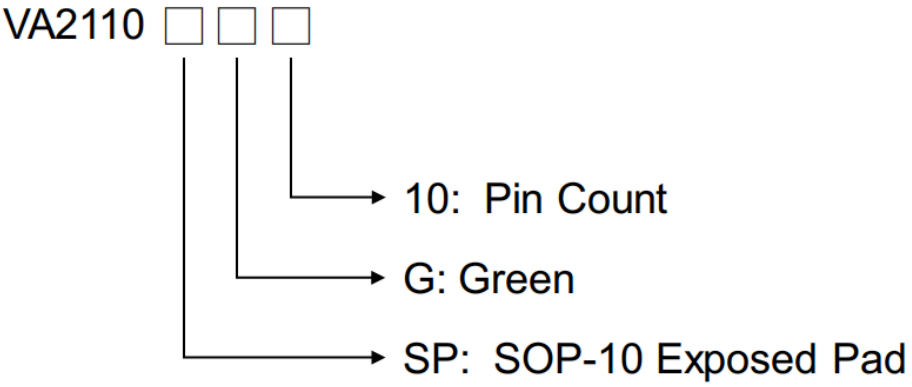
SIDE VIEW
侧视图



机械尺寸/mm Dimensions			
字符 SYMBOL	最小值 MIN	典型值 NOMINAL	最大值 MAX
A	1.50	1.60	1.70
A1	0.02	-	0.08
A2	1.35	1.45	1.55
A3	0.65	0.70	0.75
b	0.35	-	0.50
c	0.19	-	0.25
D	4.80	4.90	5.00
D1	3.20	3.30	3.40
E	3.80	3.90	4.00
E1	5.80	6.00	6.20
E2	2.00	2.10	2.20
e	1.00 BSC		
h	0.30	-	0.50
L	0.50	-	0.80
θ	0°	-	8°

Notes:
1. Package Outline Unit Description:
   BSC: Basic. Represents theoretical exact dimension or dimension target.
   MIN: Minimum dimension specified.
   MAX: Maximum dimension specified.
   REF: Reference. Represents dimension for reference use only. This value is not a device specification.
   TYP: Typical. Provided as a general value. This value is not a device specification.
2. Dimensions in Millimeters.
3. JEDEC Outline : MS-012 AA Rev. F (Standard), MS-012 BA Rev. F (Thermal)
4. Dimensions “D” does not include mold flash, protrusions or gate burrs. Mold flash, protrusions and gate burrs shall not exceed 0.51mm per side.
5. Dimensions “E1” does not include inter-lead flash, or protrusions. Inter-lead flash and protrusions shall not exceed 0.25mm per side.

Ordering Information



Part No.	Q`ty/Reel
VA2110SPG10	2,500

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