VA2205

3W Filterless Stereo Class D Audio Amplifier

Description

VA2205 is a filterless stereo Class D audio amplifier which provides DC volume control, lower supply current, high efficiency & few external components for driving speaker directly. VA2205 also integrates Anti-Pop, Output Short & Over-Heat Protection Circuitry to increase device reliability. The functionality makes this device ideal for small size LCD TVs, LCD monitors, USB powered speakers & other applications that demand more battery life.

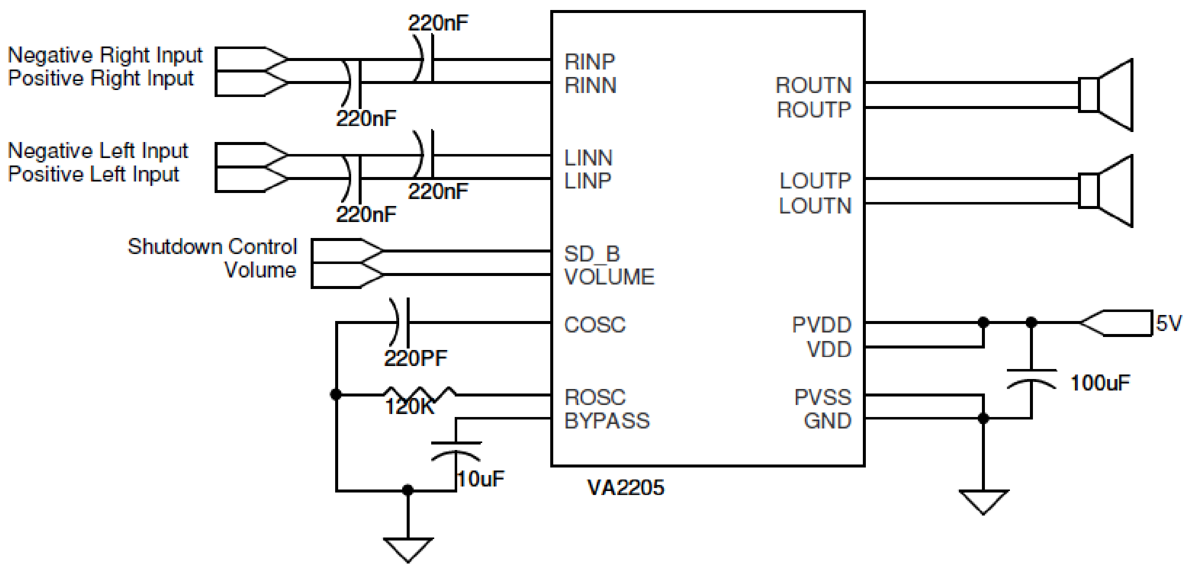
Features

- 1.7W per channel into 8Ω speaker (THD+N=10%)
- 3.06W per channel into 4Ω speaker (THD+N=10%)
- Operation voltage from 3.6V to 5.5V
- Maximum efficiency 84% into 4Ω speakers
- DC volume control range from -44dB to 20dB
- Low standby current < 10μA
- Filter-free PWM operation without LC output filters
- Integrated anti-pop, over-heat protection, short-circuit protection circuitry
- RoHS compliant TSSOP24 package with exposed pad

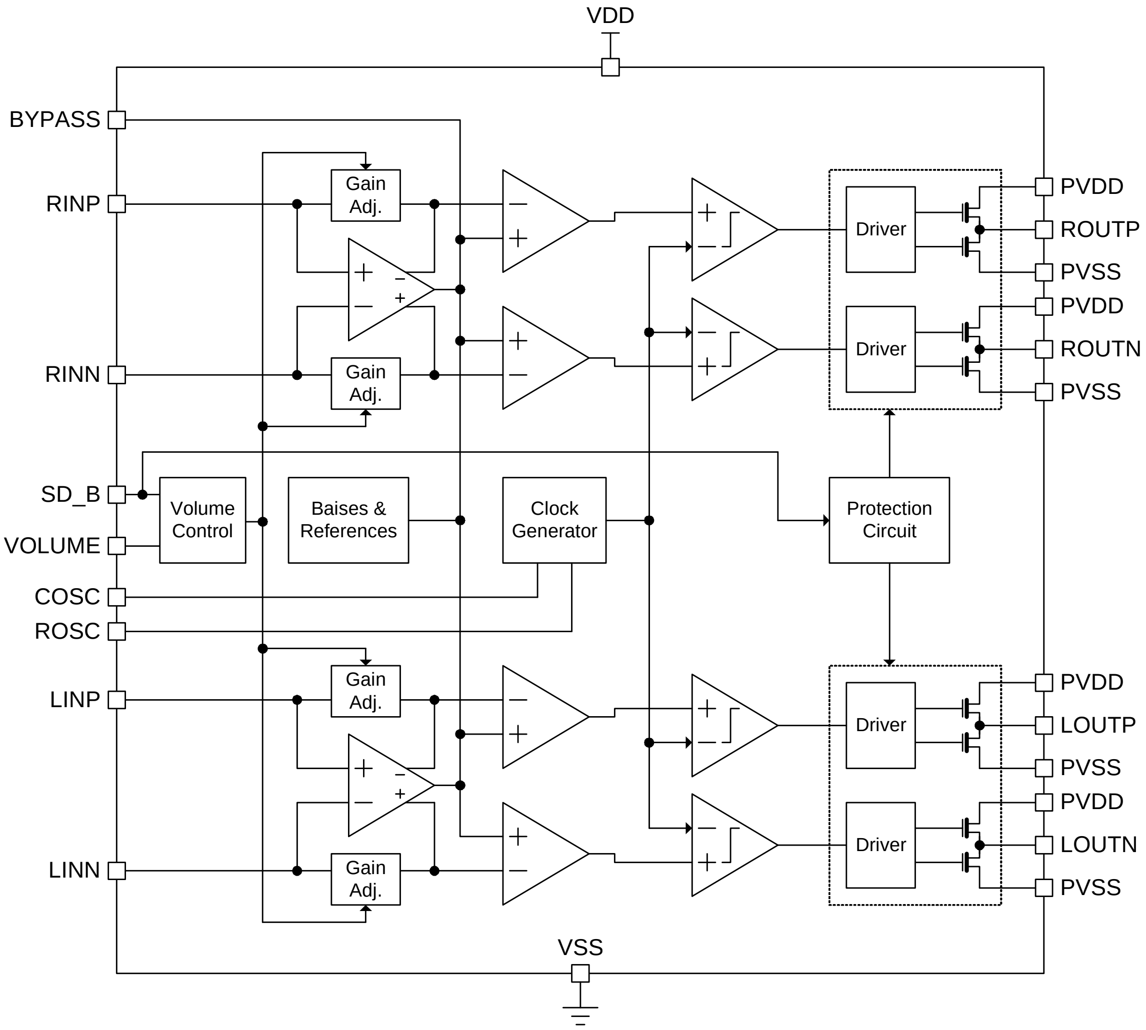
Applications

- LCD Monitor/LCD TV
- Notebook/Netbook/MID
- High Power USB Speaker
- Battery Powered Portable Electronics

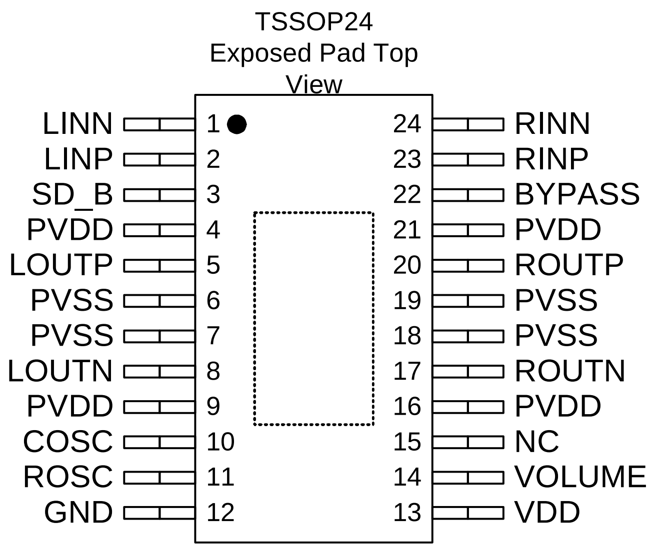
Typical Application



Functional Block Diagram



Pin Assignments And Descriptions



Pin No.	Pin	I/O/P	Function Description
1	LINN	I	Left channel negative audio signal input.
2	LINP	I	Left channel positive audio signal input.
3	SD_B	I	Shutdown mode control terminal. Low active.
4	PVDD	P	Power supply.
5	LOUTP	O	Left channel positive output.
6	PVSS	P	Power ground.
7	PVSS	P	Power ground.
8	LOUTN	O	Left channel negative output.
9	PVDD	P	Power supply.
10	COSC	O	Connects a capacitor to this terminal sets the oscillation in conjunction.
11	ROSC	I	Connects a resistor to this terminal sets the oscillation in conjuction.
12	GND	P	Power ground.
13	VDD	P	Power supply.
14	VOLUME	I	Controls the amplifier gain by supplying DC voltage to this terminal.
15	NC	–	No connection.
16	PVDD	P	Power supply.
17	ROUTN	O	Right channel negative output.
18	PVSS	P	Power ground.
19	PVSS	P	Power ground.
20	ROUTP	O	Right channel positive output.
21	PVDD	P	Power supply.
22	BYPASS	O	Internal bias reference.
23	RINP	I	Right channel positive input.
24	RINN	I	Right channel negative input.
–	PAD	–	The thermal pad has to be soldered to the PCB large ground copper area closely to sink the heat.

Absolutely Maximum Ratings

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

Symbol	Parameter	Limit	Unit
V_{DD}	Supply voltage	-0.3 to 6	V
V_I (RINN, RINP, LINN, LINP)	Input voltage	0 to V_{DD}	V
V_I (VOLUME, SD_B)	Input voltage	0 to V_{DD}	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 85	°C
$R_{(Load)}$	Minimum load resistance	3	Ω
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 functional operation are strongly recommend follow up "recommended operation conditions" table.

Recommended Operating Conditions

Over operating free-air temperature range, unless otherwise specified

Symbol	Parameter	Test Condition	Specification		Unit
			Min	Max	
V_{DD}	Supply voltage	-	3.6	5.5	V
V_{IH}	High level input voltage	SD_B	2.0	-	V
V_{IL}	Low level input voltage	SD_B	-	0.8	V
V_{VOL}	Volume terminal voltage		0	V_{DD}	V
f_{OSC}	Oscillator frequency	R_{OSC} Resistor = 100kΩ, C_{OSC} Capacitor = 220pF, VDD=5V	200	300	kHz
T_A	Operating free-air temperature		-40	85	°C
T_J	Operating junction temperature			125	°C

Electrical Characteristics

T_A = 25℃, V_{DD}= 5V, R_L = 8Ω, Gain =20dB (unless otherwise noted)

Symbol	Parameter	Test Condition	Specification			Unit
			Min	Typ.	Max	
$\|V_{OS}\|$	Output offset voltage(measured differentially)	V_I=0V, A_V=20dB, R_L=8Ω		15	25	mV
$\|I_{IH}\|$	High-Level input current	V_{DD}=5.5V, V_I=0V			1	μA

Symbol	Parameter	Test Condition		Specification			Unit
				Min	Typ.	Max	
$\|I_{IL}\|$	Low-Level input current	V_{DD}=5.5V, V_I=0V				1	μA
|PSRR|	DC power supply rejection ratio	V_{DD}=4.5V to 5.5V, Gain=20dB			68		dB
I_{DD}	Quiescent current	No Filter, No Load			10	20	mA
$I_{DD(max)}$	Maximum supply current	R_L=8Ω, P_O=1.5W (Stereo)			1.8		A
$I_{DD(SHUTDOWN)}$	Supply current In shutdown mode	SD_B=0V			1	10	μA
$R_{DS(ON)}$	Drain-Source ON-State resistance	V_{DD}=5V, I_{OUT}=500mA , T_J=25 °C	High Side		300	350	mΩ
			Low Side		300	350	

Operating Characteristics

T_A = 25℃, V_{DD}= 5V, R_L = 8Ω,(unless otherwise noted)

Symbol	Parameter	Test Condition		Specification			Unit
				Min	Typ.	Max	
$\|K_{SVR}\|$	Supply ripple rejection	100mV$_{PP}$ ripple from 20Hz-1kHz, signal input pins tie ground			60		dB
THD+N	Total harmonic distortion plus noise	f=20Hz~20kHz, P_O=1W			<0.2		%
BOM	Bandwidth of maximum power	THD+N=5%				20	kHz
P_O	Output power	f=1kHz, R_L=4Ω	THD+N=1%		2.4		W
			THD+N=10%		3.06		
SNR	Signal to noise ratio	THD+N=1%, A-weighted, f=1kHz			95		dB
V_N	Output noise floor	22Hz to 22kHz, A-weighted filter			75	80	μV
T_{TP}	Thermal trap point	-			150		°C
T_H	Thermal hystersis	-			20		°C

Functional Descriptions

Differential Input

The differential input stage of the amplifier cancels any noise that appears on both input lines of the channel. To use the VA2205 with a differential source, connect the positive lead of the audio source to the LINP/RINP input and the negative lead from the audio source to the LINN/RINN input as shown in Figure 1. To use the VA2205 with a single-ended source, AC ground either input through a capacitor or apply the audio signal to the remaining input. In a single-ended input application, the unused input should be AC grounded at the audio source instead of at the device input for best noise performance.

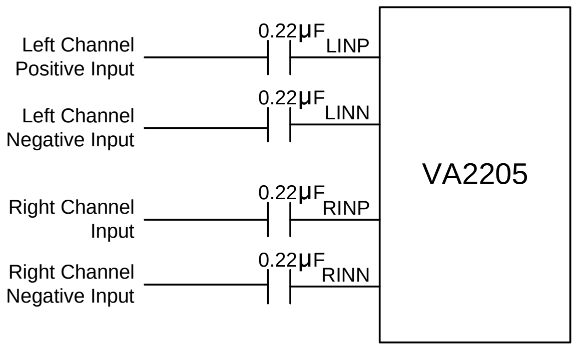


Figure 1. Differential stereo input configuration

Single-end stereo input application circuit shows in Figure 2. It's recommended LINN & RINN connect 0.22μF to ground. & Left/Right analog audio signal series connect 0.22μF to LINP & RINP.

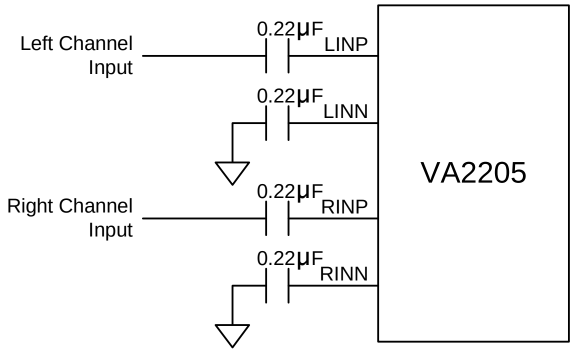


Figure 2. Single-ended stereo input application

Power Efficiency

The output transistors of VA2205 act as switches. The amount of power dissipated in the speaker may be estimated by first considering the overall efficiency of the system. The on-resistance of the output transistors is considered to cause the dominant loss in the system, the on-resistance of output transistors is small that the power loss is small and the power efficiency is high. When VA2205 connects with 8Ω loads, the power efficiency could be better than 88%.

Over-Heat Protection

The Over-Heat protection feature on the VA2205 prevents damage to the device when the internal die temperature exceeds 150°C. Once the die temperature exceeds the thermal set point, the device enters the shutdown state and the outputs are disabled. The device will back to normal operation when die temperature is reduced without external system interaction.

Output Short Protection

The VA2205 has output short circuit protection circuitry on the outputs that prevents the misconnections such as output to output short, output to GND short and output to VDD short. VA2205 enters the shutdown state and the outputs are disabled when detects output short. This is a latched fault and must be reset by cycling the voltage on the SD_B pin to a logic low and back to the logic high, or cycling the power off and then back on. This clears the short-circuit flag and allow for normal operation if the short was removed. If the short was not removed, the protection circuitry activates again.

Anti-Pop

A soft start capacitor must be added to the BYPASS pin. It recommends connecting a capacitor of 1µF from BYPASS pin to Ground. VA2205 provides fade-in function when power-on or SD_B input voltage level from 0V to V_{DD}, and fade-out function when SD_B input voltage level from V_{DD} to 0V. The pop noise can be eliminated by fade-in/fade-out function.

Bypass Capacitor

It's recommended to connect a 1µF~10µF capacitor from BYPASS pin to ground for internal bias reference & provide high power supply rejection ratio (PSRR).

Selection of C_{OSC} and R_{OSC}

The switching frequency is determined using the values of the components connected to ROSC and COSC. The frequency may be varied from 200 kHz to 300 kHz by adjusting the values chosen for R_{OSC} and C_{OSC}. The recommended values are C_{OSC} = 220 pF, R_{OSC} = 120 kΩ for a switching frequency of 250 kHz.

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.

Decoupling Capacitors

VA2205 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, three good low ESR ceramic capacitors, for example 1µF, placed as close as possible to every VDD pin works best. For filtering lower frequency noise, a larger low

ESR aluminum electrolytic capacitor of 220µF or greater placed near the audio power amplifier is suggested. The 220µF capacitor also serves as local storage capacitor for supplying current during heavy power output on the amplifier outputs. The VDD terminals provide the power to the output transistors, so a 220µF or larger capacitor should be placed by VDD terminals as near as possible.

Volume Control

The VOLUME pin controls the volume of the VA2205. It is controlled with a DC voltage, which should not exceed V_{DD}. Table 1 lists the voltage on the VOLUME pin and the corresponding gain.

The volume control circuitry of the VA2205 is internally referenced to the V_{DD} and 0V. Any common-mode noise between the VOLUME terminal and these terminals will be sensed by the volume control circuitry. If the noise exceeds the step size voltage, the gain will change. In order to minimize this effect, care must be taken to ensure the signal driving the VOLUME terminal is referenced to the V_{DD} and 0V of the VA2205. DC volume application circuit shows in Figure 3.

Voltage On Volume Pin (V) (Increasing or Fixed Gain)	Voltage On Volume Pin (V) (Decreasing Gain)	Typical Gain Of Amplifier (dB)
0.00 ~ 0.28	0.00 ~ 0.22	-37
0.29 ~ 0.39	0.23 ~ 0.34	-36
0.40 ~ 0.51	0.35 ~ 0.45	-34
0.52 ~ 0.62	0.46 ~ 0.56	-32
0.63 ~ 0.73	0.57 ~ 0.67	-30
0.74 ~ 0.84	0.68 ~ 0.79	-28
0.85 ~ 0.96	0.80 ~ 0.91	-26
0.97 ~ 1.07	0.92 ~ 1.02	-24
1.08 ~ 1.18	1.03 ~ 1.13	-22
1.19 ~ 1.29	1.14 ~ 1.25	-20
1.30 ~ 1.40	1.26 ~ 1.36	-18
1.41 ~ 1.52	1.37 ~ 1.48	-16
1.53 ~ 1.63	1.49 ~ 1.59	-14
1.64 ~ 1.74	1.60 ~ 1.70	-12
1.75 ~ 1.86	1.71 ~ 1.83	-11
1.87 ~ 1.97	1.84 ~ 1.94	-9
1.98 ~ 2.09	1.95 ~ 2.07	-7
2.10 ~ 2.21	2.08 ~ 2.19	-5
2.22 ~ 2.32	2.20 ~ 2.26	-3
2.33 ~ 2.43	2.27 ~ 2.38	-1
2.44 ~ 2.54	2.39 ~ 2.49	0
2.55 ~ 2.66	2.50 ~ 2.61	2
2.67 ~ 2.77	2.62 ~ 2.72	4
2.78 ~ 2.89	2.73 ~ 2.84	6
2.90 ~ 3.00	2.85 ~ 2.95	8
3.01 ~ 3.11	2.96 ~ 3.08	10
3.12 ~ 3.22	3.09 ~ 3.21	12
3.23 ~ 3.34	3.22~ 3.33	14
3.35 ~ 3.45	3.34 ~ 3.43	16
3.46 ~ 3.57	3.44 ~ 3.55	18
3.58 ~ VDD	3.56 ~ VDD	20

Table 1. Typical DC volume control

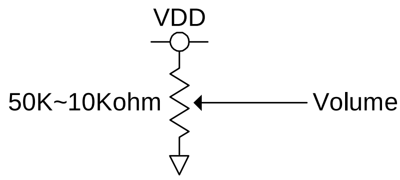


Figure 3. DC volume application circuit

The trip point, where the gain actually changes, is different depending on whether the voltage on the VOLUME pin is increasing or decreasing as a result of hysteresis about each trip point. The hysteresis ensures that the gain control is monotonic and does not oscillate from one gain step to another. A pictorial representation of the volume control can be found in Figure 4. The graph focuses on three gain steps with the trip points defined in the first and second columns of Table 1. The dotted lines represent the hysteresis about each gain step.

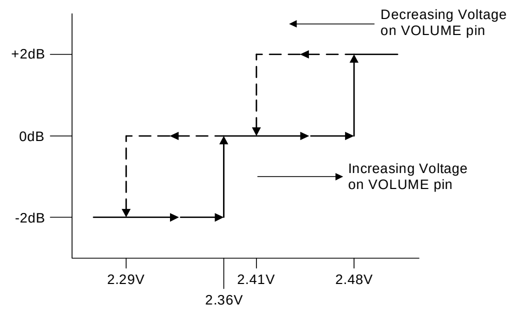


Figure 4. DC volume control operation

Shutdown Operation

The VA2205 provides a shutdown mode to reduce supply current to the absolute minimum level during periods of non-use for battery-power conservation. The SD_B input pin should be held high during normal operation when the amplifier is in use. Pulling SD_B low causes the outputs to mute and the amplifier to enter a low-current state. SD_B should never be left unconnected because the amplifier state would be unpredictable. It is recommended connecting SD_B pin with 100kΩ to V_{DD} and connect 0.1µF to ground.

Output Filters

Design the VA2205 without the filter if the lengths of traces plus cables from amplifier to speaker are short enough (< 1 inch). This case is a typical application for applications based with the Class D amplifier without any filter.

However, many applications still require the ferrite bead filter. The ferrite filter reduces EMI around 30 MHz. When selecting a ferrite bead, choose one with high impedance at high frequencies, but low impedance at low frequencies.

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

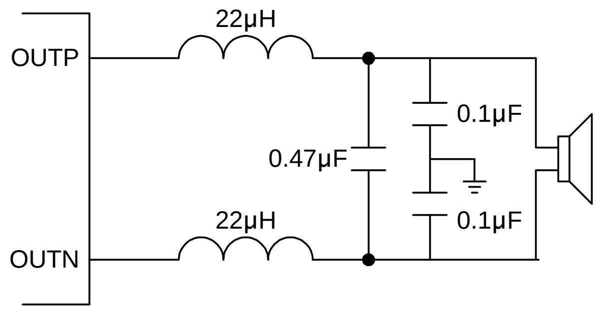


Figure 5. Typical LC output filter

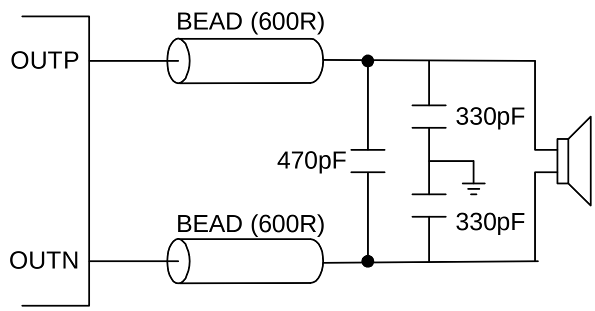
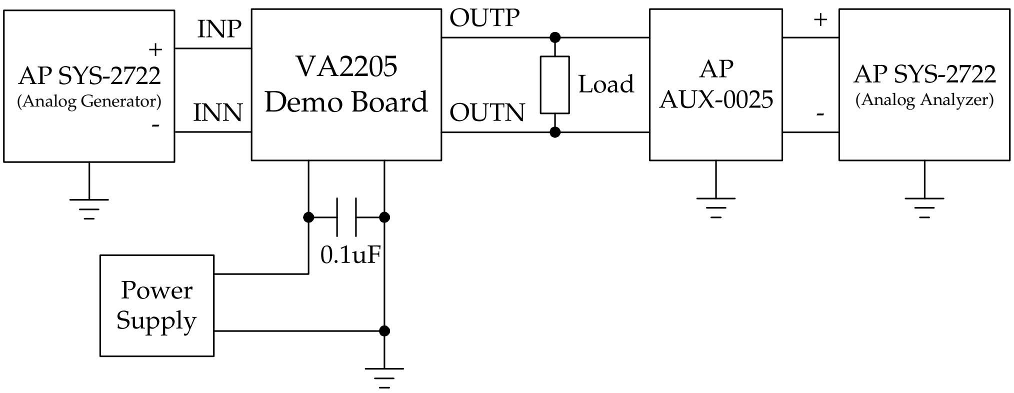


Figure 6. Typical ferrite chip bead output filter

Typical Characteristic

Test Setup Connection Diagram



*Connection is for single channel testing.

**For efficiency measurement, a 22uH inductor should be added in series with load resistor.

Typical Operating Characteristics

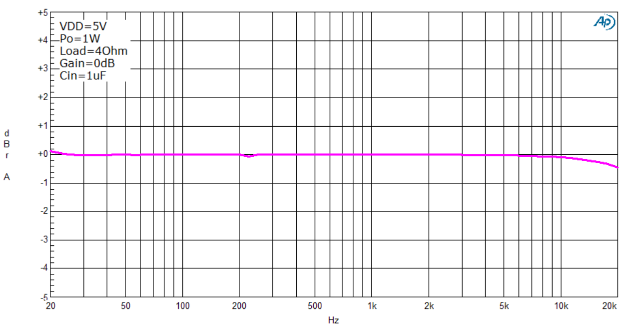


Figure 7. Frequency Response

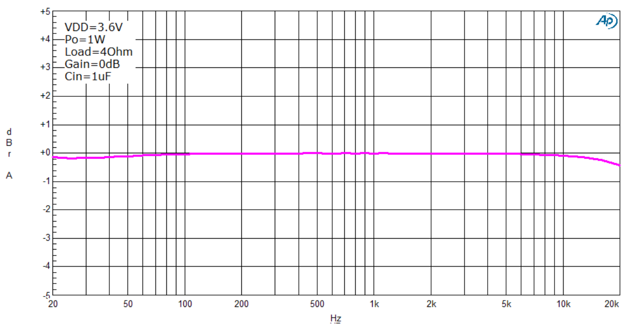


Figure 9. Frequency Response

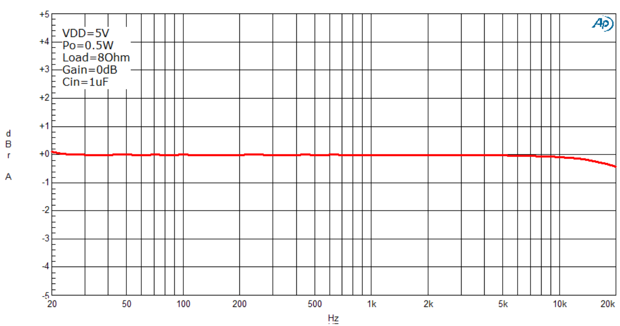


Figure 8. Frequency Response

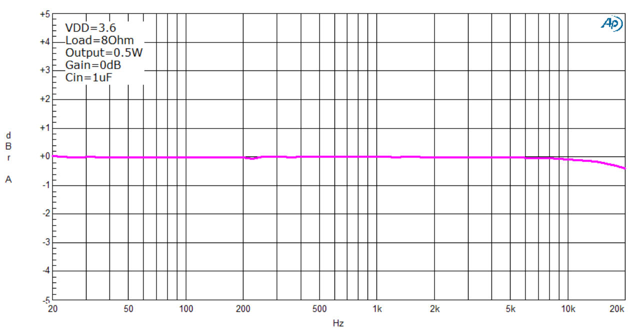


Figure 10. Frequency Response

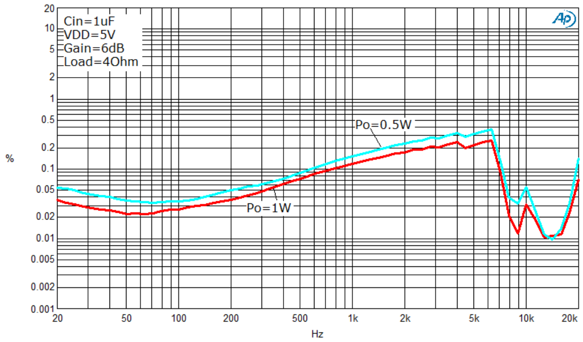


Figure 11. THD+N vs. Frequency

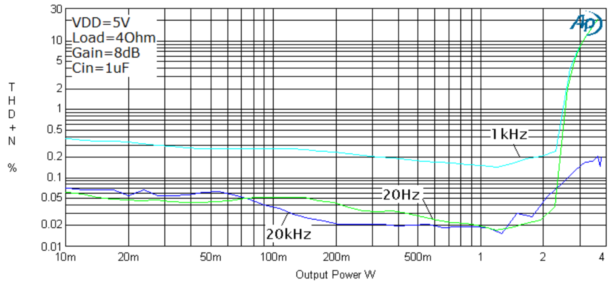


Figure 15. THD+N vs. Output Power

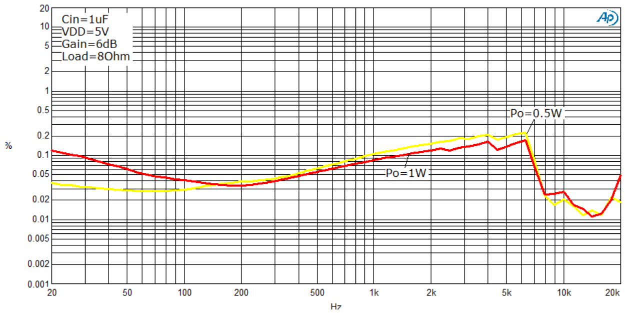


Figure 12. THD+N vs. Frequency

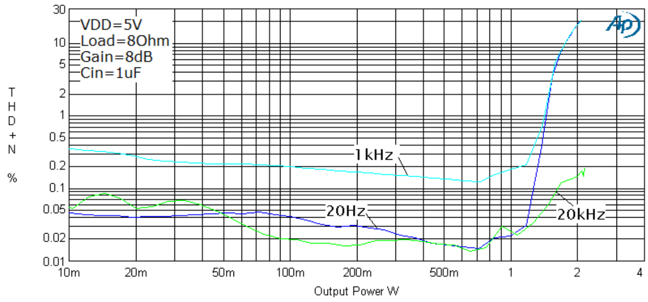


Figure 16. THD+N vs. Output Power

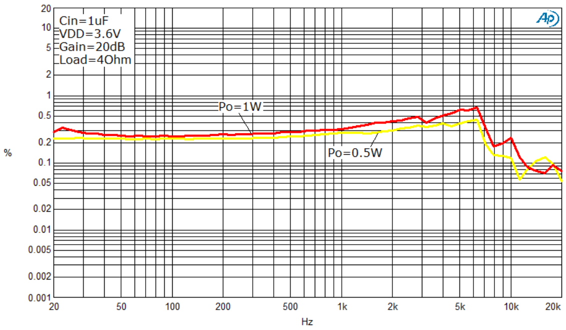


Figure 13. THD+N vs. Frequency

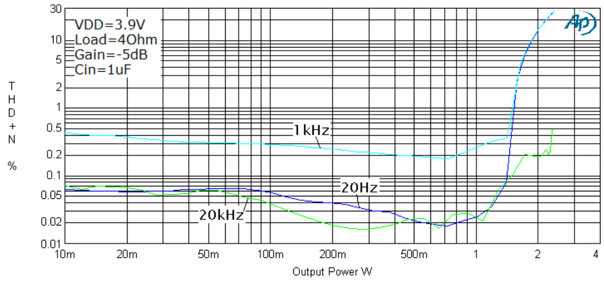


Figure 17. THD+N vs. Output Power

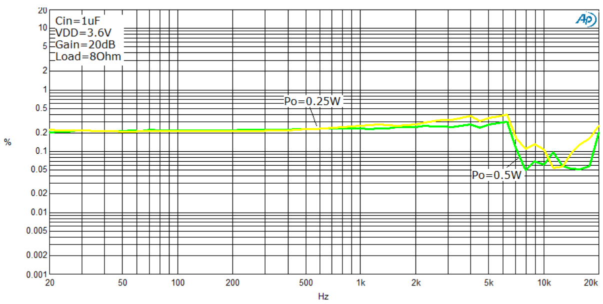


Figure 14. THD+N vs. Frequency

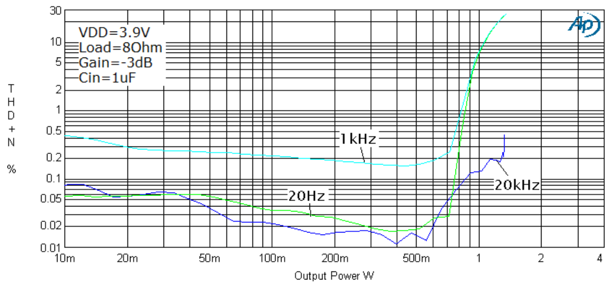


Figure 18. THD+N vs. Output Power

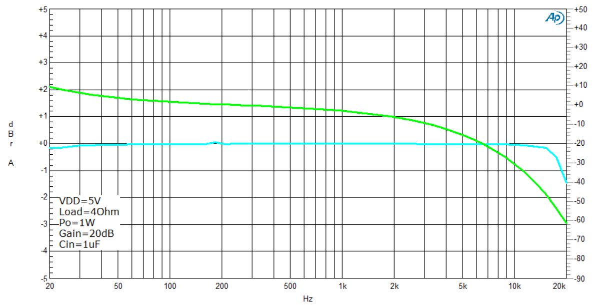


Figure 19. Gain and Phase

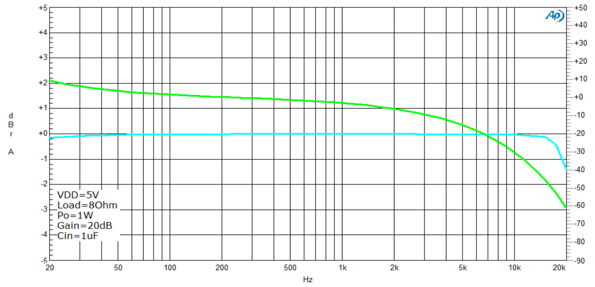


Figure 20. Gain and Phase

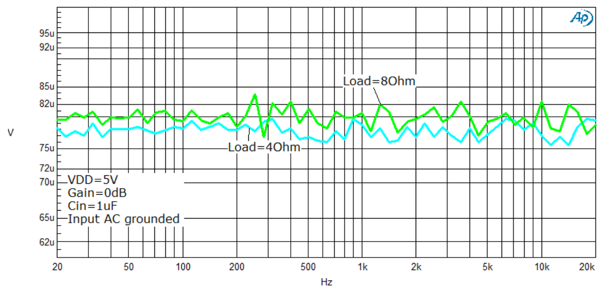


Figure 21. Integrated Noise

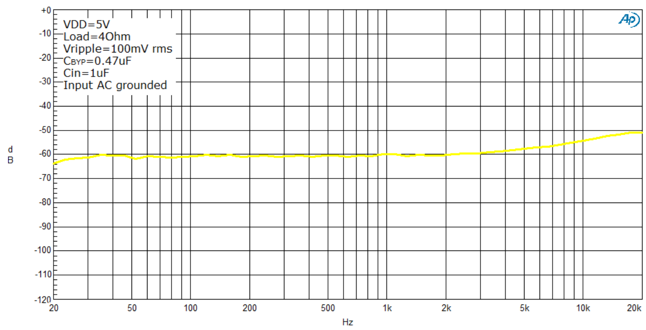


Figure 22. k_{SVR} vs. Frequency

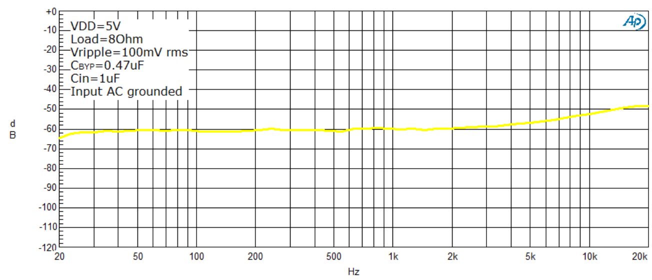


Figure 23. k_{SVR} vs. Frequency

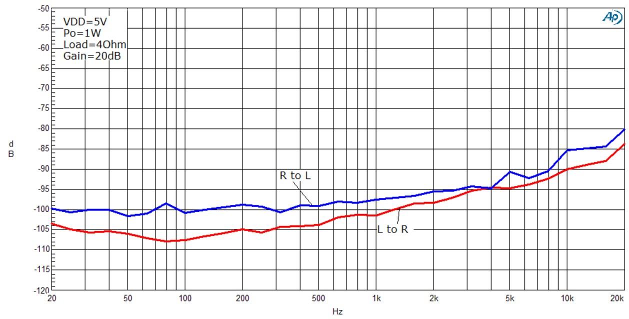


Figure 24. Crosstalk

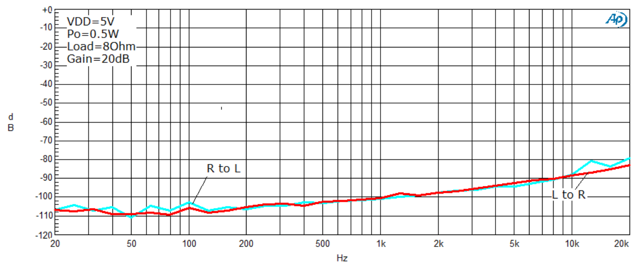


Figure 25. Crosstalk

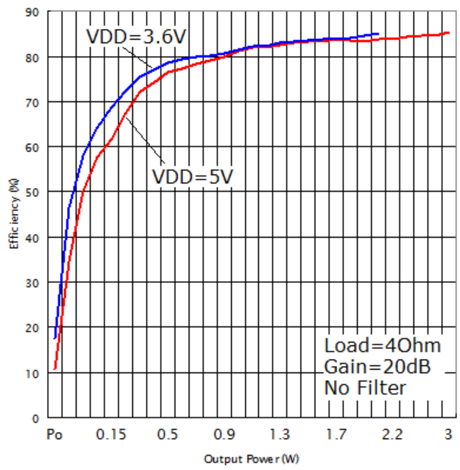


Figure 26. Efficiency

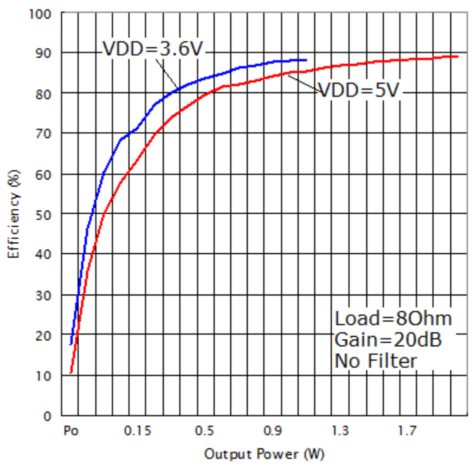


Figure 27. Efficiency

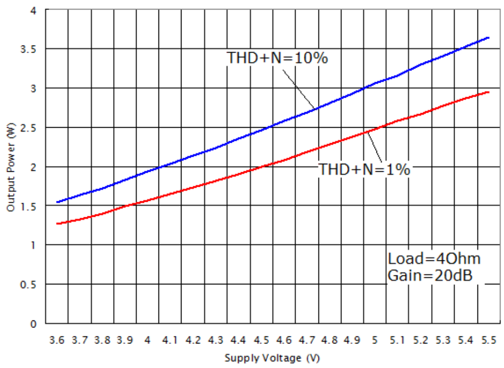


Figure 28. THD+N vs. Supply Voltage

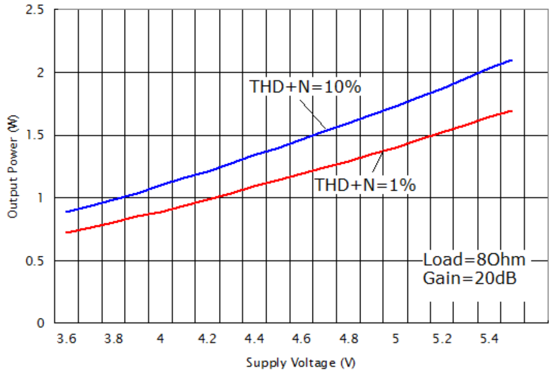


Figure 29. THD+N vs. Supply Voltage

Application Information

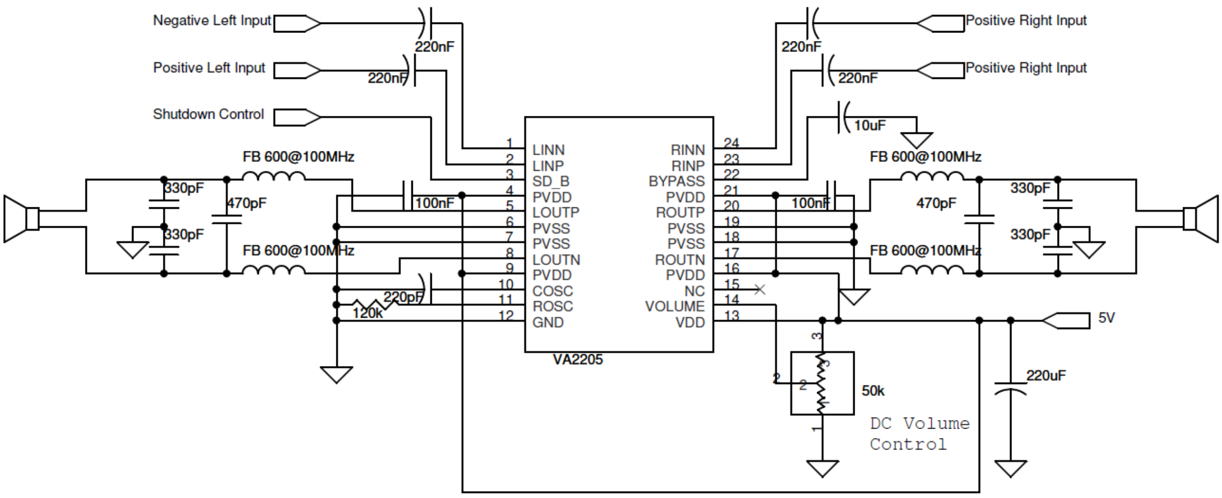


Figure 30. VA2205 with differential input configuration

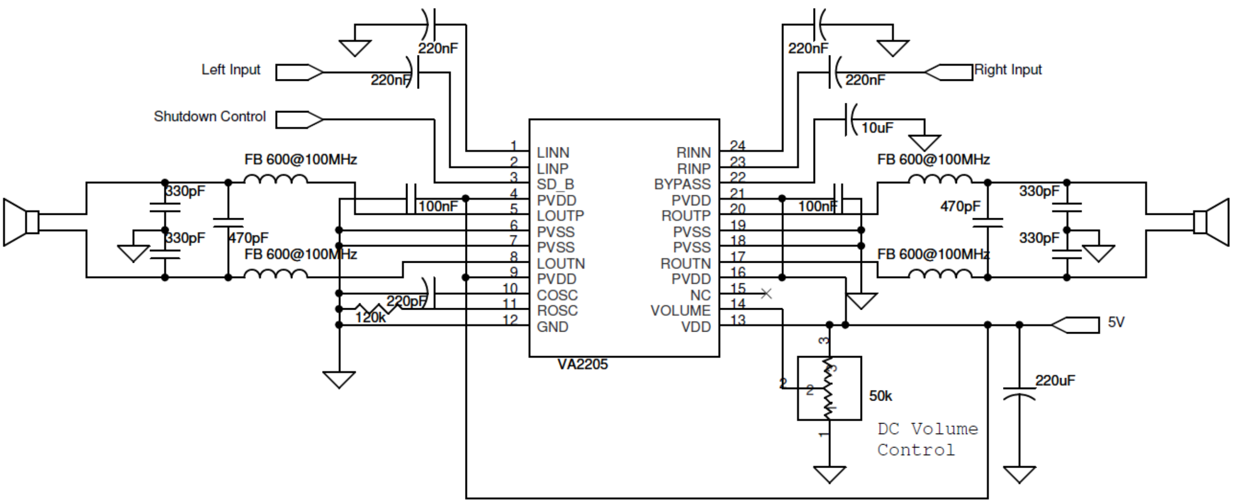
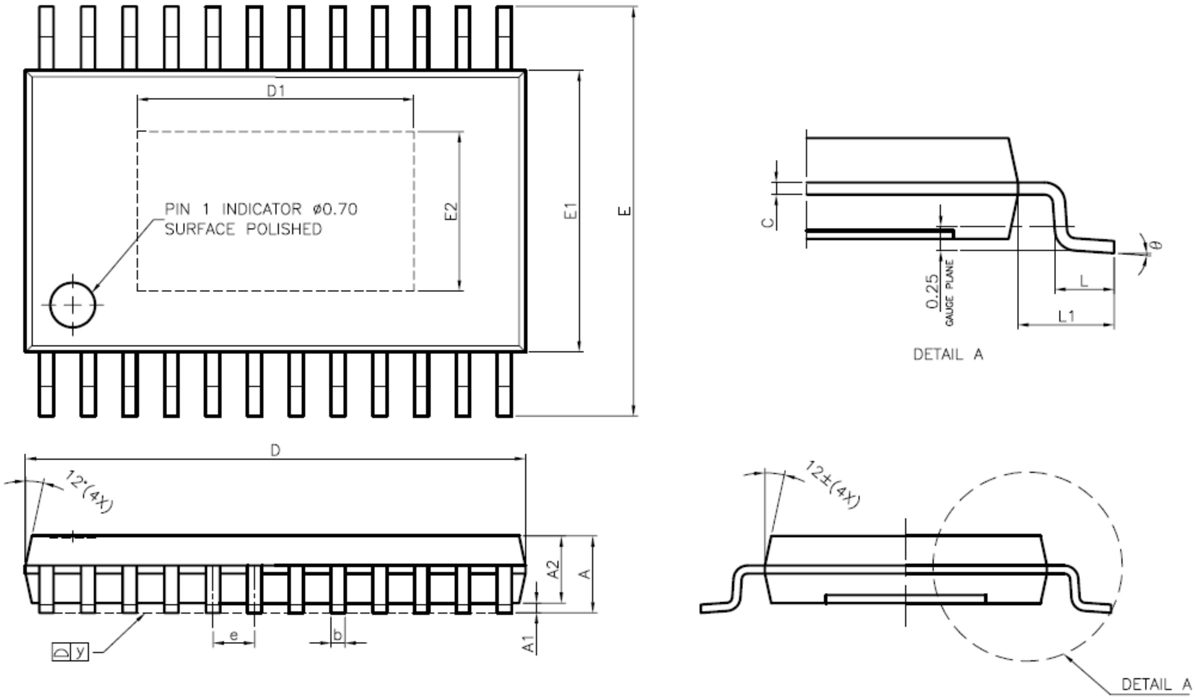


Figure 31. VA2205 with single-ended input configuration

Package Information

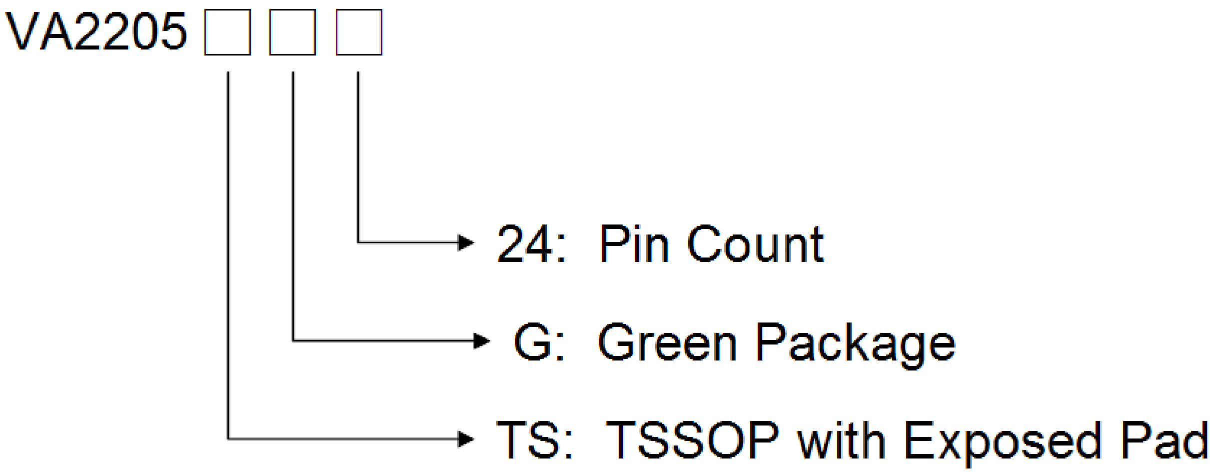
- TSSOP-24 EP



EXPOSED PAD DIMENSION (inch)						
PAD SIZE	D1			E2		
	MIN	NOM	MAX	MIN	NOM	MAX
A.)190x118mil	0.170	——	——	0.098	——	——

SYMBOLS	DIMENSIONS IN MILLIMETERS			DIMENSIONS IN INCHES		
	MIN	NOM	MAX	MIN	NOM	MAX
A	——	——	1.20	——	——	0.047
A1	0.05	——	0.15	0.002	——	0.006
A2	0.80	1.00	1.05	0.031	0.039	0.041
b	0.19	——	0.30	0.007	——	0.012
C	0.09	——	0.20	0.004	——	0.008
D	7.70	7.80	7.90	0.303	0.307	0.311
E	——	6.40	——	——	0.252	——
E1	4.30	4.40	4.50	0.170	0.173	0.177
e	——	0.65	——	——	0.026	——
L	0.45	0.60	0.75	0.018	0.024	0.030
L1	——	1.00	——	——	0.039	——
y	——	——	0.076	——	——	0.003
θ	0°	——	8°	0°	——	8°

Ordering Information



Part No.	Q`ty/Reel
VA2205TSG24	2,500

Contact Information

Viva Electronics Incorporated

10F-1, No. 32, Gaotie 2nd Rd., Zhubei City, Hsinchu County, Taiwan, R.O.C.

Tel: 886-3-6579508

Fax: 886-3-6579509

WWW: http://www.viva-elec.com.tw

Sales: sales@viva-elec.com.tw

FAE Support: FAE@viva-elec.com.tw