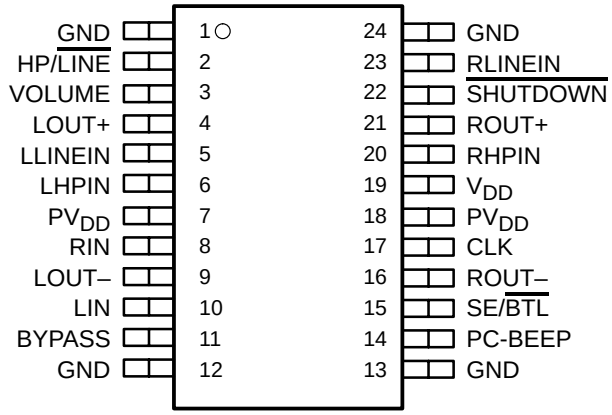
- **Compatible With PC 99 Desktop Line-Out Into 10-kΩ Load**
- **Compatible With PC 99 Portable Into 8-Ω Load**
- **Internal Gain Control, Which Eliminates External Gain-Setting Resistors**
- **DC Volume Control From 20 dB to –40 dB**
- **2-W/Ch Output Power Into 3-Ω Load**
- **Input MUX Select Terminal**
- **PC-Beep Input**
- **Depop Circuitry**
- **Stereo Input MUX**
- **Fully Differential Input**
- **Low Supply Current and Shutdown Current**
- **Surface-Mount Power Packaging 24-Pin TSSOP PowerPAD™**

PWP PACKAGE
(TOP VIEW)



description

The TPA0232 is a stereo audio power amplifier in a 24-pin TSSOP thermally enhanced package capable of delivering 2 W of continuous RMS power per channel into 3-Ω loads. This device minimizes the number of external components needed, which simplifies the design and frees up board space for other features. When driving 1 W into 8-Ω speakers, the TPA0232 has less than 0.4% THD+N across its specified frequency range.

Included within this device is integrated depop circuitry that virtually eliminates transients that cause noise in the speakers.

Amplifier gain is controlled by means of a dc voltage input on the VOLUME terminal. There are 31 discrete steps covering the range of 20 dB (maximum volume setting) to –40 dB (minimum volume setting) in 2-dB steps. When the VOLUME terminal exceeds 3.54 V, the device is muted. An internal input MUX allows two sets of stereo inputs to the amplifier. The HP/$\overline{\text{LINE}}$ terminal allows the user to select which MUX input is active regardless of whether the amplifier is in SE or BTL mode. In notebook applications, where internal speakers are driven as BTL and the line outputs (often headphone drive) are required to be SE, the TPA0232 automatically switches into SE mode when the SE/$\overline{\text{BTL}}$ input is activated, and this effectively reduces the gain by 6 dB.

The TPA0232 consumes only 10 mA of supply current during normal operation. A miserly shutdown mode reduces the supply current to less than 150 μA.

The PowerPAD package (PWP) delivers a level of thermal performance that was previously achievable only in TO-220-type packages. Thermal impedances of approximately 35°C/W are readily realized in multilayer PCB applications. This allows the TPA0232 to operate at full power into 8-Ω loads at ambient temperatures of 85°C.

AVAILABLE OPTIONS

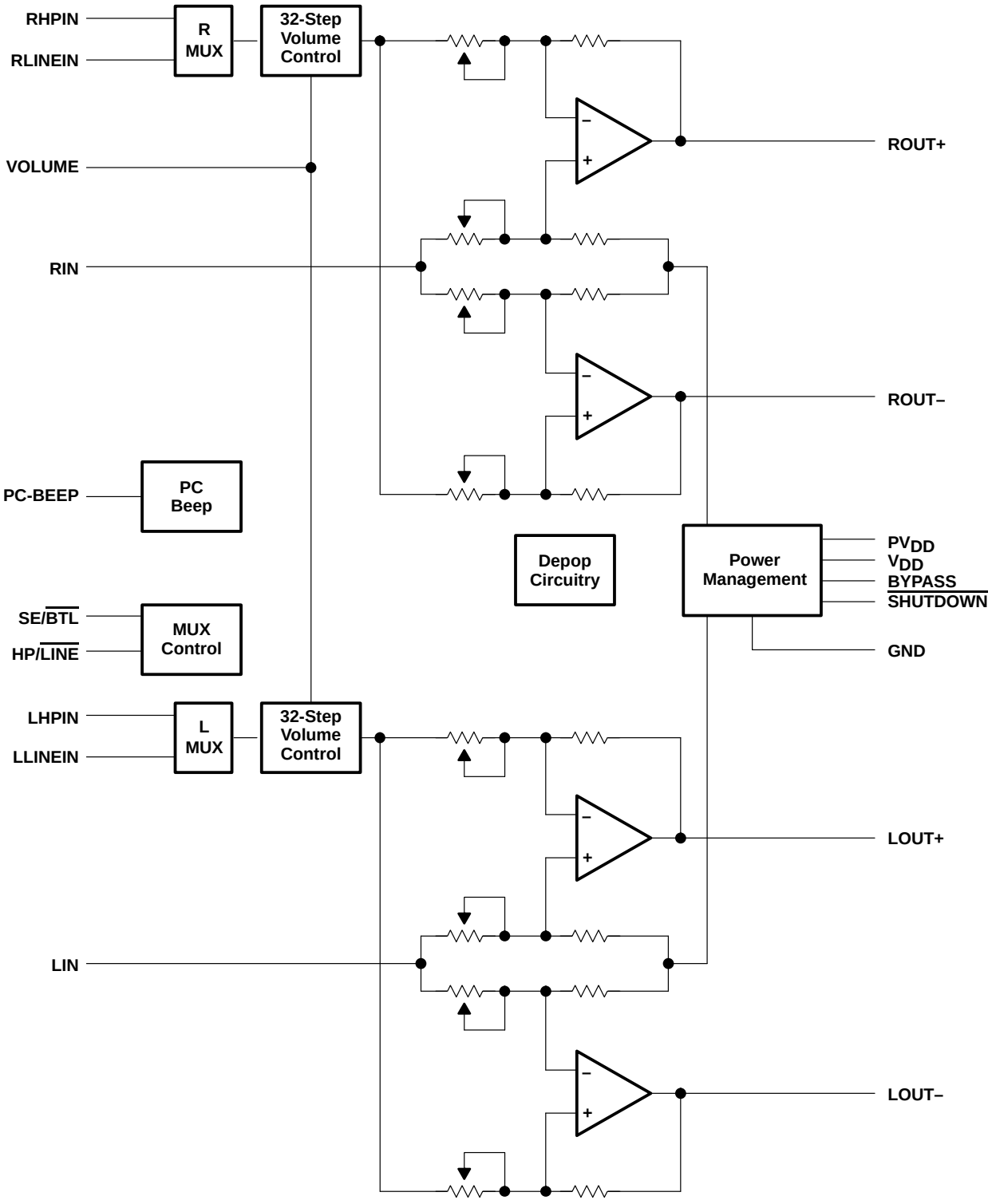
T_A	PACKAGED DEVICE
	TSSOP† (PWP)
–40°C to 85°C	TPA0232PWP

† The PWP package is available taped and reeled. To order a taped and reeled part, add the suffix R to the part number (e.g., TPA0232PWPR).

Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

PowerPAD is a trademark of Texas Instruments.

functional block diagram



Terminal Functions

TERMINAL NAME	TERMINAL NO.	I/O	DESCRIPTION
BYPASS	11		Tap to voltage divider for internal mid-supply bias generator
CLK	17	I	If a 47-nF capacitor is attached, the TPA0232 generates an internal clock. An external clock can override the internal clock input to this terminal.
GND	1, 12 13, 24		Ground connection for circuitry. Connected to thermal pad
LHPIN	6	I	Left channel headphone input, selected when SE/$\overline{\text{BTL}}$ is held high
LIN	10	I	Common left input for fully differential input. AC ground for single-ended inputs
LLINEIN	5	I	Left channel line negative input, selected when SE/$\overline{\text{BTL}}$ is held low
LOUT+	4	O	Left channel positive output in $\overline{\text{BTL}}$ mode and positive output in SE mode
LOUT–	9	O	Left channel negative output in $\overline{\text{BTL}}$ mode and high-impedance in SE mode
HP/$\overline{\text{LINE}}$	2	I	HP/$\overline{\text{LINE}}$ is the input MUX control input. When the HP/$\overline{\text{LINE}}$ terminal is held high, the headphone inputs (LHPIN or RHPIN [6, 20]) are active. When the HP/$\overline{\text{LINE}}$ terminal is held low, the line BTL inputs (LLINEIN or RLINEIN [5, 23]) are active.
PC-BEEP	14	I	The input for PC-Beep mode. PC-BEEP is enabled when a > 1-V (peak-to-peak) square wave is input to PC-BEEP.
PV_{DD}	7, 18	I	Power supply for output stage
RHPIN	20	I	Right channel headphone input, selected when SE/$\overline{\text{BTL}}$ is held high
RIN	8	I	Common right input for fully differential input. AC ground for single-ended inputs
RLINEIN	23	I	Right channel line input, selected when SE/$\overline{\text{BTL}}$ is held low
ROUT+	21	O	Right channel positive output in $\overline{\text{BTL}}$ mode and positive output in SE mode
ROUT–	16	O	Right channel negative output in $\overline{\text{BTL}}$ mode and high-impedance in SE mode
SE/$\overline{\text{BTL}}$	15	I	Hold SE/$\overline{\text{BTL}}$ low for BTL mode and hold high for SE mode
$\overline{\text{SHUTDOWN}}$	22	I	When held low, this terminal places the entire device, except PC-BEEP detect circuitry, in shutdown mode.
V_{DD}	19	I	Analog V_{DD} input supply. This terminal needs to be isolated from PV_{DD} to achieve highest performance.
VOLUME	3	I	VOLUME detects the dc level at the terminal and sets the gain for 31 discrete steps covering a range of 20 dB to –40 dB for dc levels of 0.15 V to 3.54 V. When the dc level is over 3.54 V, the device is muted.

absolute maximum ratings over operating free-air temperature range (unless otherwise noted)†

Supply voltage, V_{DD} . . . . . 6 V
Input voltage, V_I . . . . . –0.3 V to V_{DD} 0.3 V
Continuous total power dissipation . . . . . Internally limited (see Dissipation Rating Table)
Operating free-air temperature range, T_A . . . . . –40°C to 85°C
Operating junction temperature range, T_J . . . . . –40°C to 150°C
Storage temperature range, T_{stg} . . . . . –65°C to 150°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds . . . . . 260°C

† Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

DISSIPATION RATING TABLE

PACKAGE	$T_A \le 25°C$	DERATING FACTOR	$T_A = 70°C$	$T_A = 85°C$
PWP	2.7 W‡	21.8 mW/°C	1.7 W	1.4 W

‡ See the Texas Instruments document, *PowerPAD Thermally Enhanced Package Application Report* (literature number SLMA002), for more information on the PowerPAD package. The thermal data was measured on a PCB layout based on the information in the section entitled *Texas Instruments Recommended Board for PowerPAD* on page 33 of the before mentioned document.

recommended operating conditions

		MIN	MAX	UNIT
Supply voltage, V_{DD}		4.5	5.5	V
High-level input voltage, V_{IH}	SE/$\overline{\text{BTL}}$, HP/$\overline{\text{LINE}}$	4		V
	$\overline{\text{SHUTDOWN}}$	2		
Low-level input voltage, V_{IL}	SE/$\overline{\text{BTL}}$, HP/$\overline{\text{LINE}}$		3	V
	$\overline{\text{SHUTDOWN}}$		0.8	
Operating free-air temperature, T_A		–40	85	°C

electrical characteristics at specified free-air temperature, V_{DD} = 5 V, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$\lvert V_{OO}\rvert$	Output offset voltage (measured differentially)	V_I = 0 V, A_V = 2 V/V			25	mV
PSRR	Power supply rejection ratio	V_{DD} = 4 V to 5 V		67		dB
$\lvert I_{IH}\rvert$	High-level input current	V_{DD} = 5.5 V, $V_I = V_{DD}$			900	nA
$\lvert I_{IL}\rvert$	Low-level input current	V_{DD} = 5.5 V, V_I = 0 V			900	nA
Z_I	Input impedance			See Figure 28		
I_{DD}	Supply current	BTL mode		10	15	mA
		SE mode		5	7.5	
$I_{DD(SD)}$	Supply current, shutdown mode			150	300	µA

operating characteristics, V_{DD} = 5 V, T_A = 25°C, R_L = 4 Ω, Gain = 2 V/V, BTL mode (unless otherwise noted)

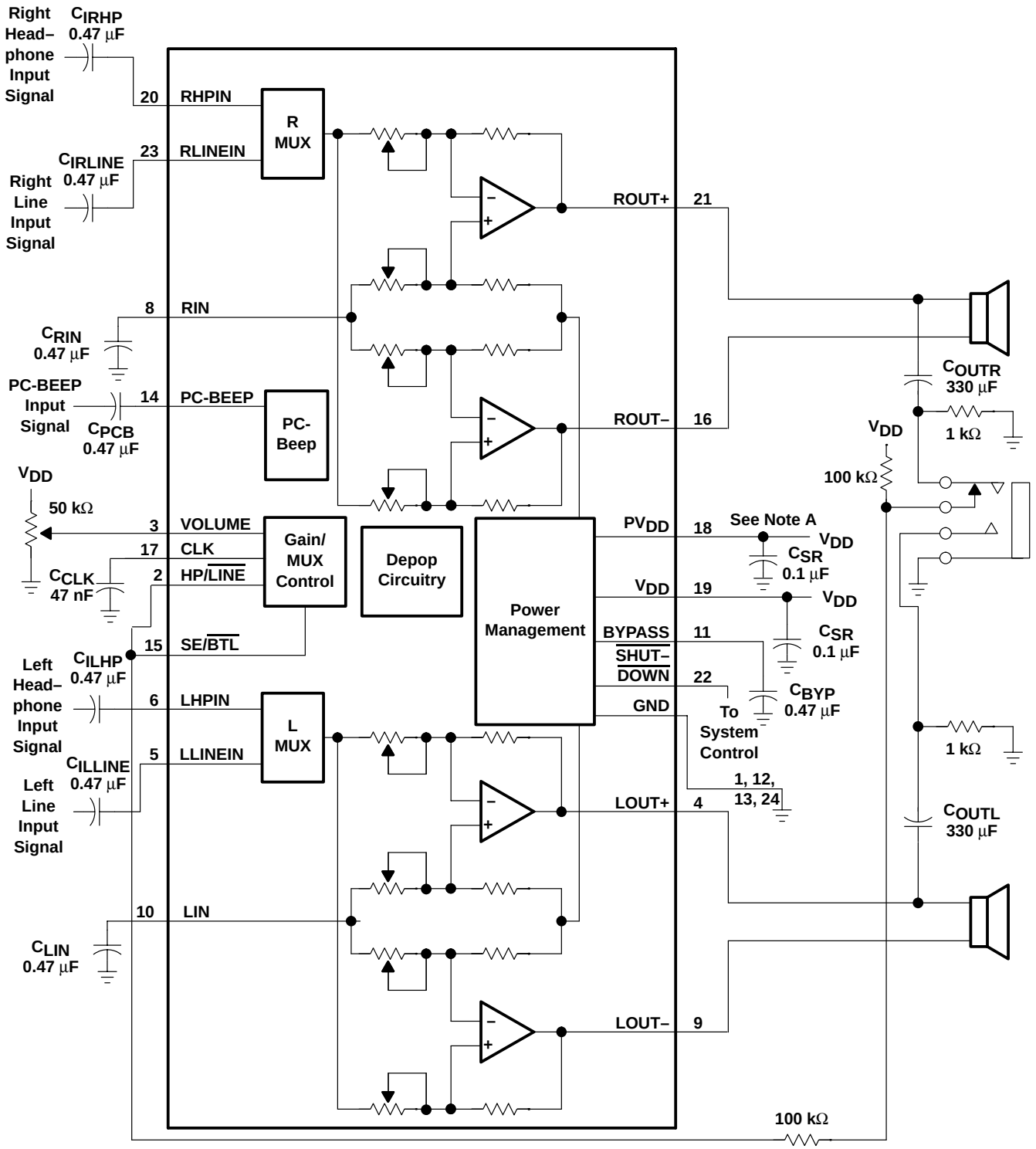
PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
P_O	Output power	THD = 1%, f = 1 kHz			2		W
THD+N	Total harmonic distortion plus noise	P_O = 1 W, f = 20 Hz to 15 kHz			0.4%		
B_{OM}	Maximum output power bandwidth	THD = 5%			>15		kHz
	Supply ripple rejection ratio	f = 1 kHz, $C_{(BYP)}$ = 0.47 µF	BTL mode		65		dB
			SE mode		60		
V_n	Noise output voltage	$C_{(BYP)}$ = 0.47 µF, f = 20 Hz to 20 kHz	BTL mode		34		μV_{RMS}
			SE mode		44		

TYPICAL CHARACTERISTICS

Table of Graphs

			FIGURE
THD+N	Total harmonic distortion plus noise	vs Output power	1, 4, 6, 8, 10
		vs Voltage gain	2
		vs Frequency	3, 5, 7, 9, 11
		vs Output voltage	12
V_n	Output noise voltage	vs Frequency	13
	Supply ripple rejection ratio	vs Frequency	14, 15
	Crosstalk	vs Frequency	16, 17, 18
	Shutdown attenuation	vs Frequency	19
SNR	Signal-to-noise ratio	vs Frequency	20
	Closed loop response		21, 22
P_O	Output power	vs Load resistance	23, 24
P_D	Power dissipation	vs Output power	25, 26
		vs Ambient temperature	27
Z_I	Input impedance	vs Gain	28

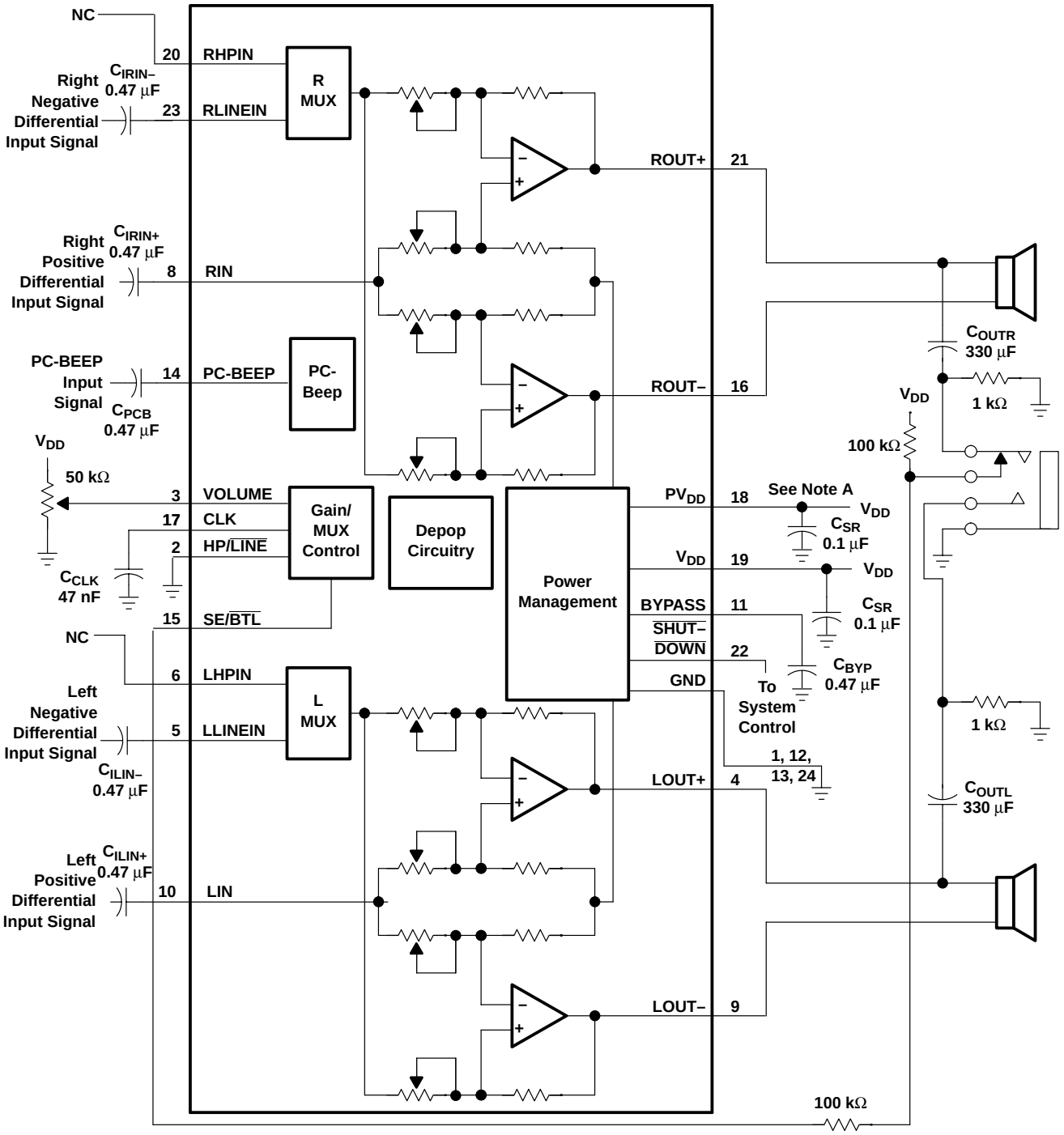
APPLICATION INFORMATION



NOTE A: A 0.1-µF ceramic capacitor should be placed as close as possible to the IC. For filtering lower-frequency noise signals, a larger electrolytic capacitor of 10 µF or greater should be placed near the audio power amplifier.

Figure 30. Typical TPA0232 Application Circuit Using Single-Ended Inputs and Input MUX

APPLICATION INFORMATION



NOTE A: A 0.1-µF ceramic capacitor should be placed as close as possible to the IC. For filtering lower-frequency noise signals, a larger electrolytic capacitor of 10 µF or greater should be placed near the audio power amplifier.

Figure 31. Typical TPA0232 Application Circuit Using Differential Inputs