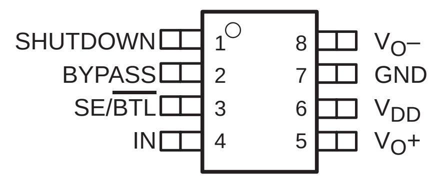
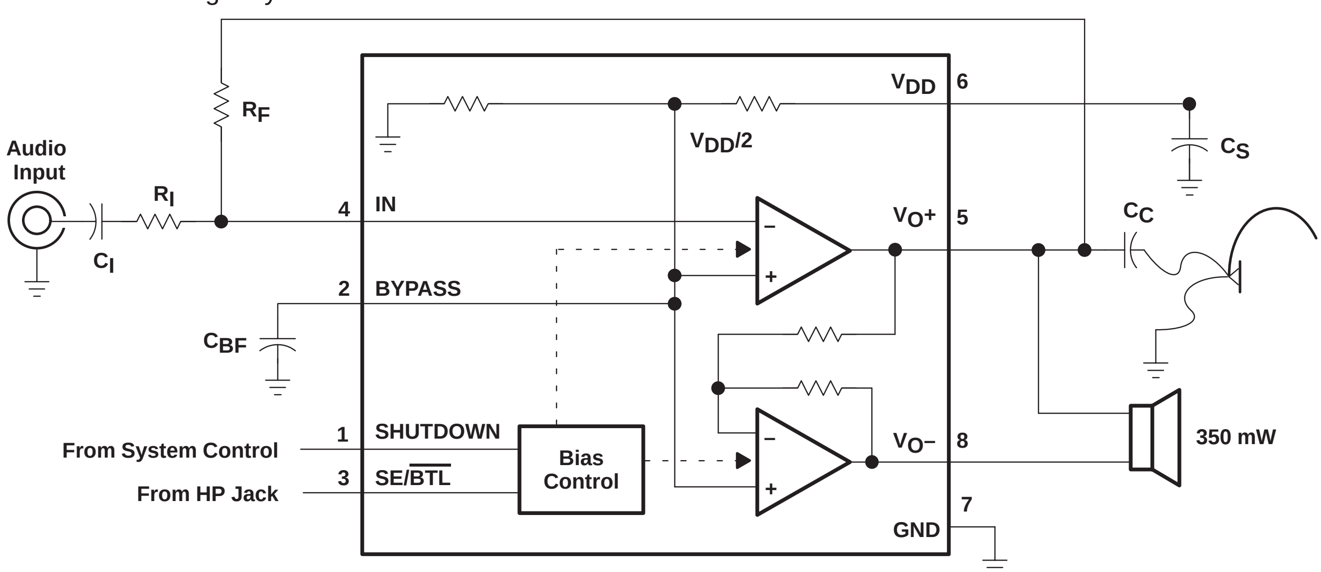
- **Fully Specified for 3.3-V and 5-V Operation**
- **Wide Power Supply Compatibility 2.5 V – 5.5 V**
- **Output Power for R_L = 8 Ω**
  - **350 mW at V_{DD} = 5 V, BTL**
  - **250 mW at V_{DD} = 5 V, SE**
  - **250 mW at V_{DD} = 3.3 V, BTL**
  - **75 mW at V_{DD} = 3.3 V, SE**
- **Shutdown Control**
  - **I_{DD} = 7 μA at 3.3 V**
  - **I_{DD} = 60 μA at 5 V**
- **BTL to SE Mode Control**
- **Integrated Depop Circuitry**
- **Thermal and Short-Circuit Protection**
- **Surface Mount Packaging**
  - **SOIC**
  - **PowerPAD™ MSOP**

description

D OR DGN PACKAGE (TOP VIEW)



The TPA311 is a bridge-tied load (BTL) or single-ended (SE) audio power amplifier developed especially for low-voltage applications where internal speakers and external earphone operation are required. Operating with a 3.3-V supply, the TPA311 can deliver 250-mW of continuous power into a BTL 8-Ω load at less than 1% THD+N throughout voice band frequencies. Although this device is characterized out to 20 kHz, its operation was optimized for narrower band applications such as cellular communications. The BTL configuration eliminates the need for external coupling capacitors on the output in most applications, which is particularly important for small battery-powered equipment. A unique feature of the TPA311 is that it allows the amplifier to switch from BTL to SE *on the fly* when an earphone drive is required. This eliminates complicated mechanical switching or auxiliary devices just to drive the external load. This device features a shutdown mode for power-sensitive applications with special depop circuitry to virtually eliminate speaker noise when exiting shutdown mode and during power cycling. The TPA311 is available in an 8-pin SOIC surface-mount package and the surface-mount PowerPAD MSOP, which reduces board space by 50% and height by 40%.



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.

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AVAILABLE OPTIONS

T_A	PACKAGED DEVICES		MSOP Symbolization
	SMALL OUTLINE† (D)	MSOP† (DGN)	
–40°C to 85°C	TPA311D	TPA311DGN	AAB

† The D and DGN packages are available taped and reeled. To order a taped and reeled part, add the suffix R to the part number (e.g., TPA311DR).

Terminal Functions

TERMINAL NAME	TERMINAL NO.	I/O	DESCRIPTION
BYPASS	2	I	BYPASS is the tap to the voltage divider for internal mid-supply bias. This terminal should be connected to a 0.1-µF to 1-µF capacitor when used as an audio amplifier.
GND	7		GND is the ground connection.
IN	4	I	IN is the audio input terminal.
SE/$\overline{\text{BTL}}$	3	I	When SE/$\overline{\text{BTL}}$ is held low, the TPA311 is in BTL mode. When SE/$\overline{\text{BTL}}$ is held high, the TPA311 is in SE mode.
SHUTDOWN	1	I	SHUTDOWN places the entire device in shutdown mode when held high (I_{DD} = 60 µA, V_{DD} = 5 V).
V_{DD}	6		V_{DD} is the supply voltage terminal.
V_O+	5	O	V_O+ is the positive output for BTL and SE modes.
$V_O–$	8	O	$V_O–$ is the negative output in BTL mode and a high-impedance output in SE mode.

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 (see Table 3) . . . –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	$T_A \leq 25°C$	DERATING FACTOR	$T_A = 70°C$	$T_A = 85°C$
D	725 mW	5.8 mW/°C	464 mW	377 mW
DGN	2.14 W§	17.1 mW/°C	1.37 W	1.11 W

§ Please 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}	2.5	5.5	V
Operating free-air temperature, T_A (see Table 3)	–40	85	°C

electrical characteristics at specified free-air temperature, V_{DD} = 3.3 V, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
V_{OO}	Output offset voltage (measured differentially)	See Note 1			5	20	mV
PSRR	Power supply rejection ratio	V_{DD} = 3.2 V to 3.4 V	BTL mode		85		dB
			SE mode		83		
I_{DD}	Supply current (see Figure 6)	BTL mode			0.7	1.5	mA
		SE mode			0.35	0.75	
$I_{DD(SD)}$	Supply current, shutdown mode (see Figure 7)				7	50	μA

NOTE 1: At 3 V < V_{DD} < 5 V the dc output voltage is approximately V_{DD}/2.

operating characteristics, V_{DD} = 3.3 V, T_A = 25°C, R_L = 8 Ω

PARAMETER		TEST CONDITIONS			MIN	TYP	MAX	UNIT
P_O	Output power, see Note 2	THD = 0.5%,	BTL mode,	See Figure 14		250		mW
		THD = 0.5%,	SE mode			110		
THD + N	Total harmonic distortion plus noise	P_O = 250 mW, See Figure 12	f = 20 Hz to 4 kHz,	Gain = 2,		1.3%		
B_{OM}	Maximum output power bandwidth	Gain = 2,	THD = 3%,	See Figure 12		10		kHz
B_1	Unity-gain bandwidth	Open Loop,	See Figure 36			1.4		MHz
	Supply ripple rejection ratio	f = 1 kHz, See Figure 5	C_B = 1 μF,	BTL mode,		71		dB
		f = 1 kHz, See Figure 3	C_B = 1 μF,	SE mode,		86		
V_n	Noise output voltage	Gain = 1, BTL,	C_B = 0.1 μF, See Figure 42	R_L = 32 Ω,		15		μV(rms)

NOTE 2: Output power is measured at the output terminals of the device at f = 1 kHz.

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
V_{OO}	Output offset voltage (measured differentially)				5	20	mV
PSRR	Power supply rejection ratio	V_{DD} = 4.9 V to 5.1 V	BTL mode		78		dB
			SE mode		76		
I_{DD}	Supply current (see Figure 6)	BTL mode			0.7	1.5	mA
		SE mode			0.35	0.75	
$I_{DD(SD)}$	Supply current, shutdown mode (see Figure 7)				60	100	μA

operating characteristics, V_{DD} = 5 V, T_A = 25°C, R_L = 8 Ω

PARAMETER		TEST CONDITIONS			MIN	TYP	MAX	UNIT
P_O	Output power, see Note 2	THD = 0.5%,	BTL mode,	See Figure 18		700		mW
		THD = 0.5%,	SE mode			300		
THD + N	Total harmonic distortion plus noise	P_O = 350 mW, See Figure 16	f = 20 Hz to 4 kHz,	Gain = 2,		1%		
B_{OM}	Maximum output power bandwidth	Gain = 2,	THD = 2%,	See Figure 16		10		kHz
B_1	Unity-gain bandwidth	Open Loop,	See Figure 37			1.4		MHz
	Supply ripple rejection ratio	f = 1 kHz, See Figure 5	C_B = 1 μF,	BTL mode,		65		dB
		f = 1 kHz, See Figure 4	C_B = 1 μF,	SE mode,		75		
V_n	Noise output voltage	Gain = 1, BTL,	C_B = 0.1 μF, See Figure 43	R_L = 32 Ω,		15		μV(rms)

NOTE 2: Output power is measured at the output terminals of the device at f = 1 kHz.

PARAMETER MEASUREMENT INFORMATION

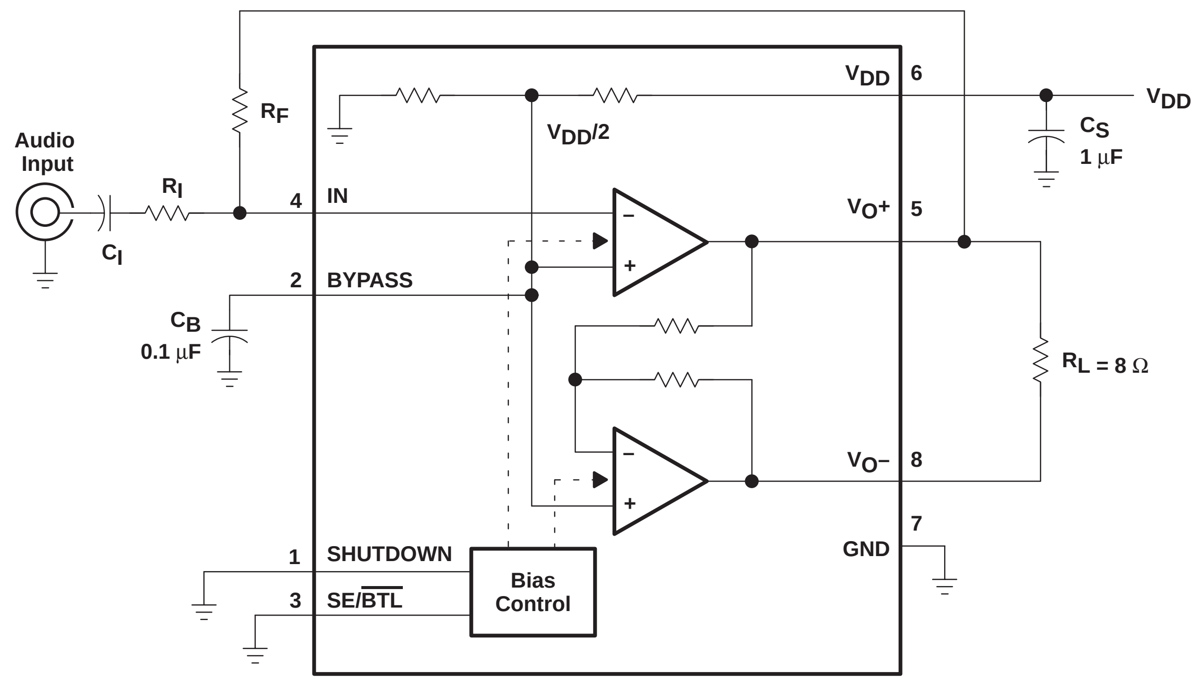

Figure 1. BTL Mode Test Circuit

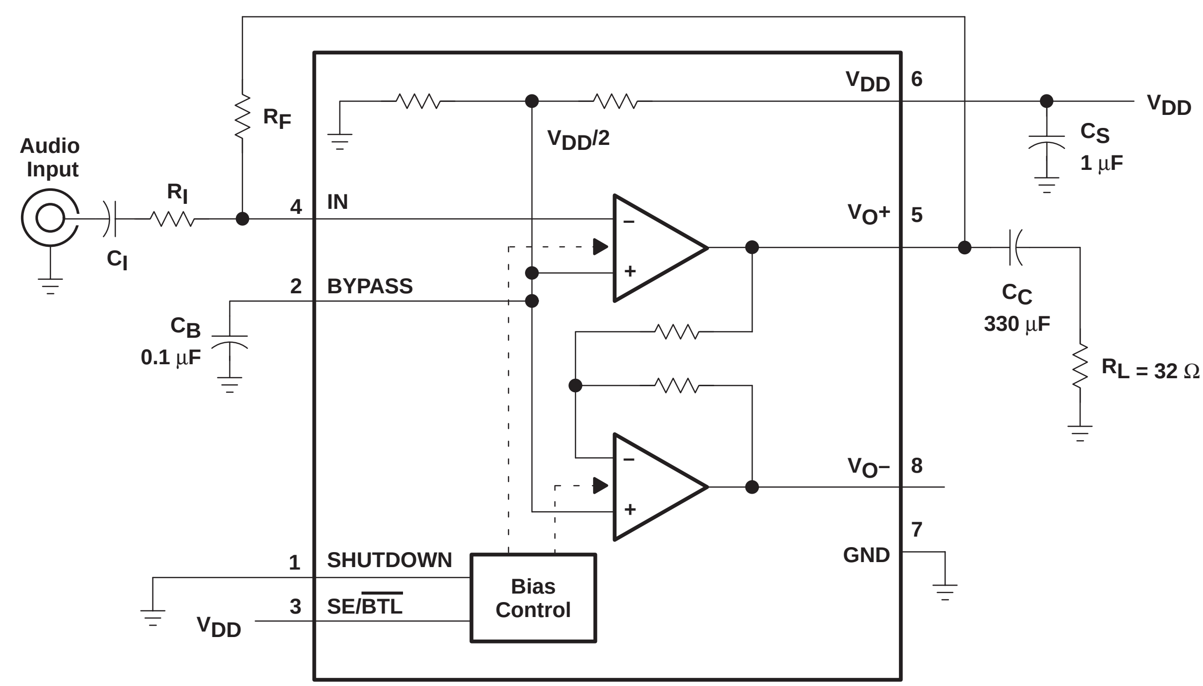

Figure 2. SE Mode Test Circuit

APPLICATION INFORMATION

application schematic

Figure 51 is a schematic diagram of a typical handheld audio application circuit, configured for a gain of –10 V/V.

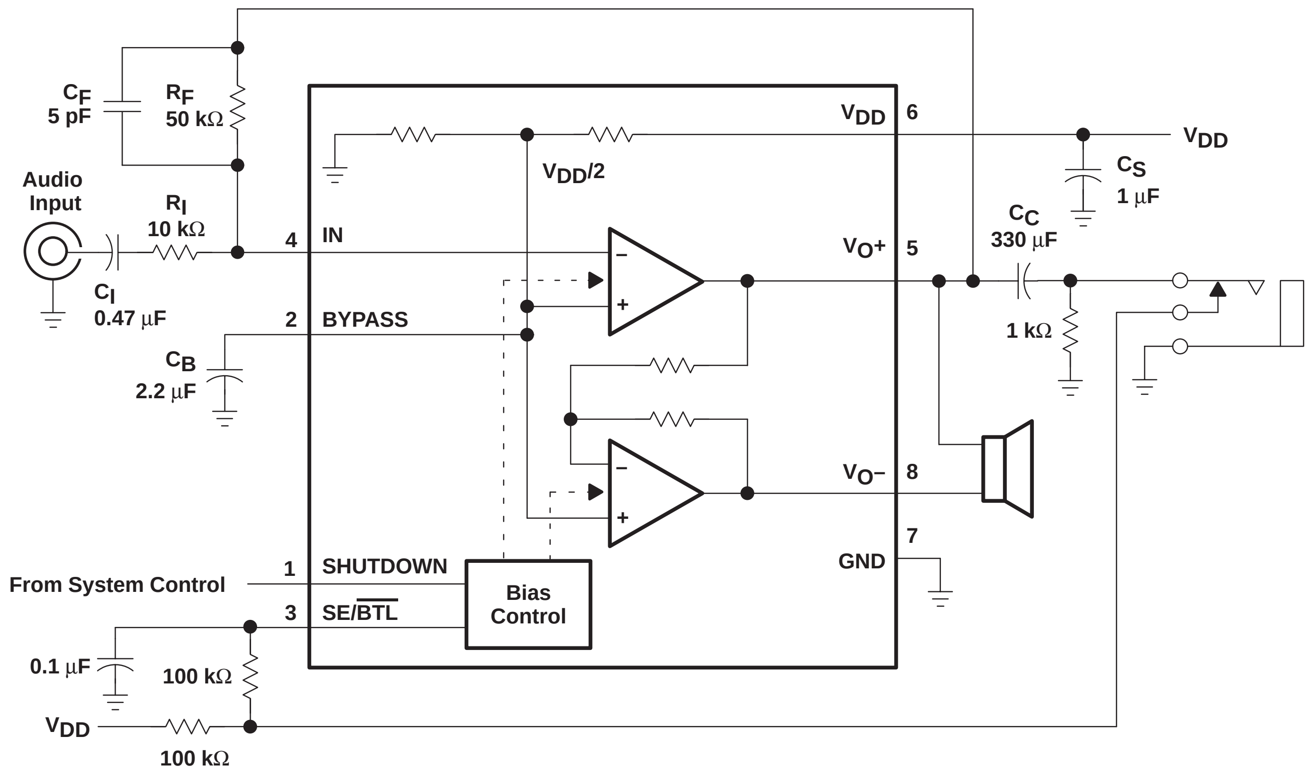

Figure 51. TPA311 Application Circuit

The following sections discuss the selection of the components used in Figure 51.

component selection

gain setting resistors, R_F and R_I

The gain for each audio input of the TPA311 is set by resistors R_F and R_I according to equation 5 for BTL mode.

$$\text{BTL Gain} = A_V = -2\left(\frac{R_F}{R_I}\right) \tag{5}$$

BTL mode operation brings about the factor 2 in the gain equation due to the inverting amplifier mirroring the voltage swing across the load. Given that the TPA311 is a MOS amplifier, the input impedance is very high, consequently input leakage currents are not generally a concern, although noise in the circuit increases as the value of R_F increases. In addition, a certain range of R_F values is required for proper start-up operation of the amplifier. Taken together it is recommended that the effective impedance seen by the inverting node of the amplifier be set between 5 kΩ and 20 kΩ. The effective impedance is calculated in equation 6.

$$\text{Effective Impedance} = \frac{R_F R_I}{R_F + R_I} \tag{6}$$

APPLICATION INFORMATION

SE/$\overline{\text{BTL}}$ operation

The ability of the TPA311 to easily switch between BTL and SE modes is one of its most important cost saving features. This feature eliminates the requirement for an additional earphone amplifier in applications where internal speakers are driven in BTL mode but external earphone or speaker must be accommodated. Internal to the TPA311, two separate amplifiers drive V_O+ and V_O–. The SE/$\overline{\text{BTL}}$ input (terminal 3) controls the operation of the follower amplifier that drives V_O– (terminal 8). When SE/$\overline{\text{BTL}}$ is held low, the amplifier is on and the TPA311 is in the BTL mode. When SE/$\overline{\text{BTL}}$ is held high, the V_O– amplifier is in a high output impedance state, which configures the TPA311 as an SE driver from V_O+ (terminal 5). I_{DD} is reduced by approximately one-half in SE mode. Control of the SE/$\overline{\text{BTL}}$ input can be from a logic-level TTL source or, more typically, from a resistor divider network as shown in Figure 52.

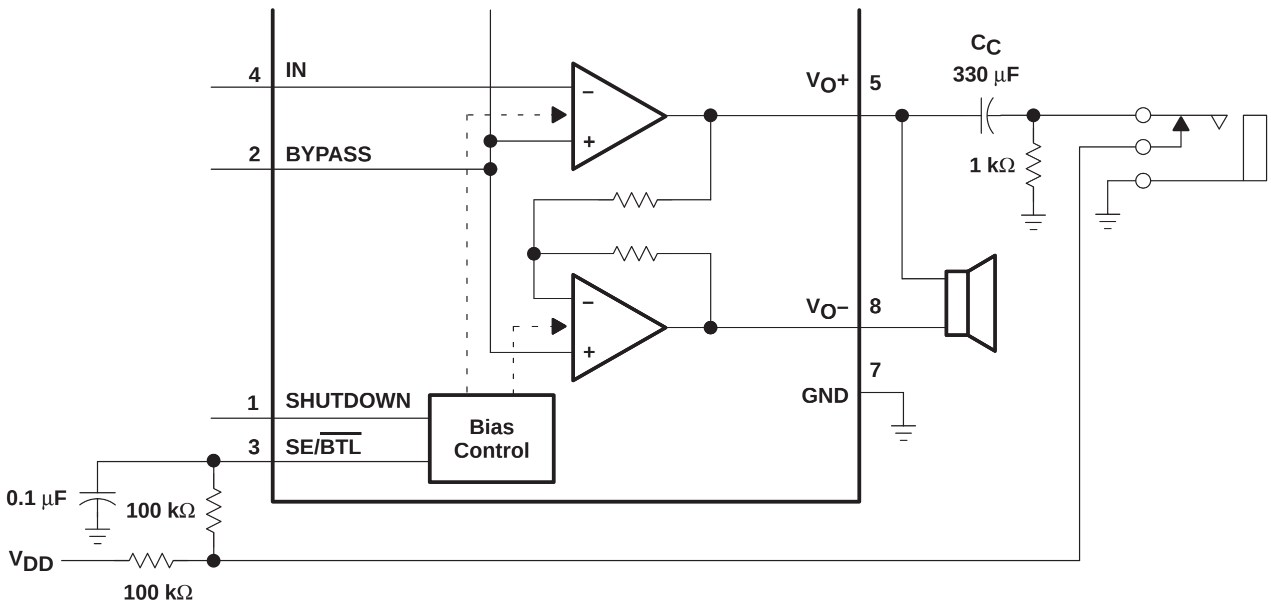

Figure 52. TPA311 Resistor Divider Network Circuit

Using a readily available 1/8-in. (3.5 mm) mono earphone jack, the control switch is closed when no plug is inserted. When closed the 100-kΩ/1-kΩ divider pulls the SE/$\overline{\text{BTL}}$ input low. When a plug is inserted, the 1-kΩ resistor is disconnected and the SE/$\overline{\text{BTL}}$ input is pulled high. When the input goes high, the V_O– amplifier is shutdown causing the BTL speaker to mute (virtually open-circuits the speaker). The V_O+ amplifier then drives through the output capacitor (C_C) into the earphone jack.

using low-ESR capacitors

Low-ESR capacitors are recommended throughout this application. A real (as opposed to ideal) capacitor can be modeled simply as a resistor in series with an ideal capacitor. The voltage drop across this resistor minimizes the beneficial effects of the capacitor in the circuit. The lower the equivalent value of this resistance the more the real capacitor behaves like an ideal capacitor.