LM4962 Stereo Ceramic Speaker Driver Application Note

National Semiconductor
Application Note 1440
Nisha Patel
April 2006

General Description

The LM4962 integrates a switching boost converter with an audio power amplifier and can be used in either mono or stereo ceramic speaker applications. For stereo applications, an external audio power amplifier (LM4951) is used in conjunction with the LM4962. This application note provides information on the performance of the LM4962 and the LM4951 in a stereo application. For further information on the LM4962 or the LM4951, refer to their respective datasheets.

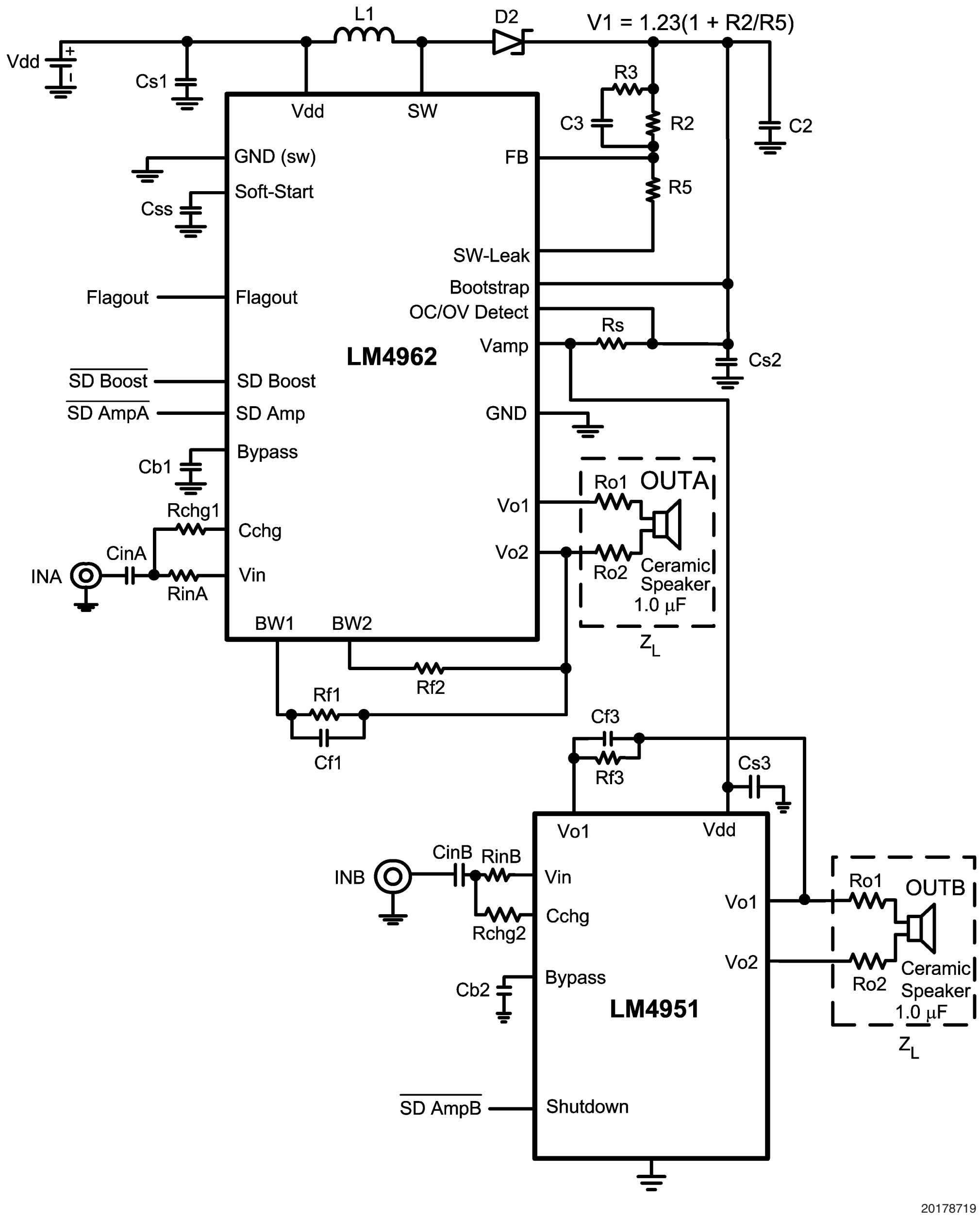


FIGURE 1. LM4962 Stereo Typical Application

General Description (Continued)

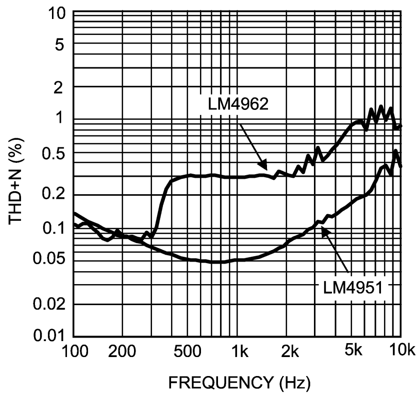
SUGGESTED COMPONENT VALUES FOR A TYPICAL APPLICATION

Item	Description	Value
Cf1, Cf3	Ceramic Capacitor	82pF
C3	Ceramic Capacitor	100pF
CinA, CinB	Ceramic Capacitor	0.39
C2, Cs1, Cs2, Cs3	Ceramic Capacitor	4.7µF
Css	Ceramic Capacitor	10nF
Cb1, Cb2	Tantalum Capacitor	1µF
D2	Schottky Diode	
L1	Inductor	10µH
R3	Resistor	1.6kΩ
R2	Resistor	25kΩ
Rchg1, Rchg2	Resistor	1kΩ
RinA, RinB, Rf2	Resistor	20kΩ
Rf1, Rf2	Resistor	200kΩ
R5	Resistor	4.9kΩ
Rs	Resistor	100mΩ
Ro1, Ro2	Resistor	15Ω

Typical Performance Characteristics

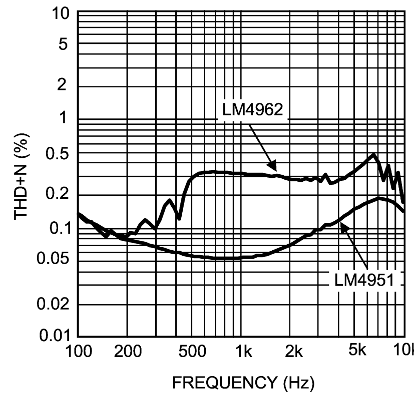
The following Typical Performance Characteristics graphs apply for Z_L = 1µF+30Ω, A_{V-BTL} = 26dB, T_A = 25˚C.

THD+N vs Frequency
V_{DD} = 3.2V, V_O = 4.95V_{RMS}
Both Channels 10Hz-10kHz



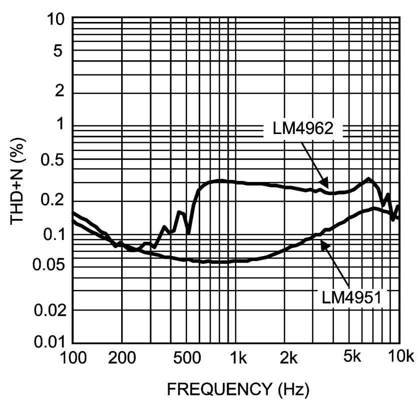
20178722

THD+N vs Frequency
V_{DD} = 4.2V, V_O = 4.95V_{RMS}
Both Channels 10Hz-10kHz



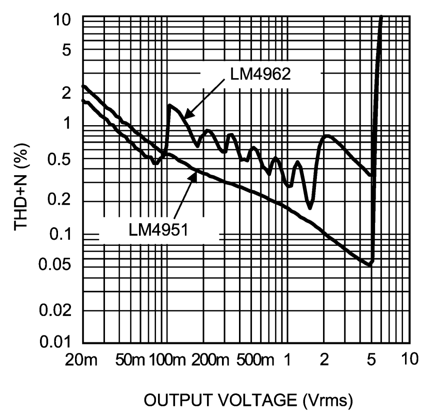
20178723

THD+N vs Frequency
V_{DD} = 5V, V_O = 4.95V_{RMS}
Both Channels 10Hz-10kHz



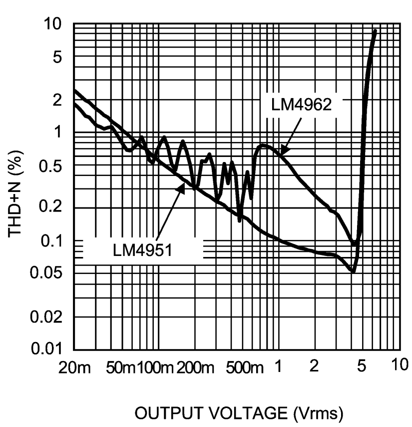
20178724

THD+N vs Output Power
V_{DD} = 3.2V, f = 1kHz, Both Channels



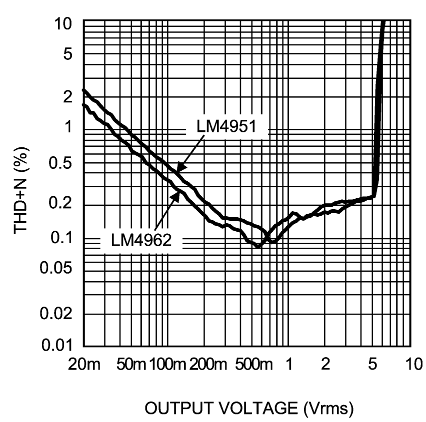
20178710

THD+N vs Output Power
V_{DD} = 3.2V, f = 10kHz, Both Channels



20178711

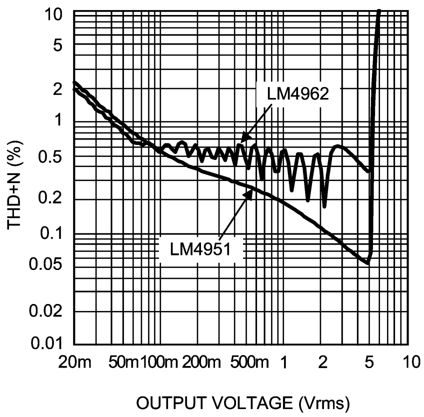
THD+N vs Output Power
V_{DD} = 3.2V, f = 100Hz, Both Channels



20178712

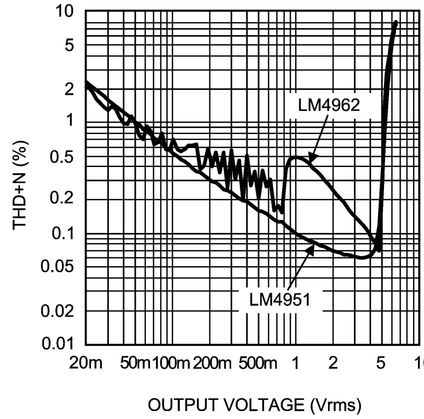
Typical Performance Characteristics (Continued)

THD+N vs Stereo Output Voltage
V_{DD} = 4.2V, f = 1kHz, Both Channels



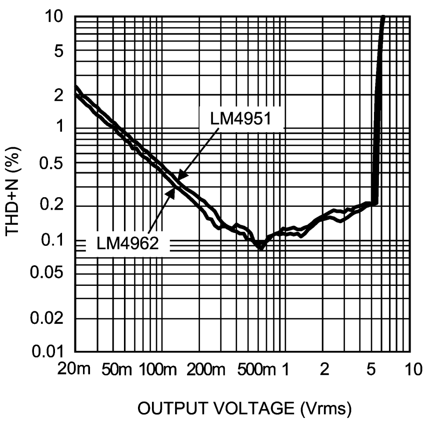
20178713

THD+N vs Stereo Output Voltage
V_{DD} = 4.2V, f = 10kHz, Both Channels



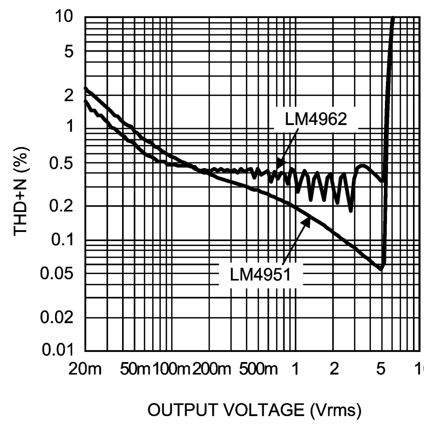
20178714

THD+N vs Stereo Output Voltage
V_{DD} = 4.2V, f = 100Hz, Both Channels



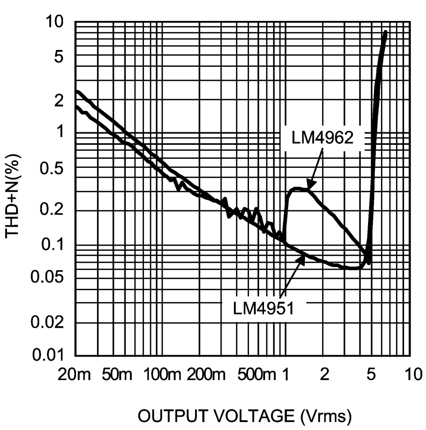
20178715

THD+N vs Stereo Output Voltage
V_{DD} = 5V, f = 1kHz, Both Channels



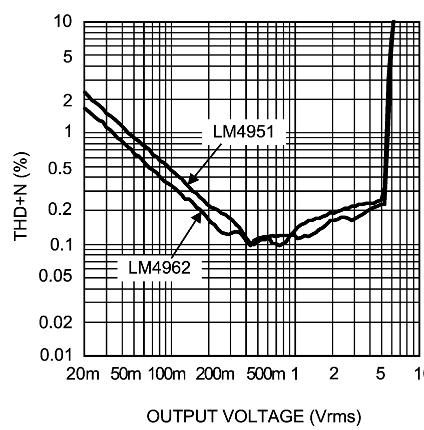
20178716

THD+N vs Stereo Output Voltage
V_{DD} = 5V, f = 10kHz, Both Channels



20178717

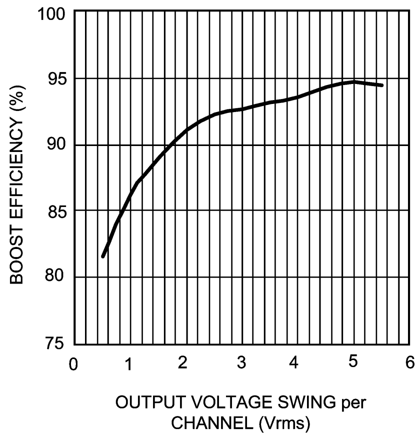
THD+N vs Stereo Output Voltage
V_{DD} = 5V, f = 100Hz, Both Channels



20178718

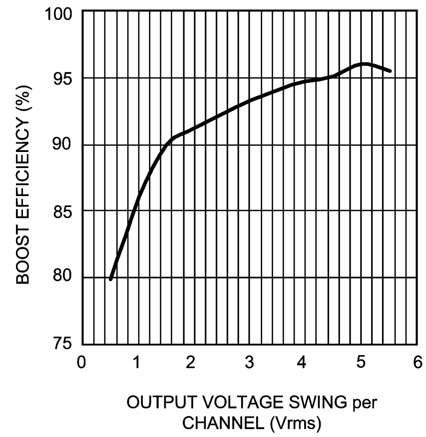
Typical Performance Characteristics (Continued)

Boost Efficiency vs Stereo Output Voltage
V_{DD} = 3V, f = 1kHz



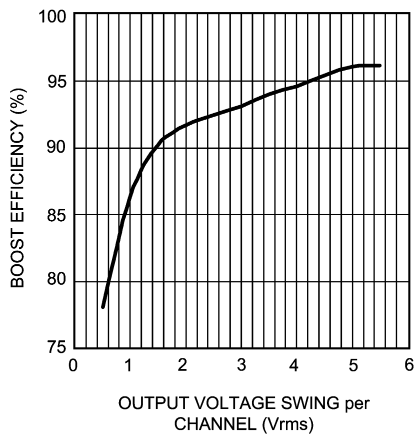
20178702

Boost Efficiency vs Stereo Output Voltage
V_{DD} = 4.2V, f = 1kHz



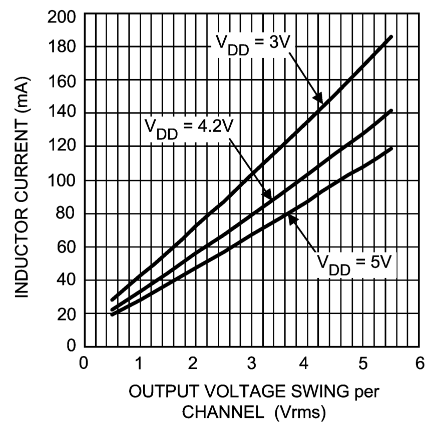
20178703

Boost Efficiency vs Stereo Output Voltage
V_{DD} = 5V, f = 1kHz



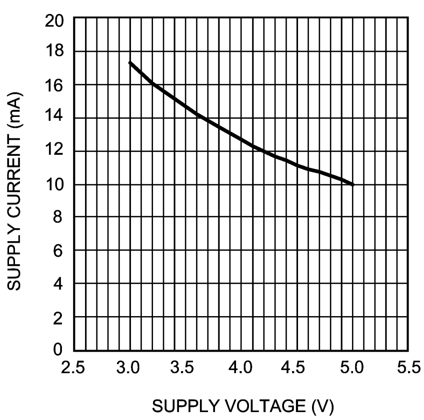
20178704

Inductor Current vs Stereo Output Voltage Swing



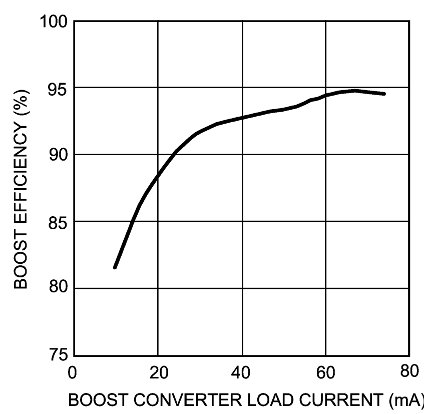
20178720

Supply Current vs Supply Voltage



20178706

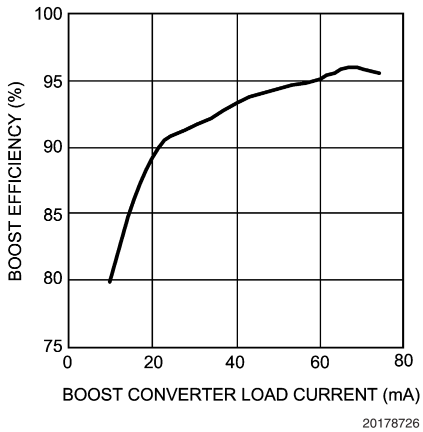
Boost Efficiency vs Boost Converter Load Current
VDD = 3.2V, V1 = 7.5V



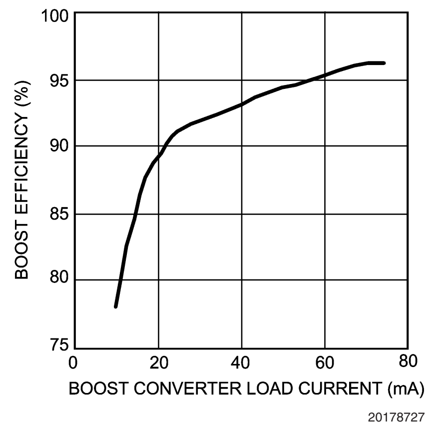
20178725

Typical Performance Characteristics (Continued)

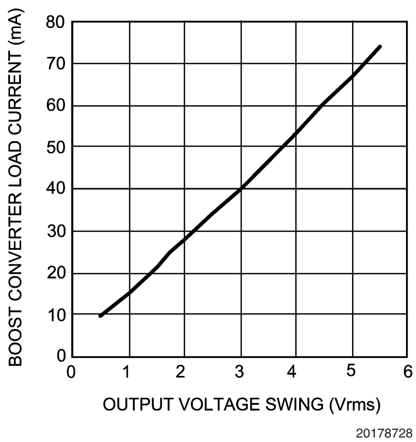
Boost Efficiency vs Boost Converter Load Current
V_{DD} = 4.2V, V1 = 7.5V



Boost Efficiency vs Boost Converter Load Current
V_{DD} = 5V, V1 = 7.5V



Boost Load Current vs Output Voltage Swing Stereo
V1 = 7.5V



Application Information

CHARACTERISTICS OF CERAMIC SPEAKERS

Because of their ultra-thin profile piezoelectric ceramic speakers are ideal for portable applications. Piezoelectric materials have high dielectric constants and their component electrical property is like a capacitor. Therefore, piezoelectric ceramic speakers essentially represent capacitive loads over frequency. Because these speakers are capacitive rather than resistive, they require less current than traditional moving coil speakers. However, ceramic speakers require high driving voltages (approximately 15Vp-p). To achieve these high output voltages in battery operated applications, the LM4962 integrates a boost converter with an audio amplifier.

OVER-CURRENT AND OVER-VOLTAGE PROTECTION FUNCTION

The protection circuitry in the LM4962 detects an over voltage/current event in both the internal amplifier and the external LM4951 amplifier.

Flag Pin

The Flagout pin indicates a fault when an over current or over voltage condition has been detected. The Flagout pin is high impedance when inactive. When active, the Flagout pin is pulled down to a 50Ω short to GND.

Over-Voltage Protection (OVP) Operation

When a voltage greater than 8.5V (min) is detected at the OC/OV Detect pin, the LM4962 indicates a fault by activating the Flagout pin. The boost converter momentarily shuts down and then reinitializes the soft-start sequence. The Flagout pin will remain active until both shutdown pins are pulled low.

Over-Current Protection (OCP) Operation

The OCP circuitry monitors the voltage across R_S to detect the output current of the boost converter. If a voltage greater than 185mV (typ) is detected the device will shut down and the Flagout pin will be activated. For the device to return to normal operation, both shutdown pins need to be pulled low to reset the Flagout pin.

Disable OCP

The Over-Current Protection Circuitry can be disabled by shorting out R_S. In this configuration, the OVP circuitry is still active.

Disable both OVP and OCP

Both features can be disabled by grounding the OC/OV Detect pin. In this configuration the Flagout pin will be inactive.

MAXIMUM AMPLIFIER POWER DISSIPATION

Power dissipation is a major concern when designing a successful amplifier. A direct consequence of the increased power delivered to the load by a bridge amplifier is an increase in internal power dissipation. Since the amplifier portion of the LM4962 has two operational amplifiers, the maximum internal power dissipation is 4 times that of a single-ended amplifier. The maximum power dissipation for a given BTL application can be derived from Equation (1).

$$P_{DMAX(AMP)} = (2V_{DD}^2) / (\pi^2 R_L) \quad (1)$$

where R_L = Ro1 + Ro2

MAXIMUM TOTAL POWER DISSIPATION

To calculate maximum total power dissipation for the LM4951, refer to the section labeled “AMPLIFIER POWER DISSIPATION” .

The total power dissipation for the LM4962 can be calculated by Equation (3):

$$P_{DMAX(TOTAL)} = (2V_{DD}^2) / (\pi^2 EFF^2 R_L) \quad (2)$$

where

EFF = efficiency of boost converter

R_L = Ro1 + Ro2

BOOST CONVERTER POWER DISSIPATION

At higher duty cycles, the increased ON-time of the switch FET means the maximum output current will be determined by power dissipation within the LM4962 FET switch. The switch power dissipation from ON-time conduction is calculated by Equation (2).

$$P_{(SWITCH)} = DC \times I_{IND}(AVE)^2 \times R_{DS}(ON) \quad (3)$$

where DC is the duty cycle.

There will be some switching losses as well, so some derating needs to be applied when calculating IC power dissipation.

SELECTING A VALUE for Ro1 and Ro2

Output resistors (Ro1 and Ro2) are used to set the minimum load impedance seen by the amplifier at high frequencies. These resistors also improve the gain and phase margin over frequency. The value of the resistors should be low compared to the operating impedance of the ceramic speaker so that losses in these resistors will not significantly contribute to overall losses. A value of 15Ω is recommended for Ro1 and Ro2 for a typical stereo application.

BOOTSTRAP PIN

The bootstrap pin in the LM4962 provides a voltage supply for the internal switch driver. Connecting the bootstrap pin to V1 (See Figure 1) allows for a higher voltage to drive the gate of the switch, thereby reducing its Ron. This configuration is necessary in applications with heavier loads. The bootstrap pin can be connected to V_{DD} when driving lighter loads to improve device performance (Iddq, THD+N, Noise, etc.). For stereo applications, the bootstrap pin should be connected to V1 to provide sufficient output drive capability.

SELECTING VALUE FOR Rchg

Both the audio power amplifier integrated in the LM4962 and the external amplifier LM4951 are designed for very fast turn on time. The Cchg pin allows the input capacitors (CinA and CinB) to charge quickly to improve click/pop performance. Rchg1 and Rchg2 protect the Cchg pins from any over/under voltage conditions caused by excessive input signal or an active input signal when the device is in shutdown. The recommended value for Rchg1 and Rchg2 is 1kΩ. If the input signal is less than V_{DD}+0.3V and greater than -0.3V, and if the input signal is disabled when in shutdown mode, Rchg1 and Rchg2 may be shorted out.

Application Information (Continued)

BAND SWITCH FUNCTION

The LM4962 features a Band Switch function which allows the user to configure the device for either receiver (earpiece) mode or ringer/loudspeaker mode. When the boost converter and both amplifiers are active, the device is in stereo ringer mode. This enables the boost converter and sets the externally configurable closed loop gain selection to BW1 for the internal audio amplifier in the LM4962. For receiver mode, the boost converter and the external LM4951 are shut down, and the internal amplifier in the LM4962 is active. In this mode, the gain selection for the internal amplifier is switched to BW2. This allows the internal amplifier to be powered directly from the battery. The LM4962 supply pin will see the battery voltage minus the voltage drop across the Schottky diode.

	SD Boost (LM4962)	SD AmpA (LM4962)	SD AmpB (LM4951)
Receiver Mode (BW2)	Low	High	Low
Boosted Stereo Ringer Mode (BW1)	High	High	High
Shutdown	Low	Low	Low

START-UP SEQUENCE

When using the LM4962 in a stereo application, correct start-up sequencing is important for optimal device performance. Using the correct start up sequence will improve click/pop performance as well as prevent transients that could reduce battery life. For ringer/loudspeaker mode, the supply voltage should be applied first, while the boost converter and the amplifier are in shutdown. The boost converter can then be activated, followed by both amplifiers (see timing diagram Figure 2). If the boost converter shutdown is toggled while either amplifier is active, an audible pop will be heard.

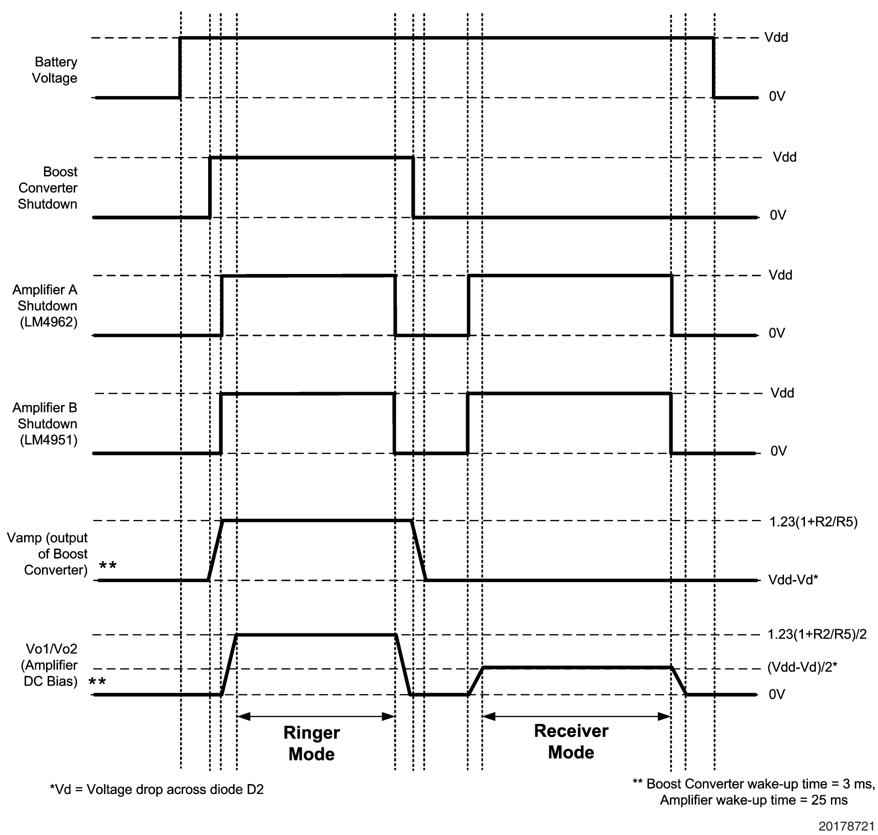


FIGURE 2. LM4962 Start-up Sequence Timing Diagram

Revision Table

Rev	Date	Description
0.1	01/26/06	Initial release.
0.2	04/18/06	Text edits (by Kevin C.), then released to the WEB.

National Semiconductor
Americas Customer
Support Center
Email: new.feedback@nsc.com
Tel: 1-800-272-9959

National Semiconductor
Europe Customer Support Center
Fax: +49 (0) 180-530 85 86
Email: europe.support@nsc.com
Deutsch Tel: +49 (0) 69 9508 6208
English Tel: +44 (0) 870 24 0 2171
Français Tel: +33 (0) 1 41 91 8790

National Semiconductor
Asia Pacific Customer
Support Center
Email: ap.support@nsc.com

National Semiconductor
Japan Customer Support Center
Fax: 81-3-5639-7507
Email: jpn.feedback@nsc.com
Tel: 81-3-5639-7560

www.national.com