LM831 Low Voltage Audio Power Amplifier

Literature Number: SNOSBP6A
LM831 Low Voltage Audio Power Amplifier

General Description
The LM831 is a dual audio power amplifier optimized for very low voltage operation. The LM831 has two independent amplifiers, giving stereo or higher power bridge (BTL) operation from two- or three-cell power supplies.

The LM831 uses a patented compensation technique to reduce high-frequency radiation for optimum performance in AM radio applications. This compensation also results in lower distortion and less wide-band noise.

The input is direct-coupled to the LM831, eliminating the usual coupling capacitor. Voltage gain is adjustable with a single resistor.

Features
- Low voltage operation, 1.8V to 6.0V
- High power, 440 mW, 8Ω, BTL, 3V
- Low AM radiation
- Low noise
- Low THD

Applications
- Portable tape recorders
- Portable radios
- Headphone stereo
- Portable speakers

Typical Application

Dual Amplifier with Minimum Parts

- AV = 46 dB
- BW = 250 Hz to 35 kHz
- P_{OUT} = 220 mW/CH, R_L = 4Ω
### Absolute Maximum Ratings

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

- **Supply Voltage, V_S:** 7.5V
- **Input Voltage, V_{IN}**: ±0.4V
- **Power Dissipation (Note 1), P_D:**
  - 1.3W (M Package)
  - 1.4W (N Package)
- **Operating Temperature (Note 1), T_{opr}**: −40°C to +85°C
- **Storage Temperature, T_{stg}**: −65°C to +150°C
- **Thermal Resistance**
  - \( \theta_{JC} \) (DIP): 27°C/W
  - \( \theta_{JA} \) (DIP): 75°C/W
  - \( \theta_{JC} \) (SO Package): 20°C/W
  - \( \theta_{JA} \) (SO Package): 95°C/W

### Electrical Characteristics

Unless otherwise specified, T_A = 25°C, V_S = 3V, f = 1 kHz, test circuit is dual or BTL amplifier with minimum parts.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Typ</th>
<th>Tested Limit</th>
<th>Unit (Limit)</th>
</tr>
</thead>
<tbody>
<tr>
<td>V_S</td>
<td>Operating Voltage</td>
<td>1.8</td>
<td>V (Min)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I_Q</td>
<td>Supply Current</td>
<td>V_{IN} = 0, Dual Mode</td>
<td>5</td>
<td>mA (Max)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>V_{IN} = 0, BTL Mode</td>
<td>6</td>
<td>mA (Max)</td>
<td></td>
</tr>
<tr>
<td>V_OS</td>
<td>Output DC Offset</td>
<td>V_{IN} = 0, BTL Mode</td>
<td>10</td>
<td>mV (Max)</td>
<td></td>
</tr>
<tr>
<td>R_IN</td>
<td>Input Resistance</td>
<td>25</td>
<td>k (Min)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>35</td>
<td>k (Max)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A_V</td>
<td>Voltage Gain</td>
<td>V_{IN} = 2.25 mV_{rms}, f = 1 kHz, Dual Mode</td>
<td>46</td>
<td>dB (Min)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>44</td>
<td>dB (Max)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PSRR</td>
<td>Supply Rejection</td>
<td>V_S = 3V + 200 mV_{rms} @ f = 1 kHz</td>
<td>46</td>
<td>dB (Min)</td>
<td></td>
</tr>
<tr>
<td>P_OD</td>
<td>Power Out</td>
<td>V_S = 3V, R_L = 4\Omega, 10% THD, Dual Mode</td>
<td>220</td>
<td>mW (Min)</td>
<td></td>
</tr>
<tr>
<td>P_ODL</td>
<td>Power Out Low, V_S</td>
<td>V_S = 1.8V, R_L = 8\Omega, 10% THD, Dual Mode</td>
<td>45</td>
<td>mW (Min)</td>
<td></td>
</tr>
<tr>
<td>P_OB</td>
<td>Power Out</td>
<td>V_S = 1.8V, R_L = 8\Omega, 10% THD, BTL Mode</td>
<td>440</td>
<td>mW (Min)</td>
<td></td>
</tr>
<tr>
<td>P_OBL</td>
<td>Power Out Low, V_S</td>
<td>V_S = 1.8V, R_L = 8\Omega, 10% THD, BTL Mode</td>
<td>90</td>
<td>mW (Min)</td>
<td></td>
</tr>
<tr>
<td>Sep</td>
<td>Channel Separation</td>
<td>Referenced to V_O = 200 mV_{rms}</td>
<td>52</td>
<td>dB (Min)</td>
<td></td>
</tr>
<tr>
<td>I_g</td>
<td>Input Bias Current</td>
<td>1</td>
<td>( \mu A ) (Max)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E_no</td>
<td>Output Noise</td>
<td>Wide Band (250 ~ 35 kHz)</td>
<td>250</td>
<td>( \mu V ) (Max)</td>
<td></td>
</tr>
<tr>
<td>THD</td>
<td>Distortion</td>
<td>V_S = 3V, P_{O} = 50 mW, f = 1 kHz, Dual</td>
<td>0.25</td>
<td>% (Max)</td>
<td></td>
</tr>
</tbody>
</table>

**Note 1:** For operation in ambient temperatures above 25°C, the device must be derated based on a 150°C maximum junction temperature and a thermal resistance of 98°C/W junction to ambient for the M package or 90°C/W junction to ambient for the N package.

### Connection Diagram

[Connection Diagram](image)

Order Number LM831M or N
See NS Package Number M16B or N16E
Typical Performance Characteristics

Supply Current vs Supply Voltage

PSRR vs Supply Voltage

Supply Current vs Temperature

PSRR vs Supply Voltage

DC Output vs Supply Voltage

Separation vs Supply Voltage
Typical Performance Characteristics (Continued)

Separation vs Frequency

Gain vs Frequency

Power Output vs Supply Voltage

Power Output vs Temperature

Gain vs Frequency

Bandwidth vs BW Capacitance
 Typical Performance Characteristics 

Dual Mode, $R_L = 4\Omega$: Distortion vs Frequency

- Gain = 65 dB
- $R_{in} = 0\Omega$, $C_{in} = 0\mu F$ 
- $V_{CC} = 18$ V

Distortion vs Power Output (Note 2)

- $V_{CC} = 3.3$ V, $R_L = 8\Omega$
- $C_{in} = R_{in} = 0$

Power Dissipation vs Power Output

- $V_{CC} = 4$ V
- $R_L = 4\Omega$, $f = 1 KHz$

Dual Mode, $R_L = 8\Omega$: Distortion vs Frequency

- Gain = 65 dB
- $R_{in} = 0\Omega$, $C_{in} = 0\mu F$
- $V_{CC} = 18$ V

Distortion vs Power Output (Note 2)

- $V_{CC} = 3.3$ V, $R_L = 8\Omega$
- $C_{in} = R_{in} = 0$

Power Dissipation vs Power Output

- $V_{CC} = 4$ V
- $R_L = 4\Omega$, $f = 1 KHz$
Typical Performance Characteristics (Continued)

- **BTL Mode, R_L = 8Ω**: Distortion vs Frequency
- **Device Dissipation vs Ambient Temperature**

- **Distortion vs Power Output (Note 2)**

- **Supply Current vs Power Output**

- **Power Dissipation vs Power Output**

**Note 2:** 1 kHz curve is measured with 400 Hz–30 kHz Filter.

TLH/8754–7
Typical Applications

BTL Amplifier with Minimum Parts

\[ A_v = 52 \text{ dB}, \quad B_W = 250 \text{ Hz to } 25 \text{ kHz} \]
\[ P_{\text{OUT}} = 440 \text{ mW}, \quad R_L = 8\Omega \]

BTL Amplifier for Hi-Fi Quality

\[ A_v = 40 \text{ dB}, \quad B_W = 20 \text{ Hz to } 20 \text{ kHz} \]
\[ P_{\text{OUT}} = 440 \text{ mW}, \quad R_L = 8\Omega \]
(Dynamic Range Over 80 dB)
Typical Applications (Continued)

Dual Amplifier for Hi-Fi Quality

\[ A_v = 54 \text{ dB}, \quad \text{BW} = 50 \text{ Hz to } 20 \text{ kHz} \]
\[ P_{\text{OUT}} = 220 \text{ mW/Ch}, \quad R_L = 4\Omega \]
(Dynamic Range Over 80 dB)

Low-Cost Power Amplifier (No Bootstrap)

\[ P_{\text{OUT}} = 150 \text{ mW/Ch}, \quad \text{BW} = 300 \text{ Hz to } 35 \text{ kHz} \]
BTL Mode is also possible

*For 3-cell applications, the 120k resistor should be changed to 20K.
**LM831 Circuit Description** Refer to the external component diagram and equivalent schematic.

The power supply is applied to Pin 9 and is filtered by resistor $R_1$ and capacitor $C_{BY}$ on Pin 16. This filtered voltage at Pin 16 is used to bias all of the LM831 circuits except the power output stage. Resistor $R_0$ generates a biasing current that sets the output DC voltage for optimum output power for any given supply voltage.

Feedback is provided to the input transistor $Q_1$ emitter by $R_6$ and $R_7$.

The capacitor $C_M$ on Pin 2 provides unity DC gain for maximum DC accuracy.

$Q_2$ provides voltage gain and the rest of the devices buffer the output load from $Q_2$'s collector.

Bootstrapping of Pin 5 by $C_{BS}$ allows maximum output swing and improved supply rejection.

$R_5$ is provided for bridge (BTL) operation.
LM831 Circuit Description (Continued)

[Diagram of the LM831 Equivalent Schematic]

TL/85-13

Obsolete

10
### External Components (Refer to External Component Diagram)

<table>
<thead>
<tr>
<th>Component</th>
<th>Comments</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>( C_O )</td>
<td>Required to stabilize output stage.</td>
<td>0.33 ( \mu F )</td>
<td>1 ( \mu F )</td>
</tr>
<tr>
<td>( C_C )</td>
<td>Output coupling capacitors for Dual Mode. Sets a low-frequency pole in the frequency response.</td>
<td>100 ( \mu F )</td>
<td>10,000 ( \mu F )</td>
</tr>
<tr>
<td>( C_{BS} )</td>
<td>Bootstrap capacitors. Sets a low-frequency pole in the power BW. Recommended value is</td>
<td>22 ( \mu F ) or (short Pins 4 &amp; 12 to 9)</td>
<td>470 ( \mu F )</td>
</tr>
<tr>
<td>( C_S )</td>
<td>Supply bypass. Larger values improve low-battery performance by reducing supply ripple.</td>
<td>47 ( \mu F )</td>
<td>10,000 ( \mu F )</td>
</tr>
<tr>
<td>( C_{BY} )</td>
<td>Filters the supply for improved low-voltage operation. Also sets turn-on delay.</td>
<td>47 ( \mu F )</td>
<td>470 ( \mu F )</td>
</tr>
<tr>
<td>( C_{NF} )</td>
<td>Sets a low-frequency response. Also affects turn-on delay.</td>
<td>10 ( \mu F )</td>
<td>100 ( \mu F )</td>
</tr>
<tr>
<td>( C_{BTL} )</td>
<td>Used only in the Bridge Mode. Connects the output of the first amplifier to the inverting input of the other through an internal resistor. Sets a low-frequency pole in one-half the frequency response.</td>
<td>0.1 ( \mu F )</td>
<td>1 ( \mu F )</td>
</tr>
<tr>
<td>( C_{BW} )</td>
<td>Improves clipping waveform and sets the high-frequency bandwidth. Works with an internal 16k resistor. (This equation applies for ( R_{AV} = 0 ). For 46 dB application, see BW–( C_{BW} ) curve.)</td>
<td>See table below</td>
<td></td>
</tr>
<tr>
<td>( R_{AV} )</td>
<td>Used to reduce the gain and improve the distortion and signal to noise. If this is desired, ( C_{BW} ) must also be used.</td>
<td>See table below</td>
<td></td>
</tr>
</tbody>
</table>

#### Typical \( A_V \)

<table>
<thead>
<tr>
<th>( R_{AV} )</th>
<th>( C_{BW} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>46 dB</td>
<td>Short</td>
</tr>
<tr>
<td>40 dB</td>
<td>82</td>
</tr>
<tr>
<td>34 dB</td>
<td>240</td>
</tr>
<tr>
<td>28 dB</td>
<td>560</td>
</tr>
</tbody>
</table>
Printed Circuit Layout for LM831N (Foil Side View) Refer to External Component Diagram

Note: Power ground pattern should be as wide as possible. Supply bypass capacitor should be as close to the IC as possible. Output compensation capacitors should also be close to the IC.
Physical Dimensions inches (millimeters)

Molded SO Package (M)
Order Number LM831M
NS Package Number M16B

Obsolete
**Physical Dimensions** inches (millimeters) (Continued)

![Diagram of physical dimensions](image)

**Molded Dual-In-Line Package (N)**
Order Number LM831N
NS Package Number N16E

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