The BA3121, BA3121F and BA3121N are ground isolation amplifiers developed for use in car audio applications. These ICs efficiently eliminate problems caused by wiring resistance, and remove noise generated by the electrical devices used in automobiles. The capacitance values of the external capacitors required for the ICs are small to allow compact and reliable set design.

● Applications
  Car audio systems

● Features
  1) Large capacitors not required
  2) High common-mode rejection ratio (57dB typ. at f = 1kHz).
  3) Low noise (\(V_{\text{NO}} = 3.5\mu\text{Vrms Typ.}\)).
  4) Low distortion (THD = 0.002% Typ.).
  5) Two channels.

● Absolute maximum ratings (Ta = 25°C)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Limits</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power supply voltage</td>
<td>Vcc</td>
<td>18</td>
<td>V</td>
</tr>
<tr>
<td>Power dissipation</td>
<td>Pd</td>
<td>800 (BA3121)*</td>
<td>mW</td>
</tr>
<tr>
<td></td>
<td></td>
<td>450 (BA3121F)*</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>900 (BA3121N)*</td>
<td></td>
</tr>
<tr>
<td>Operating temperature</td>
<td>Topr</td>
<td>-30~+85</td>
<td>°C</td>
</tr>
<tr>
<td>Storage temperature</td>
<td>Tstg</td>
<td>-55~+125</td>
<td>°C</td>
</tr>
</tbody>
</table>

* Reduced by 8.0mW (BA3121), 4.5mW (BA3121F), and 9.0mW (BA3121N) for each increase in Ta of 1°C over 25°C.

● Recommended operating conditions (Ta = 25°C)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power supply voltage</td>
<td>Vcc</td>
<td>4</td>
<td>12</td>
<td>18</td>
<td>V</td>
</tr>
</tbody>
</table>
Audio ICs

BA3121 / BA3121F / BA3121N

Block diagrams

BA3121 / BA3121F

BA3121N
### Electrical characteristics (unless otherwise noted, $T_a = 25^\circ \text{C}$, $V_{CC} = 12\text{V}$, $f = 1\text{kHz}$, $R_g = 1.8\text{k}\Omega$)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quiescent current</td>
<td>$I_Q$</td>
<td>5.6</td>
<td>9.0</td>
<td>14.0</td>
<td>mA</td>
<td>$V_{IN}=0V_{rms}$</td>
</tr>
<tr>
<td>Output noise voltage</td>
<td>$V_{NO}$</td>
<td>—</td>
<td>3.5</td>
<td>8.0</td>
<td>$\mu V_{rms}$</td>
<td>BPF=20Hz~20kHz</td>
</tr>
<tr>
<td>Voltage gain</td>
<td>$G_V$</td>
<td>$-1.5$</td>
<td>$-0.04$</td>
<td>1.5</td>
<td>dB</td>
<td>$V_O=-10\text{dBm}$, $R_g=0\Omega$</td>
</tr>
<tr>
<td>Maximum output voltage</td>
<td>$V_{OM}$</td>
<td>1.8</td>
<td>2.0</td>
<td>—</td>
<td>$V_{rms}$</td>
<td>THD=0.1%, $V_{CC}=8\text{V}$</td>
</tr>
<tr>
<td>Total harmonic distortion</td>
<td>THD</td>
<td>—</td>
<td>0.002</td>
<td>0.02</td>
<td>%</td>
<td>$V_O=0.7V_{rms}$</td>
</tr>
<tr>
<td>Common-mode rejection ratio</td>
<td>CMRR</td>
<td>41</td>
<td>57</td>
<td>—</td>
<td>dB</td>
<td></td>
</tr>
<tr>
<td>Common-mode voltage</td>
<td>$V_{CM}$</td>
<td>2.5</td>
<td>3.75</td>
<td>—</td>
<td>$V_{rms}$</td>
<td>$V_{CC}=8\text{V}$, CMRR=40dB</td>
</tr>
<tr>
<td>Ripple rejection ratio</td>
<td>RR</td>
<td>72</td>
<td>80</td>
<td>—</td>
<td>dB</td>
<td>$f_{SR}=100\text{Hz}$, $V_{RR}=-10\text{dBm}$, $R_g=0\Omega$</td>
</tr>
<tr>
<td>Channel separation</td>
<td>CS</td>
<td>—</td>
<td>82</td>
<td>—</td>
<td>dB</td>
<td>$V_{IN}=-10\text{dBm}$, $R_g=1.8k\Omega$/OPEN</td>
</tr>
<tr>
<td>Slew rate</td>
<td>SR</td>
<td>—</td>
<td>2.0</td>
<td>—</td>
<td>$V/\mu\text{s}$</td>
<td></td>
</tr>
<tr>
<td>Input resistance</td>
<td>$R_{IN}$</td>
<td>44</td>
<td>55</td>
<td>66</td>
<td>k\Omega</td>
<td></td>
</tr>
</tbody>
</table>

©Not designed for radiation resistance.
Audio ICs

BA3121 / BA3121F / BA3121N

Measurement circuits

BA3121/BA3121F

Fig. 1

BA3121N

Fig. 2

Units:
Resistance (carbon): Ω (±11%)
Capacitance (electrolytic): F (±5%)
Car-audio systems are earthed to the car body, and for this reason, electrical noise generated by the car electrics can enter the power amplifier input via the chassis, and become audible.

The BA3121 makes use of the common-mode rejection characteristics of an operational amplifier to eliminate this noise. Without the BA3121 noise enters the power amplifier input directly, when used, the CMMR of operational amplifiers 1-A and 2-A eliminates the noise.

Principles of noise elimination:

To obtain the output voltage ($e_O$)

$$V_i = \frac{R_4}{(R_3 + R_4)} \cdot e_2$$  \[1\]

$$e_O = -\frac{R_2}{R_1} e_1 + \frac{R_1 + R_2}{R_1} \cdot V_i$$  \[2\]

From \[1\] and \[2\]

$$e_O = -\frac{R_2}{R_1} e_1 + \frac{R_1 + R_2}{R_1} \cdot \frac{R_4}{(R_3 + R_4)} \cdot e_2$$

$$= -\frac{R_2}{R_1} (e_1 - e_2) + \frac{R_4}{R_1 (R_3 + R_4)} \cdot e_2$$

Ideally, if $R_1 R_4 = R_2 R_3$, and $e_1 = e_2$, the noise voltage will become zero. However, due to mismatching between the resistors, difference in the noise voltages ($e_1$ and $e_2$), and tolerances in the operational amplifier, a noise voltage does result.

With the BA3121, the elimination level of the noise is expressed as: $\text{CMMR} = 20 \log \left( \frac{e_O}{e_i} \right)$ ($e_i = e_1 = e_2$)

Therefore, $\text{CMRR} \geq 41$ dB can be guaranteed.

**Operation notes**

1. Maintain a ratio of 2:1 for the values of the capacitors connected to pin 2 ($V_{m1}$) and pin 6 ($V_{m2}$) to keep the ripple rejection ratio stable. If this ratio is maintained, the ripple rejection ratio will not vary significantly even if the capacitance values are halved.

2. If the value of the capacitor connected to pin 2 ($V_{m1}$) in the example is doubled, the bass-region CMMR will be +6 dB, and if it is halved, it will be −6 dB (see Fig. 16).
Audio ICs

BA3121 / BA3121F / BA3121N

Application example

BA3121/BA3121F

Fig. 5

Capacitor (electrolytic): F (±20%)
Audio ICs

BA3121N

TAPE DECK TUNER

IN1

4.7 μ

IN2

4.7 μ

22 μ

4.7 μ

4.7 μ

POWER AMP

SP

SP

Car Body Noise

Car Body

Units

Capacitor (electrolytic): F (±20%)

Fig. 6

Electrical characteristics curves

Fig. 7 Quiescent current vs. power supply voltage

Fig. 8 Maximum output voltage vs. power supply voltage

Fig. 9 Output noise voltage vs. power supply voltage
Audio ICs

BA3121 / BA3121F / BA3121N

Fig. 10 Voltage gain vs. power supply voltage

Fig. 11 Voltage gain vs. frequency

Fig. 12 Channel separation vs. frequency

Fig. 13 Ripple rejection ratio vs. frequency

Fig. 14 Total harmonic distortion vs. output voltage

Fig. 15 Total harmonic distortion vs. frequency

Fig. 16 Common-mode rejection ratio vs. frequency

Fig. 17 Common-mode rejection ratio vs. input voltage
Audio ICs

BA3121 / BA3121F / BA3121N

- External dimensions (Units: mm)

<table>
<thead>
<tr>
<th>BA3121</th>
<th>BA3121F</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="DIP8" /></td>
<td><img src="image2" alt="SOP8" /></td>
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<table>
<thead>
<tr>
<th>BA3121N</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image3" alt="SIP8" /></td>
</tr>
</tbody>
</table>
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