AN7198Z
Dual 20 W BTL Power IC for Car Audio

Overview
The AN7198Z is an audio power IC developed for the sound output of car audio (Dual 20 W).

A capacitor and a resistor between the output pin and GND to stop oscillation are built-in so that a space saving of set is possible. Also, it incorporates an industry’s first superior muting circuit which is free from shock noise, so that a shock noise design under the set transient condition can be made easily when the muting circuit is used together with its standby function.

In addition, it is incorporating various protective circuits to protect the IC from destruction by GND-open short circuit to GND and power supply surge which are the important subjects of power IC protection, and the IC will largely contribute to a high reliability design of equipment.

Features
- Built-in various protection circuits (Realizing high breakdown voltage against destruction)
  - Power supply surge breakdown voltage of 80 V or more
  - Ground-open breakdown voltage of 16 V or more
- Built-in standby function (Free from shock noise at STB-on/off)
- Built-in muting function
  - Free from shock noise at mute-on/off
  - Adapting attenuator method, so that abnormal sound due to waveform deformation is not generated
  - Attack time, recovery time of 50 ms or less
- Reduction in external components
  - No capacitors and resistors for oscillation stop are unnecessary
  - It eliminates the need for NF and BS electrolytic capacitors
  - Muting function is unnecessary
  - Power supply choke coil is unnecessary
- Provided with beep sound input pin
- High sound quality design

Applications
- Car audio
■ Block Diagram

![Block Diagram Image]

■ Pin Description

<table>
<thead>
<tr>
<th>Pin No.</th>
<th>Description</th>
<th>Pin No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Power supply</td>
<td>9</td>
<td>Grounding (input)</td>
</tr>
<tr>
<td>2</td>
<td>Ch.1 output (+)</td>
<td>10</td>
<td>Beep sound input</td>
</tr>
<tr>
<td>3</td>
<td>Grounding (output ch.1)</td>
<td>11</td>
<td>Ch.2 input</td>
</tr>
<tr>
<td>4</td>
<td>Ch.1 output (−)</td>
<td>12</td>
<td>Ripple filter</td>
</tr>
<tr>
<td>5</td>
<td>Standby</td>
<td>13</td>
<td>Ch.2 output (−)</td>
</tr>
<tr>
<td>6</td>
<td>Ch.1 input</td>
<td>14</td>
<td>Grounding (output ch.2)</td>
</tr>
<tr>
<td>7</td>
<td>Muting</td>
<td>15</td>
<td>Ch.2 output (+)</td>
</tr>
<tr>
<td>8</td>
<td>Grounding (board)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

■ Absolute Maximum Ratings

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Ratings</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply voltage *2</td>
<td>V_CC</td>
<td>25</td>
<td>V</td>
</tr>
<tr>
<td>Peak supply voltage *3</td>
<td>V_surge</td>
<td>60</td>
<td>V</td>
</tr>
<tr>
<td>Supply current</td>
<td>I_CC</td>
<td>9.0</td>
<td>A</td>
</tr>
<tr>
<td>Power dissipation *4</td>
<td>P_D</td>
<td>59</td>
<td>W</td>
</tr>
<tr>
<td>Operating ambient temperature *1</td>
<td>T_opr</td>
<td>−30 to +85</td>
<td>°C</td>
</tr>
<tr>
<td>Storage temperature *1</td>
<td>T_stg</td>
<td>−55 to +150</td>
<td>°C</td>
</tr>
</tbody>
</table>

Note) *1: T_a = 25°C except operating ambient temperature and storage temperature.
*2: Without signal
*3: Time = 0.2 s
*4: T_a = 85°C
ICs for Audio Common Use

Recommended Operating Range

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Ratings</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply voltage</td>
<td>$V_{CC}$</td>
<td>8.0 to 18.0</td>
<td>V</td>
</tr>
</tbody>
</table>

Electrical Characteristics at $V_{CC} = 13.2$ V, $f = 1$ kHz, $T_a = 25^\circ$C

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quiescent current</td>
<td>$I_{CQ}$</td>
<td>$V_{IN} = 0$ mV, $R_L = 4$ Ω</td>
<td>—</td>
<td>150</td>
<td>250</td>
<td>mA</td>
</tr>
<tr>
<td>Standby current</td>
<td>$I_{STB}$</td>
<td>$V_{IN} = 0$ mV, $R_L = 4$ Ω</td>
<td>—</td>
<td>1</td>
<td>10</td>
<td>μA</td>
</tr>
<tr>
<td>Output noise voltage $^1$</td>
<td>$V_{NO}$</td>
<td>$R_s = 10$ kΩ, $R_L = 4$ Ω</td>
<td>—</td>
<td>0.18</td>
<td>0.5</td>
<td>mV rms</td>
</tr>
<tr>
<td>Voltage gain 1</td>
<td>$G_{V1}$</td>
<td>$V_{IN} = 40$ mV, $R_L = 4$ Ω</td>
<td>32</td>
<td>34</td>
<td>36</td>
<td>dB</td>
</tr>
<tr>
<td>Total harmonic distortion 1</td>
<td>$THD_1$</td>
<td>$V_{IN} = 40$ mV, $R_L = 4$ Ω</td>
<td>—</td>
<td>0.05</td>
<td>0.4</td>
<td>%</td>
</tr>
<tr>
<td>Maximum output power 1</td>
<td>$P_{O1}$</td>
<td>THD = 10%, $R_L = 4$ Ω</td>
<td>16</td>
<td>18.5</td>
<td>—</td>
<td>W</td>
</tr>
<tr>
<td>Voltage $^1$</td>
<td>$V_{CC}$</td>
<td>$V_{CC} = 14.4$ V, $R_L = 4$ Ω</td>
<td>—</td>
<td>22.0</td>
<td>—</td>
<td>W</td>
</tr>
<tr>
<td>Ripple rejection ratio $^1$</td>
<td>RR</td>
<td>$R_s = 4$ Ω, $R_g = 10$ kΩ, $V_f = 1$ V rms</td>
<td>60</td>
<td>65</td>
<td>—</td>
<td>dB</td>
</tr>
<tr>
<td>Channel balance</td>
<td>CB</td>
<td>$V_{IN} = 40$ mV, $R_L = 4$ Ω</td>
<td>—</td>
<td>0</td>
<td>1</td>
<td>dB</td>
</tr>
<tr>
<td>Cross-talk $^1$</td>
<td>CT</td>
<td>$V_{IN} = 40$ mV, $R_L = 4$ Ω, $R_g = 10$ kΩ</td>
<td>60</td>
<td>79</td>
<td>—</td>
<td>dB</td>
</tr>
<tr>
<td>Output offset voltage</td>
<td>$V_{O_{off}}$</td>
<td>$R_s = 10$ kΩ, $R_L = 4$ Ω</td>
<td>—250</td>
<td>0</td>
<td>250</td>
<td>mV</td>
</tr>
<tr>
<td>Muting effect $^1$</td>
<td>MT</td>
<td>$V_O = 1$ W, $R_L = 4$ Ω</td>
<td>70</td>
<td>86</td>
<td>—</td>
<td>dB</td>
</tr>
<tr>
<td>Input impedance</td>
<td>$Z_i$</td>
<td>$V_{IN} = \pm 0.3$ V DC</td>
<td>24</td>
<td>30</td>
<td>36</td>
<td>kΩ</td>
</tr>
<tr>
<td>Voltage gain 2</td>
<td>$G_{V2}$</td>
<td>$V_{IN} = 40$ mV, $R_L = 2$ Ω</td>
<td>32</td>
<td>34</td>
<td>36</td>
<td>kΩ</td>
</tr>
<tr>
<td>Total harmonic distortion 2</td>
<td>$THD_2$</td>
<td>$V_{IN} = 40$ mV, $R_L = 2$ Ω</td>
<td>—</td>
<td>0.08</td>
<td>0.5</td>
<td>%</td>
</tr>
<tr>
<td>Maximum output power 2</td>
<td>$P_{O2}$</td>
<td>THD = 10%, $R_L = 2$ Ω</td>
<td>16</td>
<td>28</td>
<td>—</td>
<td>W</td>
</tr>
<tr>
<td>Shock noise $^2$</td>
<td>$V_S$</td>
<td>$R_s = 4$ Ω, $R_g = 10$ kΩ, $V_{MUTE} = 5$ V, $V_{STB} = $ on/off, 50 Hz HPF-on</td>
<td>—100</td>
<td>0</td>
<td>100</td>
<td>mV[p-0]</td>
</tr>
<tr>
<td>Total harmonics distortion 3</td>
<td>$THD_3$</td>
<td>$V_{IN} = 20$ mV, $f_{IN} = 20$ kHz</td>
<td>$R_g = 10$ kΩ, $R_L = \infty$</td>
<td>—</td>
<td>0.10</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Note) $^1$: Measurement using a bandwidth 15 Hz to 30 kHz (12 dB/OCT) filter.

$^2$: For $V_{STB} = $ on/off change over the standby terminal by the voltage of 0 V and 5 V at the time shown below.

<br>

Panasonic
### Terminal Equivalent Circuits

<table>
<thead>
<tr>
<th>Pin No.</th>
<th>Equivalent circuits</th>
<th>Description</th>
<th>DC voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>—</td>
<td>Supply voltage connection pin</td>
<td>13.2 V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Power supply connection pin</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td><img src="#" alt="Drive Circuit" /></td>
<td>Ch.1 output pin (+)</td>
<td>6.3 V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ch.1 positive-phase output pin</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>GND (Output)</td>
<td></td>
<td>0 V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Grounding pin for ch.1 output</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td><img src="#" alt="Drive Circuit" /></td>
<td>Ch.1 output pin (−)</td>
<td>6.3 V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ch.1 inverted-phase output pin</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td><img src="#" alt="Standby Control" /></td>
<td>Standby control pin</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Standby changeover pin</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Threshold voltage approx. 2.1 V</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td><img src="#" alt="Input Signal" /></td>
<td>Ch.1 input pin</td>
<td>0 mV to 10 mV</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ch.1 input signal applied pin</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Input impedance 30 kΩ</td>
<td></td>
</tr>
</tbody>
</table>

---

[Drive Circuit Diagram](#)  
[Standby Control Diagram](#)  
[Input Signal Diagram](#)
### Terminal Equivalent Circuits (continued)

<table>
<thead>
<tr>
<th>Pin No.</th>
<th>Equivalent circuits</th>
<th>Description</th>
<th>DC voltage</th>
</tr>
</thead>
</table>
| 7       | ![ Equivalent circuit of Pin 7](image) | Mute control pin  
Mute changeover pin  
Threshold voltage approx. 2.1 V | — |
| 8       | —                   | GND (substrate) | 0 V |
| 9       | —                   | GND (input) | 0 V |
| 10      | ![ Equivalent circuit of Pin 10](image) | Beep sound input pin  
Beep sound signal input pin  
Input impedance 15.3 kΩ | 2.1 V |
| 11      | ![ Equivalent circuit of Pin 11](image) | Ch.2 input pin  
Ch.2 input signal applied pin  
Input impedance 30 kΩ | 0 mV to 10 mV |
| 12      | ![ Equivalent circuit of Pin 12](image) | Ripple filter pin  
Output current 3 mA to 10 mA | 13.0 V |
### Terminal Equivalent Circuits (continued)

<table>
<thead>
<tr>
<th>Pin No.</th>
<th>Equivalent circuits</th>
<th>Description</th>
<th>DC voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td><img src="image1" alt="Drive Circuit" /></td>
<td>Ch.2 output pin (−) Ch.2 inverted-phase output pin</td>
<td>6.3 V</td>
</tr>
<tr>
<td>14</td>
<td>—</td>
<td>GND (output) Grounding pin for ch.2 output</td>
<td>0 V</td>
</tr>
<tr>
<td>15</td>
<td><img src="image2" alt="Drive Circuit" /></td>
<td>Ch.2 output pin (+) Ch.2 positive-phase output pin</td>
<td>6.3 V</td>
</tr>
</tbody>
</table>

### Usage Notes

1. Always attach an outside heat sink to use the chip. In addition, the outside heat sink must be fastened onto a chassis for use.
2. Connect the cooling fin to GND potential.
3. Avoid short-circuit to VCC and short circuit to GND, and load short-circuit. There is a danger of destruction under a special condition.
4. The temperature protection circuit will be actuated at $T_j = \text{approx. } 150^\circ C$, but it is automatically reset when the chip temperature drops below the above set level.
5. The overvoltage protection circuit starts its operation at $V_{CC} = \text{approx. } 20 \text{ V}$.
6. Take into consideration the heat radiation design particularly when $V_{CC}$ is set high or when the load is 2 Ω.
7. When the beep sound function is not used, open the beep sound input pin (pin10) or connect it to pin 9 with around 0.01 μF capacitor.
8. Connect only pin 9 (ground, signal source) to the signal GND of the amplifier in the previous stage. The characteristics such as distortion, etc. will be improved.
Technical Information

1. $P_D - T_a$ Curves of HZIP015-P-0745A

2. Main Characteristics

$P_O - V_{CC}$

$P_C, I_{CC} - P_O$
2. Main Characteristics (continued)

- Input voltage $V_{IN}$ (mV [rms])
- Output power $P_O$ (W)
- Total harmonic distortion THD (%)

**Table: Input Power and Output Power**

<table>
<thead>
<tr>
<th>$V_{IN}$ (mV [rms])</th>
<th>$P_O$ (0.1 W)</th>
<th>$P_O$ (1 W)</th>
<th>$P_O$ (4 W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>0.05</td>
<td>0.25</td>
<td>1.00</td>
</tr>
<tr>
<td>20</td>
<td>0.10</td>
<td>0.50</td>
<td>2.00</td>
</tr>
<tr>
<td>30</td>
<td>0.15</td>
<td>0.75</td>
<td>3.00</td>
</tr>
</tbody>
</table>

**Figure: Input Voltage vs. THD**

- $V_{CC} = 13.2$ V
- $f = 1$ kHz
- Load $R_L = 2, 4$ W
- Both channel input $R_g = 10$ kΩ

**Figure: Voltage Gain vs. Frequency**

- $V_{CC} = 13.2$ V
- $400$ Hz HPF
- THD = 10%
- Both channel input $R_g = 10$ kΩ

**Figure: Standby Current vs. Supply Voltage**

- $I_{CQ}$, $I_{STB}$ vs. $V_{CC}$
- $R_g = 4$ Ω
- Both channel input $R_g = 10$ kΩ

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*Panasonic*
2. Main Characteristics (continued)

- **V\textsubscript{NO} — V\textsubscript{CC}**
  - Output noise voltage $V\textsubscript{NO}$ (µV[rms])
  - Supply voltage $V\textsubscript{CC}$ (V)

- **V\textsubscript{NO} — R\textsubscript{g}**
  - Output noise voltage $V\textsubscript{NO}$ (µV[rms])
  - Input impedance $R\textsubscript{g}$ (Ω)

- **RR — V\textsubscript{CC}**
  - Ripple-rejection ratio $R\textsubscript{r}$ (dB)
  - Supply voltage $V\textsubscript{CC}$ (V)

- **RR — V\textsubscript{r}**
  - Ripple-rejection ratio $R\textsubscript{r}$ (dB)
  - Power supply ripple voltage $V\textsubscript{r}$ (mV[rms])

- **RR — f\textsubscript{r}**
  - Ripple-rejection ratio $R\textsubscript{r}$ (dB)
  - Power supply ripple frequency $f\textsubscript{r}$ (Hz)

- **CT — V\textsubscript{CC}**
  - Cross-talk CT (dB)
  - Supply voltage $V\textsubscript{CC}$ (V)
Technical Information (continued)

2. Main Characteristics (continued)

**CT — V\textsubscript{IN}**

![Graph of cross-talk vs. input voltage](image1)

- \( V\text{CC} = 13.2 \text{ V} \)
- \( f = 1 \text{ kHz} \)
- \( R\text{L} = 4 \text{ \Omega} \)
- 400 Hz HPF
- 30 kHz LPF
- \( R\text{g} = 10 \text{ k\Omega} \)

**CT — f**

![Graph of cross-talk vs. frequency](image2)

- \( V\text{CC} = 13.2 \text{ V} \)
- \( V\text{IN} = 40 \text{ mV}[\text{rms}] \)
- \( R\text{L} = 4 \text{ \Omega} \)
- \( R\text{g} = 10 \text{ k\Omega} \)

**MT — V\text{CC}**

![Graph of muting effect vs. supply voltage](image3)

- \( P\text{O} = 1 \text{ W} \)
- \( f = 1 \text{ kHz} \)
- \( R\text{L} = 4 \text{ \Omega} \)
- 400 Hz HPF
- 30 kHz LPF
- \( R\text{g} = 10 \text{ k\Omega} \)

**MT — V\text{IN}**

![Graph of muting effect vs. input voltage](image4)

- \( V\text{CC} = 13.2 \text{ V} \)
- \( V\text{IN} = 40 \text{ mV}[\text{rms}] \)
- \( R\text{L} = 4 \text{ \Omega} \)
- 400 Hz HPF
- 30 kHz LPF
- \( R\text{g} = 10 \text{ k\Omega} \)

**MT — f**

![Graph of muting effect vs. frequency](image5)

**MT — V\text{MUTE}**

![Graph of muting effect vs. mute voltage](image6)

- \( V\text{CC} = 13.2 \text{ V} \)
- \( P\text{O} = 1 \text{ W} \)
- \( f = 1 \text{ kHz} \)
- \( R\text{L} = 4 \text{ \Omega} \)
- 400 Hz HPF
- 30 kHz LPF
- \( R\text{g} = 10 \text{ k\Omega} \)
3. Application note

1) Standby function

(1) The power can be turned on or off by making pin 5 (standby terminal) high or low.

(2) The standby terminal has threshold voltage of approx. 2.1 V, however, it has temperature dependency of approx. \(-6 \text{ mV/}^\circ\text{C}\). The recommended range of use is shown in Table 1.

(3) The internal circuit of standby terminal is as shown in Figure 1. When the standby terminal is high, the current approximately expressed by the following equation will flow into the circuit.

\[
I_{\text{STB}} = \frac{V_{\text{STB}} - 2.7 \text{ V}}{10 \text{ k}\Omega} \quad \text{[mA]}
\]

(4) A power supply with no ripple component should be used for the control voltage of standby terminal.

<table>
<thead>
<tr>
<th>Terminal state</th>
<th>Terminal voltage</th>
<th>Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open</td>
<td>0 V</td>
<td>Standby state</td>
</tr>
<tr>
<td>Low</td>
<td>0 V to 1.0 V</td>
<td>Standby state</td>
</tr>
<tr>
<td>High</td>
<td>Higher than 3 V</td>
<td>Operating state</td>
</tr>
</tbody>
</table>

Table 1

![Figure 1](image-url)
3. Application note (continued)

2) Output line noise countermeasures

(1) In order to increase the oscillation allowance, it is unnecessary to use a capacitor and a resistor between each output terminal and GND. However, when inserting the capacitor for countermeasures against output line noise between the output terminal and GND, insert a resistor of approx. 2.2 Ω in series as shown in Figure 2. The oscillation may occur if only capacitor is used. Use it after giving a sufficient evaluation.

(2) The use of polyester film capacitor having a little fluctuation with temperature and frequency is recommended as the capacitor for countermeasures against output line noise.

3) Input terminal

(1) The reference voltage of input terminal is 0 V. When the input signal has a reference voltage other than 0 V potential, connect a coupling capacitor (of about several µF) for DC component cut in series with the input terminal. Check the low-pass frequency characteristics to determine the capacitor value.

(2) 10 kΩ or less of signal source impedance Rg can reduce the output end noise voltage.

(3) The output offset voltage fluctuates when the signal source impedance Rg is changed. A care must be taken in the case of using the circuit by directly connecting a volume control to the input terminal. In such a case, the use of coupling capacitor is recommended.

(4) If a high frequency signal from tuners enters the input terminal as noise, insert a capacitor of approx. 0.01 µF between the input terminal and input GND. When a high frequency signal is inputted, malfunction in protective circuits may occur.

4) Ripple filter

(1) In order to suppress the fluctuation of supply voltage, connect a capacitor of approx. 33 µF between RF terminal (pin 12) and GND.

(2) Relation between RR (Ripple Rejection Ratio) and a capacitor.

The larger the capacitance of the ripple filter is, the better the ripple rejection ratio becomes.

(However, there is almost no difference if the capacitance is 10 µF or more.)
Technical Information (continued)

3. Application note (continued)

4) Ripple filter (continued)

(3) Relation between the rise time of circuit and a capacitor.
   The larger the capacitance of the ripple filter is, the longer
   the time from the power on (STB-high) to the sound
   release becomes.

(4) The DC voltage of output terminal is approximately the
   middle point of the ripple filter terminal voltage.

(5) The internal circuit of ripple filter terminal is as shown in
   Figure 5 and the charge current is approx. 3 mA to 10 mA.

(6) After the power supply is turned off (STB-low), it takes
   10 seconds or less for the total circuit current to become the
   standby current (under 10\(\mu\)A). If approx. 47 k\(\Omega\) resistor
   is inserted between the ripple filter terminal and GND for
   the purpose of reducing the inspection time with set, a time
   until the current becomes the standby current can be shortened.

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5) GND terminal

(1) Be sure to short-circuit each GND terminal of
   pin 3, 8, 9 and 14 at a point outside the IC in
   use.

(2) For each GND terminal, the one-point earth,
   referenced to the GND connection point of
   electrolytic capacitor between the supply
terminal and GND, is most effective for
   reducing the distortion. Even in the worst
case, ground pin 8, 9 of input GND separately
from all the other GND terminals.

(3) Each GND terminal is not electrically short-circuited inside. Only pin 8 is connected with the substrate.

(4) Pin 9 is input signal GND. Connect only pin 9 with GND of the input.
6) Cooling fin
   (1) The cooling fin is not connected with GND terminal by using Au wire. Only pin 8 is electrically connected through the substrate.
   (2) Always attach an outside heat sink to the cooling fin. The cooling fin must be fastened onto a chassis for use. Otherwise, IC lead failure may occur.
   (3) Do not give the cooling fin any potential other than the GND potential. Otherwise, it may cause breakdown.
   (4) Connection of the cooling fin with GND can reduce the incoming noise hum. (It is unnecessary to connect with GND in use, but connect it with the power GND when the cooling fin is connected with GND)

7) Shock noise
   (1) STB on/off
      Turn on the mute circuit when switching over to the standby.
      No shock noise is released when the mute on state. However, the changeover switch of the standby terminal may make a slight shock noise. In such a case, insert a capacitor of approx. 0.01 \( \mu \text{F} \) between the standby terminal and GND.
   (2) Mute on/off
      No shock noise is released. Refer to the section on the mute function.

8) Mute function
   (1) The mute-On/Off is possible by making pin 7 (the muting terminal) high or to low.
   (2) The muting circuit is as shown in Figure 7. The amplifier gain including attenuator block is given in the following equation:
      \[
      G_V = \frac{I_1}{I_2} \times 50
      \]
      Original gain
      From the above equation, the amplifier gain can be made as 0 time by setting \( I_1 \) at 0 mA at muting.
   (3) The threshold voltage of \( V_{\text{MUTE}} \) is as follows:
      Mute-off approx. 1 V or less
      Mute-on approx. 3 V or more

![Figure 7](image-url)
Technical Information (continued)

3. Application note (continued)

8) Mute function (continued)

(4) Attack time and recovery time can be changed by the external CR of pin 7. For recommended circuits (Figure 7
22 kΩ, 1 µF), the above mentioned times are as follows:

- Attack time: Approx. 30 ms
- Recovery time: Approx. 40 ms

However, the control voltage of \( V_{MUTE} \) is assumed to be 5 V. When it is not directly controlled by
microcomputer (5 V), (such as 13.2 V separate power supply), it is necessary to change CR values because
the above times change.

(5) When the attack time and recovery time are set at 20 ms or less, pay attention to the IC with larger output
offset because it may release the shock noise.

9) Voltage gain

The voltage gain is fixed at 34 dB for the AN7198Z, and 40 dB for the AN7199Z. It is not possible to change those
values by the addition of an external resistance.

10) Beep sound input function

(1) The application circuit example when using the beep sound input is shown in Figure 8. Connect the beep signals
from the microcomputer to pin 10 via the capacitor C1 for DC cut and the resistor R1 for voltage gain adjustment.

(2) The voltage gain of beep sound terminal is approx. –6.2 dB.

The setting value of Figure 8 becomes approx. –19.7 dB (f = 1 kHz).

(3) The beep sound is outputted to the output terminals, pin 2 and pin 15.

<table>
<thead>
<tr>
<th></th>
<th>( R_{nf} )</th>
<th>( G_{VA} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>AN7198Z</td>
<td>600 Ω</td>
<td>28 dB</td>
</tr>
<tr>
<td>AN7199Z</td>
<td>300 Ω</td>
<td>34 dB</td>
</tr>
</tbody>
</table>

\[
G_{VBEEP} = \frac{R_{nf}}{2} \times \frac{1/j\omega C_1 + R_1 + 7.8 K + \frac{15 k + R_{nf}}{2}}{1/j\omega C_1 + R_1 + 7.8 K + \frac{15 k + R_{nf}}{2}} \times G_{VA}
\]

Figure 8
11) Two IC use

Figure 9 shows the application circuit example when two ICs are used:

![Application Circuit Diagram](image-url)
1) Supply terminal

Short-circuit the terminals with each other and insert an electrolytic capacitor of approx. 2200 μF into the supply terminals. However, if sufficient characteristics of the ripple rejection cannot be obtained, use an even larger capacitor or insert a 2200 μF capacitor into each IC.

The best sound quality can be obtained by inserting a 2200 μF capacitor near the terminal of each IC.

2) Standby terminal (pin 5)

Even if the standby terminals are connected with each other, there is no abnormal operation. Connect with the microcomputer after connecting the standby pins with each other. At that time, the current flowing into the standby terminal is twice as large as the current which is described in 1) Standby function.

3) Muting terminal (pin 7)

An abnormal operation does not occur even if the muting terminals are short-circuited with each other. The muting time constant changes when two ICs connection is made. If the CR constants are set at twice or 1/2 time respectively, the time constant value becomes as same as the value when one IC is used.

In terms of safety design, taking advantage of the fact that in mute-on, a large current is difficult to flow and it is difficult to cause the destruction, it is designed so that the mute terminal will become high when an abnormality such as short circuit to V_{CC} or short circuit to GND takes place. (To avoid the influence of IC in an abnormal state in using two ICs).

Do not connect a microcomputer directly to the mute terminal because the mute terminal voltage rises to approx. 12 V at that time.

4) Beep sound input terminal (pin 10)

Even if the beep sound input terminals are short circuited each other, that does not result in an abnormal operation. However, if there is a temperature difference between ICs, there may be a fluctuation of the output offset.

In order to avoid such a phenomenon, connect the ICs with each other through a resistor (47 kΩ).

5) Ripple filter terminal (pin 12)

Even if the ripple filter terminals are short circuited each other, that does not result in an abnormal operation. However, if the standby of each IC is individually controlled, the short-circuiting is not allowed. Use the circuit after connecting a capacitor (33 μF) to each IC.

12) Precautions on misuse

1) Erroneous connection in the case of short circuit to V_{CC} and short circuit to GND or load short-circuit

The AN7198Z/99Z have the breakdown voltage of 20 V or more when short circuit to V_{CC} or load short-circuit occur. However, there is a possibility of destruction, then smoke emission and ignition under a special condition. Avoid misuse and erroneous connection of the circuit.

2) Power supply surge

The power supply surge breakdown voltage is evaluated by the test circuit shown in Figure 10 and the surge waveform as shown in Figure 11 is evaluated. The withstanding capability against power supply surge is 80 V for the AN7198Z/99Z.
3. Application note (continued)

12) Precautions on misuse (continued)

(1) Destruction mode for the AN7198Z/99Z

The AN7198Z/99Z are the power ICs with high breakdown withstanding voltage but it has been found that the destruction occurs under special conditions.

- GND-open short-circuit to ground.

  Short-circuit the output terminal to the GND terminal of power supply when GND terminal of the IC is open, or a short-circuiting is made to GND when the GND terminal of the IC is over 0.7 V higher than the short-circuited output terminal.
  At that time, if \( V_{CC} = 16 \) V or more and a voltage is also applied to STB terminal, then the destruction occurs.

- The plus and minus side output terminals are short-circuited to power supply at the same time.

  If short-circuit to power supply occurs on both the plus and minus side output terminals at the same time with a short-circuit resistor which does not actuate the protection circuit, the power GND terminal current may exceed 10 A and the wire melts down since the current exceeds the capacity of Au wire.

- \( V_{CC} - \) GND reverse connection

  Parasitic device is created everywhere and the circuit destruction takes place.

4. Countermeasure for shock noise of the AN7198Z

Points of shock noise prevention

Plus and minus output of the BTL amp. is not changed suddenly by STB-on/off and Mute-on/off.

1) Standby pin to off (pin 5 \( V_{STB} = 5 \) V \( \rightarrow 0 \) V) (Standby state \( \rightarrow \) Operating state)

   (1) Ripple filter pin (pin 12) becomes on gradually (Charge up to \( V_{CC} \)) when \( V_{STB} = 0 \) V \( \rightarrow 5 \) V.

   Current source and reference voltage are on instantaneously.

   (2) Output D range suppression circuit is incorporated which limits the dynamic range of output to 0 V \( \leq V_{OUT} \leq V_{RF} - 3 V_{BE} \) when the ripple filter pin voltage is less than 6.8 V.

   DC voltage change of input circuit causes steep DC voltage change of output pin and that generates shock noise.

   This steep DC voltage change can be suppressed by the above mentioned circuit.

   Voltage of the mute pin (pin 7) makes high forcedly in the inside circuit.

(3) Input mute is on when the ripple filter pin voltage \( V_{RF} \) is less than 6.8 V.

   This prevents the shock noise which is inputted from the pre-stage of power amp.

   Also, mute is on in order to prevent the abnormal sound which is generated by clipping of waveform.

   (Output is clipped due to narrow D range at start up)

(4) DC voltage of output pin changes with 1/2 voltage of the ripple filter pin.

   Steep changes of output pin voltage is suppressed by start up gradually of the ripple filter pin.

(5) Output waveform of each plus and minus output at power supply on changes as same by symmetric placement of inverting and non-inverting amplifier which consist of BTL amp.

Image figure of output waveform, RF-pin waveform has exponential characteristics in actually.
Technical Information (continued)

4. Countermeasure for shock noise of the AN7198Z (continued)

2) Standby pin to off (pin 5 \( V_{STB} = 5 \text{ V} \rightarrow 0 \text{ V} \)) (Operating state \( \rightarrow \) Standby state)

(1) Ripple filter pin (pin 12) becomes off gradually (Discharge down to 0 V) when \( V_{STB} = 5 \text{ V} \rightarrow 0 \text{ V} \).

Current source and reference voltage are on until \( V_{RF} < 2 \text{ V}_B \).

(2) Output D range suppression circuit operates when the ripple filter pin voltage is less than 6.8 V.

The circuit limits to \( 0 \text{ V} < V_{OUT} < V_{REF} - 3 \text{ V}_B \).

DC voltage change of input circuit causes steep DC voltage change of output pin and that generates shock noise same as at standby pin is on.

This steep DC voltage change can be suppressed by the above mentioned circuit.

Voltage of the mute pin (pin 7) makes high forcedly in the inside circuit.

3) Muting on/off (Pin 7 low: Muting state, high: Operating state)

(1) AC mute circuit which mute the AC component only by the simple attenuator circuit is adopted.

Conventional system generates shock noise due to change steeply of output DC voltage by cutting of input DC voltage and muting of AC component.

3) Image figure of output waveform, RF-pin waveform has exponential characteristics in actually.
Technical Information (continued)

4. Countermeasure for shock noise of the AN7198Z (continued)

3) Muting on/off (Pin7 low: Muting state, high: Operating state) (continued)

(2) Attack and recovery time of muting on/off is determined by the external CR time constant of pin 7.

(3) There is afraid of shock noise when time constant is set to 10 ms or less.
   (Since output DC voltage is changed approx. 50 mV by muting on/off.)

![Waveform diagram showing output AC and DC voltages](image)

Figure 13

Application Circuit Example

![Application circuit diagram with components labeled](image)