2Vrms Ground Referenced Stereo Line Amplifier

**GENERAL DESCRIPTION**
The NJU72015 is an audio line Amplifier. It can swing 2Vrms (5.6V peak-to-peak) signal at 3.3V operating voltage. Ground-referenced outputs eliminate output coupling capacitor. It contains differential input. The pop noise suppression circuit removes a pop noise at the power-on and power-off.

**APPLICATIONS**
- Audio applications requiring 2Vrms outputs

**FEATURES**
- Operating Voltage +3.0 to +3.6V
- Operating Current $I_{DD}=5mA$ typ. at $V^+=3.3V$, No Signal, No Load
- Output Coupling Capacitor-less
- Differential Input
- Pop Noise Suppression Circuit
- C-MOS Technology
- Package Outline SSOP14

**BLOCK DIAGRAM**

**PIN CONFIGURATION**

<table>
<thead>
<tr>
<th>No.</th>
<th>Symbol</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>+INL</td>
<td>Lch Noninverted Input</td>
</tr>
<tr>
<td>2</td>
<td>-INL</td>
<td>Lch Inverted Input</td>
</tr>
<tr>
<td>3</td>
<td>OUTL</td>
<td>Lch Output</td>
</tr>
<tr>
<td>4</td>
<td>GND</td>
<td>Ground</td>
</tr>
<tr>
<td>5</td>
<td>MUTE</td>
<td>Mute Control</td>
</tr>
<tr>
<td>6</td>
<td>V-</td>
<td>V- Power Supply</td>
</tr>
<tr>
<td>7</td>
<td>CN</td>
<td>Flying Capacitor Negative Terminal</td>
</tr>
<tr>
<td>8</td>
<td>CP</td>
<td>Flying Capacitor Positive Terminal</td>
</tr>
<tr>
<td>9</td>
<td>V+</td>
<td>V+ Power Supply</td>
</tr>
<tr>
<td>10</td>
<td>DGND</td>
<td>Ground</td>
</tr>
<tr>
<td>11</td>
<td>UVP</td>
<td>Undervoltage Protection Input</td>
</tr>
<tr>
<td>12</td>
<td>OUTR</td>
<td>Rch Output</td>
</tr>
<tr>
<td>13</td>
<td>-INR</td>
<td>Rch Inverted Input</td>
</tr>
<tr>
<td>14</td>
<td>+INR</td>
<td>Rch Noninverted Input</td>
</tr>
</tbody>
</table>
**ABSOLUTE MAXIMUM RATING (Ta=25°C)**

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>SYMBOL</th>
<th>RATING</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Voltage</td>
<td>V+</td>
<td>+4</td>
<td>V</td>
</tr>
<tr>
<td>Power Dissipation</td>
<td>Pd</td>
<td>530 (Note1)</td>
<td>mW</td>
</tr>
<tr>
<td>Maximum Input Voltage</td>
<td>VIMAX</td>
<td>-V+0.3 to V+0.3</td>
<td>V</td>
</tr>
<tr>
<td>Operating Temperature Range</td>
<td>Topr</td>
<td>-40 to +85</td>
<td>°C</td>
</tr>
<tr>
<td>Storage Temperature Range</td>
<td>TSTG</td>
<td>-40 to +125</td>
<td>°C</td>
</tr>
</tbody>
</table>

(Note1) EIA/JEDEC STANDARD Test board (76.2x114.3x1.6mm, 2layer, FR-4) mounting

**RECOMMENDED OPERATING CONDITIONS**

(V+ = 3.3V, Ta = 25°C unless otherwise specified)

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>SYMBOL</th>
<th>TEST CONDITION</th>
<th>MIN.</th>
<th>TYP.</th>
<th>MAX.</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Voltage</td>
<td>V+</td>
<td></td>
<td>3.0</td>
<td>3.3</td>
<td>3.6</td>
<td>V</td>
</tr>
</tbody>
</table>

**ELECTRICAL CHARACTERISTICS**

* DC CHARACTERISTICS
  (V+ = 3.3V, Mute=OFF, RL=10kΩ, Ta=25°C unless otherwise specified)

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>SYMBOL</th>
<th>TEST CONDITION</th>
<th>MIN.</th>
<th>TYP.</th>
<th>MAX.</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Current</td>
<td>IOD</td>
<td>No signal, No load</td>
<td>-</td>
<td>5</td>
<td>10</td>
<td>mA</td>
</tr>
<tr>
<td>Power Supply Rejection Ratio</td>
<td>PSRR</td>
<td>V+ = 3V to 3.6V</td>
<td>-</td>
<td>80</td>
<td>-</td>
<td>dB</td>
</tr>
<tr>
<td>External undervoltage detection</td>
<td>VUV</td>
<td>-</td>
<td>1.25</td>
<td>-</td>
<td>-</td>
<td>V</td>
</tr>
<tr>
<td>External undervoltage detection hysterisis current</td>
<td>IHYS</td>
<td>-</td>
<td>5</td>
<td>-</td>
<td>-</td>
<td>uA</td>
</tr>
<tr>
<td>Output Offset Voltage</td>
<td>VOS</td>
<td>Rg=0Ω</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>mV</td>
</tr>
</tbody>
</table>

* AC CHARACTERISTICS
  (V+ = 3.3V, f= 1kHz, Vin=1Vrms [differential input], Mute=OFF, RH=10kΩ, RB=20kΩ, RL=10kΩ, Ta=25°C unless otherwise specified)

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>SYMBOL</th>
<th>TEST CONDITION</th>
<th>MIN.</th>
<th>TYP.</th>
<th>MAX.</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Output Voltage Level</td>
<td>VOMAX</td>
<td>THD=1%</td>
<td>-</td>
<td>2.3</td>
<td>-</td>
<td>Vrms</td>
</tr>
<tr>
<td>Mute Level</td>
<td>VMUTE</td>
<td>Rg=0Ω, Mute=ON</td>
<td>-</td>
<td>-80</td>
<td>-</td>
<td>dB</td>
</tr>
<tr>
<td>Equivalent Input Noise Voltage</td>
<td>VINI</td>
<td>Rg=0Ω, A-weighted</td>
<td>-</td>
<td>-106</td>
<td>-</td>
<td>dB</td>
</tr>
<tr>
<td>Total Harmonic Distortion</td>
<td>THD</td>
<td>BW:400Hz-22kHz</td>
<td>-</td>
<td>0.003</td>
<td>-</td>
<td>%</td>
</tr>
<tr>
<td>Channel Separation</td>
<td>CS</td>
<td>Rg=600Ω, Bandpass</td>
<td>-</td>
<td>110</td>
<td>-</td>
<td>dB</td>
</tr>
</tbody>
</table>

**CONTROL CHARACTERISTICS**

(V+ = 3.3V, Ta=25°C unless otherwise specified)

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>SYMBOL</th>
<th>TEST CONDITION</th>
<th>MIN.</th>
<th>TYP.</th>
<th>MAX.</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mute terminal High</td>
<td>MuteH</td>
<td>Mute=OFF</td>
<td>0.7V+</td>
<td>-</td>
<td>V+</td>
<td>V</td>
</tr>
<tr>
<td>Mute terminal Low</td>
<td>MuteL</td>
<td>Mute=ON</td>
<td>0</td>
<td>-</td>
<td>0.3V+</td>
<td>V</td>
</tr>
</tbody>
</table>
\[ V_{NI} = \text{Measurement} - 12\text{dB} \]

\[ \text{CS} \]

\[ \text{OUTL: CS} = 20 \log (\text{OUTR/OUTL}) \]

\[ \text{OUTR: CS} = 20 \log (\text{OUTL/OUTR}) \]
**APPLICATION CIRCUIT**

*1) Connect a zener diode between V- terminal and GND terminal to prevent connecting V- terminal[6pin] and V+ terminal[9pin].
Technical Information

OPERATION NOTES

• Operating Overview

The drawing in Fig 1 illustrates the internal circuit in NJU72015. The NJU72015 has a charge-pump for negative power supply, pop noise suppression circuit, external under voltage detector, and a line amplifier.

The NJU72015 operates from a single supply voltage from 3.0V to 3.6V and the NJU72015’s line drivers use a charge pump to invert the positive power supply (V+) to negative power supply (V-), see Fig 2. The output voltages are centered at zero volts with the capability to swing to the positive rail or negative rail. This feature eliminates the output capacitor that is using in conventional line driver operating by a single-supply voltage.

• Gain Setting Resistor

The drawing in Fig 1 illustrates the gain setting circuit configuration of NJU72015. The differential input gain of the NJU72015 is set by:

\[ A_v = \frac{R_{FB}}{R_{IN}} \]

The value of Gain setting resistors, \( R_{IN} \) and \( R_{FB} \), affect noise, stability and input capacitor size. Selecting values that are too low demands a large input ac-coupling capacitor, \( C_{IN} \). Selecting values that are too high increases the noise of the amplifier.

• Input Coupling Capacitor

An input capacitor, \( C_{IN} \), is required to be added in series with the audio signal into the input pins of the NJU72015. The capacitor allows the amplifier to bias the input signal to the proper DC level for optimum operation. These capacitors form a high-pass filter with the input resistor, \( R_{IN} \). The cutoff frequency is set by:

\[ f_{C(HPF)} = \frac{1}{2\pi R_{IN} C_{IN}} \]

The value of \( C_{IN} \) must be considered carefully because it directly affects the low frequency response and can distort the audio signal.
♦ Flying Capacitor

The flying capacitor is required to generate a negative power supply. To achieve a high efficiency, low-ESR capacitors (ceramic capacitor) are to be selected, and to be placed near the CP terminal (pin7) and CN terminal (pin8) so as to reduce the resistance caused by the PCB trace. The recommended value of this capacitor is 1μF. Selecting values that are too low might reduce the maximum output voltage and might not be operated to specifications.

![Fig.3 Flying capacitor @ 7pin/8pin](image)

♦ Negative supply decoupling Capacitor

To achieve a high efficiency on the negative voltage regulator (negative supply for the amplifier circuit), low ESR capacitor (ceramic capacitor) is to be used for this decoupling capacitor. This capacitor is to be placed near the V terminal (pin6) so as to reduce the resistance caused by the PCB trace. The recommended value of this capacitor is 1μF.

![Fig.4 Decoupling capacitor @ 6pin](image)

♦ Protection Diode

For protection purpose, it is advisable to place a low Vᵢ diode (Schottky diode) to Ground at V terminal (pin 6). The external diodes will protect the IC negative supply terminal when a positive voltage is accidentally applied to the pin.

![Fig.5 Negative supply terminal @ 6pin](image)

♦ External Under Voltage Protection

External under voltage detection can be used to mute the NJU72015's output before an input device can generate a pop noise. The active-mute threshold at the UVP pin is 1.25V. The user selects a resistor divider to obtain the active-mute threshold and hysteresis for the specific application. The threshold is set by:

\[
V_{\text{HYS}} = 5\mu \times R_{13} \frac{R_{11} + R_{12}}{R_{12}}
\]

\[
V_{\text{UVP}} = 1.25 \times \frac{R_{11} + R_{12}}{R_{12}} - V_{\text{HYS}}
\]

\[
= (1.25 - 5\mu \times R_{13}) \times \frac{R_{11} + R_{12}}{R_{12}}
\]

with the condition \(R_{13} >> R_{11}/R_{12}\)

For example, to obtain \(V_{\text{UVP}}=4V\) and 1V hysteresis, \(R_{11}=3kΩ\), \(R_{12}=1kΩ\) and \(R_{13}=50kΩ\). If the UVP function is not used, A pull-up resistance \(R_{\text{PULL}}\) is to be connected between UVP terminal and V+ terminal.

![System Power](image)

![Application Circuit for Using UVP](image)

![Application Circuit for Not Using UVP](image)

![Sequence of UVP Function](image)

![Fig.6 UVP function](image)
Technical Information

Power up & down sequence to minimize pop noise

To further reduce pop noise, Recommend to Fig.7 how Power up and down sequence.

- **When power supply is turned ON**
  
  To further reduce pop noise during power ON, the MUTE terminal should switch L->H after the power supply terminal has turned ON. It is recommended to have a time interval of 10msec (T_{ON}) or more between these two transitions.

- **When power supply is turned OFF**
  
  To further reduce pop noise during power OFF, the MUTE terminal should switch H->L after the power supply terminal has turned OFF. It is recommended to have a time interval of 10msec (T_{OFF}) or more between these two transitions.

Fig.7 Timing diagram when turning on power supply and intercepting it
## TERMINAL DESCRIPTION

<table>
<thead>
<tr>
<th>Terminal</th>
<th>SYMBOL</th>
<th>FUNCTION</th>
<th>EQUIVALENT CIRCUIT</th>
<th>VOLTAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 +INL</td>
<td>-INL</td>
<td>AC Input</td>
<td><img src="image" alt="AC Input Circuit" /></td>
<td>0V</td>
</tr>
<tr>
<td>2 -INL</td>
<td>-INR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13 -INR</td>
<td>+INR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 OUTL</td>
<td>OUTR</td>
<td>AC Output</td>
<td><img src="image" alt="AC Output Circuit" /></td>
<td>0V</td>
</tr>
<tr>
<td>9</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 MUTE</td>
<td></td>
<td>MUTE Control</td>
<td><img src="image" alt="MUTE Control Circuit" /></td>
<td>0V</td>
</tr>
<tr>
<td>7 CN</td>
<td></td>
<td>Flying Capacitor Negative Terminal</td>
<td><img src="image" alt="Flying Capacitor Circuit" /></td>
<td>-</td>
</tr>
<tr>
<td>8 CP</td>
<td></td>
<td>Flying Capacitor Positive Terminal</td>
<td><img src="image" alt="Flying Capacitor Circuit" /></td>
<td>-</td>
</tr>
<tr>
<td>9 DGND</td>
<td></td>
<td>Ground</td>
<td><img src="image" alt="Ground Circuit" /></td>
<td>0V</td>
</tr>
</tbody>
</table>
### TERMINAL DESCRIPTION

<table>
<thead>
<tr>
<th>Terminal</th>
<th>SYMBOL</th>
<th>FUNCTION</th>
<th>EQUIVALENT CIRCUIT</th>
<th>VOLTAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>UVP</td>
<td>Undervoltage Protection Input</td>
<td><img src="image" alt="Equivalent Circuit Diagram" /></td>
<td>-</td>
</tr>
</tbody>
</table>

- **Terminal**: 11
- **Symbol**: UVP
- **Function**: Undervoltage Protection Input
- **Equivalent Circuit**:
  - **V+**
  - **100Ω**
  - **V-**
  - **GND**
- **Voltage**: -
TYPICAL CHARACTERISTICS

IDD vs Supply Voltage
No Signal, No Load

IDD vs Supply Voltage
VDD=0V to 3V, VDD=3V to 0V

IDD vs Temperature
No Signal, No Load

VSS vs Temperature
No Signal, No Load

PSRR vs Temperature
V+=3V to 3.6V

PSRR vs Frequency
V+=3.3V, Vripple=100mVrms, RL=10kΩ, Bandpass
TYPICAL CHARACTERISTICS

**UVP Control**

- $V_{+}=3/3.3/3.6V$, $V_{IN}=1\text{Vrms (differential)}$, $f=1\text{kHz}$, $R_{L}=10k\Omega$
- $R_{1}=3k\Omega$, $R_{2}=1k\Omega$, $R_{3}=50k\Omega$, $Ta=25^\circ C$

**Maximum Output Voltage vs Supply Voltage**

- $f=1\text{kHz}$, $THD=1\%$
- $R_{L}=10k\Omega$

**Maximum Output Voltage vs Frequency**

- $V_{+}=3.3V$, $V_{IN}=1\text{Vrms (differential)}$, $f=1\text{kHz}$
- $R_{L}=10k\Omega$
- $R_{1}=3k\Omega$, $R_{2}=1k\Omega$, $R_{3}=50k\Omega$
- $Ta=-40/25/85/105^\circ C$

**UVP Control**

- $V_{+}=3/3.3/3.6V$, $V_{IN}=1\text{Vrms (differential)}$, $f=1\text{kHz}$
- $R_{L}=10k\Omega$
- $R_{1}=3k\Omega$, $R_{2}=1k\Omega$, $R_{3}=50k\Omega$
- $Ta=-40/25/85/105^\circ C$

**Voltage Gain [dB]**

- $V_{+}=3/3.3/3.6V$
- $UVP OFF$
- $UVP ON$

**UVP Control**

- $V_{+}=3.3V$, $V_{IN}=1\text{Vrms (differential)}$, $f=1\text{kHz}$
- $R_{L}=10k\Omega$
- $R_{1}=3k\Omega$, $R_{2}=1k\Omega$, $R_{3}=50k\Omega$
- $Ta=-40/25/85/105^\circ C$

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- $R_{L}=10k\Omega$
- $R_{1}=3k\Omega$, $R_{2}=1k\Omega$, $R_{3}=50k\Omega$
- $Ta=25^\circ C$

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- $V_{+}=3.3V$, $V_{IN}=1\text{Vrms (differential)}$, $f=1\text{kHz}$
- $R_{L}=10k\Omega$
- $R_{1}=3k\Omega$, $R_{2}=1k\Omega$, $R_{3}=50k\Omega$
- $Ta=25^\circ C$

**Voltage Gain [dB]**

- $V_{+}=3.3V$
- $UVP OFF$
- $UVP ON$

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- $V_{+}=3/3.3/3.6V$, $V_{IN}=1\text{Vrms (differential)}$, $f=1\text{kHz}$
- $R_{L}=10k\Omega$
- $R_{1}=3k\Omega$, $R_{2}=1k\Omega$, $R_{3}=50k\Omega$
- $Ta=-40/25/85/105^\circ C$

**Voltage Gain [dB]**

- $V_{+}=3/3.3/3.6V$
- $UVP OFF$
- $UVP ON$

**UVP Control**

- $V_{+}=3.3V$, $V_{IN}=1\text{Vrms (differential)}$, $f=1\text{kHz}$
- $R_{L}=10k\Omega$
- $R_{1}=3k\Omega$, $R_{2}=1k\Omega$, $R_{3}=50k\Omega$
- $Ta=-40/25/85/105^\circ C$

**Voltage Gain [dB]**

- $V_{+}=3.3V$
- $UVP OFF$
- $UVP ON$

**UVP Control**

- $V_{+}=3/3.3/3.6V$, $V_{IN}=1\text{Vrms (differential)}$, $f=1\text{kHz}$
- $R_{L}=10k\Omega$
- $R_{1}=3k\Omega$, $R_{2}=1k\Omega$, $R_{3}=50k\Omega$
- $Ta=25^\circ C$

**Voltage Gain [dB]**

- $V_{+}=3/3.3/3.6V$
- $UVP OFF$
- $UVP ON$

**UVP Control**

- $V_{+}=3.3V$, $V_{IN}=1\text{Vrms (differential)}$, $f=1\text{kHz}$
- $R_{L}=10k\Omega$
- $R_{1}=3k\Omega$, $R_{2}=1k\Omega$, $R_{3}=50k\Omega$
- $Ta=-40/25/85/105^\circ C$

**Voltage Gain [dB]**

- $V_{+}=3.3V$
- $UVP OFF$
- $UVP ON$
**TYPICAL CHARACTERISTICS**

**Maximum Output Voltage vs Temperature**

- $V=+3.3V$, $f=1kHz$, THD=1%, $R_L=10k\Omega$

**$V_{MUTE}$ vs Temperature**

- $V=+3.3V$, $V_{MUTE}=G_{V_{MUTE}}/G_{V_{ACTIVE}}$, A-weighted

**Mute Control**

- $V=+3.3/3.6V$, $V_{IN}=1Vrms$ (differential), $f=1kHz$, $R_L=10k\Omega$
  - $T_a=25^\circ C$

**$V_{IN}$ vs Temperature**

- $V=+3.3V$, $R_g=0\Omega$, A-weighted

**THD+N vs Temperature**

- $V=+3.3V$, $V_{IN}=1Vrms$ (differential), $f=1kHz$, $R_L=10k\Omega$, BW: 400-22kHz

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TYPICAL CHARACTERISTICS

THD+N vs Output Voltage

V+=3.3V, BW=10-22kHz (f=1kHz/1kHz), 10-80kHz (f=1kHz)

THD+N vs Output Voltage

V+=3.3V, f=1kHz, BW=10-22kHz, RL=10kΩ

THD+N vs Output Voltage

V+=3.3V, f=10kHz, BW=10-80kHz, RL=10kΩ

THD+N vs Frequency

V+=3.3V, Vo=1.8Vrms, BW=10-80kHz

THD+N vs Frequency

V+=3.3V, Vo=2.0Vrms, BW=10-80kHz

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■ TYPICAL CHARACTERISTICS

Output Voltage vs Load Resistance
V+=3.3V, f=1kHz, THD=1%

Channel Separation vs Frequency
V+=3.3V, V+=2Vrms, Rg=600Ω, BW:BandPass, RL=10kΩ

Negative Supply Voltage vs Load Current
V+=3.3V, No Signal, No Load

[CAUTION]
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