High Output Current, Rail-to-Rail Input/Output Dual CMOS Operational Amplifier

■ GENERAL DESCRIPTION
The NJU77902 is a Rail-to-Rail input and output dual CMOS operational amplifier that features high output current drive. This device is stable to capacitive load and can charge and discharge capacitance quickly by high output current up to 1000mA. In addition, it is ideal for buffer amplifiers as the output stage can supply a respectable amount of current with minimal headroom from either rail.

■ FEATURES
• Output Peak Current     1000mA (typ.)
• Rail-to-Rail Input/Output
• Wide Operating Voltage   6V to 18V
• Slew Rate               9V/μs (typ.)
• Package                ESON8-W2 (3.0mm x 3.0mm)
• Enhanced RF Noise Immunity
• CMOS Process

■ APPLICATION
• TFT-LCD panel V_{COM} driver
• Instrument Control Voltage Source

■ PIN CONFIGURATION

```
1  2  3  4  5  6  7  8
1  2  3  4  5  6  7  8

Exposed Pad

NJU77902KW2
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About Exposed Pad
Connect the Exposed Pad on the V_{SS}.
**ABSOLUTE MAXIMUM RATINGS** (Ta=25˚C, unless otherwise noted.)

<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_{DD}</td>
<td>+20</td>
<td>V</td>
</tr>
<tr>
<td>Power Dissipation</td>
<td>P_{D}</td>
<td>560(Note1), 750(Note2), 910(Note3), 2500(Note4)</td>
<td>mW</td>
</tr>
<tr>
<td>Output Peak Current</td>
<td>I_{OP}</td>
<td>1000</td>
<td>mA</td>
</tr>
<tr>
<td>Input Common Mode Voltage</td>
<td>V_{CM}</td>
<td>V_{SS}-0.3 to V_{DD}+0.3</td>
<td>V</td>
</tr>
<tr>
<td>Differential Input Voltage</td>
<td>V_{ID}</td>
<td>18 (Note5)</td>
<td>V</td>
</tr>
<tr>
<td>Operating Temperature Range</td>
<td>T_{op}</td>
<td>-40 to +85</td>
<td>°C</td>
</tr>
<tr>
<td>Storage Temperature Range</td>
<td>T_{stg}</td>
<td>-55 to +150</td>
<td>°C</td>
</tr>
</tbody>
</table>

(Note1) Mounted on glass epoxy board. (101.5×114.5×1.6mm: based on EIA/JEDEC standard, 2Layers FR-4)
(Note2) Mounted on glass epoxy board. (101.5×114.5×1.6mm: based on EIA/JEDEC standard, 2Layers FR-4, with Exposed Pad)
(Note3) Mounted on glass epoxy board. (101.5×114.5×1.6mm: based on EIA/JEDEC standard, 4Layers FR-4)
(Note4) Mounted on glass epoxy board. (101.5×114.5×1.6mm: based on EIA/JEDEC standard, 4Layers FR-4, with Exposed Pad)
(Note5) For supply voltage less than 18V, the absolute maximum rating is equal to the supply voltage.

**RECOMMENDED OPERATING CONDITION** (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_{DD}</td>
<td>6.0 to 18.0</td>
<td>V</td>
</tr>
</tbody>
</table>

**ELECTRICAL CHARACTERISTICS**

(V_{DD}=15V, V_{SS}=0V, V_{IL}=7.5V, R_{L}=10kΩ to V_{DD}/2, Ta=25˚C, unless otherwise noted.)

<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>DC CHARACTERISTICS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum Output Voltage</td>
<td>V_{OH}1</td>
<td>R_{L}=10kΩ</td>
<td>14.8</td>
<td>14.9</td>
<td>-</td>
<td>V</td>
</tr>
<tr>
<td>Maximum Output Voltage</td>
<td>V_{OH}2</td>
<td>I_{source}=200mA</td>
<td>14.2</td>
<td>14.5</td>
<td>-</td>
<td>V</td>
</tr>
<tr>
<td>Input Offset Voltage</td>
<td>V_{IO}</td>
<td>R_{S}=50Ω</td>
<td>-</td>
<td>1</td>
<td>10</td>
<td>mV</td>
</tr>
<tr>
<td>Input Offset Current</td>
<td>I_{I}</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>pA</td>
<td></td>
</tr>
<tr>
<td>Input Offset Current</td>
<td>I_{O}</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>pA</td>
<td></td>
</tr>
<tr>
<td>Large Signal Voltage Gain</td>
<td>A_{V}</td>
<td>V_{O}=13V/2V, R_{L}=10kΩ</td>
<td>65</td>
<td>90</td>
<td>-</td>
<td>dB</td>
</tr>
<tr>
<td>Common Mode Rejection Ratio</td>
<td>CMR</td>
<td>V_{IC}=0V→7.5V</td>
<td>50</td>
<td>75</td>
<td>-</td>
<td>dB</td>
</tr>
<tr>
<td>Supply Voltage Rejection Ratio</td>
<td>SVR</td>
<td>V_{DD}=6V→18V</td>
<td>60</td>
<td>75</td>
<td>-</td>
<td>dB</td>
</tr>
<tr>
<td>Input Common Mode Voltage Range</td>
<td>V_{CM}</td>
<td>CMR≥50dB</td>
<td>0</td>
<td>-</td>
<td>15</td>
<td>V</td>
</tr>
<tr>
<td>Operating Current</td>
<td>I_{DD}</td>
<td>No Signal, R_{L}=open</td>
<td>-</td>
<td>7.0</td>
<td>9.0</td>
<td>mA</td>
</tr>
<tr>
<td>AC CHARACTERISTICS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unity Gain Frequency</td>
<td>ft</td>
<td>C_{L}=10pF</td>
<td>-</td>
<td>3</td>
<td>-</td>
<td>MHz</td>
</tr>
<tr>
<td>Phase Margin</td>
<td>\Phi_{M}</td>
<td>C_{L}=10pF</td>
<td>-</td>
<td>50</td>
<td>-</td>
<td>deg</td>
</tr>
<tr>
<td>Equivalent Input Noise Voltage</td>
<td>V_{in}</td>
<td>f=1kHz, R_{S}=1000Ω</td>
<td>-</td>
<td>80</td>
<td>-</td>
<td>nV/√Hz</td>
</tr>
<tr>
<td>Total Harmonic Distortion+Noise</td>
<td>THD+N</td>
<td>G_{V}=6dB, C_{L}=10pF, f=1kHz, P_{D}=0.1W</td>
<td>-</td>
<td>0.02</td>
<td>-</td>
<td>%</td>
</tr>
<tr>
<td>Output Power</td>
<td>P_{O}</td>
<td>fin=1kHz, C_{L}=10pF, THD≤5%</td>
<td>-</td>
<td>3</td>
<td>-</td>
<td>mW</td>
</tr>
<tr>
<td>Channel Separation</td>
<td>CS</td>
<td>f=1kHz</td>
<td>-</td>
<td>120</td>
<td>-</td>
<td>dB</td>
</tr>
<tr>
<td>TRANSIENT CHARACTERISTICS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output Peak Current</td>
<td>I_{OP}</td>
<td>(Note6)</td>
<td>-</td>
<td>1000</td>
<td>-</td>
<td>mA</td>
</tr>
<tr>
<td>Slew Rate</td>
<td>SR</td>
<td>G_{L}=0dB, C_{L}=10pF, V_{in}=4Vpp, (Note7)</td>
<td>5</td>
<td>9</td>
<td>-</td>
<td>V/µs</td>
</tr>
</tbody>
</table>

(Note6) Output peak current is defined by the lower value of the output source current or output sink current.
(Note7) Slew rate is defined by the lower value of the rise or fall.
Application Notes

- Package Power, Power Dissipation and Output Power

IC is heated by own operation and possibly gets damage when the junction power exceeds the acceptable value called Power Dissipation $P_D$. The dependence of the NJU77902 $P_D$ on ambient temperature is shown in Fig 1. The plots are depended on following two points. The first is $P_D$ on ambient temperature 25 ºC, which is the maximum power dissipation. And the second is 0W, which means that the IC cannot radiate any more. The second point derives from the relation that maximum junction temperature $T_{j,\text{max}}$ is the same as storage temperature $T_{\text{stg}}$. Fig.1 is drawn by connecting those points and by the definition that the $P_D$ lower than 25 ºC is constant. Therefore, the $P_D$ is shown following formula as a function of the ambient temperature between those points.

$$P_D = \frac{T_{j,\text{max}} - T_a}{\theta_{ja}} \quad [\text{W}] \quad (T_a = 25 \, ^\circ C \text{ to } T_a = 150 \, ^\circ C)$$

Where, $\theta_{ja}$ is heat thermal resistance which depends on parameters such as package material, frame material and so on. Therefore, $P_D$ is different in each package.

While, the actual measurement of dissipation power on NJU77902 is obtained using following equation.

$$\text{(Actual Dissipation Power)} = \text{(Supply Voltage} \, V_{DD}) \times \text{(Supply Current} \, I_{DD}) - \text{(Output Power Po)}$$

The NJU77902 should be operated in lower than $P_D$ of the actual dissipation power.

To sustain the steady state operation, take account of the Dissipation Power and thermal design.

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Fig 1. Dependence of NJU77902 Power Dissipations on ambient temperature
- TYPICAL CHARACTERISTICS -

**Supply Current vs. Supply Voltage**

For $R_L = \text{OPEN}$:

- $Ta=25^\circ\text{C}$
- $Ta=-40^\circ\text{C}$
- $Ta=85^\circ\text{C}$

**Supply Current vs. Ambient Temperature**

- $V_{DD}=15\text{V}$
- $V_{DD}=18\text{V}$
- $V_{DD}=6\text{V}$

**Input Offset Voltage vs. Supply Voltage**

For $R_L = \text{OPEN}$:

- $Ta=25^\circ\text{C}$
- $Ta=-40^\circ\text{C}$
- $Ta=85^\circ\text{C}$

**Input Offset Voltage vs. Ambient Temperature**

- $V_{DD}=15\text{V}$
- $V_{DD}=18\text{V}$
- $V_{DD}=6\text{V}$

**Supply Voltage Rejection Ratio vs. Ambient Temperature**

For $R_L = \text{OPEN}$:

- $V_{DD}=15\text{V}$,
- $G_v=40\text{dB}$,
- $Ta=25^\circ\text{C}$

**Supply Voltage Rejection Ratio vs. Frequency**

For $V_{DD}=15\text{V}$,

- $G_v=40\text{dB}$,
- $Ta=25^\circ\text{C}$
Input Offset Voltage vs. Output Voltage

\( V_{DD} = 15V, V_{SS} = 0V, R_L = 10k\Omega \)

Output Voltage [V] vs. Input Offset Voltage [mV]

- \( T_a = 85^\circ C \)
- \( T_a = 25^\circ C \)
- \( T_a = -40^\circ C \)

Voltage Gain vs. Ambient Temperature

\( R_L = 10k\Omega \)

Voltage Gain [dB] vs. Ambient Temperature [°C]

- \( V_{DD} = 15V \)
- \( V_{DD} = 6V \)

Input Offset Voltage vs. Common Mode Input Voltage

\( V_{DD} = 15V, V_{SS} = 0V \)

Input Offset Voltage [mV] vs. Common Mode Input Voltage [V]

- \( T_a = 85^\circ C \)
- \( T_a = 25^\circ C \)
- \( T_a = -40^\circ C \)

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**Common Mode Rejection Ratio vs. Ambient Temperature**

- **V\text{DD} = 15V, V\text{SS} = 0V**
- **Common Mode Rejection Ratio vs. Ambient Temperature**

- **V\text{cm} = 0 to 7.5V**
- **V\text{cm} = 7.5 to 15V**

**Input Bias Current vs. Ambient Temperature**

- **V\text{DD} = 15V**
- **Input Bias Current vs. Ambient Temperature**

- **V\text{DD} = 6V**

**Common Mode Rejection Ratio vs. Frequency**

- **V\text{cm} = 1Vpp, G\text{v} = 40dB, T_a = 25\degree C**

- **V\text{DD} = 15V**
- **V\text{DD} = 6V**
Maximum Output Voltage vs. Output Sink Current

V_{DD}=15V, V_{SS}=0V, Vin+=0V, Vin-=1V

Maximum Output Voltage vs. Output Sink Current

V_{DD}=6V, V_{SS}=0V, Vin+=0V, Vin-=1V

Maximum Output Voltage vs. Output Source Current

V_{DD}=0V, V_{SS}=-15V, Vin+=0V, Vin-=1V

Maximum Output Voltage vs. Output Source Current

V_{DD}=0V, V_{SS}=-6V, Vin+=0V, Vin-=1V

Output Saturated Voltage vs. Ambient Temperature

\(I_{sink}=200mA\)

Output Saturated Voltage vs. Ambient Temperature

\(I_{source}=200mA\)
Gain Margin vs. Ambient Temperature
V+/V-=±7.5V, RL=10kΩ, Vin=-30dBm, Gv=20dB

Phase Margin vs. Ambient Temperature
V+/V-=±7.5V, RL=10kΩ, Vin=-30dBm, Gv=20dB

Unity Gain Frequency vs. Ambient Temperature
V+/V-=±7.5V, RL=10kΩ, Vin=-30dBm, Gv=20dB

Gain Margin vs. Ambient Temperature
V+/V-=±3V, RL=10kΩ, Vin=-30dBm, Gv=20dB

Phase Margin vs. Ambient Temperature
V+/V-=±3V, RL=10kΩ, Vin=-30dBm, Gv=20dB

Unity Gain Frequency vs. Ambient Temperature
V+/V-=±3V, RL=10kΩ, Vin=-30dBm, Gv=20dB
Pulse Response (Rise)
V+/V-=±7.5V, Ta=25ºC, R_L=10kΩ

Output Voltage [V] vs. Time [us]

-10 0 10 20 30 40 50

Vin

C_L=100pF
C_L=10pF

Pulse Response (Rise)
V+/V-=±3V, Ta=25ºC, R_L=10kΩ

Output Voltage [V] vs. Time [us]

-10 0 10 20 30 40 50

Vin

C_L=100pF
C_L=10pF

Pulse Response (Fall)
V+/V-=±7.5V, Ta=25ºC, R_L=10kΩ

Output Voltage [V] vs. Time [us]

-10 0 10 20 30 40 50

Vin

C_L=100pF
C_L=10pF

Pulse Response (Fall)
V+/V-=±3V, Ta=25ºC, R_L=10kΩ

Output Voltage [V] vs. Time [us]

-10 0 10 20 30 40 50

Vin

C_L=100pF
C_L=10pF

Slew Rate vs. Ambient Temperature
V+/V-=±7.5V, Vin=1Vpp, R_L=10kΩ, C_L=10pF

Slew Rate [V/us] vs. Ambient Temperature [ºC]

-60 -30 0 30 60 90 120 150

Rise
Fall

Slew Rate vs. Ambient Temperature
V+/V-=±3V, Vin=1Vpp, R_L=10kΩ, C_L=10pF

Slew Rate [V/us] vs. Ambient Temperature [ºC]

-60 -30 0 30 60 90 120 150

Rise
Fall
Voltage Follower Peak

\[ V^+/V^- = \pm 7.5\text{V}, G_v = 0\text{dB}, \quad V_i = -30\text{dBm}, \quad R_L = 10k\Omega, \quad T_a = 25^\circ\text{C} \]

Frequency [Hz]

Supply Current vs. Ambient Temperature

\[ R_L = \text{OPEN} \]

Ambient Temperature [°C]

Channel Separation vs. Frequency

\[ G_v = 40\text{dB}, \quad T_a = 25^\circ\text{C} \]

Frequency [Hz]

Input Noise Voltage vs. Frequency

\[ R_s = 100\Omega, \quad R_f = 10k\Omega, \quad T_a = 25^\circ\text{C} \]

Frequency [Hz]
**THD + Noise vs. Output Power**

For $V_{DD}=15V$, $Gv=20dB$, $R_L=10k\Omega$, $C_L=10pF$, $Ta=25^\circ C$

- THD at $f=10kHz$
- THD at $f=1kHz$
- THD at $f=100Hz$

Dissipation Power vs. Output Power

For $R_L=32\Omega$, $Ta=25^\circ C$, $f=1kHz$, Stereo

- THD at $1%$
- THD at $10%$

For $V_{DD}=12V$, $V_{DD}=9V$, $V_{DD}=6V$

Dissipation Power vs. Output Power

For $R_L=64\Omega$, $Ta=25^\circ C$, $f=1kHz$, BTL

- THD at $1%$
- THD at $10%$

For $V_{DD}=15V$, $V_{DD}=12V$, $V_{DD}=9V$

**CAUTION**

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