description

The JFET-input operational amplifiers in the TL07_ series are designed as low-noise versions of the TL08_ series amplifiers with low input bias and offset currents and fast slew rate. The low harmonic distortion and low noise make the TL07_ series ideally suited for high-fidelity and audio preamplifier applications. Each amplifier features JFET inputs (for high input impedance) coupled with bipolar output stages integrated on a single monolithic chip.

The C-suffix devices are characterized for operation from 0°C to 70°C. The I-suffix devices are characterized for operation from –40°C to 85°C. The M-suffix devices are characterized for operation over the full military temperature range of –55°C to 125°C.

AVAILABLE OPTIONS

<table>
<thead>
<tr>
<th>TA</th>
<th>V_{\text{IN, max}} AT 25°C</th>
<th>PACKAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SMALL OUTLINE (D)†</td>
<td>CHIP CARRIER (FK)</td>
</tr>
<tr>
<td>0°C to 70°C</td>
<td>10 mV</td>
<td>TL071CD</td>
</tr>
<tr>
<td></td>
<td>6 mV</td>
<td>TL071ACD</td>
</tr>
<tr>
<td></td>
<td>3 mV</td>
<td>TL071BCD</td>
</tr>
<tr>
<td></td>
<td>10 mV</td>
<td>TL072CD</td>
</tr>
<tr>
<td></td>
<td>6 mV</td>
<td>TL072ACD</td>
</tr>
<tr>
<td></td>
<td>3 mV</td>
<td>TL072BCD</td>
</tr>
<tr>
<td></td>
<td>10 mV</td>
<td>TL074CD</td>
</tr>
<tr>
<td></td>
<td>6 mV</td>
<td>TL074ACD</td>
</tr>
<tr>
<td></td>
<td>3 mV</td>
<td>TL074BCD</td>
</tr>
<tr>
<td>–40°C to 85°C</td>
<td>6 mV</td>
<td>TL071ID</td>
</tr>
<tr>
<td></td>
<td>6 mV</td>
<td>TL072ID</td>
</tr>
<tr>
<td></td>
<td>6 mV</td>
<td>TL074ID</td>
</tr>
<tr>
<td>–55°C to 125°C</td>
<td>6 mV</td>
<td>TL071MFK</td>
</tr>
<tr>
<td></td>
<td>6 mV</td>
<td>TL072MFK</td>
</tr>
<tr>
<td></td>
<td>9 mV</td>
<td>TL074MFK</td>
</tr>
</tbody>
</table>

† The D package is available taped and reeled. Add the suffix R to the device type (e.g., TL071CDR). The PW package is only available left-ended taped and reeled (e.g., TL072CPWLE).

Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.
LOW-NOISE JFET-INPUT OPERATIONAL AMPLIFIERS

TL071, TL071A, TL071B, TL072
TL072A, TL072B, TL074, TL074A, TL074B

SLOS080D – SEPTEMBER 1978 – REVISED AUGUST 1996

OFFSET N1
IN– 2 7 VCC+
IN+ 3 6 OUT
VCC – 4 5 OFFSET N2

OFFSET N1
IN– 4 5 VCC+
IN+ 1 8 OUT
VCC – 2 3 OFFSET N2

OFFSET N1
IN– 1 4 VCC+
IN+ 2 3 OUT
VCC – 5 8 OFFSET N2

OFFSET N1
IN– 1 8 VCC+
IN+ 2 7 OUT
VCC – 3 6 OFFSET N2

NC – No internal connection

symbols

TL071
OFFSET N1
IN– IN+
OUT
OFFSET N2

TL072 (each amplifier)
TL074 (each amplifier)
IN+ IN– OUT

NC – No internal connection

symbols

TL071
OFFSET N1
IN– IN+
OUT
OFFSET N2

TL072 (each amplifier)
TL074 (each amplifier)
IN+ IN– OUT

NC – No internal connection

symbols

TL071
OFFSET N1
IN– IN+
OUT
OFFSET N2

TL072 (each amplifier)
TL074 (each amplifier)
IN+ IN– OUT

NC – No internal connection

symbols

TL071
OFFSET N1
IN– IN+
OUT
OFFSET N2

TL072 (each amplifier)
TL074 (each amplifier)
IN+ IN– OUT

NC – No internal connection

symbols

TL071
OFFSET N1
IN– IN+
OUT
OFFSET N2

TL072 (each amplifier)
TL074 (each amplifier)
IN+ IN– OUT

NC – No internal connection

symbols

TL071
OFFSET N1
IN– IN+
OUT
OFFSET N2

TL072 (each amplifier)
TL074 (each amplifier)
IN+ IN– OUT

NC – No internal connection

symbols
schematic (each amplifier)

All component values shown are nominal.

<table>
<thead>
<tr>
<th>COMPONENT COUNT†</th>
<th>TL071</th>
<th>TL072</th>
<th>TL074</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resistors</td>
<td>11</td>
<td>22</td>
<td>44</td>
</tr>
<tr>
<td>Transistors</td>
<td>14</td>
<td>28</td>
<td>56</td>
</tr>
<tr>
<td>JFET</td>
<td>2</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Diodes</td>
<td>1</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Capacitors</td>
<td>1</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>epi-FET</td>
<td>1</td>
<td>2</td>
<td>4</td>
</tr>
</tbody>
</table>

† Includes bias and trim circuitry
absolute maximum ratings over operating free-air temperature range (unless otherwise noted)†

Supply voltage, \( V_{CC+} \) (see Note 1) ................................................................. 18 V
Supply voltage, \( V_{CC-} \) (see Note 1) ................................................................. \( -18 \) V
Differential input voltage, \( V_{ID} \) (see Note 2) ........................................ \( \pm 30 \) V
Input voltage, \( V_I \) (see Notes 1 and 3) .............................................................. \( \pm 15 \) V
Duration of output short circuit (see Note 4) ..................................................... unlimited
Continuous total power dissipation ................................................................. See Dissipation Rating Table
Operating free-air temperature range, \( T_A \):

- C suffix ................................................................. 0°C to 70°C
- I suffix ................................................................. -40°C to 85°C
- M suffix ................................................................. -55°C to 125°C
Storage temperature range ................................................................. -65°C to 150°C
Case temperature for 60 seconds: FK package ............................................... 260°C
Lead temperature 1.6 mm (1/16 inch) from case for 10 seconds: J, JG, or W package ..................................................... 300°C
Lead temperature 1.6 mm (1/16 inch) from case for 10 seconds: D, N, P, or PW package ..................................................... 260°C

† Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under “recommended operating conditions” is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

NOTES:
1. All voltage values, except differential voltages, are with respect to the midpoint between \( V_{CC+} \) and \( V_{CC-} \).
2. Differential voltages are at \( IN+ \) with respect to \( IN- \).
3. The magnitude of the input voltage must never exceed the magnitude of the supply voltage or 15 V, whichever is less.
4. The output may be shorted to ground or to either supply. Temperature and/or supply voltages must be limited to ensure that the dissipation rating is not exceeded.

DISSIPATION RATING TABLE

<table>
<thead>
<tr>
<th>PACKAGE</th>
<th>( T_A \leq 25°C ) POWER RATING</th>
<th>DERATING FACTOR</th>
<th>DERATE ABOVE ( T_A )</th>
<th>( T_A = 70°C ) POWER RATING</th>
<th>( T_A = 85°C ) POWER RATING</th>
<th>( T_A = 125°C ) POWER RATING</th>
</tr>
</thead>
<tbody>
<tr>
<td>D (8 pin)</td>
<td>680 mW</td>
<td>5.8 mW/°C</td>
<td>33°C</td>
<td>465 mW</td>
<td>378 mW</td>
<td>N/A</td>
</tr>
<tr>
<td>D (14 pin)</td>
<td>680 mW</td>
<td>7.6 mW/°C</td>
<td>60°C</td>
<td>604 mW</td>
<td>490 mW</td>
<td>N/A</td>
</tr>
<tr>
<td>FK</td>
<td>680 mW</td>
<td>11.0 mW/°C</td>
<td>88°C</td>
<td>680 mW</td>
<td>680 mW</td>
<td>273 mW</td>
</tr>
<tr>
<td>J</td>
<td>680 mW</td>
<td>11.0 mW/°C</td>
<td>88°C</td>
<td>680 mW</td>
<td>680 mW</td>
<td>273 mW</td>
</tr>
<tr>
<td>JG</td>
<td>680 mW</td>
<td>8.4 mW/°C</td>
<td>69°C</td>
<td>672 mW</td>
<td>546 mW</td>
<td>210 mW</td>
</tr>
<tr>
<td>N</td>
<td>680 mW</td>
<td>9.2 mW/°C</td>
<td>76°C</td>
<td>680 mW</td>
<td>597 mW</td>
<td>N/A</td>
</tr>
<tr>
<td>P</td>
<td>680 mW</td>
<td>8.0 mW/°C</td>
<td>65°C</td>
<td>640 mW</td>
<td>520 mW</td>
<td>N/A</td>
</tr>
<tr>
<td>PW (8 pin)</td>
<td>525 mW</td>
<td>4.2 mW/°C</td>
<td>70°C</td>
<td>525 mW</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>PW (14 pin)</td>
<td>700 mW</td>
<td>5.6 mW/°C</td>
<td>70°C</td>
<td>700 mW</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>W</td>
<td>680 mW</td>
<td>8.0 mW/°C</td>
<td>65°C</td>
<td>640 mW</td>
<td>520 mW</td>
<td>200 mW</td>
</tr>
</tbody>
</table>
### Electrical Characteristics, $V_{CC} = \pm 15$ V (unless otherwise noted)

| PARAMETER                              | TEST CONDITIONS† | $T_A‡$ | TL071C | TL071A | TL071B | TL071I | TL072C | TL072A | TL072B | TL072I | TL074C | TL074A | TL074B | TL074I | UNIT   |
|----------------------------------------|------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| $V_{IO}$ Input offset voltage          | $V_O = 0$, $R_S = 50 \Omega$ | 25°C   | 3      | 10     | 3      | 6      | 2      | 3      | 3      | 6      |        |        |        |        | mV     |
| $\alpha V_{IO}$ Temperature coefficient of input offset voltage | $V_O = 0$, $R_S = 50 \Omega$ | Full range | 18     | 18     | 18     | 18     |        |        |        |        |        |        |        |        | μV/°C  |
| $I_O$ Input offset current            | $V_O = 0$        | 25°C   | 5      | 100    | 5      | 100    | 5      | 100    | 5      | 100    |        |        |        |        | nA     |
| $I_B$ Input bias current§              | $V_O = 0$        | 25°C   | 65     | 200    | 65     | 200    | 65     | 200    | 65     | 200    |        |        |        |        | pA     |
| $V_{ICR}$ Common-mode input voltage range | $R_L = 10 \text{k}\Omega$ | 25°C   | ±11    | –12    | ±11    | –12    | ±11    | –12    | ±11    | –12    |        |        |        |        | V      |
| $V_{OM}$ Maximum peak output voltage swing | $R_L = 10 \text{k}\Omega$ | 25°C   | ±12    | ±13.5  | ±12    | ±13.5  | ±12    | ±13.5  | ±12    | ±13.5  |        |        |        |        | V      |
| $A_{VD}$ Large-signal differential voltage amplification | $V_O = \pm 10 \text{V}$, $R_L \geq 2 \text{k}\Omega$ | 25°C   | 25     | 200    | 50     | 200    | 50     | 200    | 50     | 200    |        |        |        |        | V/mV   |
| $B_1$ Unity-gain bandwidth            |                  | 25°C   | 3      |        | 3      |        | 3      |        | 3      |        |        |        |        |        | MHz    |
| $r_I$ Input resistance                |                  | 25°C   | $10^2$ |        | $10^2$ |        | $10^2$ |        | $10^2$ |        |        |        |        |        | Ω      |
| CMRR Common-mode rejection ratio      | $V_{IC} = V_{ICR}$min, $V_O = 0$, $R_S = 50 \Omega$ | 25°C   | 70     | 100    | 75     | 100    | 75     | 100    | 75     | 100    |        |        |        |        | dB     |
| $k_{SVR}$ Supply-voltage rejection ratio ($\Delta V_{CC}/\Delta V_I$) | $V_{CC} = \pm 9 \text{V}$ to $\pm 15 \text{V}$, $V_O = 0$, $R_S = 50 \Omega$ | 25°C   | 70     | 100    | 80     | 100    | 80     | 100    | 80     | 100    |        |        |        |        | dB     |
| $I_{CC}$ Supply current (each amplifier) | $V_O = 0$, No load | 25°C   | 1.4    | 2.5    | 1.4    | 2.5    | 1.4    | 2.5    | 1.4    | 2.5    |        |        |        |        | mA     |
| $V_{O1}/V_{O2}$ Crosstalk attenuation  | $A_{VD} = 100$ | 25°C   | 120    |        | 120    |        | 120    |        | 120    |        |        |        |        |        | dB     |

† All characteristics are measured under open-loop conditions with zero common-mode voltage unless otherwise specified.
‡ Full range is $T_A = 0°C$ to $70°C$ for TL071_C, TL071_A, TL071_B and is $T_A = –40°C$ to $85°C$ for TL071_I.
§ Input bias currents of a FET-input operational amplifier are normal junction reverse currents, which are temperature sensitive as shown in Figure 4. Pulse techniques must be used that maintain the junction temperature as close to the ambient temperature as possible.
electrical characteristics, $V_{CC} = \pm 15$ V (unless otherwise noted)

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>TEST CONDITIONS†</th>
<th>$T_A$‡</th>
<th>TL071M</th>
<th>TL072M</th>
<th>TL074M</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{IO}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>mV</td>
</tr>
<tr>
<td>Input offset voltage</td>
<td>$V_O = 0$, $R_S = 50 \Omega$</td>
<td>$25^\circ C$</td>
<td>3</td>
<td>6</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Full range</td>
<td>9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\alpha V_{IO}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>\mu V/°C</td>
</tr>
<tr>
<td>Temperature coefficient of</td>
<td>$V_O = 0$, $R_S = 50 \Omega$</td>
<td>Full range</td>
<td>18</td>
<td>18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>input offset voltage</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$I_{IO}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>pA</td>
</tr>
<tr>
<td>Input offset current</td>
<td>$V_O = 0$</td>
<td>$25^\circ C$</td>
<td>5</td>
<td>100</td>
<td>5</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Full range</td>
<td>20</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$I_{IB}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>nA</td>
</tr>
<tr>
<td>Input bias current‡</td>
<td>$V_O = 0$</td>
<td>$25^\circ C$</td>
<td>65</td>
<td>200</td>
<td>65</td>
<td>200</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$V_{ICR}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>Common-mode input voltage range</td>
<td></td>
<td>$25^\circ C$</td>
<td>$\pm 12$</td>
<td>to $\pm 12$</td>
<td>$\pm 12$</td>
<td>to $\pm 12$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$V_{OM}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>Maximum peak output voltage swing</td>
<td></td>
<td>$25^\circ C$</td>
<td>$\pm 12$</td>
<td>$\pm 12$</td>
<td>$\pm 12$</td>
<td>$\pm 12$</td>
</tr>
<tr>
<td>$R_L = 10 , k\Omega$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$R_L \geq 10 , k\Omega$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$R_L \geq 2 , k\Omega$</td>
<td></td>
<td></td>
<td>$\pm 10$</td>
<td>$\pm 10$</td>
<td>$\pm 10$</td>
<td></td>
</tr>
<tr>
<td>$A_{VD}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>V/mV</td>
</tr>
<tr>
<td>Large-signal differential voltage amplification</td>
<td>$V_O = \pm 10$ V, $R_L \geq 2$ k\Omega</td>
<td>$25^\circ C$</td>
<td>35</td>
<td>200</td>
<td>35</td>
<td>200</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$B_1$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>MHz</td>
</tr>
<tr>
<td>Unity-gain bandwidth</td>
<td>$T_A = 25^\circ C$</td>
<td></td>
<td>3</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$r_i$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input resistance</td>
<td>$T_A = 25^\circ C$</td>
<td></td>
<td>10$^{12}$</td>
<td>10$^{12}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CMRR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>\Omega</td>
</tr>
<tr>
<td>Common-mode rejection ratio</td>
<td></td>
<td>$25^\circ C$</td>
<td>80</td>
<td>86</td>
<td>80</td>
<td>86</td>
</tr>
<tr>
<td>$V_{IC} = V_{ICR} \min$, $V_O = 0$, $R_S = 50 \Omega$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$k_{SVR}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td>Supply-voltage rejection ratio</td>
<td></td>
<td>$25^\circ C$</td>
<td>80</td>
<td>86</td>
<td>80</td>
<td>86</td>
</tr>
<tr>
<td>$\Delta V_{CC} = \pm 9$ V to $\pm 15$ V, $V_O = 0$, $R_S = 50 \Omega$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$I_{CC}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td>Supply current (each amplifier)</td>
<td></td>
<td>$25^\circ C$</td>
<td>1.4</td>
<td>2.5</td>
<td>1.4</td>
<td>2.5</td>
</tr>
<tr>
<td>$V_O = 0$, No load</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$V_{O1}/V_{O2}$</td>
<td></td>
<td>$25^\circ C$</td>
<td>120</td>
<td>120</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crosstalk attenuation</td>
<td>$A_{VD} = 100$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

† Input bias currents of a FET-input operational amplifier are normal junction reverse currents, which are temperature sensitive as shown in Figure 4. Pulse techniques must be used that will maintain the junction temperature as close to the ambient temperature as possible.

‡ All characteristics are measured under open-loop conditions with zero common-mode voltage unless otherwise specified. Full range is $T_A = -55^\circ C$ to $125^\circ C$. 
operating characteristics, $V_{CC} = \pm 15\,V$, $T_A = 25^\circ C$

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>TEST CONDITIONS</th>
<th>TL07xM</th>
<th>ALL OTHERS</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>SR</td>
<td>$V_I = 10,V$, $C_L = 100,pF$, $R_L = 2,k\Omega$, See Figure 1</td>
<td>5 13</td>
<td>8 13</td>
<td>V/\mu s</td>
</tr>
<tr>
<td>$t_r$ Rise time overshoot factor</td>
<td>$V_I = 20,mV$, $C_L = 100,pF$, $R_L = 2,k\Omega$, See Figure 1</td>
<td>0.1</td>
<td>0.1</td>
<td>\mu s</td>
</tr>
<tr>
<td>$V_n$ Equivalent input noise voltage</td>
<td>$R_S = 20,\Omega$, $f = 1,kHz$, $f = 10,Hz$ to $10,kHz$</td>
<td>18</td>
<td>18</td>
<td>nV/\sqrt{Hz}</td>
</tr>
<tr>
<td>$I_n$ Equivalent input noise current</td>
<td>$R_S = 20,\Omega$, $f = 1,kHz$</td>
<td>0.01</td>
<td>0.01</td>
<td>pA/\sqrt{Hz}</td>
</tr>
<tr>
<td>THD Total harmonic distortion</td>
<td>$V_{T_{rms}} = 6,V$, $R_L \geq 2,k\Omega$, $R_S \leq 1,k\Omega$, $f = 1,kHz$</td>
<td>0.003%</td>
<td>0.003%</td>
<td></td>
</tr>
</tbody>
</table>

PARAMETER MEASUREMENT INFORMATION

![Figure 1. Unity-Gain Amplifier](image1.png)

![Figure 2. Gain-of-10 Inverting Amplifier](image2.png)

![Figure 3. Input Offset Voltage Null Circuit](image3.png)
## TYPICAL CHARACTERISTICS

### Table of Graphs

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>vs Parameter</th>
<th>Figure</th>
</tr>
</thead>
<tbody>
<tr>
<td>$I_{IB}$</td>
<td>Input bias current</td>
<td>vs Free-air temperature</td>
<td>4</td>
</tr>
<tr>
<td>$V_{OM}$</td>
<td>Maximum output voltage</td>
<td>vs Frequency</td>
<td>5, 6, 7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>vs Free-air temperature</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>vs Load resistance</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>vs Supply voltage</td>
<td>10</td>
</tr>
<tr>
<td>$A_{VD}$</td>
<td>Large-signal differential voltage amplification</td>
<td>vs Free-air temperature</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td></td>
<td>vs Frequency</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Phase shift</td>
<td>vs Frequency</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Normalized unity-gain bandwidth</td>
<td>vs Free-air temperature</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>Normalized phase shift</td>
<td>vs Free-air temperature</td>
<td>13</td>
</tr>
<tr>
<td>CMRR</td>
<td>Common-mode rejection ratio</td>
<td>vs Free-air temperature</td>
<td>14</td>
</tr>
<tr>
<td>$I_{CC}$</td>
<td>Supply current</td>
<td>vs Supply voltage</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td></td>
<td>vs Free-air temperature</td>
<td>16</td>
</tr>
<tr>
<td>$P_D$</td>
<td>Total power dissipation</td>
<td>vs Free-air temperature</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Normalized slew rate</td>
<td>vs Free-air temperature</td>
<td>18</td>
</tr>
<tr>
<td>$V_{N}$</td>
<td>Equivalent input noise voltage</td>
<td>vs Frequency</td>
<td>19</td>
</tr>
<tr>
<td>THD</td>
<td>Total harmonic distortion</td>
<td>vs Frequency</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Large-signal pulse response</td>
<td>vs Time</td>
<td>21</td>
</tr>
<tr>
<td>$V_O$</td>
<td>Output voltage</td>
<td>vs Elapsed time</td>
<td>22</td>
</tr>
</tbody>
</table>
TYPICAL CHARACTERISTICS†

INPUT BIAS CURRENT

vs

FREE-AIR TEMPERATURE

Figure 4

MAXIMUM PEAK OUTPUT VOLTAGE

vs

FREQUENCY

Figure 5

MAXIMUM PEAK OUTPUT VOLTAGE

vs

FREQUENCY

Figure 6

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.
TYPICAL CHARACTERISTICS†

MAXIMUM PEAK OUTPUT VOLTAGE vs FREE-AIR TEMPERATURE

![Graph showing maximum peak output voltage vs free-air temperature](image1)

\[ V_{OM} = \text{Maximum Peak Output Voltage} - V \]

\[ R_L = 10 \, k\Omega \]

\[ R_L = 2 \, k\Omega \]

\[ V_{CC} = \pm 15 \, V \]

See Figure 2

Figure 8

MAXIMUM PEAK OUTPUT VOLTAGE vs LOAD RESISTANCE

![Graph showing maximum peak output voltage vs load resistance](image2)

\[ V_{OM} = \text{Maximum Peak Output Voltage} - V \]

\[ R_L = \text{Load Resistance} - k\Omega \]

\[ V_{CC} = \pm 15 \, V \]

\[ T_A = 25^\circ C \]

See Figure 2

Figure 9

MAXIMUM PEAK OUTPUT VOLTAGE vs SUPPLY VOLTAGE

![Graph showing maximum peak output voltage vs supply voltage](image3)

\[ V_{OM} = \text{Maximum Peak Output Voltage} - V \]

\[ R_L = 10 \, k\Omega \]

\[ T_A = 25^\circ C \]

Figure 10

LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION vs FREE-AIR TEMPERATURE

![Graph showing large-signal differential voltage amplification vs free-air temperature](image4)

\[ A_{VD} = \text{Large-Signal Differential Voltage Amplification} - V/mV \]

\[ V_{CC} = \pm 15 \, V \]

\[ V_O = \pm 10 \, V \]

\[ R_L = 2 \, k\Omega \]

Figure 11

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.
TYPICAL CHARACTERISTICS†

LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION AND PHASE SHIFT 

vs FREQUENCY

Figure 12

NORMALIZED UNITY-GAIN BANDWIDTH AND PHASE SHIFT 

vs FREE-AIR TEMPERATURE

Figure 13

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.
TYPICAL CHARACTERISTICS†

COMMON-MODE REJECTION RATIO

\[ \text{CMRR} = \frac{V_{\text{IN}}}{V_{\text{NOISE}}} \]

\[ V_{\text{CC}} = \pm 15 \, \text{V} \]

\[ R_L = 10 \, \text{k}\Omega \]

\[ T_A = \text{Free-Air Temperature} \, \text{°C} \]

SUPPLY CURRENT PER AMPLIFIER

\[ I_{\text{CC}} = \frac{I_{\text{IN}}}{2} \]

\[ V_{\text{CC}} = \pm 15 \, \text{V} \]

\[ T_A = 25 \, \text{°C} \]

No Signal

No Load

SUPPLY CURRENT PER AMPLIFIER vs FREE-AIR TEMPERATURE

Figure 14

TOTAL POWER DISSIPATION vs FREE-AIR TEMPERATURE

\[ P_D = \frac{V_{\text{CC}}^2}{R_L} \]

\[ V_{\text{CC}} = \pm 15 \, \text{V} \]

No Signal

No Load

Figure 17

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.
NORMALIZED SLEW RATE

FREE-AIR TEMPERATURE

1.15
1.10
1.05
1.00
0.95
0.90
0.85

VCC± = ±15 V
RL = 2 kΩ
CL = 100 pF

Normalized Slew Rate – V/µs

TA – Free-Air Temperature – °C

0
25
50
75
100
125

-75
-50
-25
0
25
50
75
100
125

Figure 18

EQUIVALENT INPUT NOISE VOLTAGE

VCC± = ±15 V

AvD = 10
RL = 2 kΩ
TA = 25°C

f – Frequency – Hz

10
20
30
40
50

0
10
20
30
40
50

Figure 19

TOTAL HARMONIC DISTORTION

VCC± = ±15 V

AvD = 1

VRMS = 6 V
TA = 25°C

f – Frequency – Hz

100
400
1 k
4 k
10 k
40 k
100 k

Figure 20

VOLTAGE-FOLLOWER

LARGE-SIGNAL PULSE RESPONSE

VCC± = ±15 V

RL = 2 kΩ
C L = 100 pF
TA = 25°C

V and VO – Input and Output Voltages – V

-6
-4
-2
0
2
4
6

Figure 21
TYPICAL CHARACTERISTICS

OUTPUT VOLTAGE

VS

ELAPSED TIME

V_{O} \text{ – Output Voltage – } mV

V_{CC} = \pm 15 V

R_{L} = 2 \, \Omega

T_{A} = 25^\circ C

0

0.1

0.2

0.3

0.4

0.5

0.6

0.7

0

20

40

60

80

100

120

140

160

180

200

220

240

260

280

t \text{ – Elapsed Time – } \mu s

Overshoot

90%

10%

Figure 22
APPLICATION INFORMATION

Table of Application Diagrams

<table>
<thead>
<tr>
<th>APPLICATION DIAGRAM</th>
<th>PART NUMBER</th>
<th>FIGURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5-Hz square-wave oscillator</td>
<td>TL071</td>
<td>23</td>
</tr>
<tr>
<td>High-Q notch filter</td>
<td>TL071</td>
<td>24</td>
</tr>
<tr>
<td>Audio-distribution amplifier</td>
<td>TL074</td>
<td>25</td>
</tr>
<tr>
<td>100-kHz quadrature oscillator</td>
<td>TL072</td>
<td>26</td>
</tr>
<tr>
<td>AC amplifier</td>
<td>TL071</td>
<td>27</td>
</tr>
</tbody>
</table>

Figure 23. 0.5-Hz Square-Wave Oscillator

Figure 24. High-Q Notch Filter

Figure 25. Audio-Distribution Amplifier
APPLICATION INFORMATION

NOTE A: These resistor values may be adjusted for a symmetrical output.

Figure 26. 100-kHz Quadrature Oscillator

Figure 27. AC Amplifier
Texas Instruments and its subsidiaries (TI) reserve the right to make changes to their products or to discontinue any product or service without notice, and advise customers to obtain the latest version of relevant information to verify, before placing orders, that information being relied on is current and complete. All products are sold subject to the terms and conditions of sale supplied at the time of order acknowledgement, including those pertaining to warranty, patent infringement, and limitation of liability.

TI warrants performance of its semiconductor products to the specifications applicable at the time of sale in accordance with TI’s standard warranty. Testing and other quality control techniques are utilized to the extent TI deems necessary to support this warranty. Specific testing of all parameters of each device is not necessarily performed, except those mandated by government requirements.

CERTAIN APPLICATIONS USING SEMICONDUCTOR PRODUCTS MAY INVOLVE POTENTIAL RISKS OF DEATH, PERSONAL INJURY, OR SEVERE PROPERTY OR ENVIRONMENTAL DAMAGE (“CRITICAL APPLICATIONS”). TI SEMICONDUCTOR PRODUCTS ARE NOT DESIGNED, AUTHORIZED, OR WARRANTED TO BE SUITABLE FOR USE IN LIFE-SUPPORT DEVICES OR SYSTEMS OR OTHER CRITICAL APPLICATIONS. INCLUSION OF TI PRODUCTS IN SUCH APPLICATIONS IS UNDERSTOOD TO BE FULLY AT THE CUSTOMER’S RISK.

In order to minimize risks associated with the customer’s applications, adequate design and operating safeguards must be provided by the customer to minimize inherent or procedural hazards.

TI assumes no liability for applications assistance or customer product design. TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right of TI covering or relating to any combination, machine, or process in which such semiconductor products or services might be or are used. TI’s publication of information regarding any third party’s products or services does not constitute TI’s approval, warranty or endorsement thereof.

Copyright © 1998, Texas Instruments Incorporated