24 DEVICES COVER MILITARY, INDUSTRIAL AND COMMERCIAL TEMPERATURE RANGES

- Low-Power Consumption
- Wide Common-Mode and Differential Voltage Ranges
- Low Input Bias and Offset Currents
- Output Short-Circuit Protection
- Low Total Harmonic Distortion . . . 0.003% TYP

Types TLO80 thru TLO85, TLO80A THRU TLO84A
TLO81B, TLO82B, TLO84B
JFET-INPUT OPERATIONAL AMPLIFIERS
C2297, FEBRUARY 1977 - REVISED SEPTEMBER 1983

IC PREAMPLIFIER RESPONSE CHARACTERISTICS

FIGURE 31

DEVICE TYPES, SUFFIX VERSIONS, AND PACKAGES

<table>
<thead>
<tr>
<th>TLO80</th>
<th>TLO81</th>
<th>TLO82</th>
<th>TLO83</th>
<th>TLO84</th>
<th>TLO85</th>
</tr>
</thead>
<tbody>
<tr>
<td>TLO80.I</td>
<td>JG, P</td>
<td>JG, P</td>
<td>JG, P</td>
<td>J, N</td>
<td>J, N</td>
</tr>
<tr>
<td>TLO80.AC</td>
<td>JG, P</td>
<td>JG, P</td>
<td>JG, P</td>
<td>J, N</td>
<td>J, N</td>
</tr>
<tr>
<td>TLO80.BC</td>
<td>JG, P</td>
<td>JG, P</td>
<td>JG, P</td>
<td>J, N</td>
<td>J, N</td>
</tr>
</tbody>
</table>

*These combinations are not defined by the data sheet.
TYPES TL080 THRU TL085, TL080A THRU TL084A
TL081B, TL082B, TL084B
JFET-INPUT OPERATIONAL AMPLIFIERS

TL083, TL083A
J OR N DUAL-IN-LINE PACKAGE
(TOP VIEW)

#1 IN+ 1 IN+ 14 #1 OFFSET N1
#1 OFFSET N2 2 13 VCC+
VCC - 4 11 NC
#2 OFFSET N2 5 10 #2 OUT
#2 IN+ 6 9 VCC+
#2 IN- 7 #2 OFFSET N1

Notes: 1 and 13 are internally interconnected

TL084, TL084A, TL084B
J OR N DUAL-IN-LINE PACKAGE
(TOP VIEW)

AMPL #1 OUT 1 OUT 14 AMPL
IN+ 12 IN+ 13 IN- #4
IN- 11 VCC-
VCC+ 10 VCC-
#3 IN+ 9 IN+ 8 IN- #3
IN- 7 OUT 6 OUT

TL083M . . . FH OR FK
CHIP CARRIER PACKAGE
(TOP VIEW)

#1 OFFSET N1 
IN+ 1 NC 1 NC
VCC+ 2 NC 2 NC
#1 OFFSET N2 
NC 3 VCC+ 3 VCC+
#2 OFFSET N1 
#2 OFFSET N1 4 5 6 7 8
IN+ 13 NC 13 NC
VCC+ 12 NC 12 NC
#2 OFFSET N2 
NC 9 10 11 12 13
VCC+ 8 7 6 5 4
VCC+ 4 5 6 7 8
VCC+ 3 2 1 0 1

Symbols

TL085
N DUAL-IN-LINE PACKAGE
(TOP VIEW)

AMPL #1 IN+ 1 IN+ 14 AMPL
IN+ 2 13 IN+ #4
IN- 3 12 OUT
OUT 4 11 VCC+
VCC+ 5 10 OUT
VCC+ 6 9 IN+ #3
IN- 7 8 IN- #3
IN- 8 7 6 5 4
VCC+ 3 2 1 0 1
NC—No internal connection

TL081
TL083 (each amplifier)

TL082 (each amplifier)

TL084 (each amplifier)

TL085 (each amplifier)

Texas Instruments

Port office Box 229012 * Dallas, Texas 75266
TYPES TL080 THRU TL085, TL080A THRU TL084A
TL081B, TL082B, TL084B
JFET-INPUT OPERATIONAL AMPLIFIERS

The TL08_ JFET-input operational amplifier family is designed to offer a wider selection than any previously developed operational amplifier family. Each of these JFET-input operational amplifiers incorporates well-matched, high-voltage JFET and bipolar transistors in a monolithic integrated circuit. The devices feature high slew rates, low input bias and offset currents, and low offset voltage temperature coefficient. Offset adjustment and external compensation options are available within the TL08_ family.

Device types with an "M" suffix are characterized for operation over the full military temperature range of -55°C to 125°C, those with an "I" suffix are characterized for operation from -25°C to 85°C, and those with a "C" suffix are characterized for operation from 0°C to 70°C.

**Schematic (each amplifier)**

**Absolute maximum ratings over operating free-air temperature range (unless otherwise noted)**

<table>
<thead>
<tr>
<th></th>
<th>TL08_ M</th>
<th>TL08_ I</th>
<th>TL08_ C AC</th>
<th>TL08_ BC AC</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply voltage, VCC_+</td>
<td>18 V</td>
<td>18 V</td>
<td>18 V</td>
<td>18 V</td>
<td>V</td>
</tr>
<tr>
<td>Supply voltage, VCC_-</td>
<td>-18 V</td>
<td>-18 V</td>
<td>-18 V</td>
<td>-18 V</td>
<td>V</td>
</tr>
<tr>
<td>Differential input voltage (see Note 1)</td>
<td>±30 V</td>
<td>±30 V</td>
<td>±30 V</td>
<td>±30 V</td>
<td>V</td>
</tr>
<tr>
<td>Input voltage (see Notes 1 and 2)</td>
<td>±15 V</td>
<td>±15 V</td>
<td>±15 V</td>
<td>±15 V</td>
<td>V</td>
</tr>
<tr>
<td>Duration of output short circuit (see Note 4)</td>
<td>unlimited</td>
<td>unlimited</td>
<td>unlimited</td>
<td>unlimited</td>
<td></td>
</tr>
<tr>
<td>Continuous total dissipation at or below 25°C free-air temperature (see Note 5)</td>
<td>680 mW</td>
<td>680 mW</td>
<td>680 mW</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating free-air temperature range</td>
<td>-55 to 125°C</td>
<td>-25 to 85°C</td>
<td>0 to 70°C</td>
<td></td>
<td>°C</td>
</tr>
<tr>
<td>Storage temperature range</td>
<td>-65 to 150°C</td>
<td>-65 to 150°C</td>
<td>-65 to 150°C</td>
<td></td>
<td>°C</td>
</tr>
<tr>
<td>Lead temperature 1.6 mm (1/16 inch) from case for 60 seconds</td>
<td>FH, FK, J, JG, or W package</td>
<td>300°C</td>
<td>300°C</td>
<td>300°C</td>
<td>°C</td>
</tr>
<tr>
<td>Lead temperature 1.8 mm (1/16 inch) from case for 10 seconds</td>
<td>N or P package</td>
<td>260°C</td>
<td>260°C</td>
<td></td>
<td>°C</td>
</tr>
</tbody>
</table>

**Notes:**
1. All voltage values, except differential voltages, are with respect to the midpoint between VCC_+ and VCC_-
2. Differential voltages are at the noninverting input terminal with respect to the inverting input terminal.
3. The magnitude of the input voltage must never exceed the magnitude of the supply voltages or 15 volts, 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.
5. For operation above 25°C free-air temperature, refer to Dissipation Derating Curves in Section 2. In the J and JG packages, TL08_ M chips are alloy-mounted, TL08_ I, TL08_ C AC, and TL08_ BC AC chips are glass-mounted.

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POST OFFICE BOX 25088 DALLAS, TEXAS 75222

3-137
## TYPES TL080M, TL081M, TL082M, TL083M, TL084M
### LOW-NOISE JFET-INPUT OPERATIONAL AMPLIFIERS

**electrical characteristics, VCC = ±15 V (unless otherwise noted)**

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>TEST CONDITIONS</th>
<th>TL080M, TL081M</th>
<th>TL082M, TL083M</th>
<th>TL084M</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MIN</td>
<td>TYP</td>
<td>MAX</td>
<td>MIN</td>
<td>TYP</td>
</tr>
<tr>
<td><strong>VDD</strong></td>
<td>VCC = 0, Rg = 50 Ω</td>
<td>TA = 25°C</td>
<td>3</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td><strong>VNO</strong></td>
<td>VCC = 0, Rg = 50 Ω</td>
<td>TA = -55°C to 125°C</td>
<td>9</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td><strong>IIO</strong></td>
<td>VCC = 0</td>
<td>TA = 25°C</td>
<td>5</td>
<td>100</td>
<td>5</td>
</tr>
<tr>
<td><strong>IB</strong></td>
<td>VCC = 0</td>
<td>TA = 25°C</td>
<td>30</td>
<td>200</td>
<td>30</td>
</tr>
<tr>
<td><strong>VCRO</strong></td>
<td>VCC = 0</td>
<td>TA = -55°C to 125°C</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td><strong>CM</strong></td>
<td>VCC = 0</td>
<td>TA = 25°C</td>
<td>±11</td>
<td>±12</td>
<td>±11</td>
</tr>
<tr>
<td><strong>CMR</strong></td>
<td>VCC = 0</td>
<td>TA = 25°C</td>
<td>±12</td>
<td>±13.6</td>
<td>±12</td>
</tr>
<tr>
<td><strong>ADV</strong></td>
<td>VCC = ±10 V, RL ≥ 2 kΩ</td>
<td>TA = 25°C</td>
<td>25</td>
<td>200</td>
<td>25</td>
</tr>
<tr>
<td><strong>ADC</strong></td>
<td>VCC = ±10 V, RL ≥ 2 kΩ</td>
<td>TA = -55°C to 125°C</td>
<td>15</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td><strong>R1</strong></td>
<td>TA = 25°C</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>MHz</td>
</tr>
<tr>
<td><strong>C</strong></td>
<td>TA = 25°C</td>
<td>10Ω</td>
<td>10Ω</td>
<td>10Ω</td>
<td>10Ω</td>
</tr>
<tr>
<td><strong>CMRR</strong></td>
<td>VCC = VCR min, VCC = 0</td>
<td>TA = 25°C</td>
<td>80</td>
<td>86</td>
<td>80</td>
</tr>
<tr>
<td><strong>VBR</strong></td>
<td>VCC = ±15 V to ±9 V, VCC = 0</td>
<td>TA = 25°C</td>
<td>80</td>
<td>86</td>
<td>80</td>
</tr>
<tr>
<td><strong>ICC</strong></td>
<td>No load, VCC = 0</td>
<td>TA = 25°C</td>
<td>1.4</td>
<td>2.8</td>
<td>1.4</td>
</tr>
</tbody>
</table>

*All characteristics are measured under open-loop conditions with zero common-mode input voltage unless otherwise specified.

Input bias currents of a JFET-input operational amplifier are normal junction reverse currents, which are temperature sensitive as shown in Figure 18. Pulse techniques must be used that will maintain the junction temperatures as close to the ambient temperature as is possible.
### Electrical Characteristics

**VCC ± = ±15 V (unless otherwise noted)**

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>TEST CONDITIONS</th>
<th>TLO609</th>
<th>TLO610C</th>
<th>TLO610C</th>
<th>TLO610C</th>
<th>TLO610C</th>
<th>TLO610C</th>
<th>TLO610C</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>V_{DD}</strong> Input offset voltage</td>
<td>V_{DD} = 0.15 V</td>
<td>0.05 V</td>
<td>0.05 V</td>
<td>0.05 V</td>
<td>0.05 V</td>
<td>0.05 V</td>
<td>0.05 V</td>
<td>0.05 V</td>
<td>mV</td>
</tr>
<tr>
<td><strong>R_{G}</strong> - 50 Ω</td>
<td>R_{G} = 50 Ω</td>
<td>20 Ω</td>
<td>20 Ω</td>
<td>20 Ω</td>
<td>20 Ω</td>
<td>20 Ω</td>
<td>20 Ω</td>
<td>20 Ω</td>
<td></td>
</tr>
<tr>
<td><strong>T_{A}</strong> - full range</td>
<td>T_{A} = 25°C</td>
<td>3.0 mV</td>
<td>3.0 mV</td>
<td>3.0 mV</td>
<td>3.0 mV</td>
<td>3.0 mV</td>
<td>3.0 mV</td>
<td>3.0 mV</td>
<td></td>
</tr>
<tr>
<td><strong>T_{A} &lt; 0°C</strong></td>
<td>T_{A} = full range</td>
<td>3.0 mV</td>
<td>3.0 mV</td>
<td>3.0 mV</td>
<td>3.0 mV</td>
<td>3.0 mV</td>
<td>3.0 mV</td>
<td>3.0 mV</td>
<td></td>
</tr>
<tr>
<td><strong>T_{A} &gt; 0°C</strong></td>
<td>T_{A} = full range</td>
<td>3.0 mV</td>
<td>3.0 mV</td>
<td>3.0 mV</td>
<td>3.0 mV</td>
<td>3.0 mV</td>
<td>3.0 mV</td>
<td>3.0 mV</td>
<td></td>
</tr>
<tr>
<td><strong>I_{D}</strong> Input offset current</td>
<td>V_{DD} = 0.15 V</td>
<td>0.025 mA</td>
<td>0.025 mA</td>
<td>0.025 mA</td>
<td>0.025 mA</td>
<td>0.025 mA</td>
<td>0.025 mA</td>
<td>0.025 mA</td>
<td>mA</td>
</tr>
<tr>
<td><strong>R_{G}</strong> - 50 Ω</td>
<td>R_{G} = 50 Ω</td>
<td>2.5 mA</td>
<td>2.5 mA</td>
<td>2.5 mA</td>
<td>2.5 mA</td>
<td>2.5 mA</td>
<td>2.5 mA</td>
<td>2.5 mA</td>
<td></td>
</tr>
<tr>
<td><strong>T_{A}</strong> - full range</td>
<td>T_{A} = 25°C</td>
<td>2.5 mA</td>
<td>2.5 mA</td>
<td>2.5 mA</td>
<td>2.5 mA</td>
<td>2.5 mA</td>
<td>2.5 mA</td>
<td>2.5 mA</td>
<td></td>
</tr>
<tr>
<td><strong>T_{A} &lt; 0°C</strong></td>
<td>T_{A} = full range</td>
<td>2.5 mA</td>
<td>2.5 mA</td>
<td>2.5 mA</td>
<td>2.5 mA</td>
<td>2.5 mA</td>
<td>2.5 mA</td>
<td>2.5 mA</td>
<td></td>
</tr>
<tr>
<td><strong>T_{A} &gt; 0°C</strong></td>
<td>T_{A} = full range</td>
<td>2.5 mA</td>
<td>2.5 mA</td>
<td>2.5 mA</td>
<td>2.5 mA</td>
<td>2.5 mA</td>
<td>2.5 mA</td>
<td>2.5 mA</td>
<td></td>
</tr>
<tr>
<td><strong>I_{L}</strong> Input bias current</td>
<td>V_{DD} = 0.15 V</td>
<td>0.025 mA</td>
<td>0.025 mA</td>
<td>0.025 mA</td>
<td>0.025 mA</td>
<td>0.025 mA</td>
<td>0.025 mA</td>
<td>0.025 mA</td>
<td>mA</td>
</tr>
<tr>
<td><strong>R_{G}</strong> - 50 Ω</td>
<td>R_{G} = 50 Ω</td>
<td>2.5 mA</td>
<td>2.5 mA</td>
<td>2.5 mA</td>
<td>2.5 mA</td>
<td>2.5 mA</td>
<td>2.5 mA</td>
<td>2.5 mA</td>
<td></td>
</tr>
<tr>
<td><strong>T_{A}</strong> - full range</td>
<td>T_{A} = 25°C</td>
<td>2.5 mA</td>
<td>2.5 mA</td>
<td>2.5 mA</td>
<td>2.5 mA</td>
<td>2.5 mA</td>
<td>2.5 mA</td>
<td>2.5 mA</td>
<td></td>
</tr>
<tr>
<td><strong>T_{A} &lt; 0°C</strong></td>
<td>T_{A} = full range</td>
<td>2.5 mA</td>
<td>2.5 mA</td>
<td>2.5 mA</td>
<td>2.5 mA</td>
<td>2.5 mA</td>
<td>2.5 mA</td>
<td>2.5 mA</td>
<td></td>
</tr>
<tr>
<td><strong>T_{A} &gt; 0°C</strong></td>
<td>T_{A} = full range</td>
<td>2.5 mA</td>
<td>2.5 mA</td>
<td>2.5 mA</td>
<td>2.5 mA</td>
<td>2.5 mA</td>
<td>2.5 mA</td>
<td>2.5 mA</td>
<td></td>
</tr>
</tbody>
</table>

1 All characteristics are measured under open-loop conditions with zero common-mode input voltage unless otherwise specified. For range for T_{A} = 25°C to 65°C for TL0611C, and 0°C to 70°C for TL0612C, TL061C, and TL062C.

2 Input bias currents of a FET-input operational amplifier are normal junction reverse currents, which are temperature sensitive as shown in Figure 1B. Pulse techniques must be used to ensure that the junction temperatures are close to the ambient temperature as is possible.
TYPES TL080 THRU TL085, TL080A THRU TL084A
TL081B, TL082B, TL084B
JFET-INPUT OPERATIONAL AMPLIFIERS

Operating characteristics, $V_{CC} = \pm 15 \text{ V}$, $T_A = 25^\circ \text{C}$

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>TEST CONDITIONS</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>SR</td>
<td>$V_i = 10 \text{ V}$, $R_L = 2 \text{ k}\Omega$</td>
<td>8</td>
<td>13</td>
<td></td>
<td>V/µs</td>
</tr>
<tr>
<td></td>
<td>$C_L = 100 \text{ pF}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>See Figure 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$t_r$</td>
<td>$V_i = 20 \text{ mV}$, $R_L = 2 \text{ k}\Omega$</td>
<td>0.1</td>
<td></td>
<td></td>
<td>µs</td>
</tr>
<tr>
<td></td>
<td>$C_L = 100 \text{ pF}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>See Figure 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$V_{no}$</td>
<td>$R_g = 100 \Omega$</td>
<td>18</td>
<td></td>
<td></td>
<td>mV/√Hz</td>
</tr>
<tr>
<td></td>
<td>$f = 1 \text{ kHz}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$i_n$</td>
<td>$R_g = 100 \Omega$</td>
<td>0.01</td>
<td></td>
<td></td>
<td>pA/V</td>
</tr>
<tr>
<td></td>
<td>$f = 1 \text{ kHz}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>THD</td>
<td>$V_{in(max)} = 10 \text{ V}$, $R_L = 1 \text{ k}\Omega$</td>
<td>0.003%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$R_L = 2 \text{ k}\Omega$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$f = 1 \text{ kHz}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

PARAMETER MEASUREMENT INFORMATION

FIGURE 1—UNITY-GAIN AMPLIFIER
FIGURE 2—GAIN-OF-10 INVERTING AMPLIFIER
FIGURE 3—FEED-FORWARD COMPENSATION

INPUT OFFSET VOLTAGE NULL CIRCUITS

FIGURE 4
FIGURE 5

T dismissed
TYPICAL CHARACTERISTICS

**MAXIMUM PEAK OUTPUT VOLTAGE**

**FREQUENCY**

![Graph showing maximum peak output voltage vs. frequency](image)

**FREE AIR TEMPERATURE**

![Graph showing maximum peak output voltage vs. free air temperature](image)

**LOAD RESISTANCE**

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

**SUPPLY VOLTAGE**

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

**LARGE SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION**

**FREQUENCY**

![Graph showing large signal differential voltage amplification vs. frequency](image)

**FREE AIR TEMPERATURE**

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

**PHASE SHIFT (Input signal)**

![Graph showing phase shift vs. frequency](image)

**FREQUENCY WITH FEED-FORWARD COMPENSATION**

![Graph showing frequency with feed-forward compensation](image)

---

**FIGURE 3—FEED-FORWARD COMPENSATION**

**FIGURE 6**

**FIGURE 7**

**FIGURE 8**

**FIGURE 9**

**FIGURE 10**

**FIGURE 11**

**FIGURE 12**

**FIGURE 13**

**FIGURE 14**

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Data at high and low temperatures are applicable only within the rated operating free air temperature ranges of the various devices. A 12-pF compensation capacitor is used with TL080 and TL080A.

---

**Texas Instruments**

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TYPES TL080 THRU TL085, TL080A THRU TL084A
TL081B, TL082B, TL084B
JFET-INPUT OPERATIONAL AMPLIFIERS

TYPICAL CHARACTERISTICS

FIGURE 18
INPUT BIAS CURRENT
FREE-AIR TEMPERATURE

FIGURE 19
VOLTAGE FOLLOWER LARGE-SIGNAL FREQUENCY RESPONSE
FREE-AIR TEMPERATURE

FIGURE 20
TOTAL HARMONIC DISTORTION
FREE-AIR TEMPERATURE

FIGURE 21
COMMON-MODE REJECTION RATIO
FREE-AIR TEMPERATURE

FIGURE 22
EQUIVALENT INPUT NOISE VOLTAGE
FREQUENCY

FIGURE 23
TOTAL HARMONIC DISTORTION
FREQUENCY

\(^1\)Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices. A 12-pF compensation capacitor is used with TL080 and TL080A.
TYPES TL080 THRU TL086, TL080A THRU TL084A  
TL081B, TL082B, TL084B  
JFET-INPUT OPERATIONAL AMPLIFIERS

TYPICAL APPLICATION DATA

FIGURE 24—0.5-Hz SQUARE-WAVE OSCILLATOR

FIGURE 25—HIGH-Q NOTCH FILTER

FIGURE 26—AUDIO DISTRIBUTION AMPLIFIER

FIGURE 27—100-kHz QUADRATURE OSCILLATOR

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

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TYPICAL APPLICATION DATA

OUTPUT A

2 kHz/div
SECOND-ORDER BANDPASS FILTER

f₀ = 100 kHz, Q = 30, GAIN = 4

OUTPUT B

2 kHz/div
CASCADED BANDPASS FILTER

f₀ = 100 kHz, Q = 69, GAIN = 16

FIGURE 28—POSITIVE-FEEDBACK BANDPASS FILTER

FIGURE 29—IC PREAMPLIFIER