

Power Operational Amplifier

FEATURES

- LOW COST
- HIGH VOLTAGE - 100 VOLTS
- HIGH OUTPUT CURRENT- 50 AMP PULSE OUTPUT, 15 AMP CONTINUOUS
- 170 WATT DISSIPATION CAPABILITY
- 130 V/ μ S SLEW RATE
- 500kHz POWER BANDWIDTH

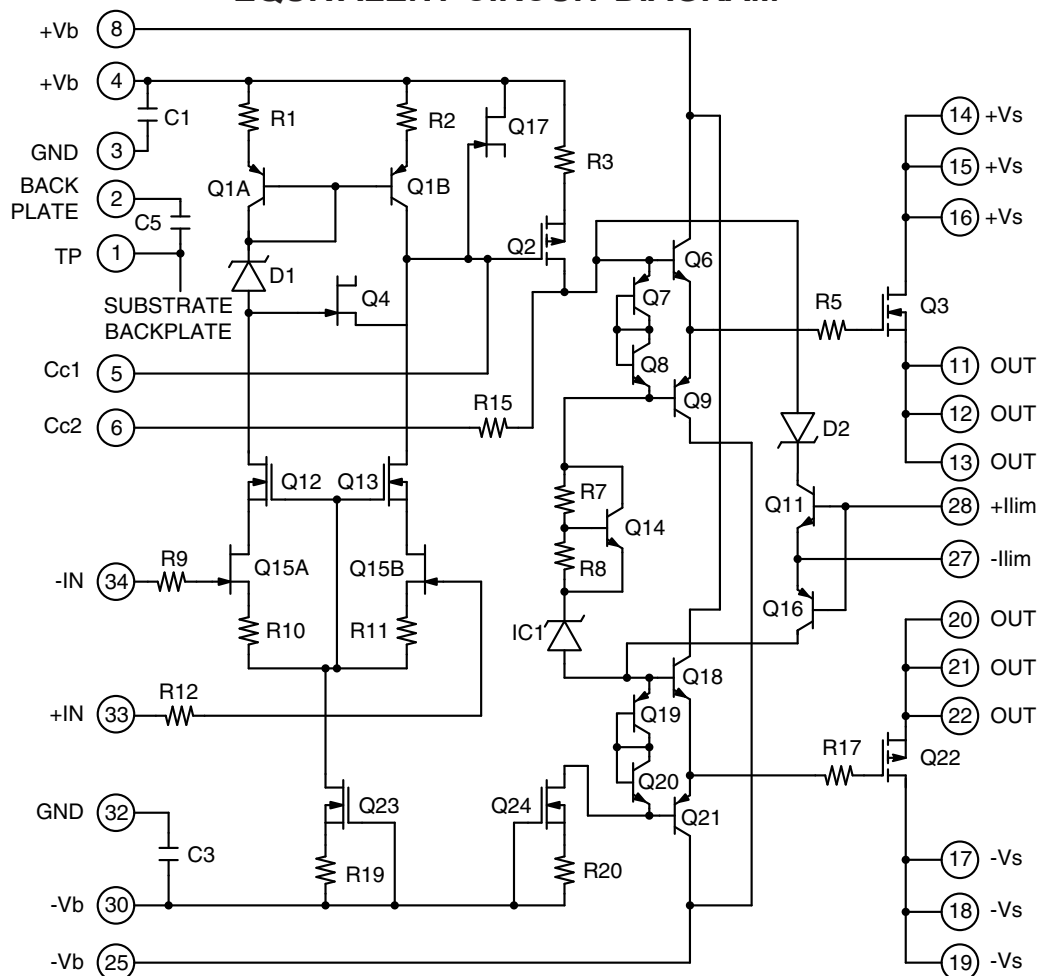
APPLICATIONS

- INKJET PRINTER HEAD DRIVE
- PIEZO TRANSDUCER DRIVE
- INDUSTRIAL INSTRUMENTATION
- REFLECTOMETERS
- ULTRA-SOUND TRANSDUCER DRIVE

DESCRIPTION

The MP111 operational amplifier is a surface mount constructed component that provides a cost-effective solution in many industrial applications. The MP111 offers outstanding performance that rivals much more expensive hybrid components yet has a footprint of only 4 sq in. The MP111 has many optional features such as four-wire current limit sensing and external compensation. The 500 kHz power bandwidth and 15 amp continuous and 50A pulse output of the MP111 makes it a good choice for piezo transducer drive applications. The MP111 is built on a thermally conductive but electrically insulating substrate that can be mounted to a heat sink.

EQUIVALENT CIRCUIT DIAGRAM



ABSOLUTE MAXIMUM RATINGS

| Parameter | Symbol | Min | Max | Units |
|-----------------------------------|--------|-----|------------------|-------|
| SUPPLY VOLTAGE, $+V_S$ to $-V_S$ | | | 100 | V |
| SUPPLY VOLTAGE, $+V_B$ (Note 6) | | | $+V_S$, +15 | V |
| SUPPLY VOLTAGE, $-V_B$ (Note 6) | | | $-V_S$, -15 | V |
| OUTPUT CURRENT, peak, within SOA | | | 50 | A |
| POWER DISSIPATION, internal, DC | | | 170 | W |
| INPUT VOLTAGE | | | $+V_B$ to $-V_B$ | V |
| DIFFERENTIAL INPUT VOLTAGE | | -25 | +25 | V |
| TEMPERATURE, pin solder, 10s | | | 225 | °C |
| TEMPERATURE, junction (Note 2) | | | 175 | °C |
| TEMPERATURE, storage | | -40 | +105 | °C |
| OPERATING TEMPERATURE RANGE, case | | -40 | +85 | °C |

SPECIFICATIONS

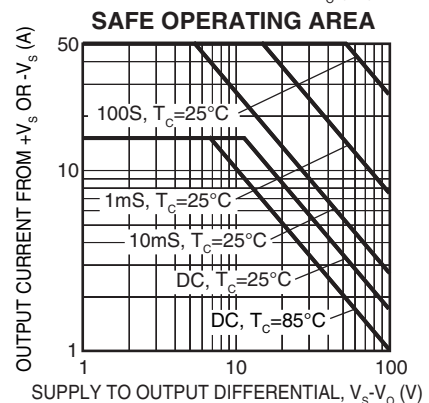
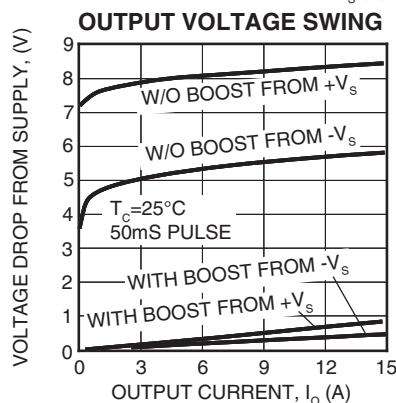
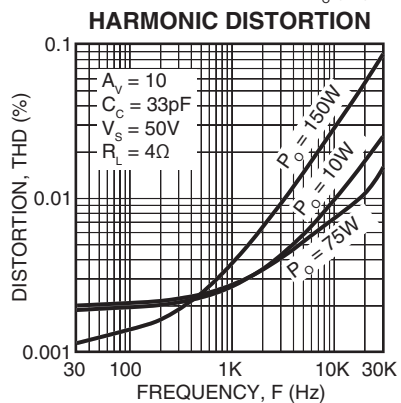
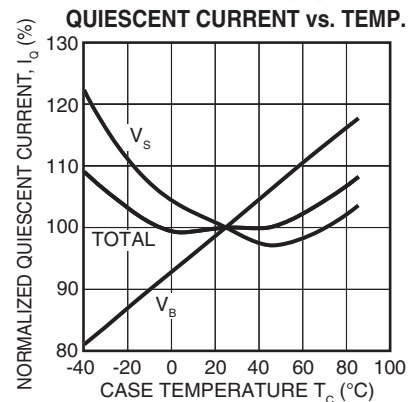
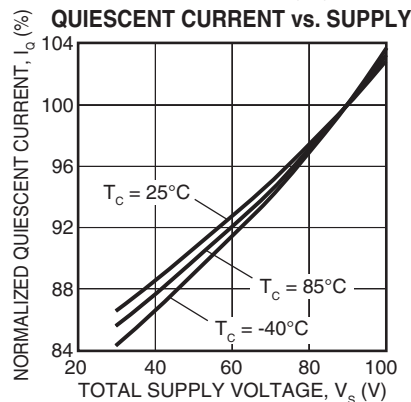
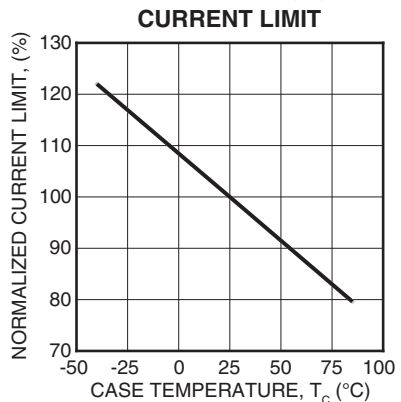
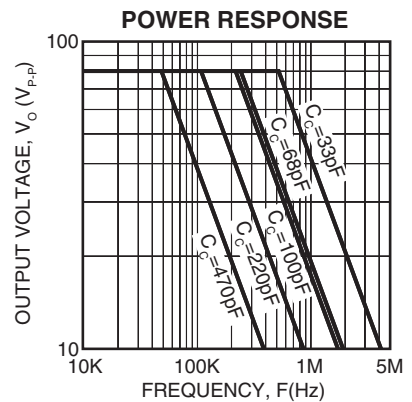
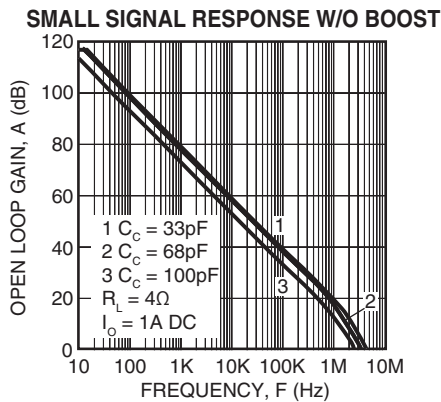
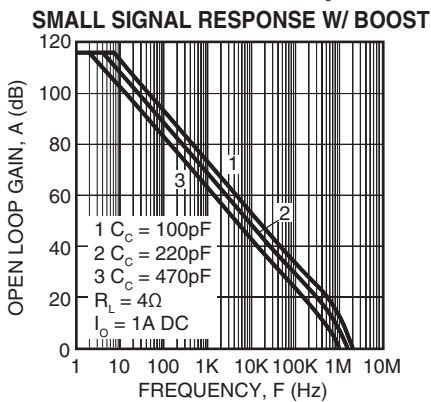
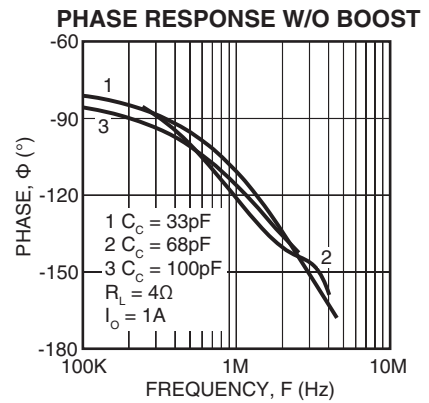
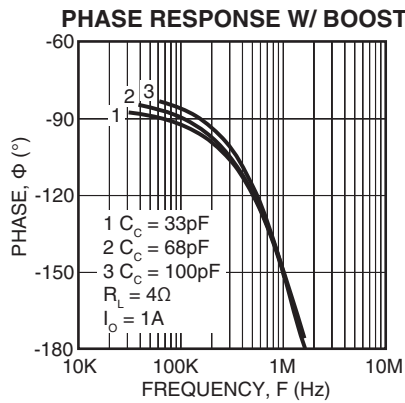
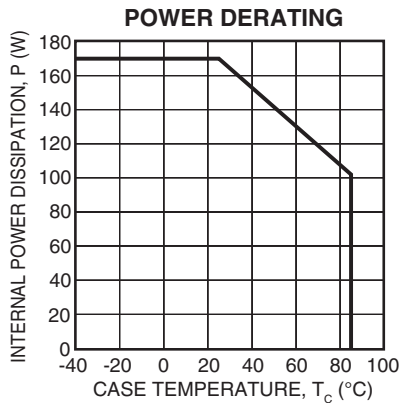
| Parameter | Test Conditions (Note 1) | Min | Typ | Max | Units |
|---------------------------------|--|--------------|--------------|-------------|------------------------------|
| INPUT | | | | | |
| OFFSET VOLTAGE | | | 1 | 5 | mV |
| OFFSET VOLTAGE, vs. temperature | Full temp range | | 50 | | $\mu\text{V}/^\circ\text{C}$ |
| OFFSET VOLTAGE, vs. supply | | | | 20 | $\mu\text{V}/\text{V}$ |
| BIAS CURRENT, initial (Note 3) | | | | 100 | pA |
| BIAS CURRENT, vs. supply | | | | 0.1 | pA/V |
| OFFSET CURRENT, initial | | | | 50 | pA |
| INPUT RESISTANCE, DC | | | 10^{11} | | Ω |
| INPUT CAPACITANCE | | | 4 | | pF |
| COMMON MODE VOLTAGE RANGE | | | | $+V_B - 15$ | V |
| COMMON MODE VOLTAGE RANGE | | | | $-V_B + 15$ | V |
| COMMON MODE REJECTION, DC | | 92 | | | dB |
| NOISE | 1MHz BW, $R_S = 1\text{K}\Omega$ | | 10 | | μV_{RMS} |
| GAIN | | | | | |
| OPEN LOOP, @ 15Hz | $R_L = 10\text{K}\Omega$, $C_C = 33\text{pF}$ | 96 | | | dB |
| GAIN BANDWIDTH PRODUCT @ 1MHz | $C_C = 33\text{pF}$ | | 6 | | MHz |
| PHASE MARGIN | Full temp range | 45 | | | ° |
| OUTPUT | | | | | |
| VOLTAGE SWING | $I_O = 15\text{A}$ | $+V_S - 10$ | $+V_S - 8.4$ | | V |
| VOLTAGE SWING | $I_O = -15\text{A}$ | $-V_S + 10$ | $-V_S + 5.8$ | | V |
| VOLTAGE SWING | $I_O = 15\text{A}$, $+V_B = +V_S + 10\text{V}$ | $+V_S - 0.8$ | | | V |
| VOLTAGE SWING | $I_O = -15\text{A}$, $-V_B = -V_S - 10\text{V}$ | $-V_S + 1.0$ | | | V |

| Parameter | Test Conditions (Note 1) | Min | Typ | Max | Units |
|--|---|----------|----------|----------|----------------------|
| CURRENT, CONTINUOUS, DC | | 15 | | | A |
| SLEW RATE, $A_V = -20$ | $C_C = 33\text{pF}$ | 100 | 130 | | V/ μS |
| SETTLING TIME to 0.1% | 2V step | | 1 | | μS |
| RESISTANCE | No load, DC | | 3 | | Ω |
| POWER BANDWIDTH 180V _{P-P} | $C_C = 33\text{pF}$, $+V_S = 50\text{V}$, $-V_S = -50\text{V}$ | | 500 | | kHz |
| POWER SUPPLY | | | | | |
| VOLTAGE | | ± 15 | ± 45 | ± 50 | V |
| CURRENT, quiescent | | | 142 | 157 | mA |
| THERMAL | | | | | |
| RESISTANCE, AC, junction to case (Note 5) | Full temp range, $F \geq 60\text{Hz}$ | | | 0.65 | $^{\circ}\text{C/W}$ |
| RESISTANCE, DC, junction to case | Full temp range, $F < 60\text{Hz}$ | | | 0.88 | $^{\circ}\text{C/W}$ |
| RESISTANCE, junction to air | Full temp range | | | 13 | $^{\circ}\text{C/W}$ |
| TEMPERATURE RANGE, case | | -40 | | +85 | $^{\circ}\text{C}$ |

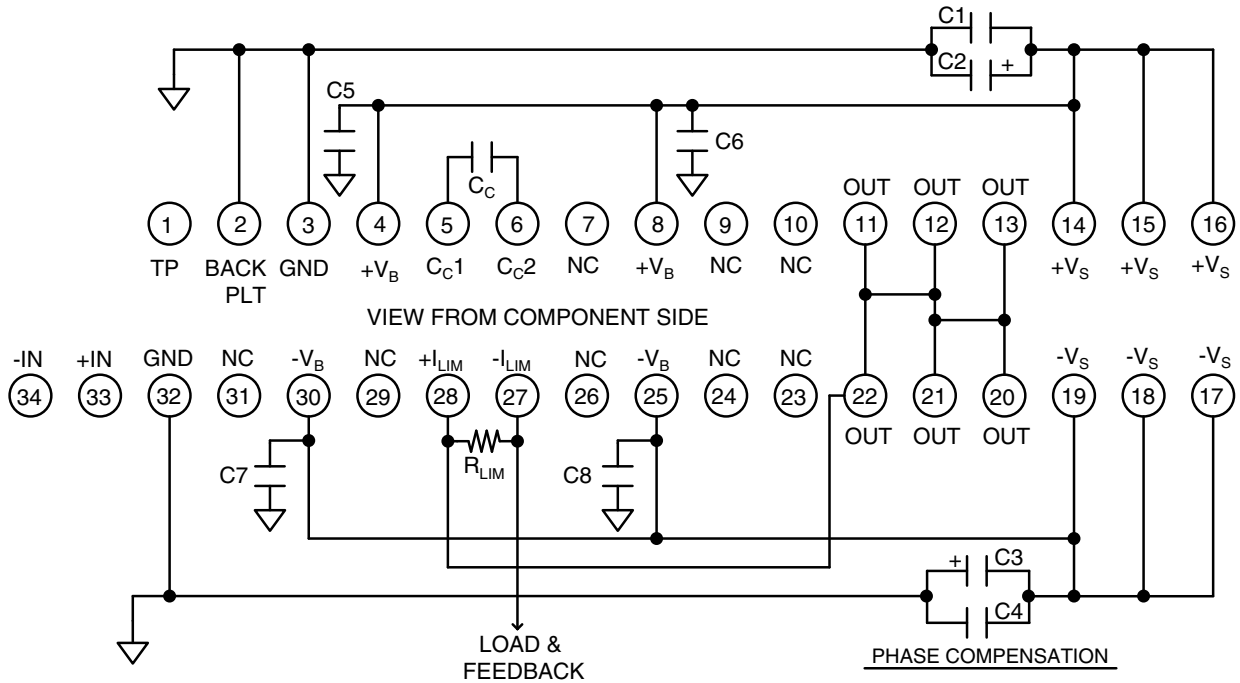
NOTES: * The specification of MP111A is identical to the specification for MP111 in the applicable column to the left.

1. Unless otherwise noted: $T_C = 25^{\circ}\text{C}$, $C_C = 100\text{pF}$. DC input specifications are value given. Power supply voltage is typical rating.
2. Long term operation at the maximum junction temperature will result in reduced product life. Derate internal power dissipation to achieve high MTTF.
3. Doubles for every 10°C of case temperature increase.
4. $+V_S$ and $-V_S$ denote the positive and negative supply voltages to the output stage. $+V_B$ and $-V_B$ denote the positive and negative supply voltages to the input stages.
5. Rating applies if the output current alternates between both output transistors at a rate faster than 60Hz.
6. Power supply voltages $+V_B$ and $-V_B$ must not be less than $+V_S$ and $-V_S$ respectively.

TYPICAL PERFORMANCE GRAPHS



EXTERNAL CONNECTIONS



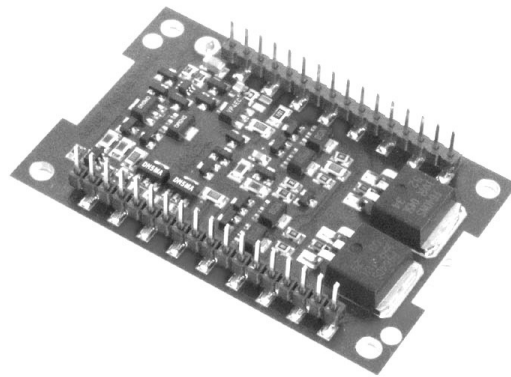
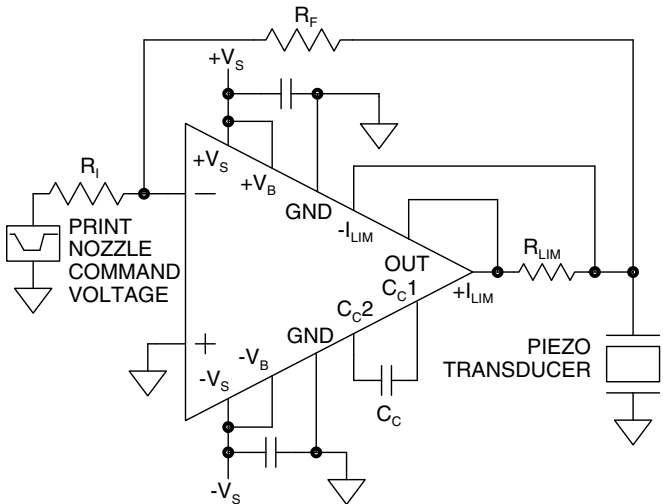
NOTES:
 C_C IS NPO (COG) RATED FOR FULL SUPPLY VOLTAGE $+V_S$ TO $-V_S$.
 BOTH PINS 3 AND 32 REQUIRED CONNECTED TO SIGNAL GROUND.
 C_2 AND C_3 ELECTROLYTIC $\geq 10\mu F$ PER AMP OUTPUT CURRENT.
 C_1, C_4, C_5-8 HIGH QUALITY CERAMIC $\geq 0.1\mu F$.
 ALL OUTPUT PINS MUST BE TIED TOGETHER.
 SEE PACKAGE OUTLINE FD IN THE OUTLINE DIMENSIONS DATASHEET.

| C_C | GAIN W/O BOOST | TYP. SLEW RATE |
|-------|----------------|----------------|
| 100pF | ≥ 1 | 55 V/ μ S |
| 68pF | ≥ 4 | 60 V/ μ S |
| 33pF | ≥ 10 | 130 V/ μ S |

| C_C | GAIN W BOOST | TYP. SLEW RATE |
|-------|--------------|----------------|
| 470pF | ≥ 3 | 12 V/ μ S |
| 220pF | ≥ 6 | 27 V/ μ S |
| 100pF | ≥ 10 | 55 V/ μ S |

**TYPICAL APPLICATION
 INKJET NOZZLE DRIVE**

The MP111's fast slew rate and wide power bandwidth make it an ideal nozzle driver for industrial inkjet printers. The 50 amp pulse output capability can drive hundreds of inkjet nozzles simultaneously.



**34-pin DIP
 PACKAGE STYLE FD**

GENERAL

Please read Application Note 1 "General Operating Considerations" which covers stability, power supplies, heat sinking, mounting, current limit, SOA interpretation, and specification interpretation. Visit www.cirrus.com for design tools that help automate tasks such as calculations for stability, internal power dissipation, current limit, heat sink selection, Apex Microtechnology's complete Application Notes library, Technical Seminar Workbook and Evaluation Kits.

GROUND PINS

The MP111 has two ground pins (pins 3, 32). These pins provide a return for the internal capacitive bypassing of the small signal portions of the MP111. The two ground pins are not connected together on the substrate. Both of these pins are required to be connected to the system signal ground.

SAFE OPERATING AREA

The MOSFET output stage of the MP111 is not limited by second breakdown considerations as in bipolar output stages. Only thermal considerations and current handling capabilities limit the SOA (see Safe Operating Area graph on previous page). The output stage is protected against transient flyback by the parasitic body diodes of the output stage MOSFET structure. However, for protection against sustained high energy flyback external fast-recovery diodes must be used.

COMPENSATION

The external compensation capacitor C_C is connected between pins 5 and 6. Unity gain stability can be achieved with any capacitor value larger than 100pF for a minimum phase margin of 45 degrees. At higher gains more phase shift can usually be tolerated in most designs and the compensation capacitor value can be reduced resulting in higher bandwidth and slew rate. Use the typical operating curves as a guide to select C_C for the application. An NPO (COG) type capacitor is required rated for the full supply voltage (100V).

OVERVOLTAGE PROTECTION

Although the MP111 can withstand differential input voltages up to $\pm 25V$, additional external protection is recommended. In most applications 1N4148 signal diodes connected anti-parallel across the input pins is sufficient. In more demanding applications where bias current is important diode connected JFETs such as 2N4416 will be required. See Q1 and Q2 in Figure 1. In either case the differential input voltage will be clamped to $\pm 0.7V$. This is usually sufficient overdrive to produce the maximum power bandwidth. Some applications will also need over voltage protection devices connected to the power supply rails. Unidirectional zener diode transient suppressors are recommended. The zeners clamp transients to voltages within the power supply rating and also clamp power supply reversals to ground. Whether the zeners are used or not the system power supply should be evaluated for transient performance including power-on overshoot and power-off polarity reversals as well as line regulation. See Z1 and Z2 in Figure 1.

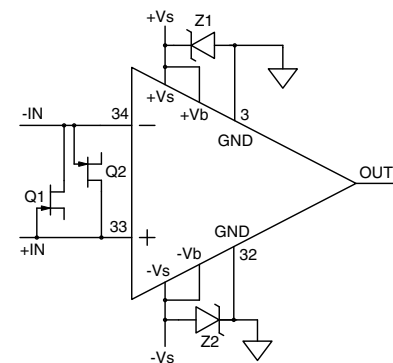


FIGURE 1.
OVERVOLTAGE PROTECTION

POWER SUPPLY BYPASSING

Bypass capacitors to power supply terminals $+V_S$ and $-V_S$ must be connected physically close to the pins to prevent local parasitic oscillation in the output stage of the MP111. Use electrolytic capacitors at least 10 μ F per output amp required. Bypass the electrolytic capacitors with high quality ceramic capacitors (X7R) 0.1 μ F or greater. In most applications power supply terminals $+V_b$ and $-V_b$ will be connected to $+V_S$ and $-V_S$ respectively. Supply voltages $+V_b$ and $-V_b$ are bypassed internally but both ground pins 3 and 32 must be connected to the system signal ground to be effective. In all cases power to the buffer amplifier stage of the MP111 at pins 8 and 25 must be connected to $+V_b$ and $-V_b$ at pins 4 and 30 respectively. Provide local bypass capacitors at pins 8 and 25. See the external connections diagram on page 1.

CURRENT LIMIT

The two current limit sense lines are to be connected directly across the current limit sense resistor. For the current limit to work correctly pin 28 must be connected to the amplifier output side and pin 27 connected to the load side of the current limit resistor R_{LIM} as shown in Figure 2. This connection will bypass any parasitic resistances R_P , formed by socket and solder joints as well as internal amplifier losses. The current limiting resistor may not be placed anywhere in the output circuit except where shown in Figure 2. The value of the current limit resistor can be calculated as follows: $R_{LIM} = .65 / I_{LIMIT}$

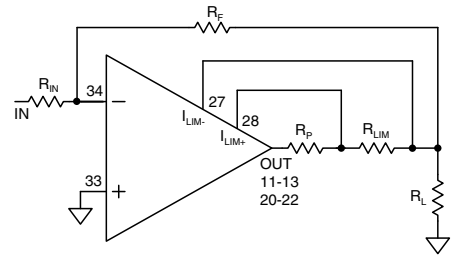


FIGURE 2. 4 WIRE CURRENT LIMIT

BOOST OPERATION

With the boost feature the small signal stages of the amplifier are operated at a higher supply voltages than the amplifier's high current output stage. +V_b (pins 4,8) and -V_b (pins 25,30) are connected to the small signal stages and +V_s (pins 14-16) and -V_s (pins 17-19) are connected to the high current output stage. An additional 10V on the +V_b and -V_b pins is sufficient to allow the small signal stages to drive the output stage into the triode region and improve the output voltage swing for extra efficient operation when required. When the boost feature is not needed +V_s and -V_s are connected to the +V_b and -V_b pins respectively. The +V_b and -V_b pins must not be operated at supply voltages less than +V_s and -V_s respectively.

BACKPLATE GROUNDING

The substrate of the MP111 is an insulated metal substrate. It is required that it be connected to signal ground. Connect pin 2 (back plate) to signal ground. The back plate will then be AC grounded to signal ground through a 1μF capacitor.

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