

# Power Operational Amplifier

## FEATURES

- HIGH VOLTAGE - 200 VOLTS
- HIGH OUTPUT CURRENT (10A continuous)
- 100 WATT DISSIPATION CAPABILITY
- 140 kHz POWER BANDWIDTH
- TEMPERATURE MONITOR
- INTEGRATED SHUT-DOWN

## APPLICATIONS

- INK JET PRINTER HEAD DRIVE
- PIEZO TRANSDUCER DRIVE
- INDUSTRIAL INSTRUMENTATION
- REFLECTOMETERS
- ULTRA-SOUND TRANSDUCER DRIVE

## DESCRIPTION

The MP118 is a SMT operational amplifier that provides a cost effective solution in many industrial applications. The MP118 offers outstanding performance that rivals much more expensive hybrid components, but yet has a footprint of only  $\approx 26\text{cm}^2$  ( $4\text{ in}^2$ ). The 140 kHz power bandwidth and 10A output of the MP118 makes it a good choice for piezo transducer drive applications. The MP118 is built on a thermally conductive but electrically insulating substrate that can be mounted to a heat sink.

MP118 is based on the MP108 design, but offers lower quiescent current consumption and new features for enhanced system protection. The newly introduced over-current protection and temperature monitoring circuitry will shut-down the system before any permanent damage occurs.

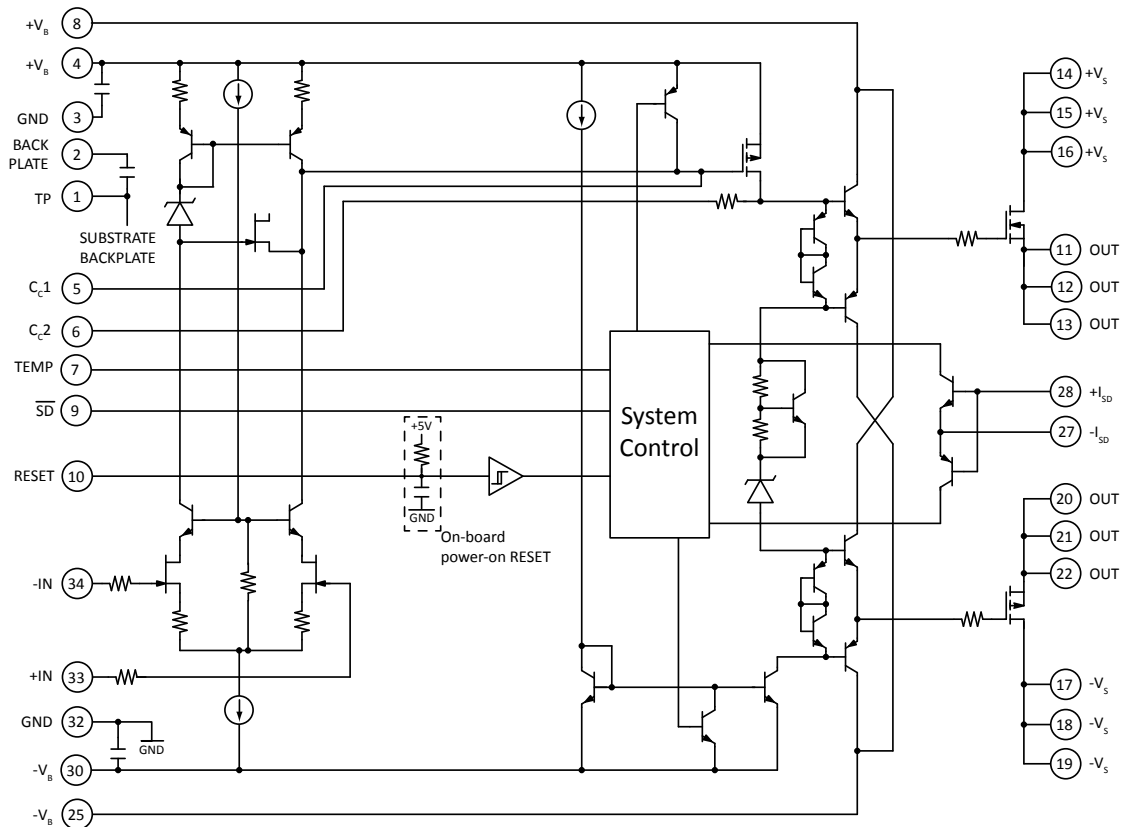


Figure 1: Equivalent Circuit Diagram (for Illustration Purposes Only – Not Accurate Representation)

## ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Min	Max	Units
SUPPLY VOLTAGE, +V <sub>S</sub> to -V <sub>S</sub>			200	V
SUPPLY VOLTAGE, +V <sub>B</sub> (Note 4, 6)			+V <sub>S</sub> +15	V
SUPPLY VOLTAGE, -V <sub>B</sub> (Note 4, 6)			-V <sub>S</sub> -15	V
OUTPUT CURRENT, peak, within SOA			12	A
POWER DISSIPATION, internal, DC			100	W
INPUT VOLTAGE			+V <sub>B</sub> to -V <sub>B</sub>	V
TEMPERATURE, pin solder, 10s			225	°C
TEMPERATURE, junction (Note 2)			150	°C
TEMPERATURE, storage		-40	+105	°C
OPERATING TEMPERATURE RANGE, case		-40	+100	°C
$\overline{SD}$ , RESET Signal		-0.3	5.5	V

## SPECIFICATIONS

### INPUT

Parameter	Test Conditions (Note 1)	MP118			MP118A			Units
		Min	Typ	Max	Min	Typ	Max	
OFFSET VOLTAGE	Full temp range		1	5		*	3	mV
OFFSET VOLTAGE, vs. temperature			50			*		μV/°C
OFFSET VOLTAGE, vs. supply				20			*	μV/V
BIAS CURRENT, initial (Note 3)				100			70	pA
BIAS CURRENT, vs. supply				0.1			*	pA/V
OFFSET CURRENT, initial				50			30	pA
INPUT RESISTANCE, DC			10 <sup>11</sup>			*		Ω
INPUT CAPACITANCE			4			*		pF
COMMON MODE VOLTAGE RANGE				+V <sub>B</sub> -15			*	V
COMMON MODE VOLTAGE RANGE				-V <sub>B</sub> +15			*	V
COMMON MODE REJECTION, DC		92			*			dB
NOISE	20 kHz BW, R <sub>s</sub> = 1kΩ		2			*		μV RMS

### GAIN

Parameter	Test Conditions (Note 1)	MP118			MP118A			Units
		Min	Typ	Max	Min	Typ	Max	
OPEN LOOP, 15 Hz	R <sub>L</sub> = 10kΩ C <sub>C</sub> = 10pF	96	120		*	*		dB
GAIN BANDWIDTH PRODUCT @ 1 MHz	C <sub>C</sub> = 10pF		56			*		MHz
PHASE MARGIN	FULL temp range, C <sub>C</sub> = 150pF	45	60		*	*		degrees

### POWER SUPPLY

Parameter	Test Conditions (Note 1)	MP118			MP118A			Units
		Min	Typ	Max	Min	Typ	Max	
VOLTAGE		±15	±75	±100	*	*	*	V
CURRENT, quiescent			25	30		*	27	mA

OUTPUT		MP118			MP118A			Units
Parameter	Test Conditions (Note 1)	Min	Typ	Max	Min	Typ	Max	
VOLTAGE SWING	$I_O = 10A$	$+V_S - 10$	$+V_S - 8.6$		*	*		V
VOLTAGE SWING	$I_O = -10A$	$-V_S + 10$	$-V_S + 7$		*	*		V
VOLTAGE SWING	$I_O = 10A, +V_B = +V_S + 10V$	$+V_S - 1.6$			*			V
VOLTAGE SWING	$I_O = -10A, -V_B = -V_S - 10V$	$-V_S + 5.1$			*			V
CURRENT, CONTINUOUS, DC		10			11			A
SLEW RATE, $\Delta V = -20$	$C_C = 10pF$	65			*			V/ $\mu s$
SETTLING TIME to 0.1%	2V step		0.55			*		$\mu s$
RESISTANCE	No load, DC		5			*		$\Omega$
POWER BANDWIDTH 180VP-P	$C_C = 10pF, +V_S = 100V, -V_S = -100V$		140			*		kHz

THERMAL		MP118/MP118A			
Parameter	Test Conditions (Note 1)	Min	Typ	Max	Units
RESISTANCE, AC, junction to case (Note 5)	Full temp range, $F \geq 60$ Hz			1	$^{\circ}C/W$
RESISTANCE, DC, junction to case	Full temp range, $F < 60$ Hz			1.25	$^{\circ}C/W$
RESISTANCE, junction to air	Full temp range			13	$^{\circ}C/W$
TEMPERATURE RANGE, case		-40		+85	$^{\circ}C$

TEMPERATURE SENSOR		MP118/MP118A			
Parameter	Test Conditions (Note 1)	Min	Typ	Max	Units
Temp Sensor Output Voltage, $V_{TEMP}$	$T_C = 25^{\circ}C$		2.298		V
Temp Sensor Gain			-13.6		mV/ $^{\circ}C$
Temperature Accuracy	$T_C = -40^{\circ}C$ to $+85^{\circ}C$			$\pm 2.2$	$^{\circ}C$

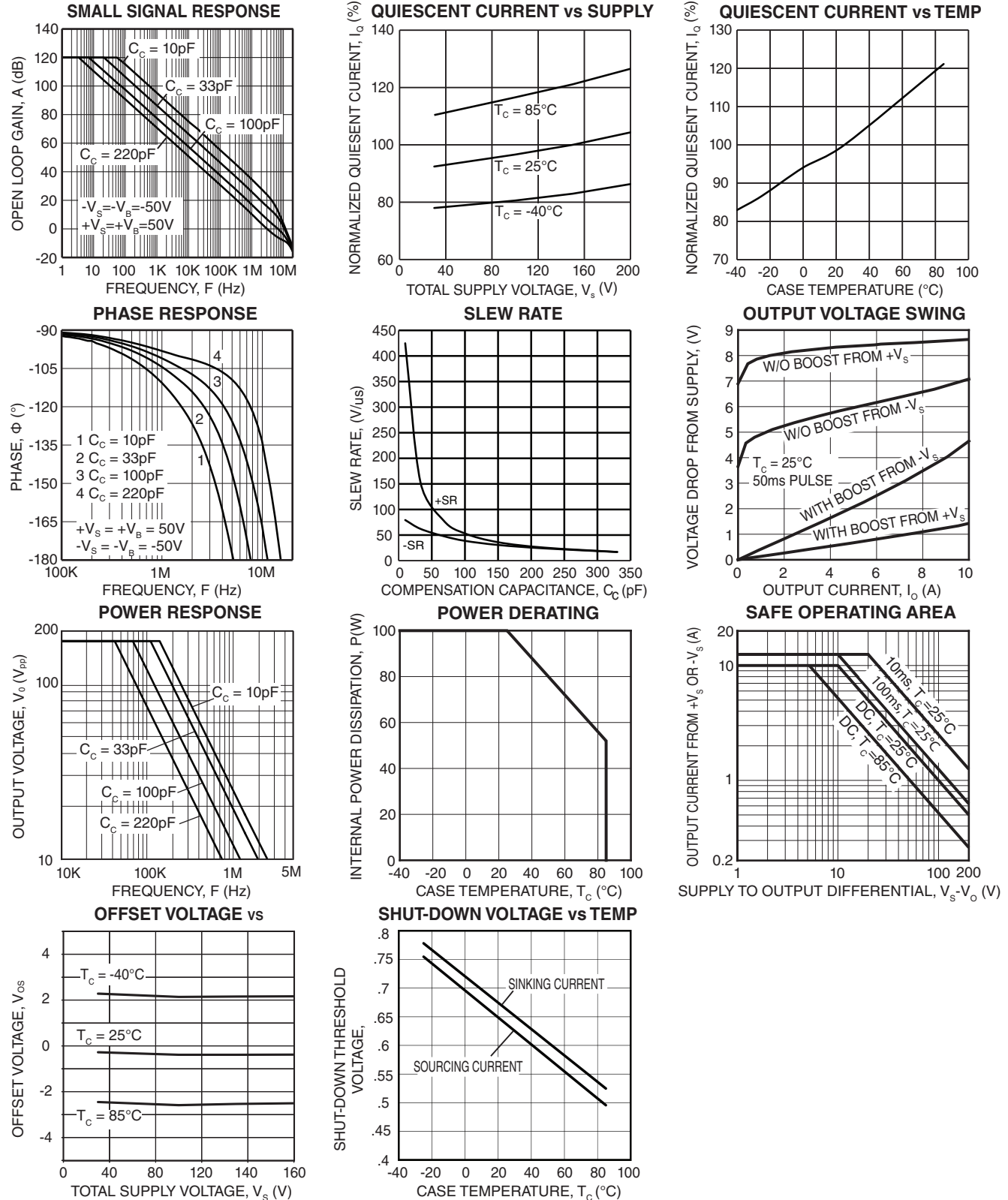
SYSTEM PROTECTION		MP118/MP118A			
Parameter	Test Conditions (Note 1)	Min	Typ	Max	Units
Thermal System Shut-down, $T_{SD}$			100		$^{\circ}C$
Thermal Shut-down Hysteresis			8		$^{\circ}C$
Shut-down voltage ( $+I_{SD}$ to $-I_{SD}$ )			$\pm 0.65V$		V
$\overline{SD}$ Active Level (Note 8)		0		0.2	V
$\overline{SD}$ Active Minimum Pulse width		1			$\mu s$
RESET High Level (Note 7)		4.5		5.5	V
RESET Low Level (Note 7)		0		0.2	V

**NOTES:**

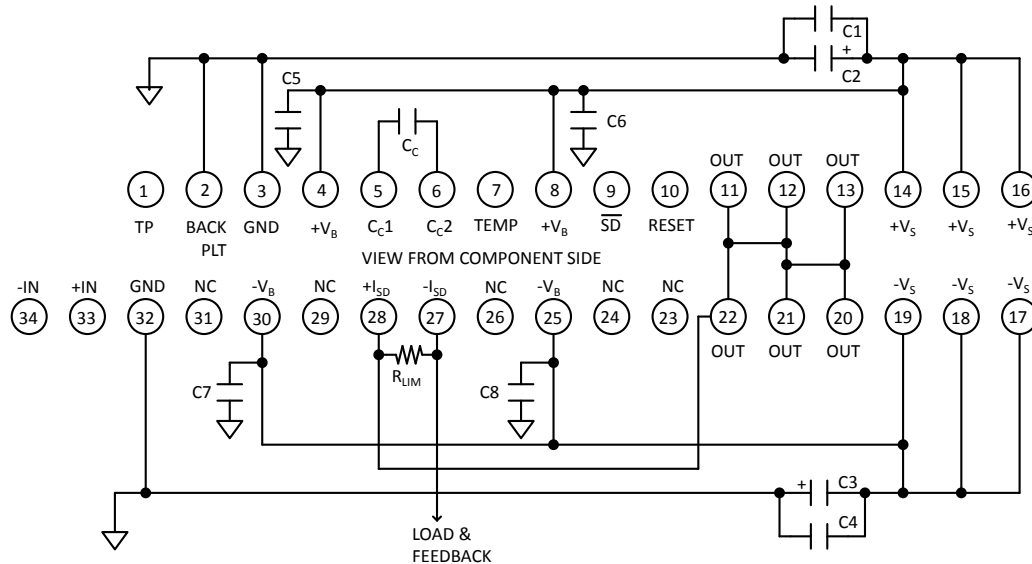
- \* The specification of MP118A is identical to the specification for the MP118 in the applicable column to the left
- 1. Unless otherwise noted:  $T_C = 25^{\circ}C$ ,  $C_C = 100pF$ . DC input specifications are value given. Power supply voltage is typical rating.
- 2. Long term operation at the maximum junction temperature will result in reduced product life. Derate internal power dissipation to achieve high MTTF.
- 3. Doubles for every  $10^{\circ}C$  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.
- 7. The RESET signal is edge sensitive. A transition from low to high level triggers the MP118 shut-down function.
- 8. The  $\overline{SD}$  signal needs to be an "open drain" signal, meaning that it is "high impedance" when not active low.

**TYPICAL PERFORMANCE GRAPHS**

**Figure 2: Typical Performance Graphs**



**Figure 3: External Connections**



**NOTES:**

1.  $C_C$  has to be NPO (COG) rated for full supply voltage  $+V_S$  to  $-V_S$ . Typical values are provided in the section "COMPENSATION"
2. Both pins 3 and 32 have to be connected to signal ground.
3. C2 and C3 are electrolytic capacitors with  $10\mu F$  per amp output current.
4. C1, C4, C5-C8 need to be high quality ceramic 100nF capacitors.
5. All OUT pins (pins 11-13 and 20-22) need to be tied together.

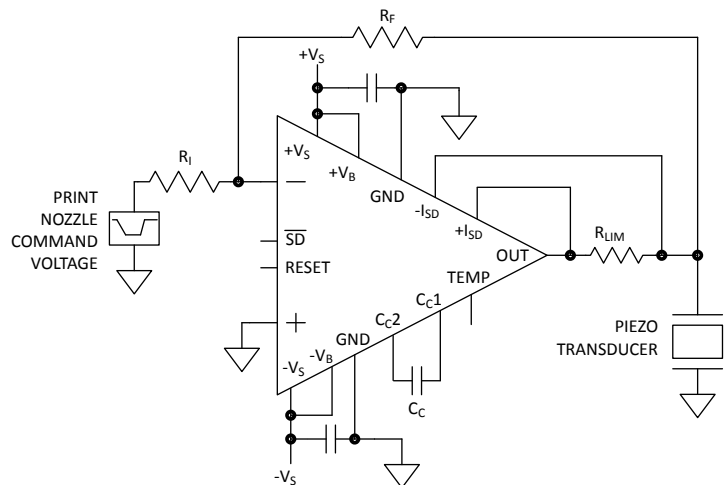
**TYPICAL APPLICATION**

The MP118's fast slew rate and wide power bandwidth make it an ideal nozzle driver for industrial inkjet printers. The 10A output capability can drive hundreds of nozzles simultaneously.

Figure 4 shows a high level outline of MP118 in a typical piezo transducer drive application.

**GENERAL**

Please read Application Note 1 "General Operating Considerations" which covers stability, power supplies, heat sinking, mounting, current limit, SOA interpretation. Visit [www.apexanalog.com](http://www.apexanalog.com) for Apex Microtechnology, Inc's complete Application Notes library, Technical Seminar Workbook and Evaluation Kits.



**Figure 4: Typical Application**

**GROUND PINS**

The MP118 has two ground pins (pins 3, 32). These pins provide a return for the internal capacitive bypassing of the small signal portions of the MP118. 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 MP118 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 page 4). 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 a capacitor value of at least 150pF 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 (200V).

Gain	$C_C$
1	150pF
2	68pF
5	33pF
20	10pF

**OVERVOLTAGE PROTECTION**

Although the MP118 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 (Q1 and Q2 in Figure 5). 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 (Z1 and Z2 in Figure 5). The zener diodes clamp transients to voltages within the power supply rating and also clamp power supply reversals to ground. Whether zener diodes 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.

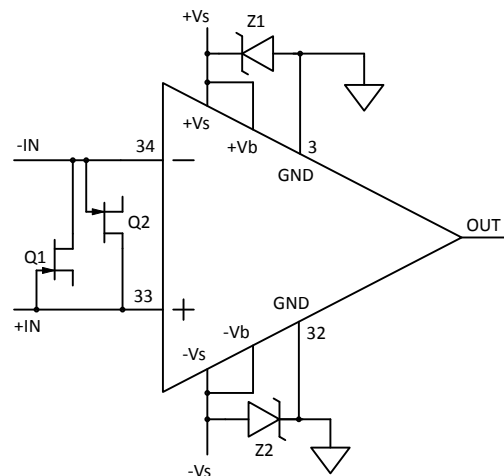
**POWER SUPPLY BYPASSING**

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 MP118. Use electrolytic capacitors at least 10 $\mu$ F per output amp required. Bypass the electrolytic capacitors with high quality ceramic capacitors (X7R) 0.1 $\mu$ 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 MP118 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 5 (Figure 3).

**TEMPERATURE SENSING CIRCUIT**

A temperature sensor provides pin 7 a voltage that is proportional to the case temperature. The temperature sense pin can source/sink  $\pm 50\mu A$ .

**Figure 5: Overvoltage Protection**



## INTEGRATED SHUT-DOWN FEATURE

MP118 includes a latching shut-down circuit that allows turning off the output stage by any of the following conditions:

1. MP118 detects an over-temperature condition (see section “Temperature Protection”)
2. MP118 detects an over-current condition (see section “Over-Current Shut-Down Protection”)
3. The external shut-down pin 9 ( $\overline{SD}$ ) is active low.

The latching shut-down can be reset by applying a RESET pulse (raising edge) on the RESET pin 10.

**Note:** If the RESET pulse is applied while one the shut-down conditions still exists (over-temperature or ( $\overline{SD}$ ) active low), the RESET pulse is ignored and the MP118 will remain turned off.

## TEMPERATURE PROTECTION

The temperature sensor will shut-down the MP118 once it detects a temperature at or above 100°C. The temperature protection includes a hysteresis to ensure the proper cooling down of the system.

**Note:** The system will remain shut-down while the over-temperature condition exists. If the RESET pulse is applied while an over-temperature condition exists, the pulse is ignored and the MP118 will remain turned off.

## EXTERNAL SHUT-DOWN SIGNAL

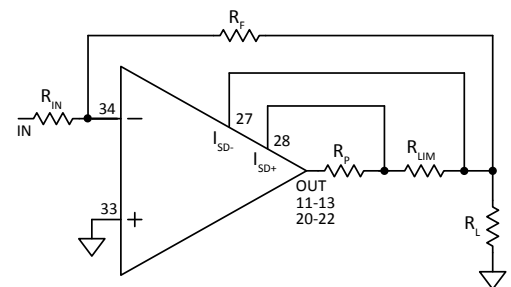
MP118 can be shut-down also by applying a low signal to the ( $\overline{SD}$ ) pin. The signal ( $\overline{SD}$ ) needs to be high impedance when not active, and pulled to GND level when active.

**Note:**

1. If monitored, a logic 0 at the ( $\overline{SD}$ ) output indicates the part is in thermal shutdown.
2. If ( $\overline{SD}$ ) goes from logic 0 to 1, then it has traversed the hysteresis window and is now ready for a RESET

## OVER-CURRENT SHUT-DOWN PROTECTION

Two current sense lines are to be connected directly across the current sense resistor. For the over-current protection to work correctly, pin 28 must be connected to the amplifier output side and pin 27 connected to the load side of the current sense resistor  $R_{LIM}$  as shown in Figure 6. This connection will bypass any parasitic resistances  $R_P$ , formed by socket and solder joints as well as internal amplifier losses. The current sense resistor may not be placed anywhere in the output circuit except where shown in the figure. The value of the current sense resistor can be calculated as follows:  $R_{LIM} = 0.65V/I_{SD}$



**Figure 6: Over-current Protection**

## BOOST OPERATION

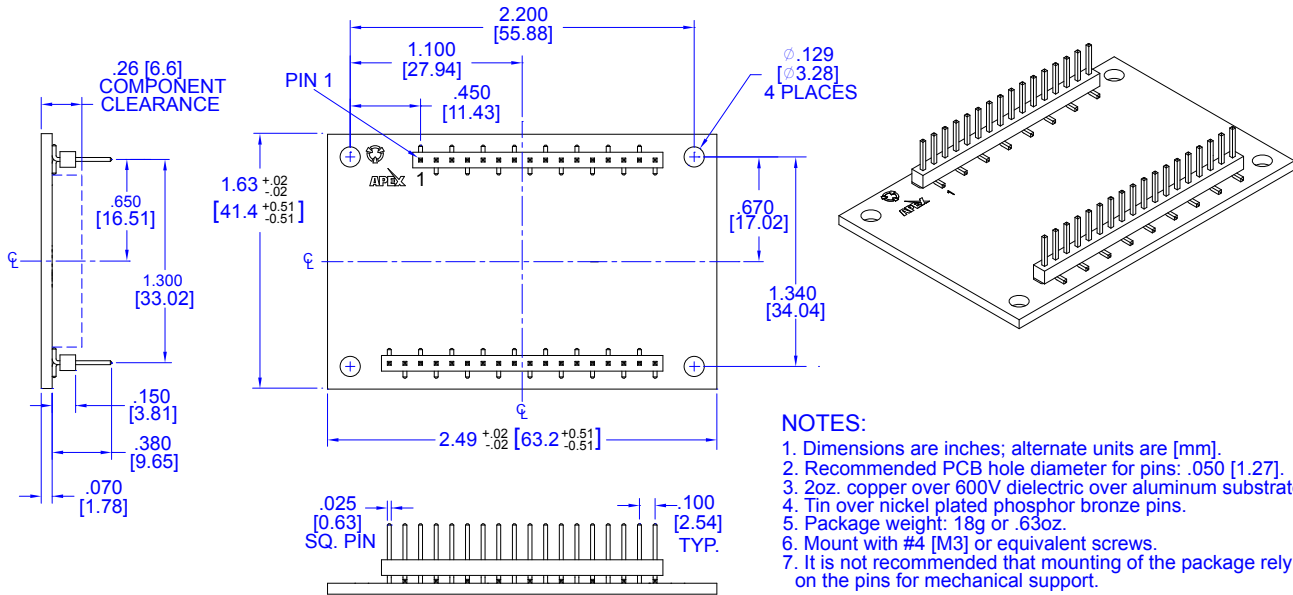
With the boost feature the small signal stages of the amplifier are operated at higher supply voltages than the amplifier’s high current output stage.  $+V_B$  (pins 4, 8) and  $-V_B$  (pins 25, 30) are connected to the small signal stages and  $+V_S$  (pins 14-16) and  $-V_S$  (pins 17-19) are connected 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 MP118 is an insulated metal substrate. This substrate must 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.

**FD PACKAGE**



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