

## Power Operational Amplifier

RoHS  
COMPLIANT

### FEATURES

- High Voltage - 200V
- High Output Current 10A continuous
- 100W Dissipation Capability
- 140 kHz Power Bandwidth
- Temperature Monitor
- Integrated Shut-Down



### APPLICATIONS

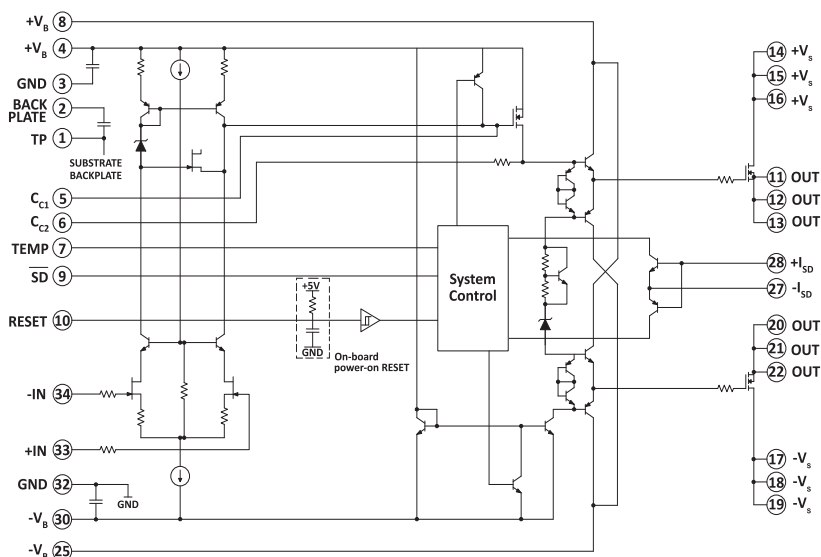
- Ink Jet Printer Head Drive
- Piezo Transducer Drive
- Industrial Instrumentation
- Reflectometers
- Ultra-Sound Transducer Drive

### 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 in<sup>2</sup>). 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.

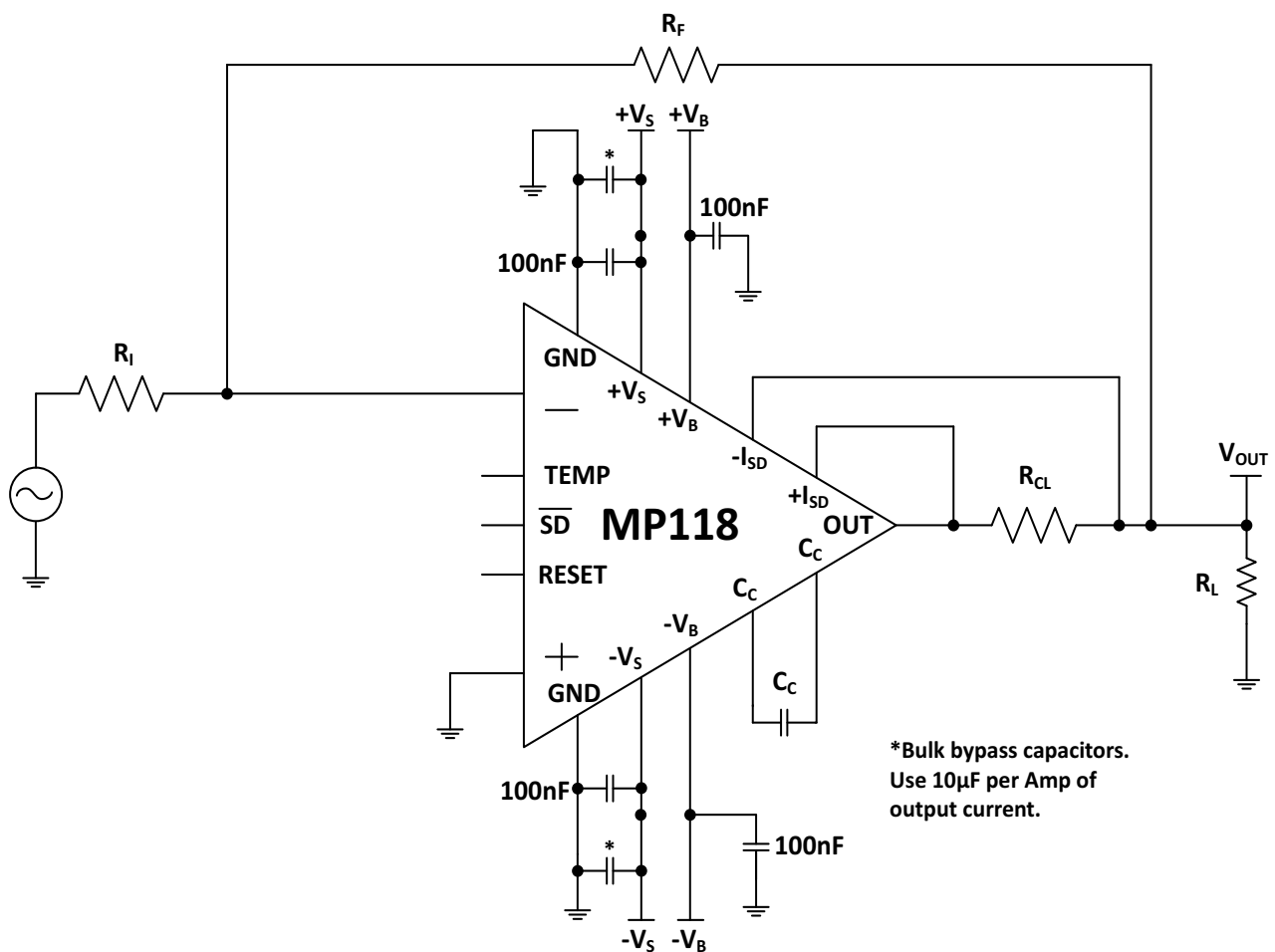
MP118 is based on the MP108 design, but offers lower quiescent current consumption and new features for enhanced system protection. The newly introduced over-current protection and temperature monitoring circuitry will shut-down the system before any permanent damage occurs.

Figure 1: Equivalent Schematic



## TYPICAL CONNECTION

Figure 2: Typical Connection



## PINOUT AND DESCRIPTION TABLE

Figure 3: External Connections

		<b>-IN</b>	<b>34</b>
		<b>+IN</b>	<b>33</b>
<b>1</b>	<b>NC</b>	<b>GND</b>	<b>32</b>
<b>2</b>	<b>BACK PLT</b>	<b>NC</b>	<b>31</b>
<b>3</b>	<b>GND</b>	<b>-V<sub>B</sub></b>	<b>30</b>
<b>4</b>	<b>+V<sub>B</sub></b>	<b>NC</b>	<b>29</b>
<b>5</b>	<b>C<sub>C1</sub></b>	<b>+I<sub>SD</sub></b>	<b>28</b>
<b>6</b>	<b>C<sub>C2</sub></b>	<b>-I<sub>SD</sub></b>	<b>27</b>
<b>7</b>	<b>TEMP</b>	<b>NC</b>	<b>26</b>
<b>8</b>	<b>+V<sub>B</sub></b>	<b>-V<sub>B</sub></b>	<b>25</b>
<b>9</b>	<b><math>\overline{\text{SD}}</math></b>	<b>NC</b>	<b>24</b>
<b>10</b>	<b>RESET</b>	<b>NC</b>	<b>23</b>
<b>11</b>	<b>OUT</b>	<b>OUT</b>	<b>22</b>
<b>12</b>	<b>OUT</b>	<b>OUT</b>	<b>21</b>
<b>13</b>	<b>OUT</b>	<b>OUT</b>	<b>20</b>
<b>14</b>	<b>+V<sub>S</sub></b>	<b>-V<sub>S</sub></b>	<b>19</b>
<b>15</b>	<b>+V<sub>S</sub></b>	<b>-V<sub>S</sub></b>	<b>18</b>
<b>16</b>	<b>+V<sub>S</sub></b>	<b>-V<sub>S</sub></b>	<b>17</b>

**MP118**  
(viewed from  
backplate)

Pin Number	Name	Description
2	BPLT	AC coupling to backplate. Connect to signal ground.
3, 32	GND	Ground. Pins 3 and 32 are not connected on the unit. Connect both pins to system signal ground.
4, 8	+V <sub>B</sub>	The positive boost supply rail. Short to +V <sub>S</sub> if unused. See applicable section.
5, 6	CC	Compensation capacitor connection. Select value based on Phase Compensation. See applicable section.
7	TEMP	The temperature sensing pin. Provides a voltage proportional to the case temperature.
9	$\overline{\text{SD}}$	The external shutdown pin. Logic 0 places the unit into shutdown.
10	RESET	The reset pin. A pulse to this pin will allow the unit to operate after shutdown.
11, 12, 13, 20, 21, 22	OUT	The output. Short all 6 pins together and connect to the OUT side of R <sub>CL</sub> (see figure 2). Load and feedback resistors connect to the other side of R <sub>CL</sub> .
14, 15, 16	+V <sub>S</sub>	The positive supply rail.
17, 18, 19	-V <sub>S</sub>	The negative supply rail.
25, 30	-V <sub>B</sub>	The negative boost supply rail. Short to -V <sub>S</sub> if unused. See applicable section.
27	-I <sub>SD</sub>	The negative shutdown current limit. Connect to load side of R <sub>CL</sub> . See applicable section.
28	+I <sub>SD</sub>	The positive shutdown current limit. Connect to OUT side of R <sub>CL</sub> . See applicable section.
33	+IN	The non-inverting input.
34	-IN	The inverting input.
All Others	NC	No connection.

- Notes: 1) C<sub>C</sub> has to be NPO (COG) rated for full supply voltage +V<sub>S</sub> to -V<sub>S</sub>. Typical values are provided in the section "COMPENSATION"
- 2) Both pins 3 and 32 have to be connected to signal ground.
- 3) All OUT pins (pins 11-13 and 20-22) need to be tied together.

## SPECIFICATIONS

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.  $\pm V_B = \pm V_S$

### ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Max	Units
Supply Voltage, total	$+V_S$ to $-V_S$	200	V
Supply Voltage, $+V_B$ <sup>1, 2</sup>	$+V_B$	$+V_S + 15$	V
Supply Voltage, $-V_B$ <sup>1, 2</sup>	$-V_B$	$-V_S - 15$	V
Output Current, peak, within SOA	$I_O$	12	A
Power Dissipation, internal, DC	$P_D$	100	W
Input Voltage	$V_{IN}$	$+V_B$ to $-V_B$	V
Temperature, pin solder, 10s		225	$^\circ\text{C}$
Temperature, junction <sup>3</sup>	$T_J$	150	$^\circ\text{C}$
Temperature, storage		+105	$^\circ\text{C}$
Operating Temperature Range, case	$T_C$	+100	$^\circ\text{C}$
$\overline{SD}$ , Reset Signal		5.5	V

1.  $+V_S$  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.
2. Power supply voltages  $+V_B$  and  $-V_B$  must not be less than  $+V_S$  and  $-V_S$  respectively.
3. Long term operation at the maximum junction temperature will result in reduced product life. Derate internal power dissipation to achieve high MTTF.

**INPUT**

Parameter	Test Conditions	Min	Typ	Max	Units
Offset Voltage	Full temp range		1	5	mV
Offset Voltage vs. temperature			50		$\mu\text{V}/^{\circ}\text{C}$
Offset Voltage vs. supply				20	$\mu\text{V}/\text{V}$
Bias Current, initial <sup>1</sup>				100	pA
Bias Current vs. supply				0.1	pA/V
Offset Current, initial				50	pA
Input Resistance, DC			$10^{11}$		$\Omega$
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	20 kHz BW, $R_s = 1\text{ k}\Omega$		2		$\mu\text{V RMS}$

1. Doubles for every  $10^{\circ}\text{C}$  of case temperature increase.

**GAIN**

Parameter	Test Conditions	Min	Typ	Max	Units
Open Loop, 15 Hz	$R_L = 10\text{ k}\Omega$ $C_C = 10\text{ pF}$	96	120		dB
Gain Bandwidth Product @ 1 MHz	$C_C = 10\text{ pF}$		56		MHz
Phase Margin	Full temp range, $C_C = 150\text{ pF}$	45	60		$^{\circ}$
Power Bandwidth 180VP-P	$C_C = 10\text{ pF}$ , $+V_S = 100\text{ V}$ , $-V_S = -100\text{ V}$		140		kHz

**POWER SUPPLY**

Parameter	Test Conditions	MP118			Units
		Min	Typ	Max	
Voltage		$\pm 15$	$\pm 75$	$\pm 100$	V
Current, quiescent			25	30	mA

## OUTPUT

Parameter	Test Conditions	Min	Typ	Max	Units
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			A
Slew Rate, A 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		$\Omega$

## THERMAL

Parameter	Test Conditions	Min	Typ	Max	Units
Resistance, AC, junction to case <sup>1</sup>	Full temp range, F>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	$^{\circ}C$

1. Rating applies if the output current alternates between both output transistors at a rate faster than 60Hz.

## TEMPERATURE SENSOR

Parameter	Test Conditions	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**

Parameter	Test Conditions	Min	Typ	Max	Units
Thermal System Shut-down, $T_{SD}$			100		°C
Thermal Shut-down Hysteresis			8		°C
Shut-down voltage ( $+I_{SD}$ to $-I_{SD}$ )			$\pm 0.65V$		V
<u>SD</u> Active Level <sup>1</sup>		0		0.2	V
<u>SD</u> Active Minimum Pulse width		1			$\mu s$
Reset High Level <sup>2</sup>		4.5		5.5	V
Reset Low Level <sup>2</sup>		0		0.2	V

1. The SD signal needs to be an “open drain” signal, meaning that it is “high impedance” when not active low.

2. The RESET signal is edge sensitive. A transition from low to high level triggers the MP118 shut-down function.



## TYPICAL PERFORMANCE GRAPHS

Figure 4: Small Signal Response

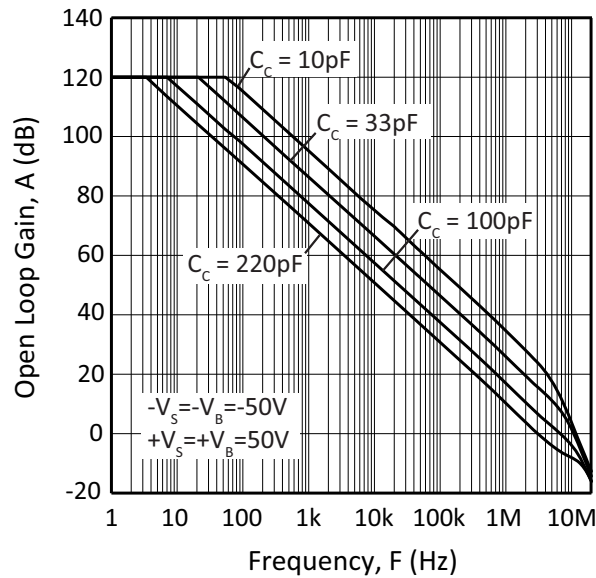


Figure 5: Phase Response

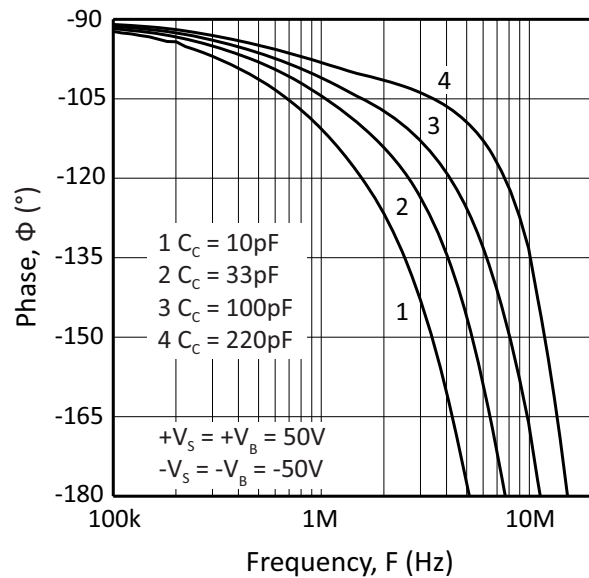


Figure 6: Quiescent Current vs. Temperature

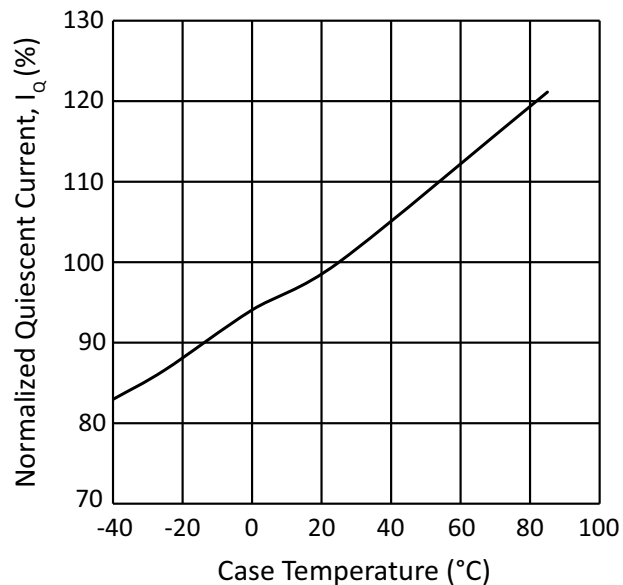


Figure 7: Quiescent Current vs. Supply

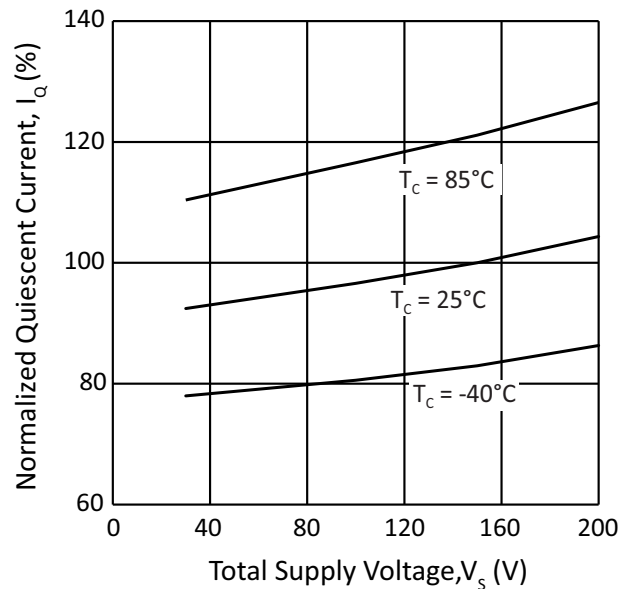


Figure 8: Slew Rate

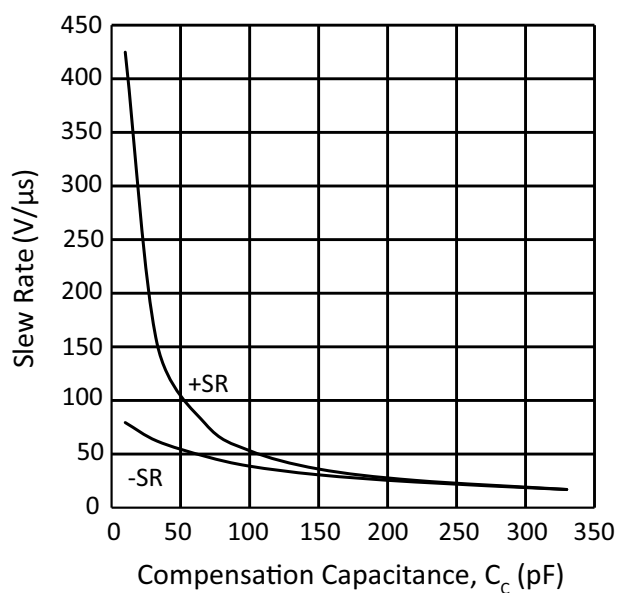


Figure 9: Output Voltage Swing

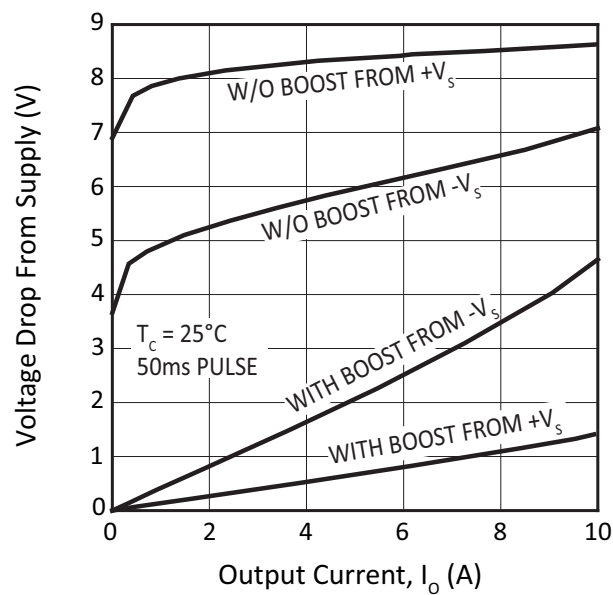


Figure 10: Power Response

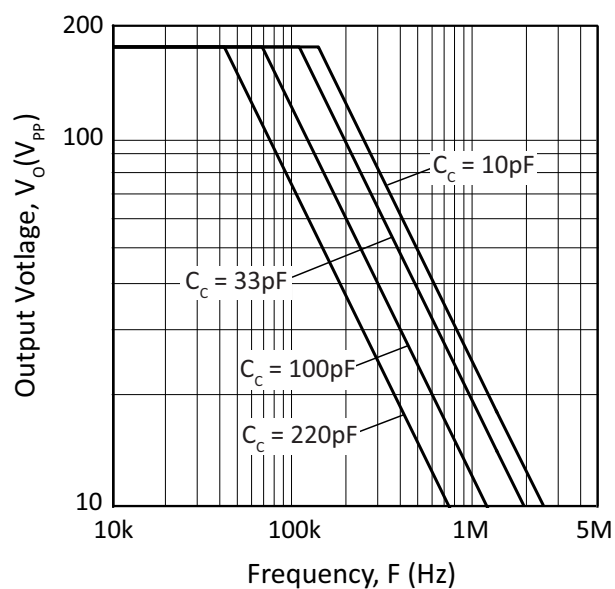


Figure 11: Power Derating

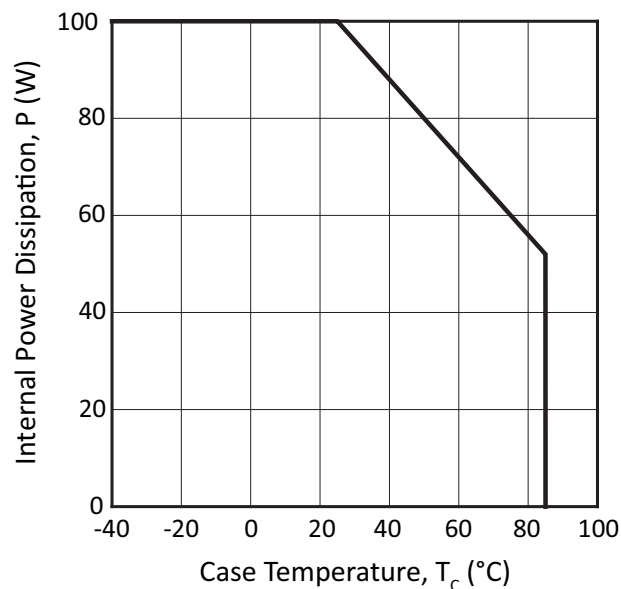


Figure 12: Offset Voltage

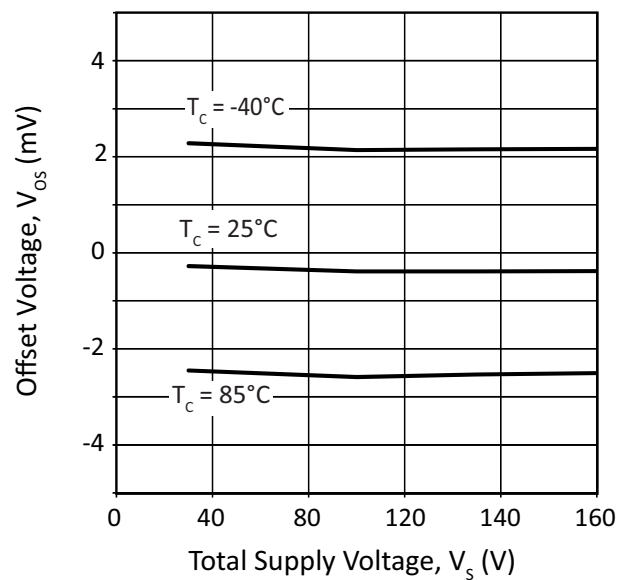
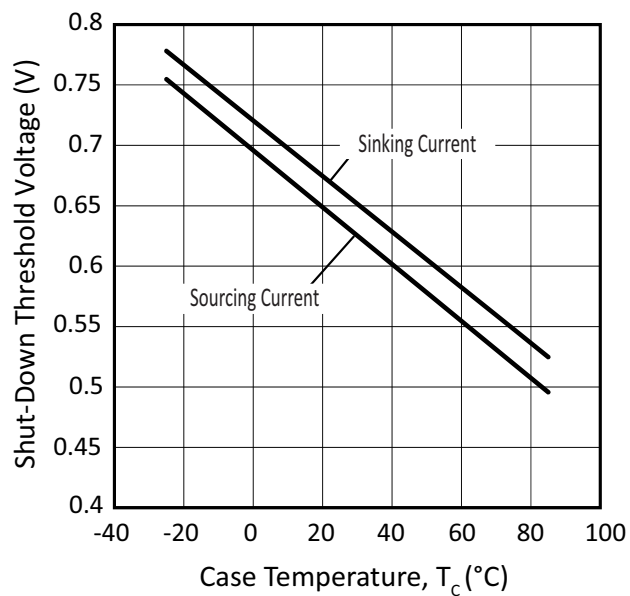


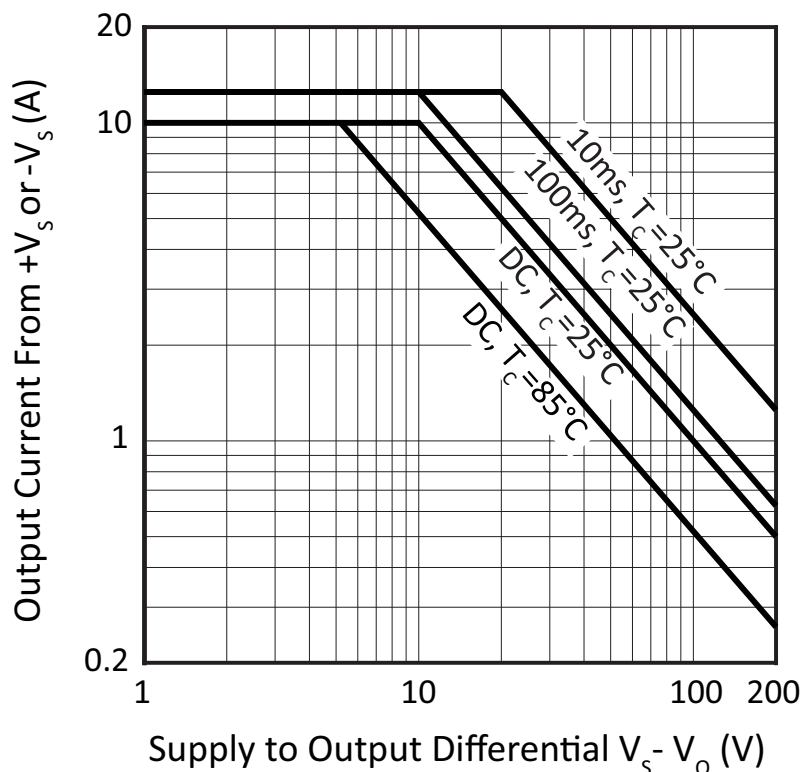
Figure 13: Shut-Down Voltage vs. Temperature



## SAFE OPERATING AREA (SOA)

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. 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.

Figure 14: SOA



## GENERAL

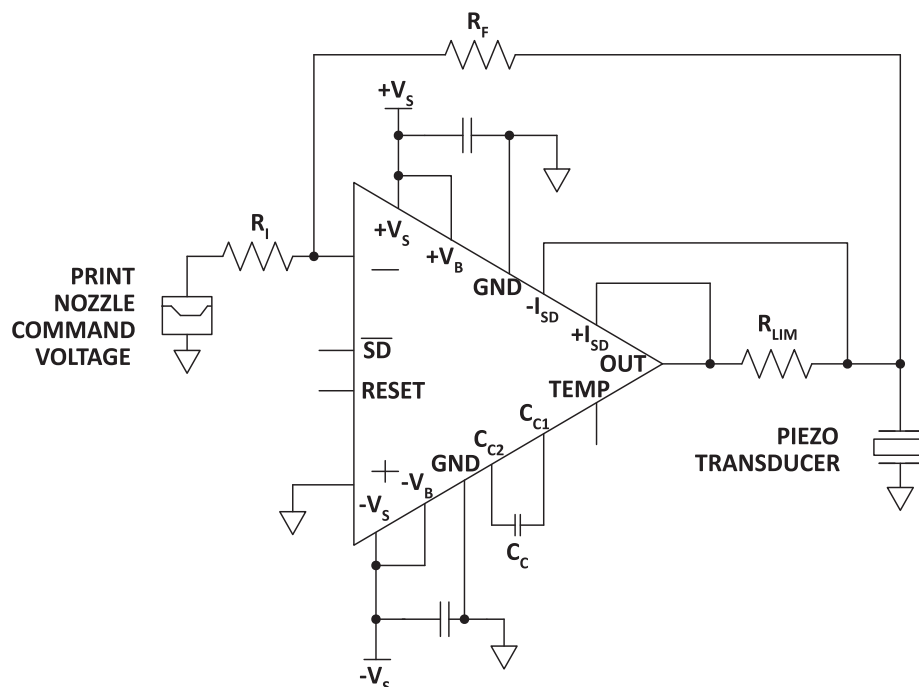
Please read Application Note 1 “General Operating Considerations” which covers stability, supplies, heat sinking, mounting, current limit, SOA interpretation, and specification interpretation. Visit [www.apexanalog.com](http://www.apexanalog.com) for Apex Microtechnology’s complete Application Notes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

## 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 15 shows a high level outline of MP118 in a typical piezo transducer drive application.

Figure 15: 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.

## COMPENSATION

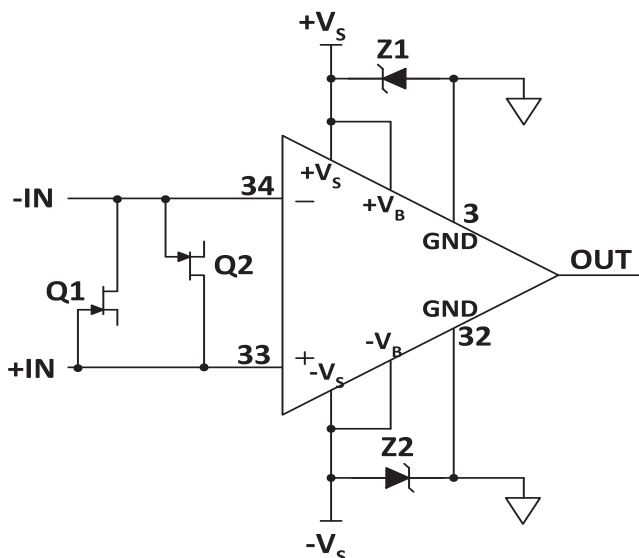
The external compensation capacitor  $C_C$  is connected between pins 5 and 6. Unity gain stability can be achieved with a capacitor value of at least 150pF for a minimum phase margin of 45 degrees. At higher gains more phase shift can usually be tolerated in most designs and the compensation capacitor 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 16). 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 16). 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.

Figure 16: 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 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 (Figure 3) and the typical connections diagram (Figure 2).

## 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  $\pm 50\mu A$ .

## 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”)
- 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 of 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.

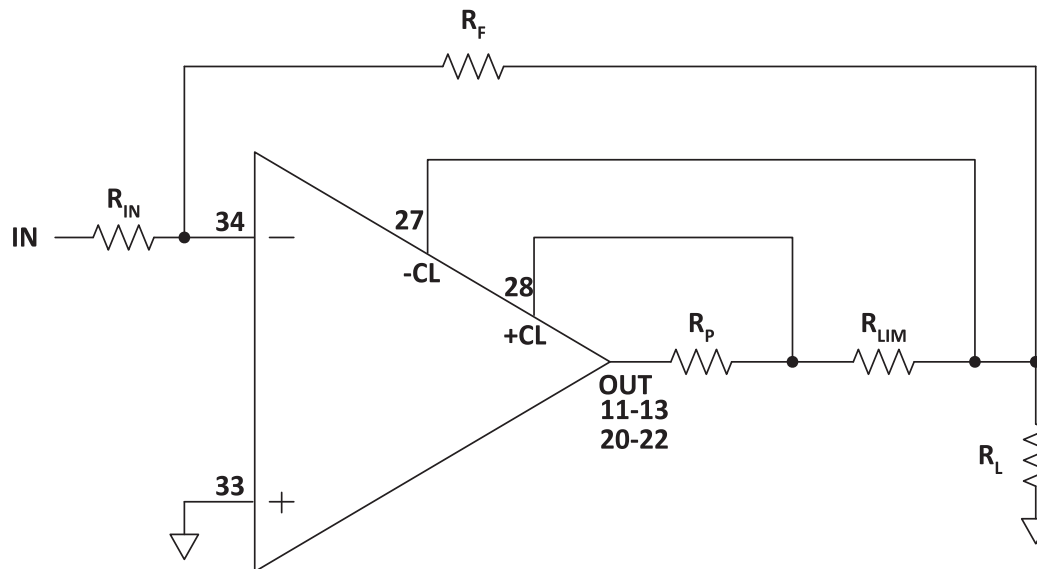
- Notes:**
- 1) If monitored, a logic 0 at the  $\overline{SD}$  output indicates the part is in thermal shutdown.
  - 2) If  $\overline{SD}$  goes from logic 0 to 1, then it has traversed the hysteresis window and is now ready for a RESET

## 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 17. 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:

$$R_{LIM} = \frac{0.65V}{I_{SD}}$$

Figure 17: 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

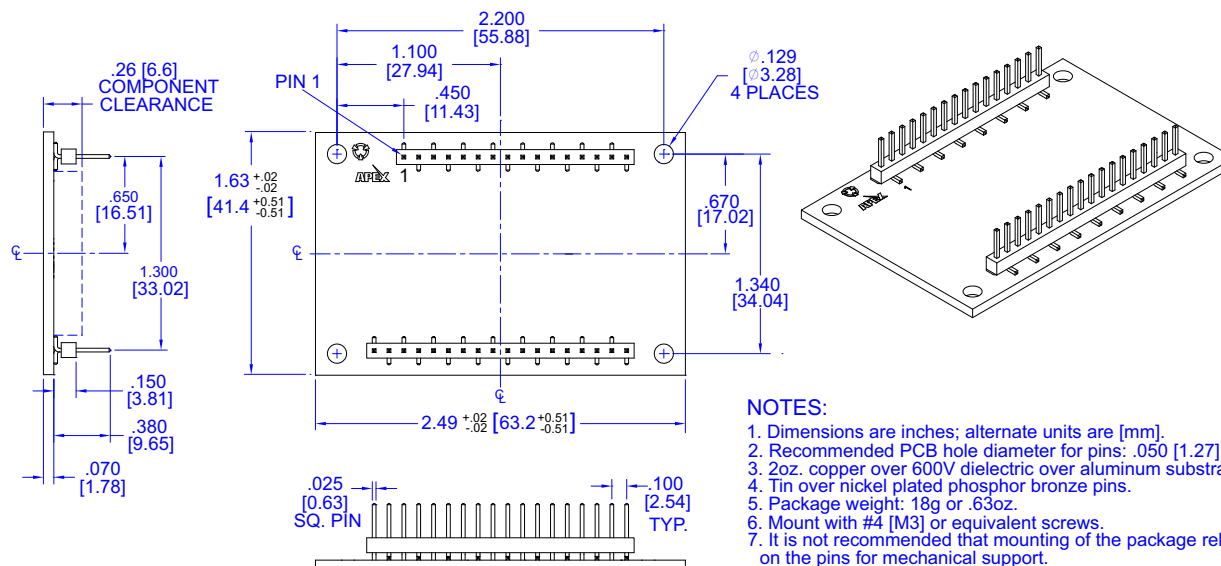
The substrate of the MP118 is an insulated metal substrate. This substrate must be connected to signal ground. Connect pin 2 (back plate) to signal ground. The back plate will then be AC grounded to signal ground through a  $1\mu\text{F}$  capacitor.



## PACKAGE OPTIONS

Part Number	Apex Package Style	Description
MP118	FD	34-pin Open Frame

### FD PACKAGE



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