MP106

Power Amplifier

FEATURES

- Optimized Solution to Drive Dynamic Capacitive Loads
- Drive Capability 0-540nF
- Short Term Output current >30A (within SOA)
- High Internal Power Dissipation of 130W
- Fixed Gain -15V/V or -20V/V
- Optimized for Achieving a -36V Output Voltage Swing
- Slew Rate of 50 V/µs

APPLICATIONS

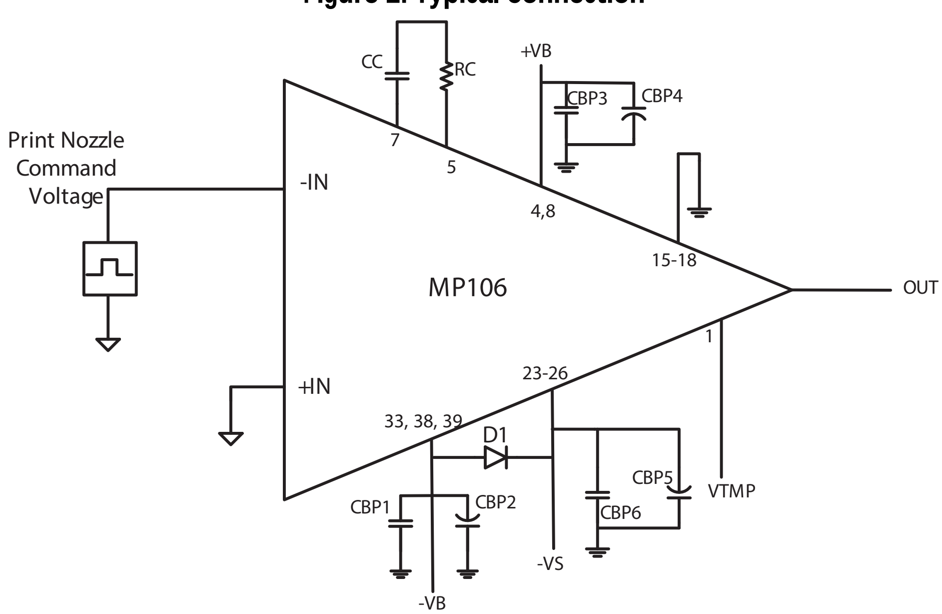
- Piezoelectric Actuation for Inkjet Printers

DESCRIPTION

The MP106 is a high output power amplifier for driving capacitive loads such as piezo devices used in ink-jet printing applications. The MP106 utilizes Apex proprietary technology with discrete semiconductor and passive elements on a thermally highly conductive, but electrically isolated package, delivering high power in a very compact module.

The amplifier gain is fixed at -15V/V or -20V/V. It is optimized to achieve a -36V output voltage swing even at a small output voltage offset with a single 3V DAC. A combination of internal and external compensation provides optimum slew rate and insures stability while reducing the overall number of required components. Auxiliary voltages (+V_B and -V_B) for the amplifier stage are used to reduce the power loss in the output drivers.

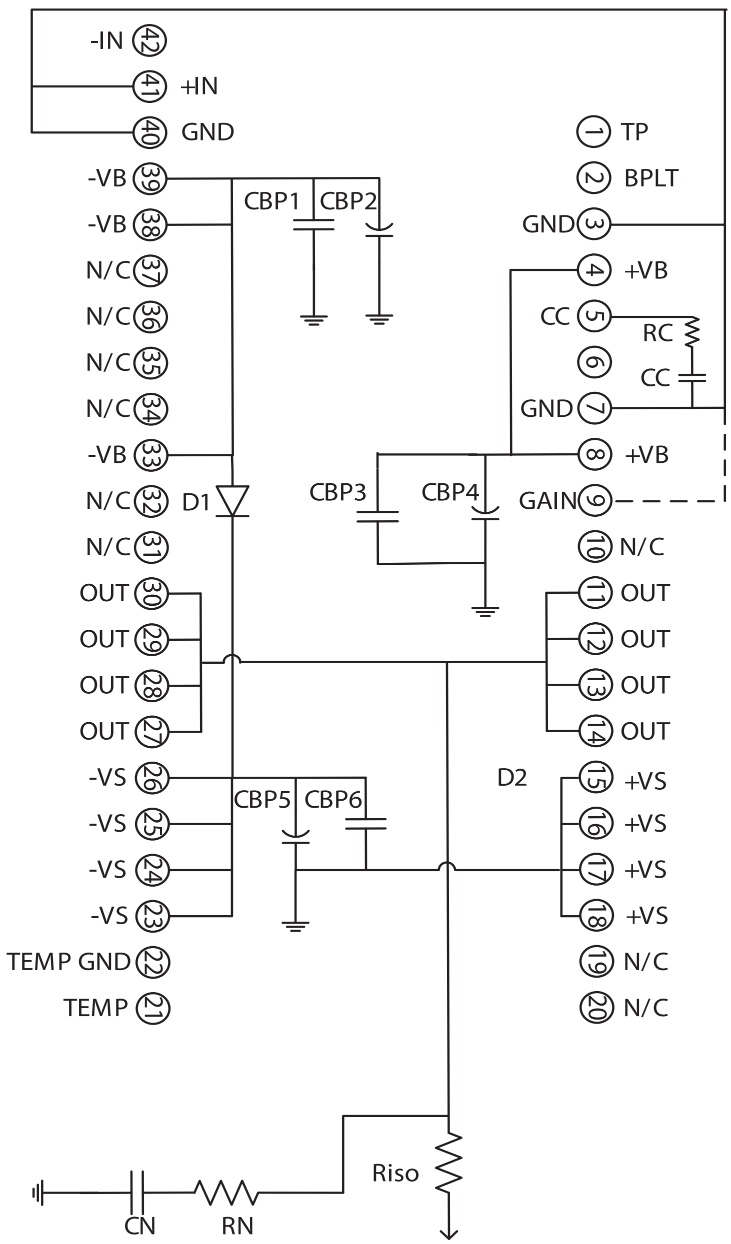
Figure 1: Typical Connection



PINOUT AND DESCRIPTION TABLE

The package of MP106 is designed to be mounted above the print head if desired. Therefore, the width of the amplifier is less than the width of the Samba print head. Please check the positioning of the connectors and the location of the components carefully to avoid any damage during mounting or any short to ground. All pins except those marked TP, N/C, TEMP or GAIN must be connected externally for proper operation. The diodes between $+V_S/+V_B$ and $-V_B/-V_S$ are recommended to prevent damage of the amplifier during power sequencing.

Figure 2: External Connections



Pin Number	Name	Description
1	TP	Do not connect
2	BPLT	Backplate. Connect to signal ground
3	GND	Signal Ground
4	$+V_B$	Positive amplifier operating voltage (“Boost” voltage)
5	CC	External compensation capacitor. Connect compensation capacitor and resistor in series between this pin and ground pin.
6	N/C	Not connected
7	GND	Signal Ground
8	+VB	Positive amplifier operating voltage (“Boost” voltage)
9	GAIN	Gain. Connect to pin 7 (GND) for a gain of 20. Leave open for a gain of 15.
10	N/C	Not connected
11,12,13,14	OUT	Amplifier output. Must be connected also to pins 27, 28, 29, 30
15,16,17,18	$+V_S$	Positive supply pins. Connect these pins to power ground.
19,20	N/C	Not connected
21	TEMP	Temperature sensor output
22	TEMP GND	Signal Ground
23,24,25,26	$-V_S$	Negative amplifier output stage supply voltage
27,28,29,30	OUT	Amplifier output. Must be connected also to pins 11, 12, 13, 14
31,32	N/C	Not connected
33	$-V_B$	Negative amplifier operating voltage (“Boost” voltage)
34,35,36,37	N/C	Not connected
38, 39	$-V_B$	Negative amplifier operating voltage (“Boost” voltage)
40	GND	Signal Ground
41	+IN	Non-inverting amplifier input
42	-IN	Inverting amplifier input

SPECIFICATIONS

Unless notes otherwise, the electrical characteristics are based on T_C=25°C, $+V_S$=0V, $-V_S$=-48V, $+V_B$=15V, $-V_B$=-60V

ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Min	Max	Units
Supply Voltage	$-V_s$	-60	-15	V
Positive Boost Supply	$+V_B$		+15	V
Negative Boost Supply	$-V_B$	$-V_S$-15	$-V_S$	V
Output Current, peak	I_o		32	A
Power Dissipation	P_D		130	W
Input Voltage	V_{IN}	-0.5	+10	V

Temperature, pin solder, 10s max	T_S		225	°C
Operating Temperature Range, case	T_C	-25	+85	°C

AMPLIFIER ELECTRICAL CHARACTERISTICS

Parameter	Test Conditions	Min	Typ	Max	Units
Input Voltage, V_{IN}[1]		0	0-3	5	V
Offset Voltage, initial		-7	3	7	mV
Offset Voltage vs. Temperature	Full Temp Range	7.2			µV/°C
Offset Voltage vs. Supply		72			µV/V
Bias Current, initial			300	550	nA
Input Resistance, DC			160		MΩ
Input Capacitance			3		pF
Input Noise @ 10 kHz			12		nV/√Hz

1. With $|A_V|\geq15$ and the negative supply rail of -40V, a 5V input would drive the amplifier into the rail. The specification only indicates that an accidental 5V input signal does not cause any harm to the amplifier.

GAIN

Parameter	Test Conditions	Min	Typ	Max	Units
Amplifier Gain, A_V,	Pin 9 open	-14.7	-15	-15.3	V/V
Amplifier Gain, A_V,	Pin 9 connected to pin 7	-19.7	-20	-20.3	V/V
Open Loop Gain (@15 Hz)			96		dB
Gain Bandwidth Product, 1 MHz			8.5		MHz
Power Bandwidth, 40 p-p			280		kHz

OUTPUT

Parameter[1]	Test Conditions	Min	Typ	Max	Units
Voltage Swing, $+V_S$	$+V_B$=13V, $-V_S$=-14V, $-V_B$=-27, Io=10A	$+V_S$-1			V
Voltage Swing, $-V_S$	$+V_B$=13V, $-V_S$=-14V, $-V_B$=-27, Io=10A			$-V_S$+2	V
Voltage Swing, $-V_S$	$+V_B$=13V, $-V_B$=$-V_S$=-14V, I_O=10A			$-V_S$+5	V
Current, continuous		10			A
Current, peak				30	A
Slew rate	A_V=-15, CL=540nF, RL=0.1Ω, V_{OUT} = 40V pulse	45			V/µs

1. $-V_S$ and GND are power supply lines that will carry currents of up to 32A peak (540nF load, 50V/µs slew rate). Therefore proper dimensioning of PCB traces and the power supply itself need to be considered.

POWER SUPPLY

Parameter[1]	Test Conditions	Min	Typ	Max	Units
Supply Voltage, $-V_S$		-60	-48	-15	V
Positive Boost Supply, $+V_B$			15		V
Negative Boost Supply, $-V_B$			-60		V
Quiescent current, $+V_B$ Iq	$-V_S$= -48V, $-V_B$= -61V, $+V_B$= +13V	20	24	28	mA
Quiescent current, $-V_B$ Iq	$-V_S$= -48V, $-V_B$= -61V, $+V_B$= +13V	22	30	36	mA

1. $-V_S$ and GND are power supply lines that will carry currents of up to 32A peak (540nF load, 50V/µs slew rate). Therefore proper dimensioning of PCB traces and the power supply itself need to be considered.

THERMAL

Parameter	Test Conditions	Min	Typ	Max	Units
Resistance, AC, Junction to Case				0.5	°C/W
Resistance, DC, Junction to Case				2.1	°C/W
Resistance, Junction to Air				13.2	°C/W
Temperature Range, Case		0		85	°C

TEMPERATURE SENSOR

Parameter	Test Conditions	MP106			MP106			Units
		Min	Typ	Max	Min	Typ	Max	
Temperature Sensor Output, V_{TEMP}	T_C = 25°C		2.98			*		V
Temperature Sensor Gain			10			*		mV/°C
Temperature Accuracy	T_C = -40°C to 85°C			±1			*	°C

TYPICAL PERFORMANCE GRAPHS

Figure 3: Closed Loop Phase vs. Frequency

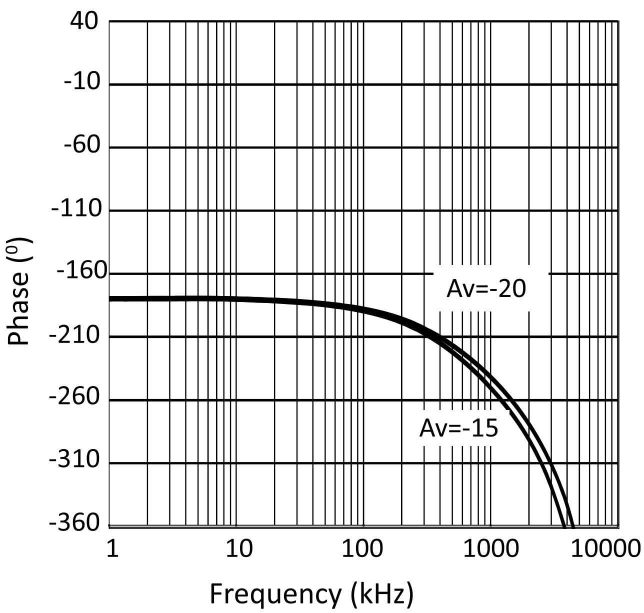


Figure 4: Closed Loop Gain vs. Frequency

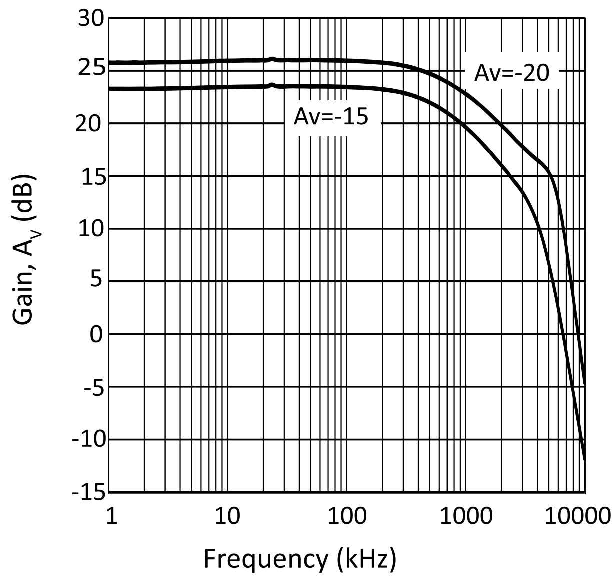


Figure 5: +V_B Quiescent Current

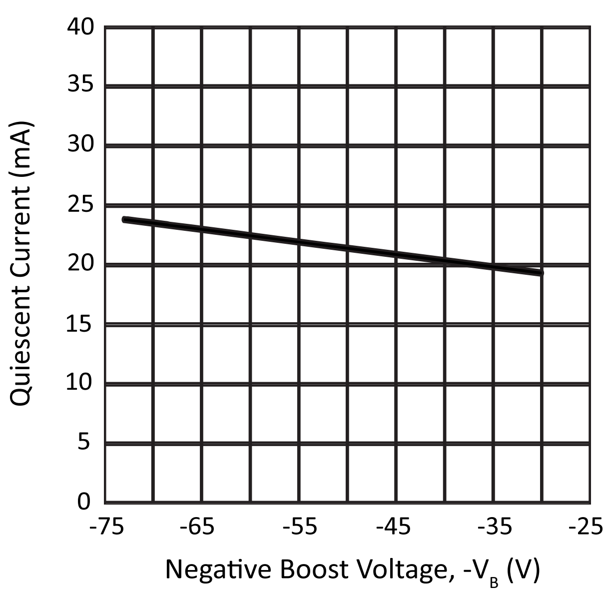


Figure 6: -V_B Quiescent Current

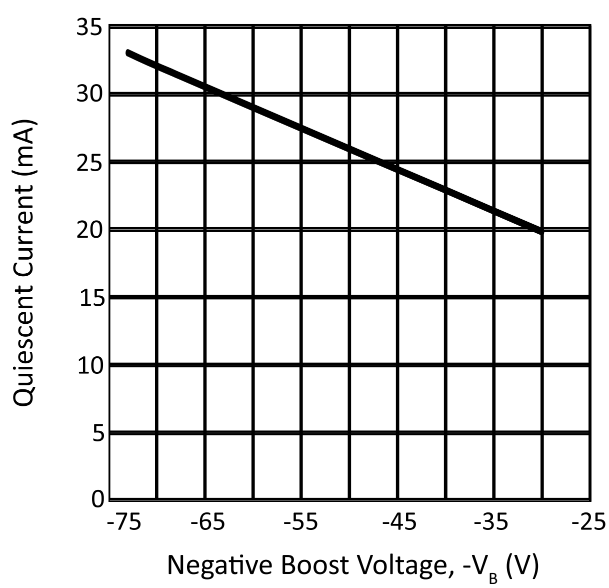


Figure 7: Minimum Slew Rate vs. Output Voltage

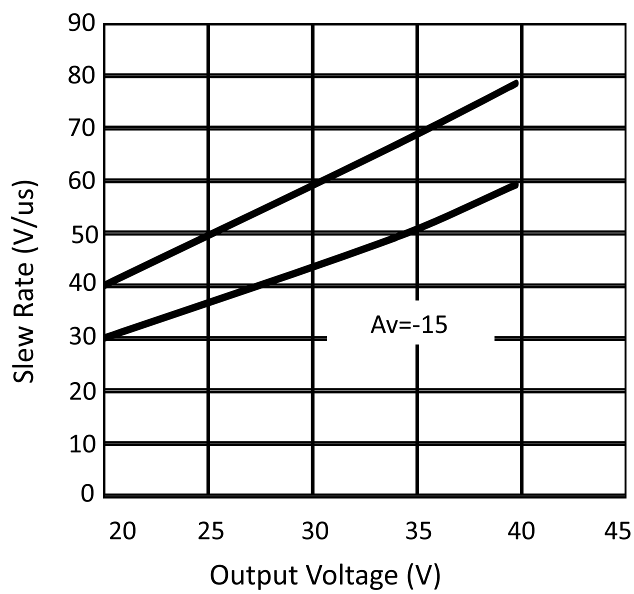


Figure 8: $-V_S$ Voltage drop when $-V_S=-V_B$

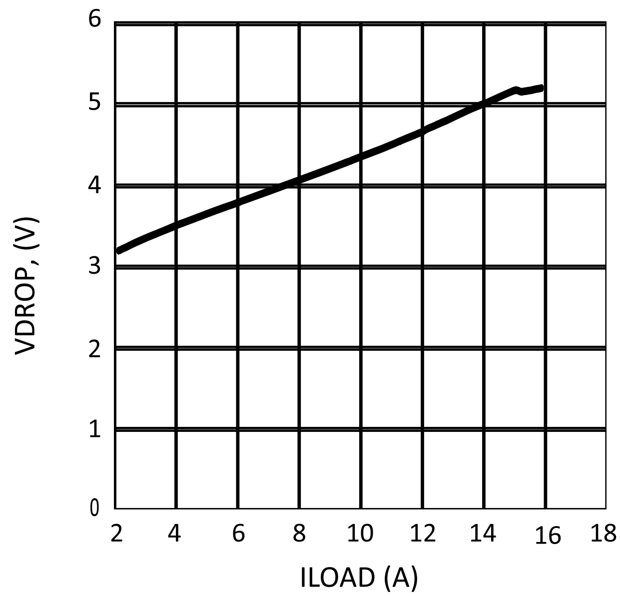


Figure 9: Pulse Response for 540nF Load

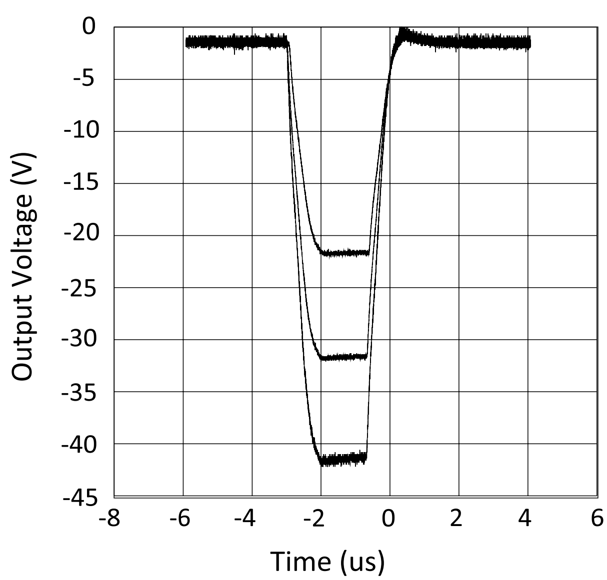
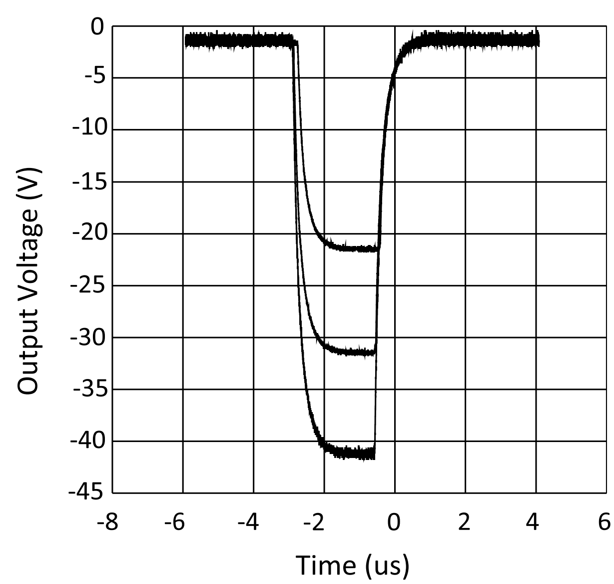


Figure 10: Pulse Response for No Load



SAFE OPERATING AREA (SOA)

The MOSFET output stage of the MP106 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). The output stage is protected against transient fly back by the parasitic body diodes of the output stage MOSFET structure. However, for protection against sustained high energy fly back external fast recovery diodes must be used.

Figure 11: Safe Operating Area (SOA)

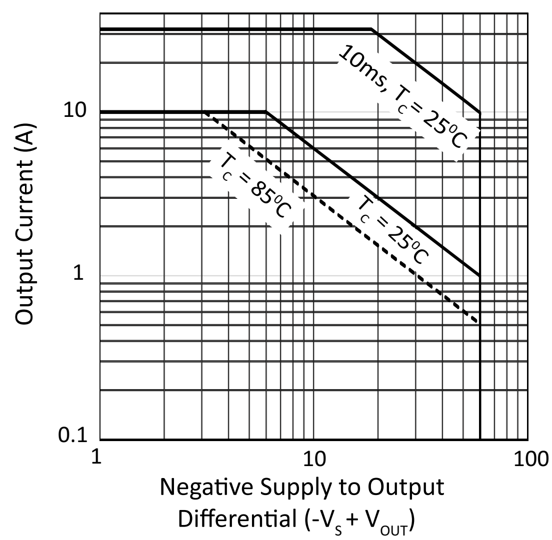
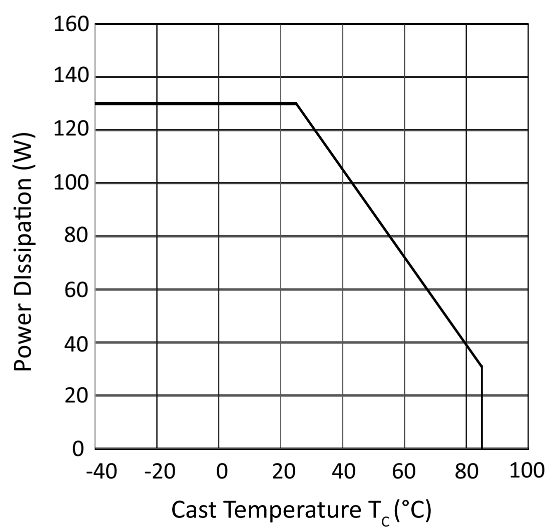


Figure 12: Power Derating



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 for Apex Microtechnology’s complete Application Notes library, Technical Seminar Workbook, and Evaluation Kits.

POWER SEQUENCING

A diode should be connected between -VS and -VB as shown in typical connections drawing in figure 1 to avoid damage to the MP106. If diode is not connected, the board should be powered on in the following sequence:

- $-V_S$
- $-V_B$
- $+V_B$

AMPLIFIER GAIN

The amplifier gain is set to an inverting gain of -15. When the gain pin is shorted to ground (pin 7), the amplifier gain increases to a gain of -20.

POWER SUPPLY BYPASSING

Bypass capacitors to power supply terminal $-V_S$ must be connected physically close to the pins to prevent local parasitic oscillation in the output stage of the MP106. Use electrolytic capacitors at least 10µF per output amp required. Bypass the electrolytic capacitors with high quality ceramic capacitors (X7R) 0.1µF or greater. A bypass capacitor of 0.1µF or greater is recommended for the +VB and -VB terminals.

SNUBBER CIRCUIT

When using the amplifier with a capacitive load up to 540nF, an output snubber circuit should be used to stabilize the output signal of the amplifier. A capacitor value of 22nF and a resistor value of 5Ω are recommended for a snubber circuit.

COMPENSATION

External compensation capacitor Cc and compensation resistor Rc are connected from pin 5 to pin 7 as shown in typical connection drawing in figure 1. For piezo loads up to 540nF, a compensation of 220pF and 750Ω are recommended.

SERIES ISOLATION RESISTOR, RS

To insure stability with all capacitive loads a series isolation resistor should be included between the output and the load as shown in the external connections drawing. A 0.1Ω resistor works well for capacitive loads up to 540nF. The resistor will affect the rise and fall time of the output pulse at the capacitive load. This can be compensated for on the input signal.

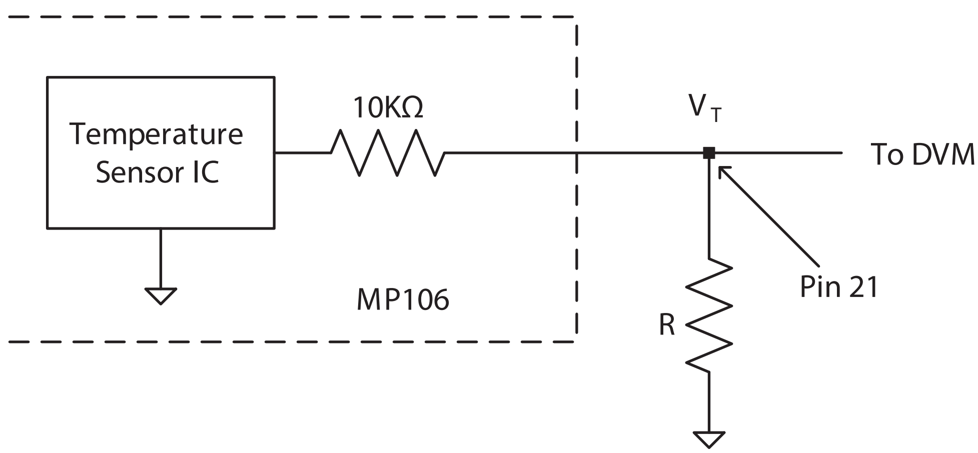
BACKPLATE GROUNDING

The substrate of the MP106 is an insulated metal substrate. It is required that it be connected to signal ground. This is accomplished when the ground pin (Pin 7) is properly connected to signal ground

TEMPERATURE SENSING

The MP106 consists of two IC temperature sensors, located near the two output MOSFETs. The scale factor of the sensor is 10mV/°C. The output voltage of the sensor is equal to approximately 2.98 V at room temperature (T_C = 25°C). The sensor has an uncalibrated temperature error of + 1°C. The scale factor of the sensor can be adjusted by connecting an optional resistor "R" (refer Fig 13) to TMP pin using the following equation, where T is case temperature in °C.

Figure 13: Temperature Sensor



$$V_T = \frac{R}{10000 + R}(0.01T + 2.73)$$

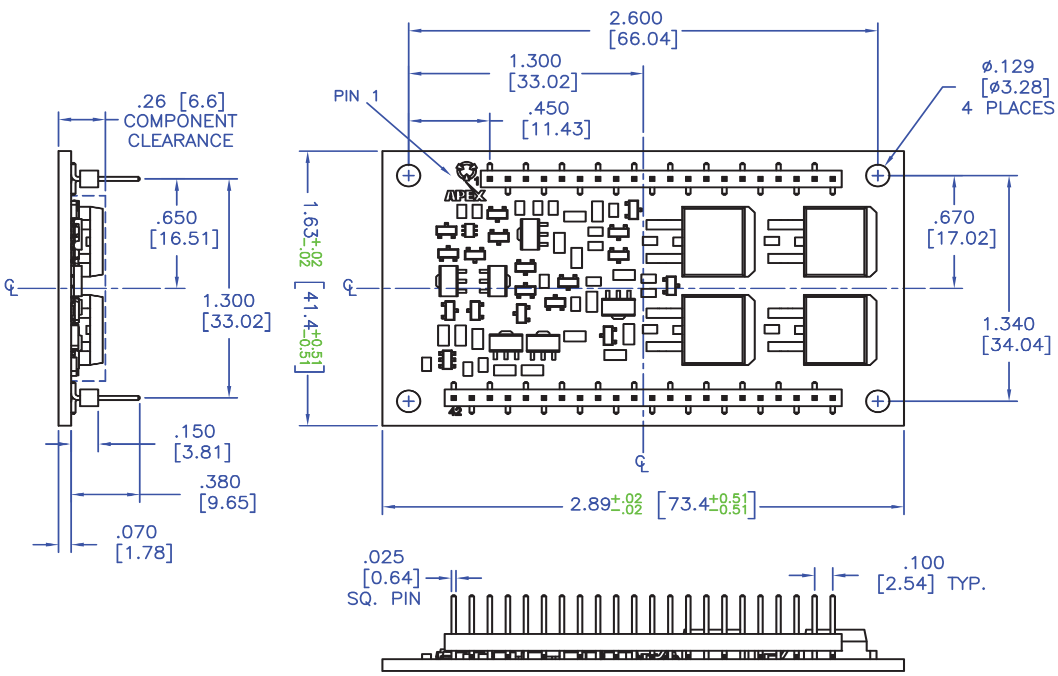
POWER SUPPLY PROTECTION

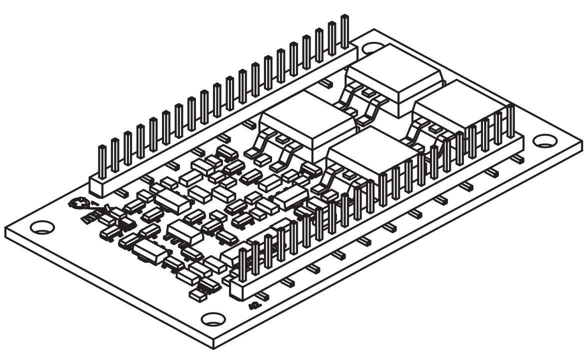
Unidirectional zener diode transient suppressors are recommended as protection on the supply pins. The zeners clamp transients to voltages within the power supply rating and also clamp power supply reversals to ground. Whether the zeners are used or not, the system power supply should be evaluated for transient performance including power-on overshoot and power-off polarity reversal as well as line regulation. Conditions which can cause open circuits or polarity reversals on either power supply rail should be avoided or protected against. Reversals or opens on the negative supply rail is known to induce input stage failure. Unidirectional TVS diodes prevent this, and it is desirable that they be both electrically and physically as close to the amplifier as possible.

PACKAGE OPTIONS

Part Number	Apex Package Style	Description
MP106	FC	42-pin Open Frame

PACKAGE STYLE FC





NOTES:

1. Dimensions are inches; alternate units are [mm].
2. Recommended PCB hole diameter for pins: .050 [1.27].
3. 2oz. copper over 600V dielectric over aluminum substrate.
4. Tin over nickel plated phosphor bronze pins.
5. Package weight:
6. Mount with #4 or equivalent screws.
7. It is not recommended that mounting of the package rely on the pins for mechanical support.

Note: Shown components and component location for illustration purposes only.

NEED TECHNICAL HELP? CONTACT APEX SUPPORT!

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