MP206

2-Channel Power Amplifier Print Head Driver

FEATURES

- Optimized Solution to Drive Dynamic Capacitive Loads
- Peak Output Current: 21A
- Slew Rate: 100V/µs (at 180nF load)
- Maximum Pulse Voltage: up to ±60V (with boost supplies)
- Temperature Sensor
- 30-pin Open Frame Package

APPLICATION

- Piezoelectric Actuation for Inkjet Printheads
  - Fujifilm Dimatix Samba G3L
  - Fujifilm Dimatix GMA series

DESCRIPTION

The MP206 is a 2-channel high output power amplifier for driving capacitive loads such as piezo devices used in inkjet printing applications. The amplifier provides flexibility in output drive; it can provide positive or negative pulses to a constantly changing number of piezo nozzles. MP206 is built on a thermally conductive, but electrically isolated substrate, delivering high power in a very compact module.

The amplifier gain is fixed at approximately 19.85V/V in non-inverting mode (or -15.7V/V for inverting mode). It is optimized to achieve a 0 to 40V (or -40 to 0V) output voltage swing. A combination of internal and external compensation allows MP206 to be tailor-fit to any of the print heads listed above, providing optimum slew rate and ensuring stability. Auxiliary voltages ($+V_B$ and $-V_B$) for the amplifier stage are used to reduce the power loss in the output drivers.

Figure 1: Block Diagram

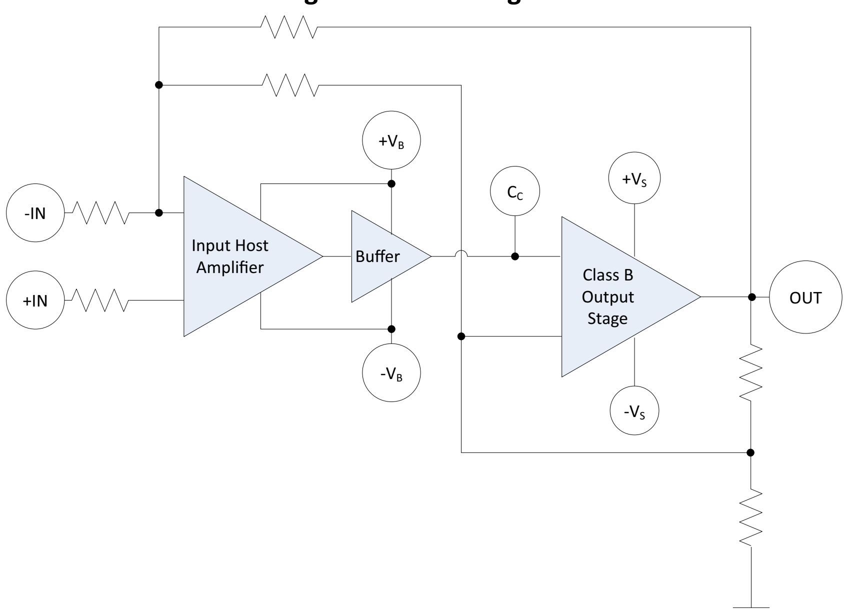
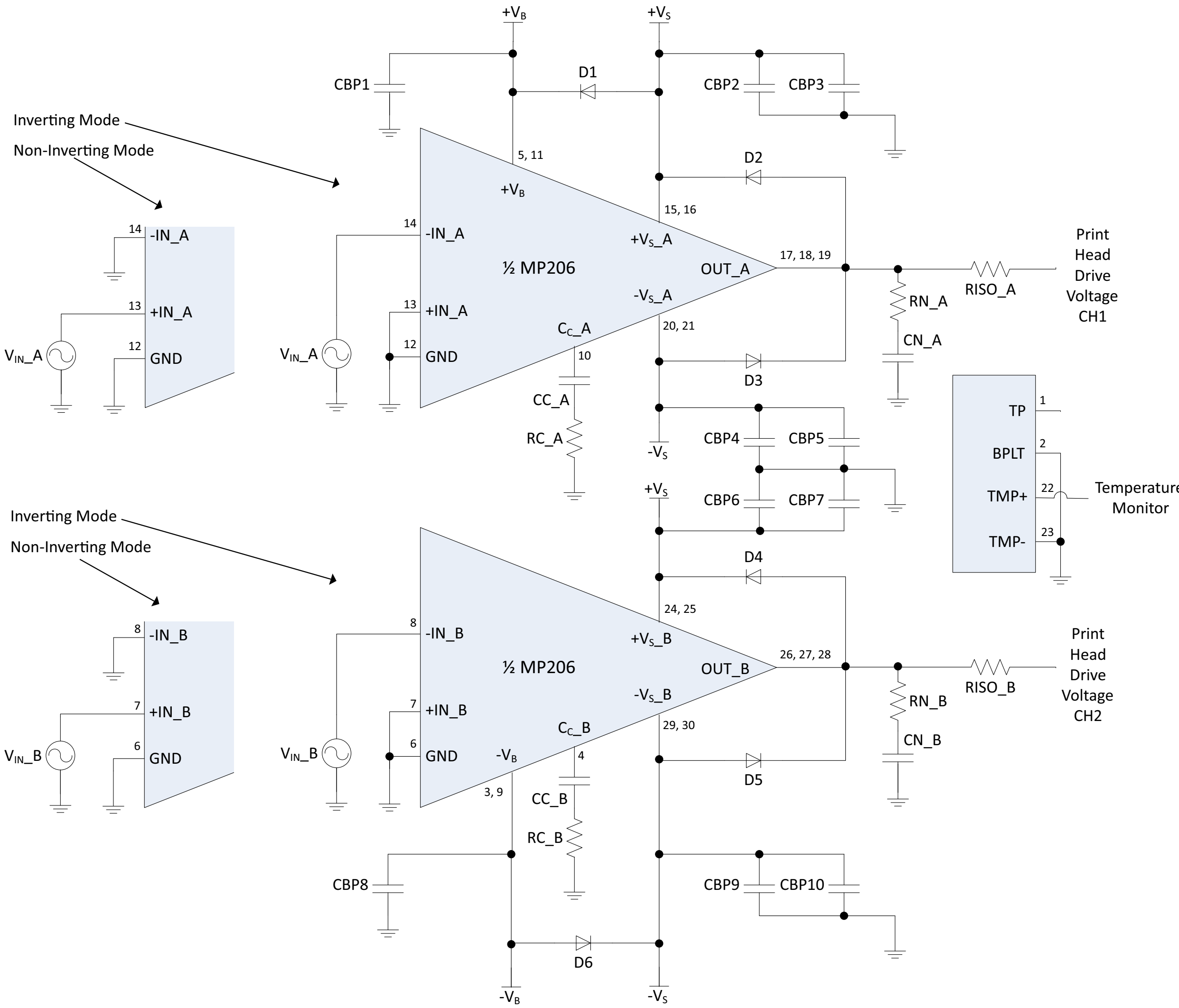


Figure 2: Typical Connection



The above components and supply voltages are application-specific. Please see the following table for suggested values. Note that these values may be altered (within the Absolute Maximum Ratings of the MP206) for special applications.

SUGGESTED CIRCUIT VALUES FOR VARIOUS PRINTHEADS

Print Head	Positive Pulse Printheads	Negative Pulse Printheads (Samba G3L and GMA series)
Mode	Non-Inverting	Inverting
+VB	40 to 58V (5W capability)	18V (2W capability)
-VB	-18V (2W capability)	-40 to -58V (5W capability)
+VS	40V (100W capability)	0 (Ground)
-VS	0 (Ground)	-40V (100W capability)
CBP1, 8	1µF, X7R, 100V	1µF, X7R, 100V
CBP2, 6	1µF, X7R, 100V	DNP
CBP3, 7	220µF, ELEC, 100V	DNP
CBP4, 9	DNP	1µF, X7R, 100V
CBP5, 10	DNP	220µF, ELEC, 100V
D1, 6	MUR140	MUR140
D2, 3, 4, 5	MUR420	MUR420
CC_A, CC_B	150pF, COG, 100V	150pF, COG, 100V
RC_A, RC_B	750 Ω, 1/8 W	750 Ω, 1/8W
CN_A, CN_B	22nF, X7R, 100V	22nF, X7R, 100V
RN_A, RN_B	5 Ω, 1/8W	5 Ω, 1/8W
RISO_A, RISO_B	0.2 Ω, 2W	0.2 Ω, 5W

Legend:

X7R	Ceramic capacitor with temperature stability rating of X7R or better
DNP	Do not populate
ELEC	Electrolytic capacitor
COG	Ceramic capacitor with temperature stability rating of COG or better

Figure 3: Example Non-Inverting Schematic (One Channel)

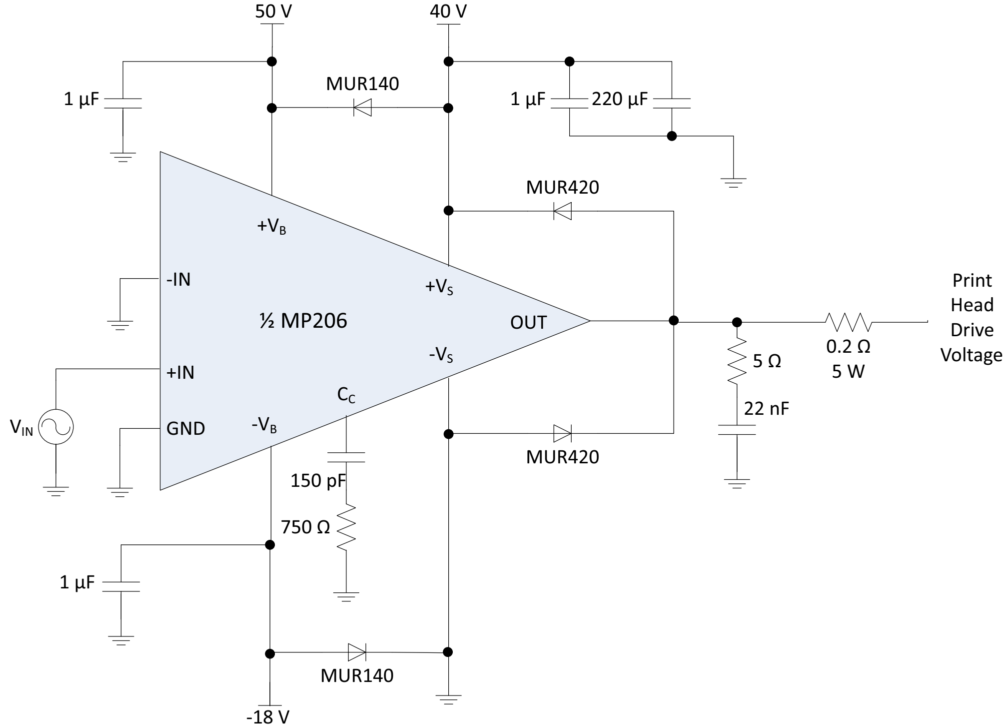
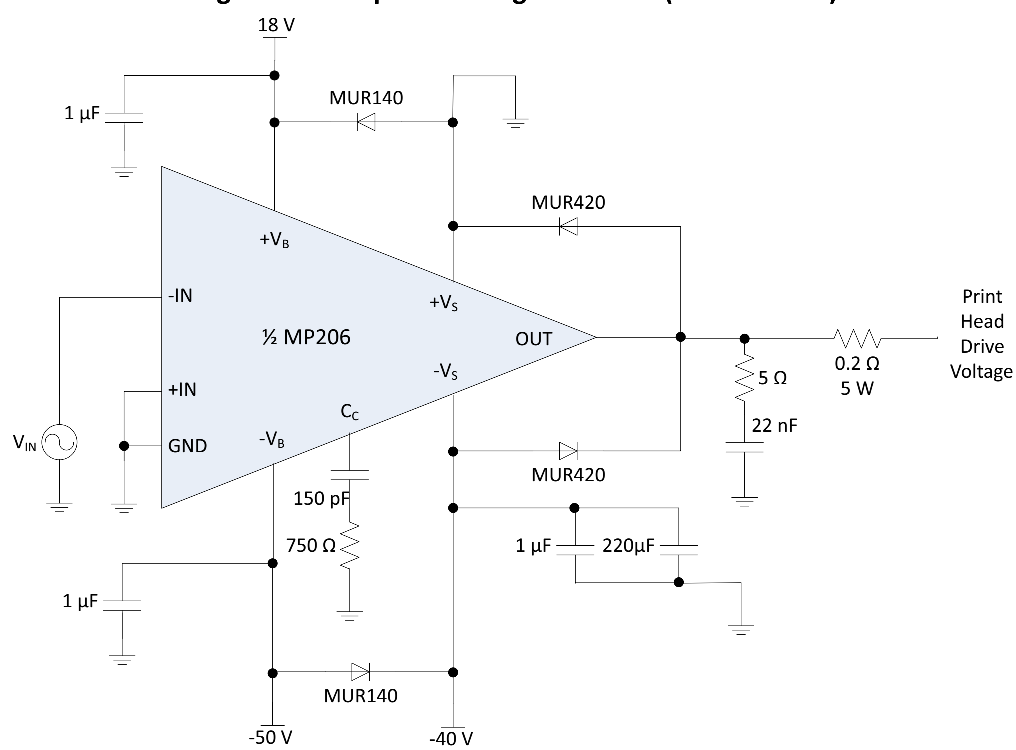
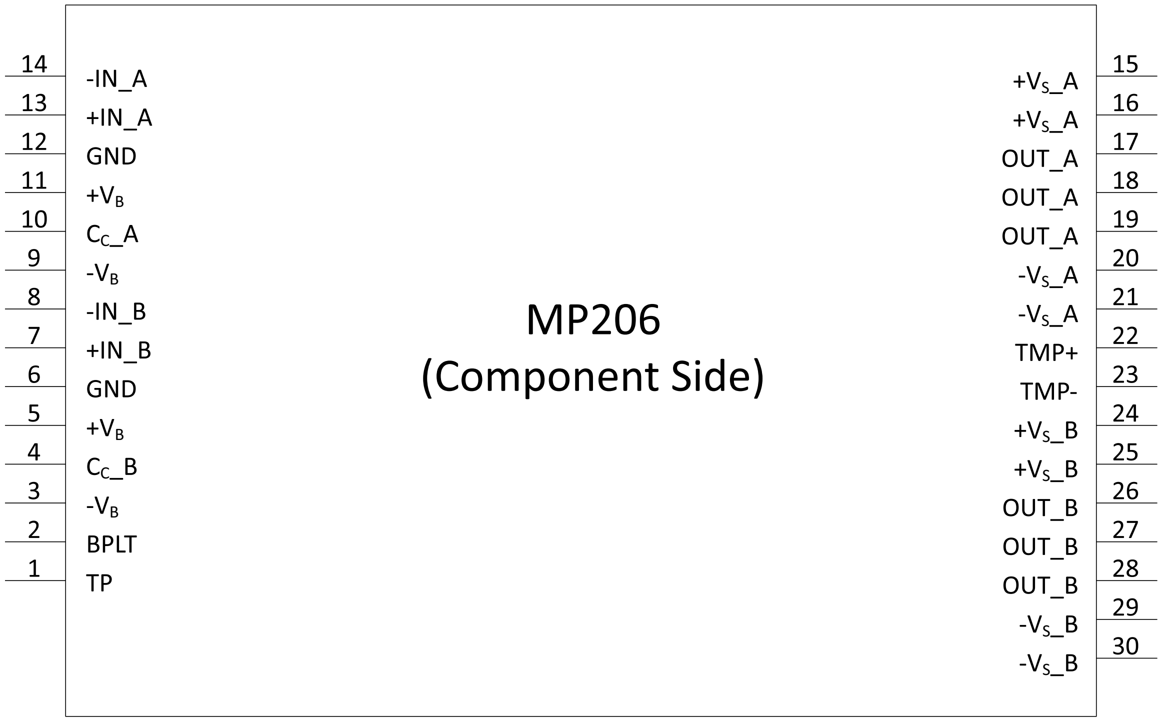


Figure 4: Example Inverting Schematic (One Channel)



PINOUT AND DESCRIPTION TABLE

Figure 5: Pinout Diagram



Pin	I/O	Description
1	TP	Apex test point. No connection.
2	BPLT	AC coupling to backplate. Connect to signal ground.
3, 9	$-V_B$	The negative boost supply rail. Short to $-V_S$ if unused. See application section. Both $-V_B$ pins must be connected, even if only one channel is in use.
4	C_C_B	Compensation capacitor connection for channel B. Select value based on specific Print Head. See applicable section.
5, 11	$+V_B$	The positive boost supply rail. Short to $+V_S$ if unused. See applicable section. Both $+V_B$ pins must be connected, even if only one channel is in use.
6, 12	GND	Ground. Pins 6 and 12 are not connected on the unit. Connect both pins to system signal ground.
7	+IN_B	The non-inverting input for channel B.
8	-IN_B	The inverting input for channel B.
10	C_C_A	Compensation capacitor connection for channel A. Select value based on specific Print Head. See applicable section.
13	+IN_A	The non-inverting input for channel A.
14	-IN_A	The inverting input for channel A.
15, 16	$+V_S$_A	The positive supply rail for channel A.
17, 18, 19	OUT_A	The output for channel A. Connect to the Print Head drive voltage pins.
20, 21	$-V_S$_A	The negative supply rail for channel A.
22	TMP+	Case temperature sensor positive node. This node will output a voltage directly proportional to absolute temperature. See Temperature Sensing section below for transfer equation.
23	TMP-	Case temperature sensor negative node. Connect to ground.
24, 25	$+V_S$_B	The positive supply rail for channel B.
26, 27, 28	OUT_B	The output for channel B. Connect to the Print Head drive voltage pins.
29, 30	$-V_S$_B	The negative supply rail for channel B.

SPECIFICATIONS

Unless otherwise noted: T_C = 25°C. DC input specifications are ± value given. Power supply voltage is typical rating. $\pm V_B = \pm V_S$. C_C = 150pF, R_C = 750 Ω, C_N = 22nF, R_N = 5 Ω, R_{ISO} = 0.2 Ω.

ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Min	Max	Unit
Total Supply Voltage	$+V_S$ to $-V_S$		60	V
Total Boost Supply Voltage	$+V_B$ to $-V_B$		90	V
Positive Boost Supply	$+V_B$	$+V_S$-0.6	$+V_S$+20	V
Negative Boost Supply	$-V_B$	$-V_S$-20	$-V_S$+0.6	V
Output Current, Peak, per Channel	I_{OUT}		21	A
Power Dissipation, per channel	P_D		70	W
Input Voltage	V_{IN}	-0.5	+5.0	V
Temperature, pin solder, 10s			225	°C
Temperature, junction [1]	T_J		175	°C
Temperature, storage		-40	105	°C
Operating Temperature Range, case	T_C	-40	+85	°C

1. 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	Unit
Input Voltage, V_{IN}	Non-Inverting mode	0		3.0	V
Input Voltage, V_{IN}	Inverting Mode	0		4.0	V
Offset Voltage		0	6	10	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 Impedance, inverting			2		kΩ
Input Impedance, non-inverting			160		MΩ
Input Capacitance			3		pF
Noise, referred to input	f = 10 kHz		13		nV/√Hz

GAIN

Parameter	Test Conditions	Min	Typ	Max	Unit
Inverting Gain, $-A_V$	Inverting mode	-15.85	-15.70	-15.55	V/V
Non-Inverting Gain, $+A_V$	Non-Inverting mode	19.70	19.85	20.0	V/V
Gain Bandwidth Product, 1 MHz			20		MHz
Power Bandwidth	$V_{OUT} = 40V_{P-P}$ sine, Load = 1 kΩ	300			kHz

OUTPUT

Parameter	Test Conditions	Min	Typ	Max	Unit
Output Voltage Swing, w/ Boost	I_{OUT}=10A, $\|V_B\| = \|V_S\| + 10V$	$+V_S-1$			V
Output Voltage Swing, w/ Boost	I_{OUT}=-10A, $\|V_B\| = \|V_S\| + 10V$			$-V_S+2$	V
Output Voltage Swing, w/o Boost	I_{OUT}=10A, $\|V_B\| = \|V_S\|$	$+V_S-5$			V
Output Voltage Swing, w/o Boost	I_{OUT}=10A, $\|V_B\| = \|V_S\|$			$-V_S+5$	V
Current, continuous, per channel		10		15	A
Current, peak, per channel	240 kHz, 40% Duty Cycle			21	A
Slew Rate	Non-Inverting, Load=180nF + 0.5 Ω, 40V pulse	90	97		V/µs
Slew Rate	Inverting mode, Load = 270 nF + 0.5 Ω, 40V pulse	75	82		V/µs

POWER SUPPLY

Parameter	Test Conditions	Min	Typ	Max	Unit
Supply Voltage, $+V_S$	$-V_S = 0V$	15	48	60	V
Supply Voltage, $-V_S$	$+V_S = 0V$	-60	-48	-15	V
Supply Voltage, $+V_B$ [1]		$+V_S$		$+V_S+20$	V
Supply Voltage, $-V_B$ [1]		$-V_S-20$		$-V_S$	V
Quiescent Current, $+V_S$ to $-V_S$ [2]			0		mA
Quiescent Current, $+V_B$ to $-V_B$			36	50	mA

1. For proper operation, $\pm V_B$ must be at least ±18V, respectively. In addition, the voltages at $\pm V_B$ must not be lower in magnitude than their respective $\pm V_S$ voltage.
2. In addition to quiescent current, $+V_S$ and $-V_S$ will carry all load current. Be sure to select power supply and PCB trace widths accordingly.

THERMAL

Parameter	Test Conditions	Min	Typ	Max	Unit
Resistance, AC, Junction to Case	2 channels loaded		0.5		°C/W
Resistance, DC, Junction to Case	f < 60 Hz, 2 channels loaded			2.1	°C/W
Resistance, Junction to Air			13		°C/W
Temperature Range, Case		-40		85	°C

TEMPERATURE SENSOR

Parameter	Test Conditions	Min	Typ	Max	Unit
Temperature Accuracy	T_C = -40°C to 85°C			±1	°C

TYPICAL PERFORMANCE GRAPHS

Figure 6: Closed Loop Gain vs. Frequency

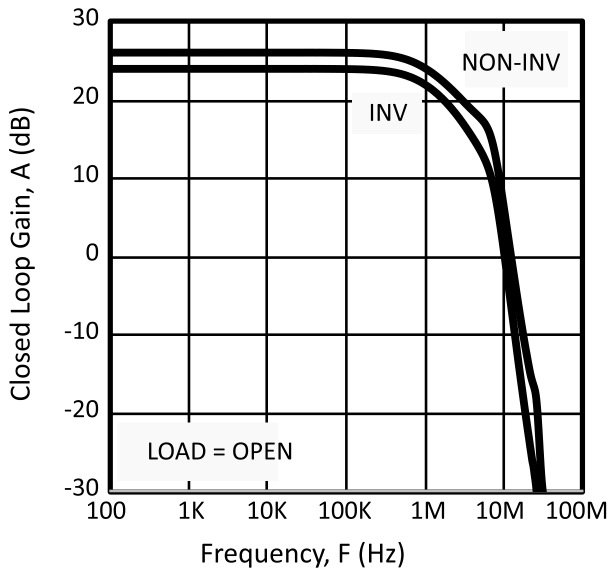


Figure 7: Closed Loop Phase vs. Frequency

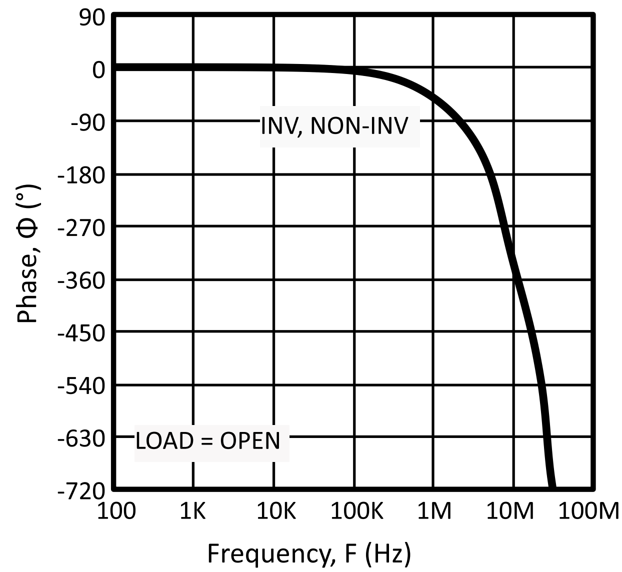


Figure 8: Power Derating

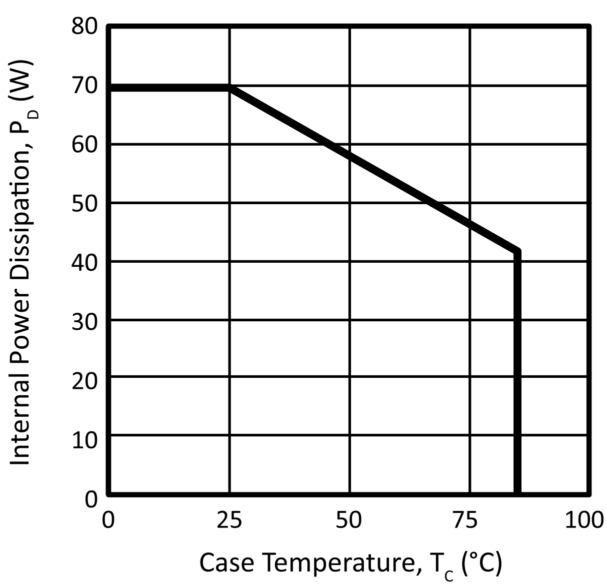


Figure 9: Slew Rate vs Output Voltage

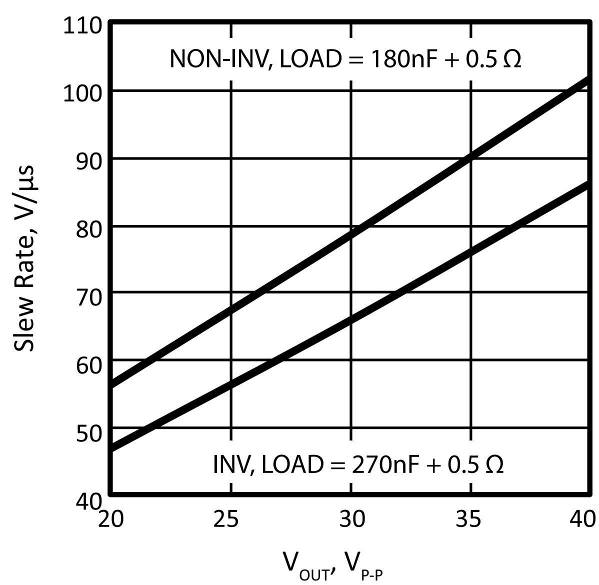


Figure 10: Voltage Drop, $V_B = V_S$

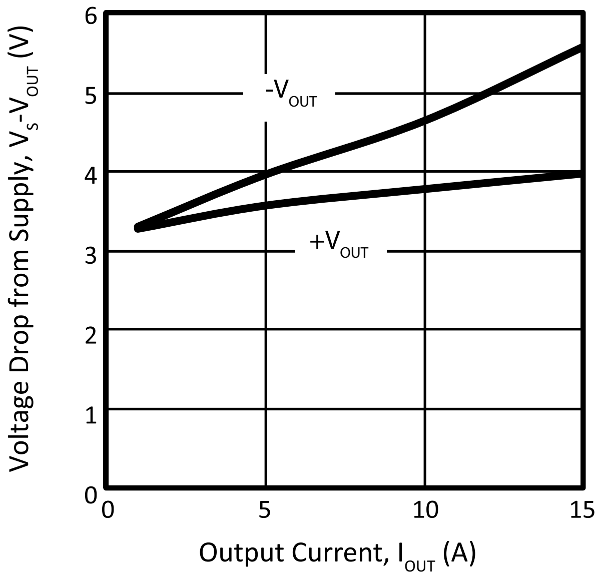


Figure 11: Voltage Drop, $\pm V_B = \pm V_S \pm 18V$

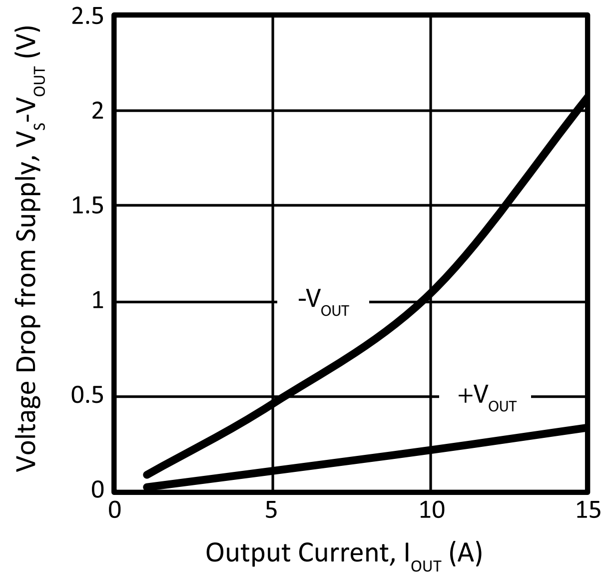


Figure 12: Pulse Response, Non-Inverting

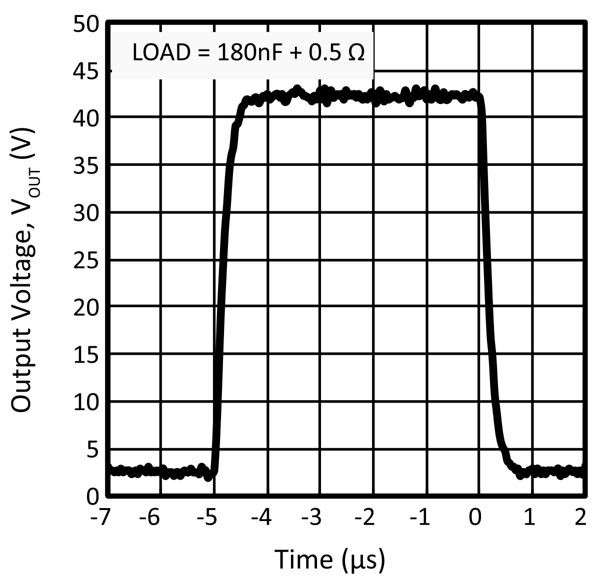
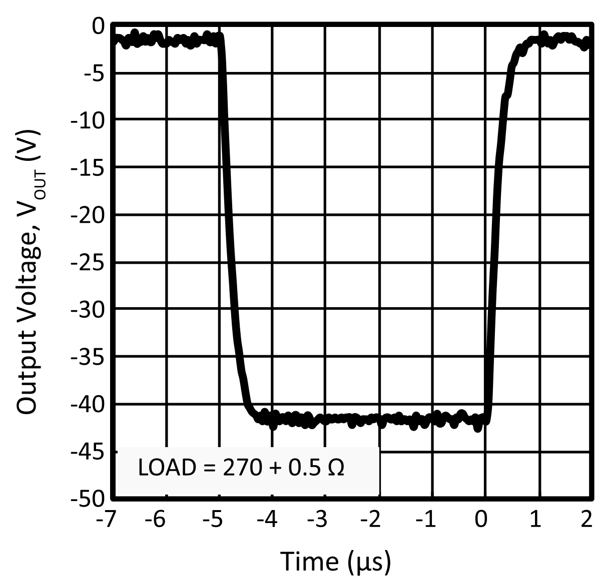


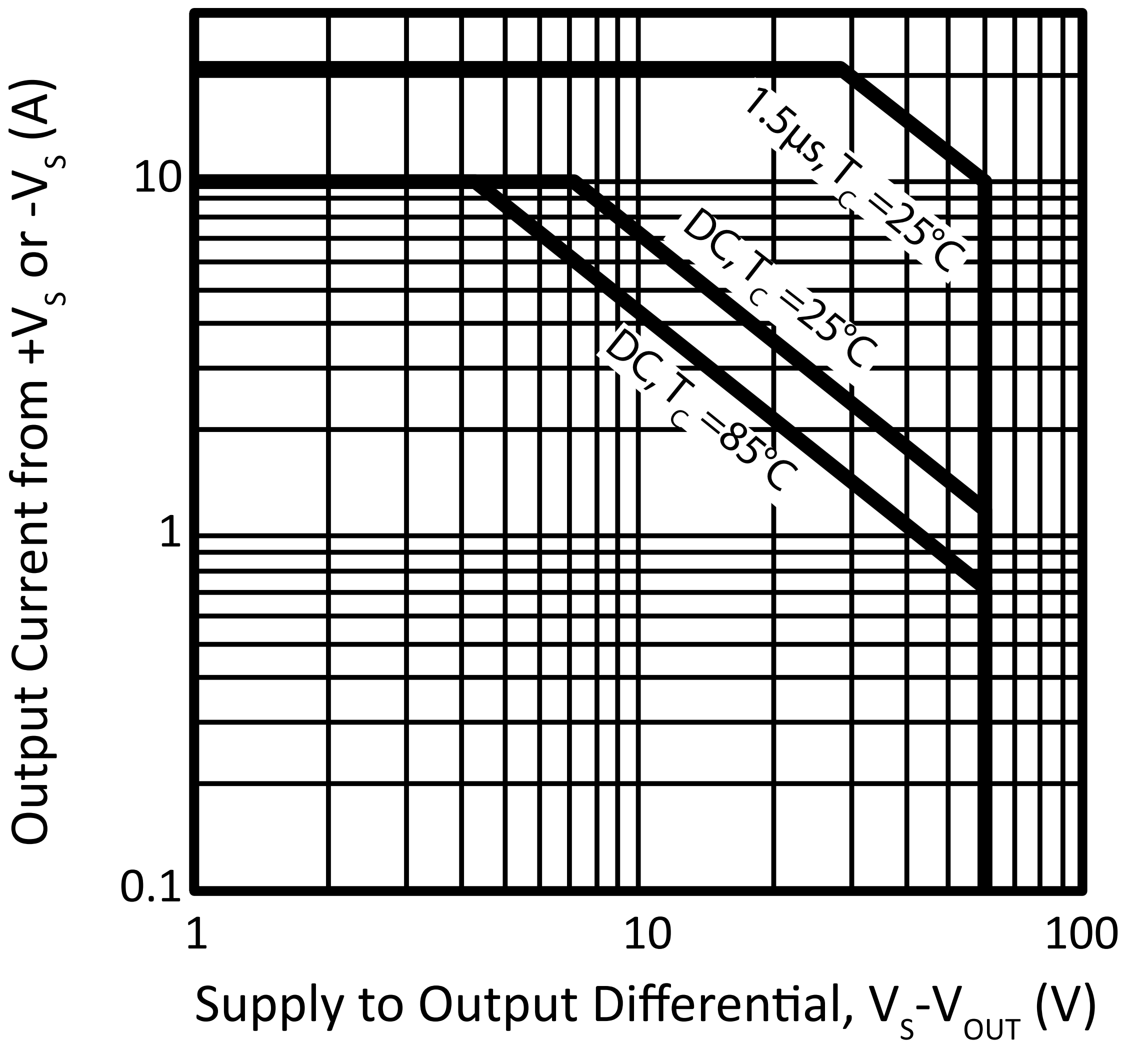
Figure 13: Pulse Response, Inverting



SAFE OPERATING AREA

The MOSFET output stage of the MP206 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 reverse-recovery diodes must be used.

Figure 14: Safe Operating Area (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 for Apex Microtechnology's complete Application Notes library, Technical Seminar Workbook, and Evaluation Kits.

BOOST SUPPLIES

Boost supplies are an optional feature that allows the output stage to swing closer to $\pm V_S$. This works by powering the input stage of the amplifier with higher supply voltages (requiring much lower current), therefore driving the output MOSFETs deeper into the triode region. This allows MP206 to output close to 0V, even when one of the $\pm V_S$ supplies is simply grounded. This also allows for more efficient operation in the amplifier, as a lower V_S voltage magnitude may be used when boost supplies are enabled.

To use boost supplies, the designer has the choice to connect $\pm V_B$ to:

1. Fixed, high-voltage low-current supplies referenced to ground, or
2. Floating, low-voltage low-current supplies referenced to $\pm V_S$.

In either case, the recommended power supply sequencing should follow a profile as shown below:

Figure 15: Example Power Supply Sequence Profile for Boost Supplies (Non Inverting)

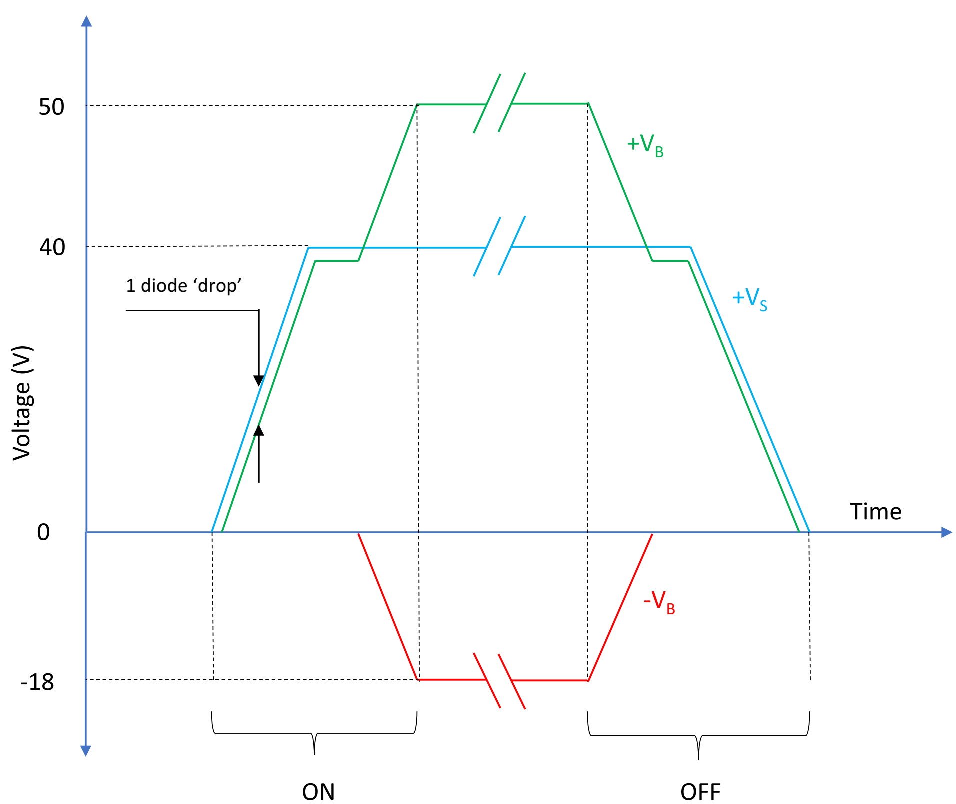
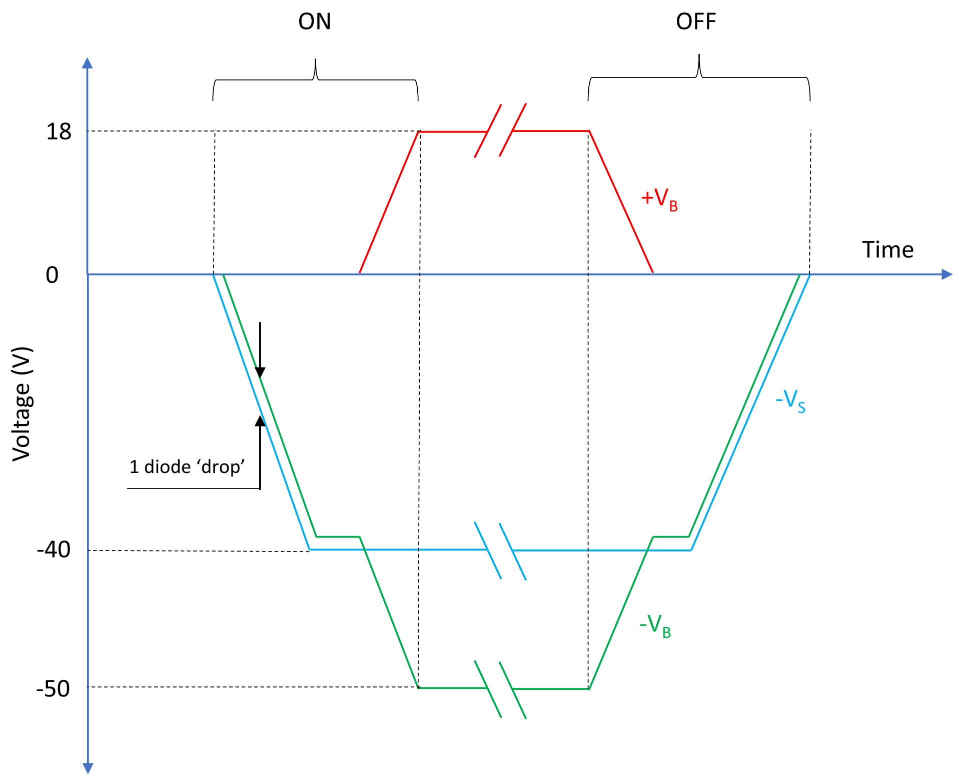


Figure 16: Example Power Supply Sequence Profile for Boost Supplies (Inverting)



The 1 diode 'drop' is satisfied by D1 and D6 in the typical connection. If one of the $\pm V_S$ supplies is ground, ramp the corresponding $\pm V_B$ supply simultaneously with the opposite $\pm V_B$ supply.

If boost supplies are not desired, connect $+V_B$ to $+V_S$ and $-V_B$ to $-V_S$.

POWER SUPPLY BYPASSING

Bypass capacitors to power supply terminals $\pm V_S$ must be connected physically close to the pins to prevent local parasitic oscillation in the output stage of the MP206. Use electrolytic capacitors at least 10µF per Ampere of output current required. Bypass the electrolytic capacitors with high quality ceramic capacitors (X7R) 0.1µF or greater. Bypass capacitors are not required for a supply that is directly connected to ground. A bypass capacitor of 0.1µF or greater is recommended for the $+V_B$ and $-V_B$ terminals. See Typical Connection.

POWER SUPPLY PROTECTION

Unidirectional Transient Voltage Suppressor (TVS) diodes are recommended as protection on the supply pins. These diodes clamp transients to voltages within the power supply rating and clamp power supply reversals to ground. Whether the diodes 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 are 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.

COMPENSATION

When using MP206 with large capacitive loads (such as that presented by a Print Head when all nozzles are driven), compensation techniques are needed to keep the amplifier stable. This is accomplished by a combination of a compensation capacitor/resistor (C_C and R_C), a snubber circuit (C_N and R_N), and an isolation resistor (R_{ISO}). Use the recommended values presented in the “Suggested Circuit Values for Various Print Heads” table for best performance.

TEMPERATURE SENSING

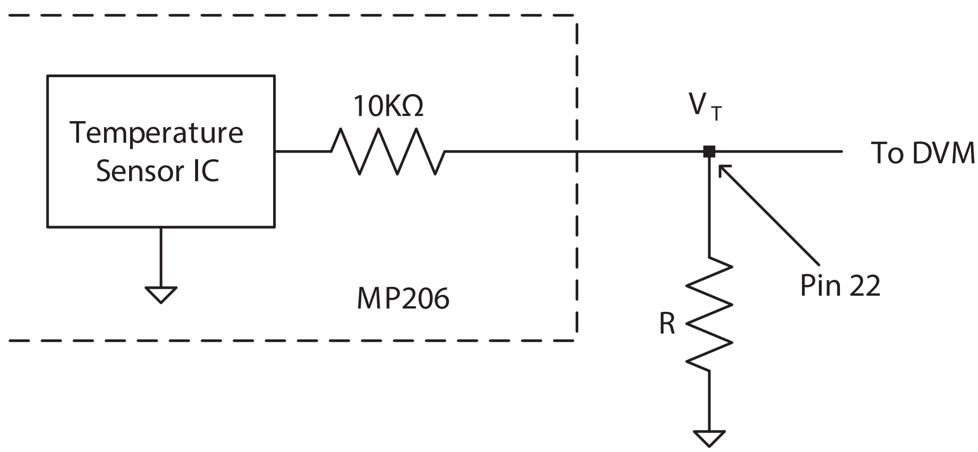
The MP206 contains an IC temperature sensor, located near the output MOSFETs. Temperature can be derived using the following equation:

$$T[°C] = \frac{V_{TEMP}}{10\frac{mV}{°C}} - 273°C$$

The scale factor of the sensor can be adjusted by connecting an optional resistor “R” (refer Fig 17) to TMP+ pin using the following equation:

$$T[°C] = \frac{V_{TEMP}}{\frac{R}{R + 10k\Omega}10\frac{mV}{°C}} - 273°C$$

Figure 17: Temperature Sensor



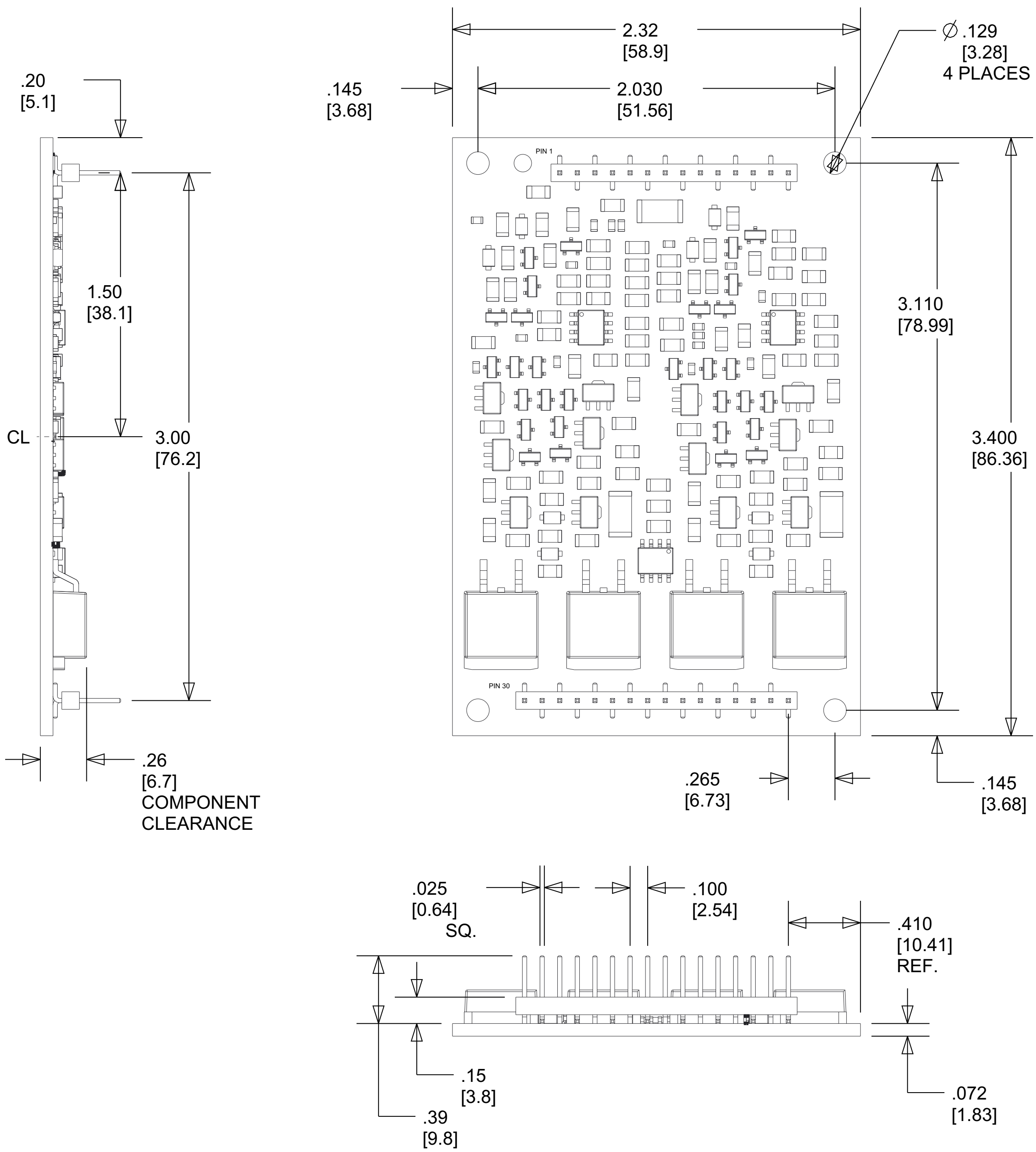
FULL LOADING

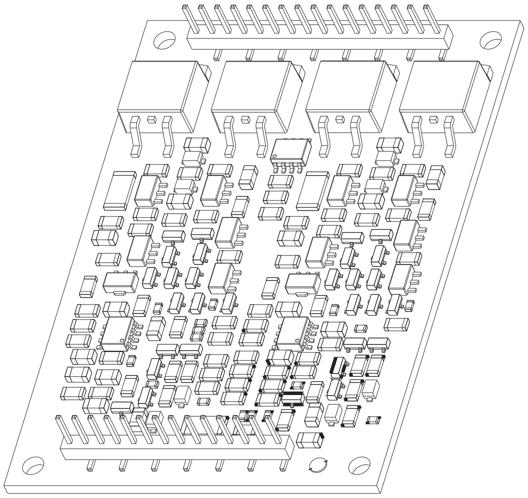
Consider the Safe Operating Area and Power Dissipation to ensure safe operation during all printing processes. Note that there is no current limit nor automatic temperature shutdown; the MP206 may permanently fail if the safe operating area is violated.

PACKAGE OPTIONS

Part Number	Apex Package Style	Description
MP206	KP	30-pin Open Frame

PACKAGE STYLE KP





NOTES:
1. Dimensions are in inches [mm].
2. Recommended PCB hole diameter for pins: 0.050 [1.27].
4. 2oz. copper over 600V dielectric over aluminum substrate.
5. Tin over nickel plated phospher bronze pins.
6. It is not recommended that mounting of the package rely on the pins for mechanical support.
7. Use #4 or equivalent screws to mount to heat sink.
8. Package Weight: 35 grams.

NEED TECHNICAL HELP? CONTACT APEX SUPPORT!

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