



M.S.KENNEDY CORP.

**DUAL HIGH VOLTAGE/  
VERY HIGH CURRENT  
OPERATIONAL AMPLIFIER**

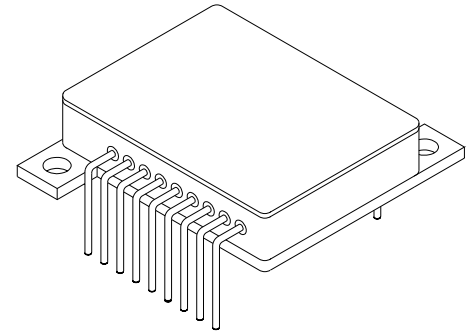
**186**

4707 Dey Road Liverpool, N.Y. 13088

(315) 701-6751

**FEATURES:**

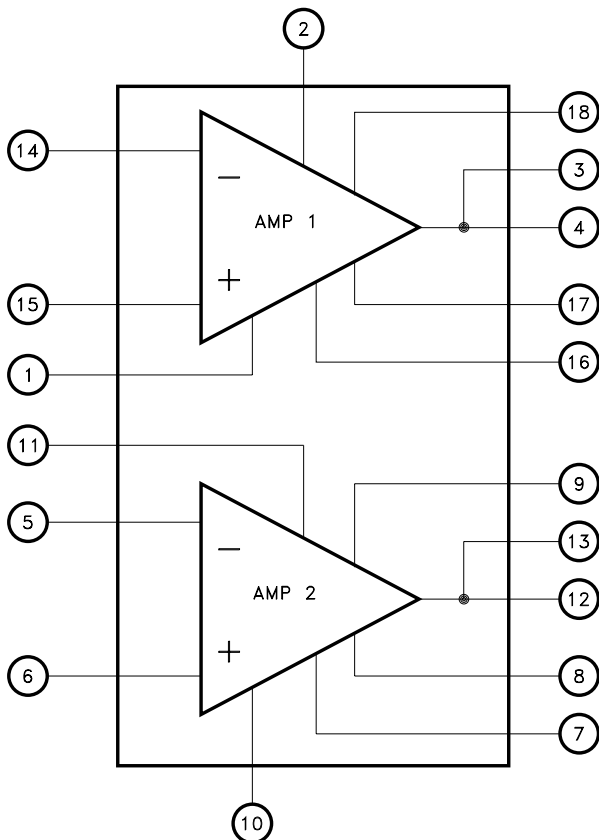
- Space Efficient Dual Amplifier
- High Voltage Operation:  
Single Supply: +8V to +60V  
Dual Supply: ±4V to ±30V
- High Output Current: 8 Amp Continuous Per Amplifier
- High Speed: 9V/μS
- Low Quiescent Current: 26 mA Per Amplifier Typ.
- Adjustable Current Limits
- Thermal Shutdown
- Enable/Status Pin For Output Disable Control
- Available with Three Lead Form Configurations
- Contact MSK for MIL-PRF-38534 Qualification Status



**DESCRIPTION:**

The MSK 186 is a dual high power operational amplifier ideal for use with a wide variety of loads. With operation from either single or dual supplies, it offers excellent design flexibility. Power dissipation is kept to a minimum with a quiescent current rating of only 26mA per amplifier, while 8 Amps of continuous available output current makes it a very good low cost choice for motor drive circuits and audio amplification. The design is internally protected against current overloads and overtemperature conditions. The current limit can also be user-selected through the use of a resistor/potentiometer or voltage out/current out DAC. The MSK 186 is packaged in a hermetically sealed, isolated 18 pin power DIP with bolt down tabs for applications that require heat sinking.

**EQUIVALENT SCHEMATIC**



**TYPICAL APPLICATIONS**

- Servo Driver
- Actuator Driver
- Audio Amplifier
- Power Supplies
- Bridge Amps
- Stereo Amps

**PIN-OUT INFORMATION**

1 -VCC 1	18 E/S 1
2 +VCC 1	17 ILIM 1
3 OUTPUT 1	16 VR 1
4 OUTPUT 2	15 +VIN 1
5 -VIN 2	14 -VIN 1
6 +VIN 2	13 OUTPUT 2
7 VR 2	12 OUTPUT 2
8 ILIM 2	11 +VCC 2
9 E/S 2	10 -VCC 2

## ABSOLUTE MAXIMUM RATINGS

⑦

$V_{CC}$  Total Supply Voltage . . . . . 60V  
 $\pm I_{OUT}$  Peak Output Current (within S.O.A.) . . . . . 10A  
 $V_{IND}$  Input Voltage . . . . (-VCC)-0.5V to (+VCC)+0.5V  
 $V_{CM}$  Input Voltage . . . . . (-VCC)-0.1V to (+VCC)-3V  
 $T_J$  Junction Temperature . . . . . Internal Protection  
 (See Application Note)

$T_{ST}$  Storage Temperature Range . . . -65°C to +150°C  
 $T_{LD}$  Lead Temperature Range . . . . . 300°C  
 (10 seconds)  
 $T_C$  Case Operating Temperature  
 MSK186H/E . . . . . -55°C to +125°C  
 MSK186 . . . . . -25°C to +85°C  
 $R_{TH}$  Thermal Resistance (Per Amplifier)  
 Junction to Case @ 125°C . . . . . 1.2°C/W

## ELECTRICAL SPECIFICATIONS

Parameter	Test Conditions ① ②	Group A Subgroup	MSK186H/E			MSK186			Units
			Min.	Typ.	Max.	Min.	Typ.	Max.	
<b>STATIC</b>									
Supply Voltage Range ③	-V <sub>CC</sub> to +V <sub>CC</sub>	-	8	-	60	8	-	60	V
Quiescent Current (Per Amp)	$V_{IN} = 0V$	1	-	±26	±35	-	±26	±38	mA
		2,3	-	±26	±38	-	-	-	mA
Quiescent Current (Per Amp) Overcurrent or TempShutdown Mode	$V_{IN} = 0V$	-	-	±6	-	-	±6	-	mA
<b>INPUT</b>									
Input Offset Voltage	$V_{IN} = 0V$	1	-	±1	±7.5	-	±1	±10	mV
Input Offset Voltage Drift	$V_{IN} = 0V$	-	-	±20	-	-	±20	-	μV/°C
Input Bias Current ③	$V_{IN} = 0V$	1	-	±100	±500	-	±100	±750	nA
Input Offset Current ③	$V_{IN} = 0V$	1	±1	±5	±50	-	±5	±75	nA
Input Impedance	f = DC Differential	-	-	10 <sup>7</sup>	-	-	10 <sup>7</sup>	-	Ω
Input Capacitance	f = DC Differential	-	-	6	-	-	6	-	pF
Common Mode Rejection Ratio ③	(-V <sub>CC</sub> )-0.1 ≤ $V_{IN}$ ≤ (+V <sub>CC</sub> )-3V	1	80	95	-	75	95	-	dB
Input Voltage Noise Density	f = 1KHz	-	-	70	-	-	70	-	nV/√Hz
<b>OUTPUT</b>									
Output Voltage Swing	$I_{OUT} = 2.0A$ ③	4	±26.5	±27.5	-	±26.5	±27.5	-	V
	$I_{OUT} = 8.0A$	4	±25	±26	-	±25	±26	-	V
Output Current ③	Continuous	4	±8	-	-	±8	-	-	A
Enable/ Shutdown Input ③	$V_{E/S}$ High- Output Enabled E/S Open or High	4	VR+24	-	-	VR+24	-	-	V
	$V_{E/S}$ Low- Output Disabled E/S Forced Low	4	-	-	VR+0.8	-	-	VR+0.8	V
	$I_{E/S}$ High- Output Enabled E/S Indicates High	-	-	-50	-	-	-50	-	μA
	$I_{E/S}$ Low- Output Disabled E/S Indicates Low	-	-	-55	-	-	-55	-	μA
Output Disable Time		-	-	1	-	-	1	-	μS
Output Enable Time		-	-	3	-	-	3	-	μS
<b>TRANSFER CHARACTERISTICS</b>									
Slew Rate	$A_V = 1$ $V_{OUT} = 50V_{p-p}$ $R_L = 4\Omega$	-	-	9	-	-	9	-	V/μS
Open Loop Voltage Gain ③	$V_{OUT} = \pm 25V$ $R_L = 1K\Omega$	4	100	110	-	100	110	-	dB
Settling Time ±0.1% ③	$A_V = -10$ 50V Step	-	-	20	-	-	20	-	μS

### NOTES:

- ① Unless otherwise specified  $\pm V_{CC} = \pm 30V_{DC}$ ,  $V_R = 0V$  and E/S Pin is open.
- ② All electrical specifications apply to each amplifier.
- ③ Devices shall be capable of meeting the parameter, but need not to be tested. Typical parameters are for reference only.
- ④ Industrial grade and 'E' suffix devices shall be tested to subgroups 1 and 4 unless otherwise specified.
- ⑤ Military grade devices ('H' suffix) shall be 100% tested to subgroups 1,2,3 and 4.
- ⑥ Subgroup 1,4  $T_A = T_C = +25^\circ C$   
 Subgroup 2  $T_A = T_C = +125^\circ C$   
 Subgroup 3  $T_A = T_C = -55^\circ C$
- ⑦ Continuous operation at or above absolute maximum ratings may adversely effect the device performance and/or life cycle.

## APPLICATION NOTES

### POWER SUPPLIES:

For the MSK 186 maximum total supply voltage is specified as 60V. However, dual and unbalanced power supply operation is permissible as long as total supply voltage does not exceed 60V.

### POWER SUPPLY BYPASSING:

Power supply terminals must be effectively decoupled with a high and low frequency bypass circuit to avoid power supply induced oscillation. An effective decoupling scheme consists of a 0.1 $\mu$ F ceramic capacitor in parallel with a 10 $\mu$ F tantalum capacitor for each power supply pin to ground. In addition, it is recommended that a 0.01 $\mu$ F capacitor be placed between  $\pm V_{CC}$  as close to the amplifiers as possible.

### CURRENT LIMIT:

The MSK 186 offers accurate, user-selectable current limit. Unlike typical designs that use a power resistor in series with the output to sense load, the MSK 186 senses the load indirectly and therefore does not require a resistor to handle the full output current. Current limit is selected by controlling the input to the I<sub>LIM</sub> pin (0 to 633 $\mu$ A).

The easiest method is to use a resistor or potentiometer connected between VR and the I<sub>LIM</sub> pin. Use the following equation to select proper resistor value:

$$R_{CL} = \frac{75,000}{I_{LIM}} - 7.5K\Omega$$

A low level control signal (0-633 $\mu$ A) can also be used to control the current level digitally. If the pin is left open, the current is programmed to OA, while connecting I<sub>LIM</sub> directly to VR sets the output current to it's maximum, typically 10A.

### SAFE OPERATING AREA:

The safe operating area curve is a graphical representation of the power handling capability of the amplifier under various conditions. Power dissipation of the device is equal to the product of the voltage across the output transistor times the output current. As can be seen in the curve on page 5, safe operating current decreases with an increase in temperature as well as an increase in the voltage across the output transistor. Therefore, for maximum amplifier performance it is important to keep case temperature as low as possible and to keep  $\pm V_{CC}$  as close to the output rail as achievable.

### VR PIN

The MSK 186 features a reference (VR) pin to which the I<sub>LIM</sub> and the E/S pin are referred. VR simply provides a reference point accessible to the user that can be set to V<sub>-</sub>, ground, or any reference of the user's choice. VR cannot be set below the negative supply or above (V<sub>+</sub>)-8V. If the minimum V<sub>s</sub> is used, VR must be set at V<sub>-</sub>.

### COMPENSATION:

For normal operation output compensation is not typically required. However, if the MSK 186 is intended to be driven into current limit the user may find that an R/C network is required. A snubber network from the output to ground for each amplifier will provide stability. If driving large capacitive or inductive loads, a snubber network will also enhance stability. Typically 3 $\Omega$  to 10 $\Omega$  in series with 0.01 $\mu$ F is acceptable.

### THERMAL PROTECTION:

The amplifiers are equipped with thermal protection circuitry that protects each amplifier from damage caused by excessive junction temperature. The output is disabled when the junction temperature reaches approximately 160°C. After the junction temperature cools to approximately 140°C, the output is again enabled. The thermal protection may cycle on and off depending on the output load and signal conditions; this may have an undesirable effect on the load.

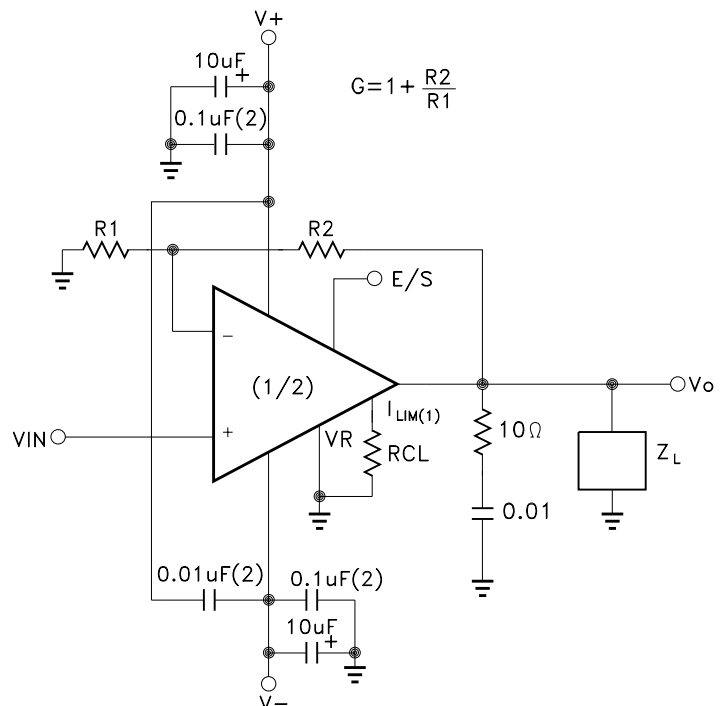
It should be noted that even though this internal protection circuitry does protect against overload conditions, it does not take the place of proper heat sinking. For reliable operation, junction temperature should be limited to 150°C, maximum.

### ENABLE/STATUS PIN:

For the MSK 186 this pin actually has a dual function. First, when the pin is forced low, the output stage is disabled. Second, it can be monitored to determine if the device is in thermal shutdown. These functions can be used on the same device with either single or dual supplies. For normal operation, the E/S pin must be left open or pulled at least 2.4 volts above the VR pin. In noisy applications, a small value capacitor between the E/S pin and VR may be required.

To disable the output, the user must pull the E/S pin low, no greater than 0.8V above VR. To once again enable the device, the E/S pin must be brought at least 2.4 volts above VR or be disconnected. It should be noted that when the E/S pin is high, the internal thermal shutdown is still active.

If the E/S pin is used to monitor thermal shutdown, during normal operation the voltage on the E/S pin is typically 3.5V above VR. Once shutdown has occurred this voltage will drop to approximately 350mV above VR.

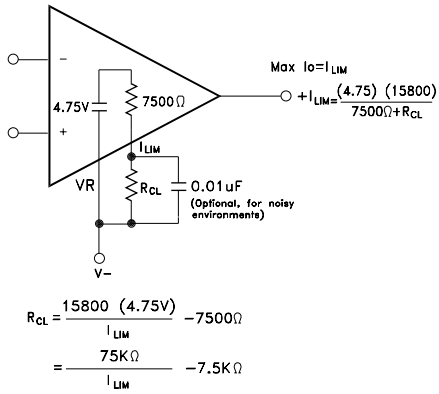


NOTE: (1) I<sub>LIM</sub> connected to VR achieves the maximum current limit, 10A(peak). (2) Connect capacitors directly to package power supply pins.

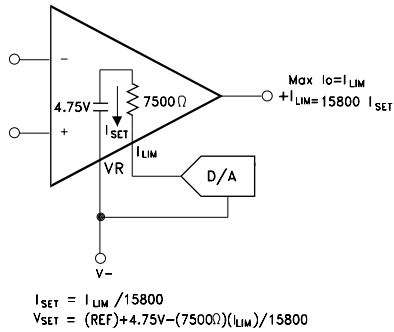
TYPICAL CONNECTION DIAGRAM

# APPLICATION NOTES cont.

## RESISTOR METHOD



## DAC METHOD (Current or voltage)



DESIRED CURRENT LIMIT	RESISTOR(1) (R <sub>CL</sub> )	CURRENT (I <sub>SET</sub> )	VOLTAGE (V <sub>SET</sub> )
0A	I <sub>LIM</sub> Open	0uA	(VR)+4.75V
2.5A	22.6KΩ	158uA	(VR)+3.56V
3A	17.4KΩ	190uA	(VR)+3.33V
4A	11.3KΩ	253uA	(VR)+2.85V
5A	7.5KΩ	316uA	(VR)+2.38V
6A	4.99KΩ	380uA	(VR)+1.90V
7A	3.24KΩ	443uA	(VR)+1.43V
8A	1.87KΩ	506uA	(VR)+0.95V
9A	845Ω	570uA	(VR)+0.48V
10A	I <sub>LIM</sub> Connected to VR	633uA	(VR)

NOTE: (1) Resistors are nearest standard 1% values.

Figure 1  
Adjustable Current Limit

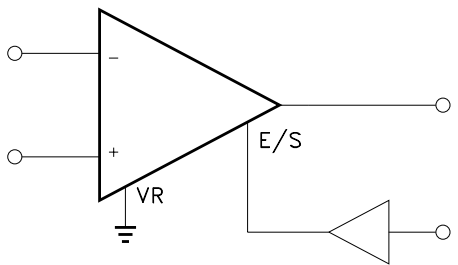


Figure 2  
Output Disable with a Single Supply

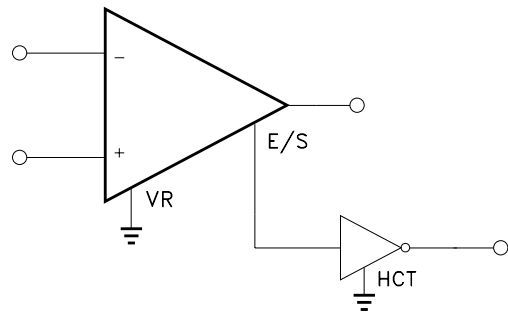


Figure 3  
Thermal Shutdown Status With a Single Supply

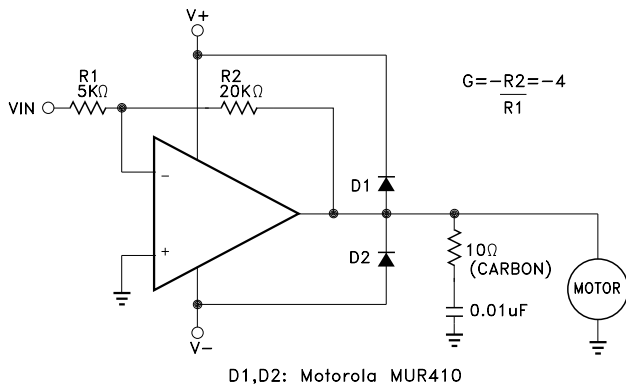


Figure 4  
Motor Drive Circuit

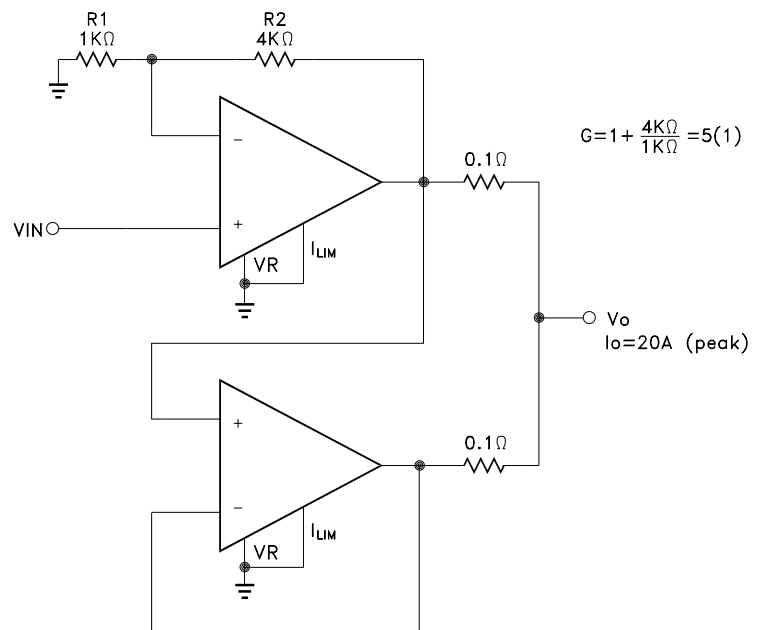
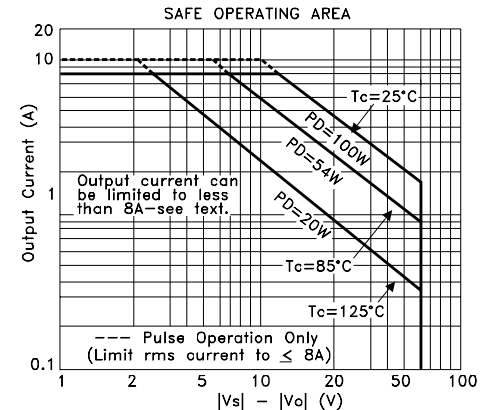
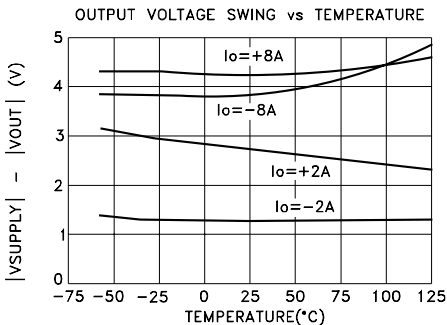
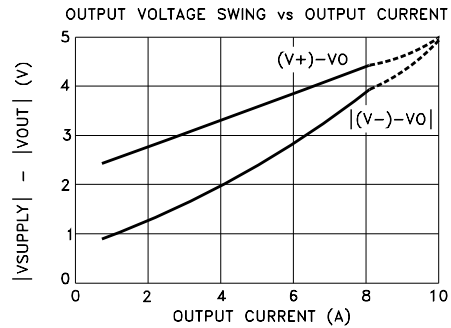
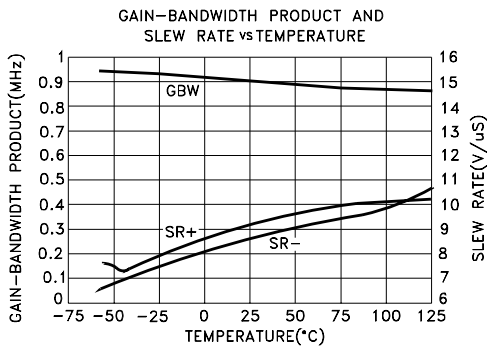
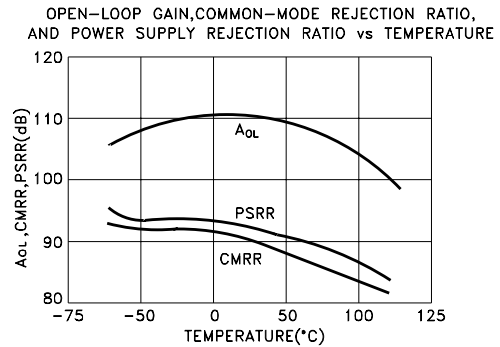
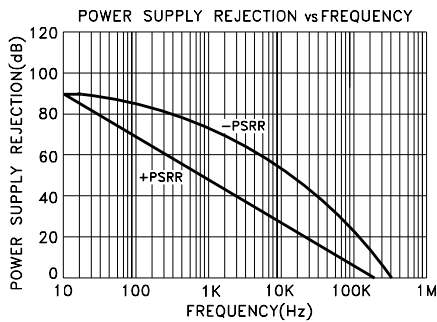
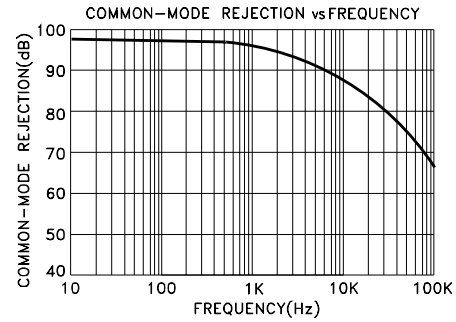
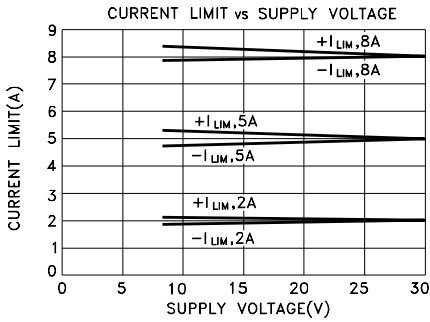
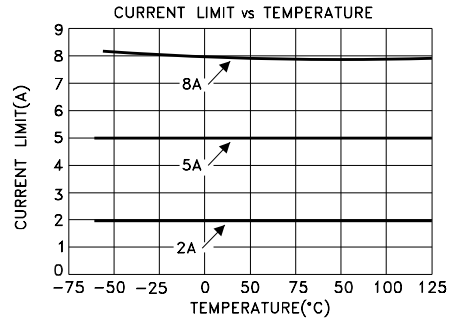
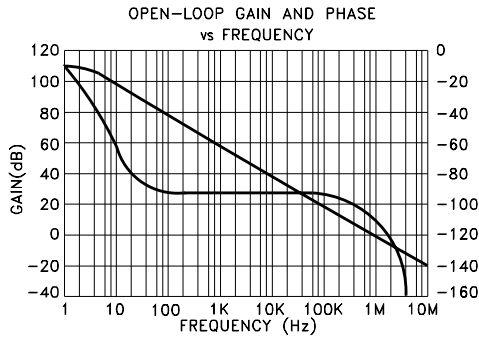
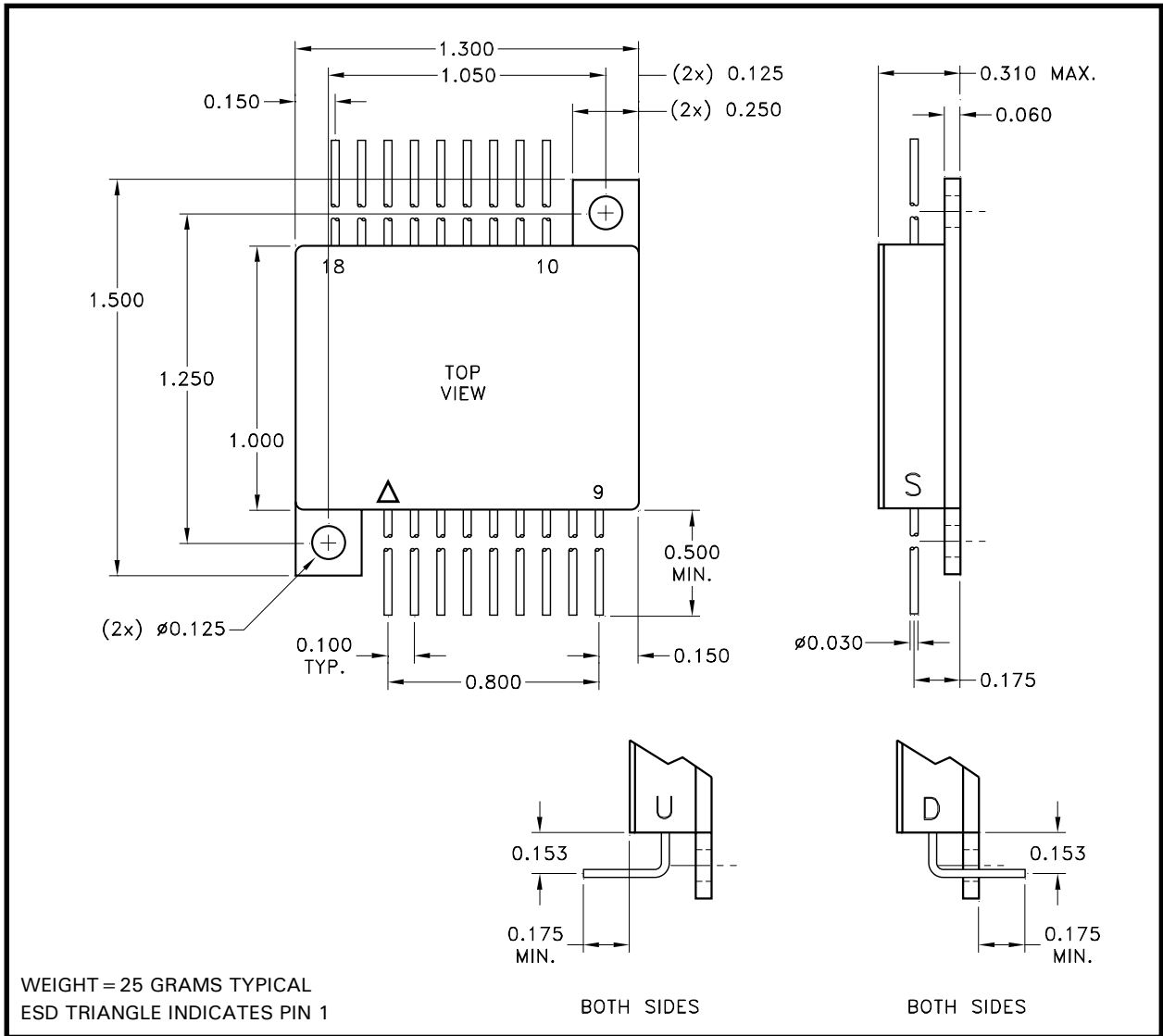


Figure 5  
Parallel Output For Increased Output Current

# TYPICAL PERFORMANCE CURVES



# MECHANICAL SPECIFICATIONS



ALL DIMENSIONS ARE  $\pm 0.010$  INCHES UNLESS OTHERWISE LABELED.

## ORDERING INFORMATION

186 H U

### LEAD CONFIGURATIONS

S = STRAIGHT; U = BENT UP; D = BENT DOWN

### SCREENING

BLANK = INDUSTRIAL; E = EXTENDED RELIABILITY

H = MIL-PRF-38534 CLASS H

### GENERAL PART NUMBER

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Please visit our website for the most recent revision of this datasheet.

Contact MSK for MIL-PRF-38534 qualification status.