MIL-PRF-38534 CERTIFIED

M.S.KENNEDY CORP.

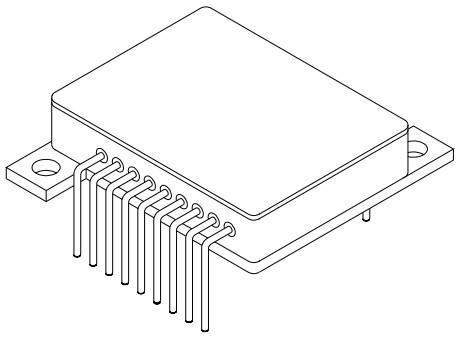
DUAL HIGH VOLTAGE/ VERY HIGH CURRENT OPERATIONAL AMPLIFIER

186

4707 Dey Road Liverpool, N.Y. 13088 (315) 701-6751

FEATURES:

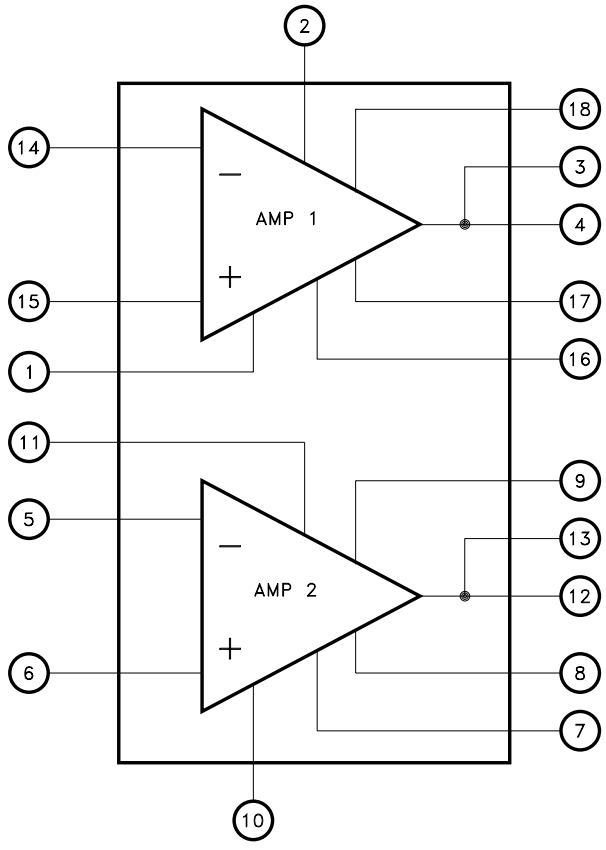
- Space Efficient Dual Amplifier
- High Voltage Operation:
  Single Supply: +8V to +60V
  Dual Supply: ±4V to ±30V
- High Output Current: 8 Amp Continuous Per Amplifier
- High Speed: 9V/μS
- Low Quiescent Current: 26 mA Per Amplifier Typ.
- Adjustable Current Limits
- Thermal Shutdown
- Enable/Status 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 Min.	MSK186H/E Typ.	MSK186H/E Max.	MSK186 Min.	MSK186 Typ.	MSK186 Max.	Units
STATIC									
Supply Voltage Range ③	-Vcc to +Vcc	-	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
INPUT									
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	-	-	10^7	-	-	10^7	-	Ω
Input Capacitance	f = DC Differential	-	-	6	-	-	6	-	pF
Common Mode Rejection Ratio ③	(-V_{CC})-0.1≤ V_{IN} ≤ (+V_{CC})-3V	1	80	95	-	75	95	-	dB
Input Voltage Noise Density	f = 1KHz	-	-	70	-	-	70	-	nV/√Hz
OUTPUT									
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+2.4	-	-	VR+2.4	-	-	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
TRANSFER CHARACTERISTICS									
Slew Rate	A_V = 1 V_{OUT} = 50Vp-p R_L = 4Ω	-	-	9	-	-	9	-	V/μS
Open Loop Voltage Gain ③	V_{OUT} = ±25V R_L = 1KΩ	4	100	110	-	100	110	-	dB
Settling Time ±0.1% ③	A_V = -10 50V Step	-	-	20	-	-	20	-	μS

NOTES:

① Unless otherwise specified ±V_{CC} = ±30VDC, 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°C
Subgroup 2 T_A = T_C = +125°C
Subgroup 3 T_A = T_C = -55°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 0.1μF ceramic capacitor in parallel with a 10μF tantalum capacitor for each power supply pin to ground. In addition, it is recommended that a 0.01μF capacitor be placed between $\pm$Vcc 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_{LIM} pin (0 to 633μA).

The easiest method is to use a resistor or potentiometer connected between VR and the I_{LIM} 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 (0-633μA) 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_{LIM} 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 $\pm$Vcc as close to the output rail as achievable.

VR PIN

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

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 3Ω to 10Ω in series with 0.01μF 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.

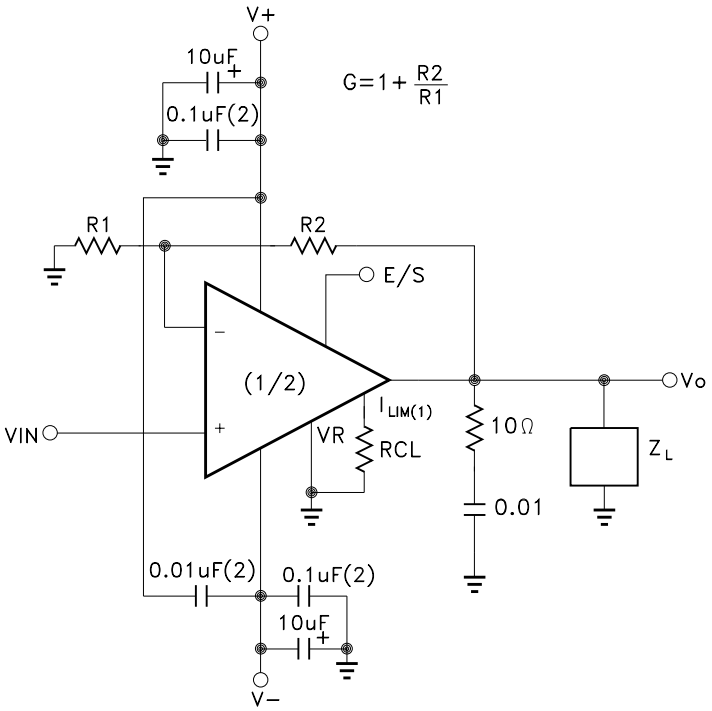
It should be noted that even though this internal protection circuitry does protect against overload conditions, it does not take the place of proper heat sinking. For reliable operation, junction temperature should be limited to 150°C, maximum.

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.

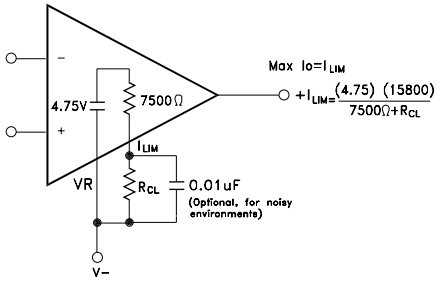


NOTE: (1) I_{LIM} connected to VR achieves the maximum current limit, 10A(peak). (2) Connect capacitors directly to package power supply pins.

TYPICAL CONNECTION DIAGRAM

APPLICATION NOTES cont.

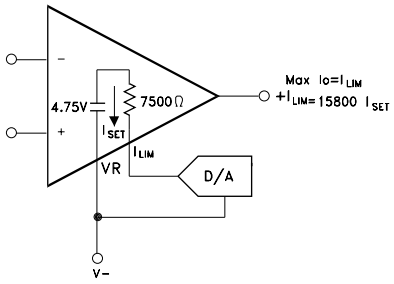
RESISTOR METHOD



$$R_{CL} = \frac{15800\ (4.75V)}{I_{LIM}} - 7500\Omega$$

$$= \frac{75K\Omega}{I_{LIM}} - 7.5K\Omega$$

DAC METHOD (Current or voltage)



$I_{SET} = I_{LIM} / 15800$

$V_{SET} = (REF) + 4.75V - (7500\Omega)(I_{LIM}) / 15800$

DESIRED CURRENT LIMIT	RESISTOR(1) (R_{CL})	CURRENT (I_{SET})	VOLTAGE (V_{SET})
0A	I_{LIM} 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_{LIM} Connected to VR	633uA	(VR)

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

Figure 1
Adjustable Current Limit

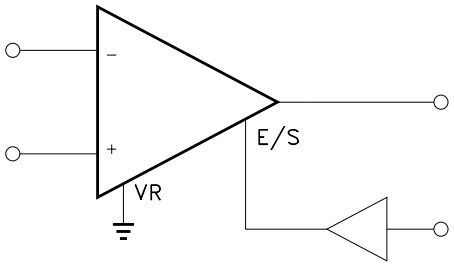


Figure 2
Output Disable with a Single Supply

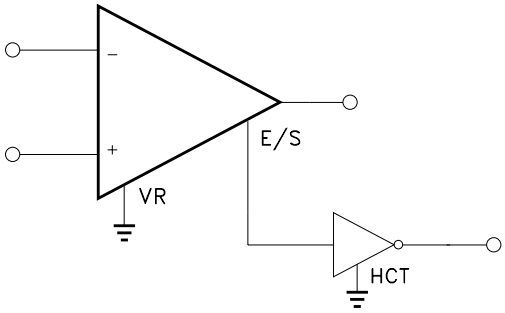


Figure 3
Thermal Shutdown Status With a Single Supply

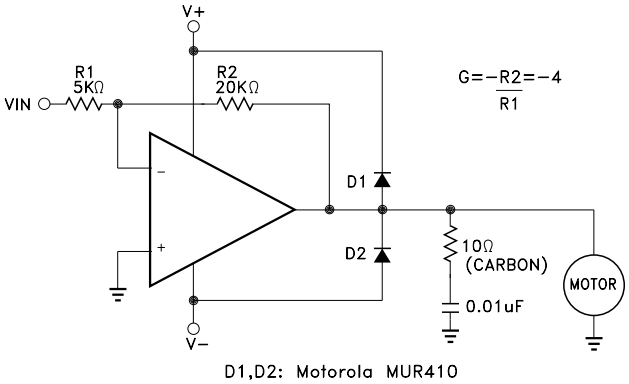


Figure 4
Motor Drive Circuit

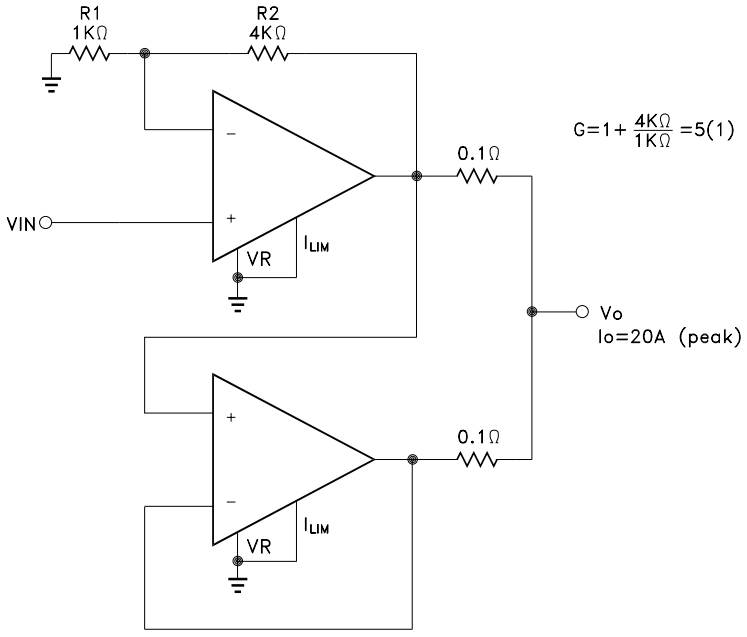
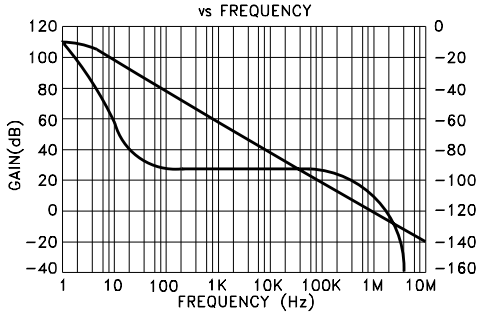


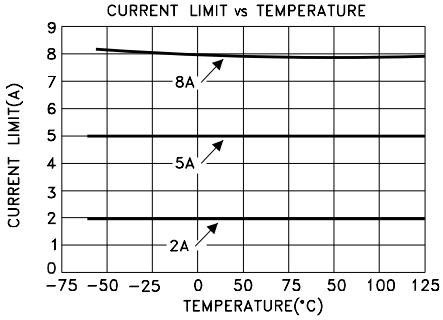
Figure 5
Parallel Output For Increased Output Current

TYPICAL PERFORMANCE CURVES

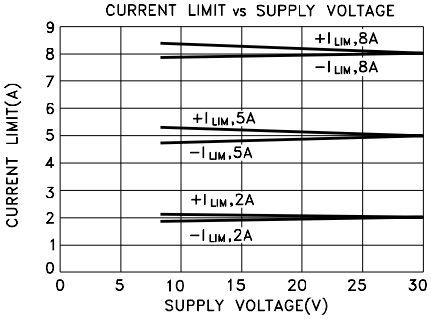
OPEN–LOOP GAIN AND PHASE vs FREQUENCY



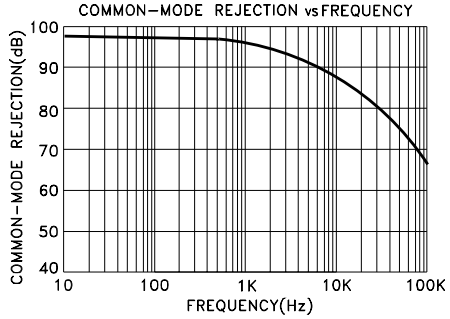
CURRENT LIMIT vs TEMPERATURE



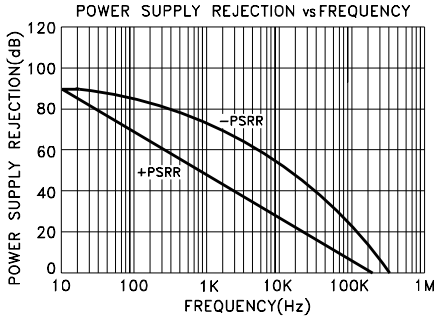
CURRENT LIMIT vs SUPPLY VOLTAGE



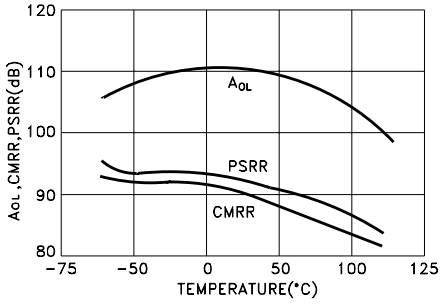
COMMON–MODE REJECTION vs FREQUENCY



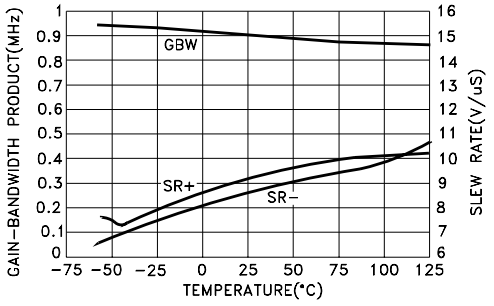
POWER SUPPLY REJECTION vs FREQUENCY



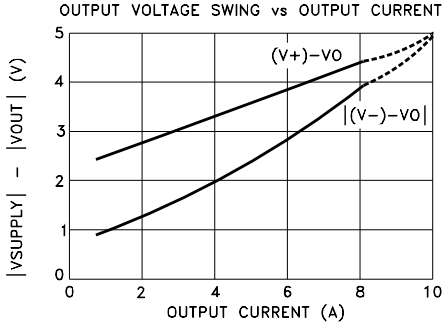
OPEN–LOOP GAIN,COMMON–MODE REJECTION RATIO, AND POWER SUPPLY REJECTION RATIO vs TEMPERATURE



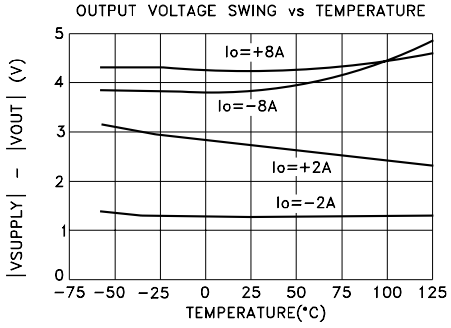
GAIN–BANDWIDTH PRODUCT AND SLEW RATE vs TEMPERATURE



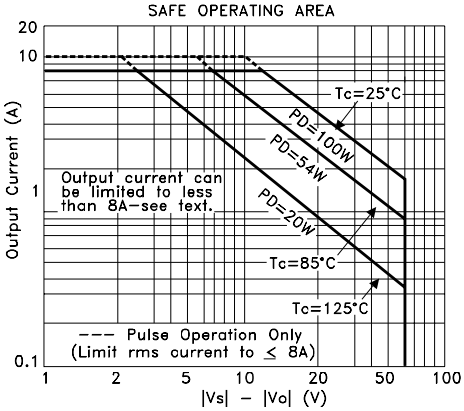
OUTPUT VOLTAGE SWING vs OUTPUT CURRENT



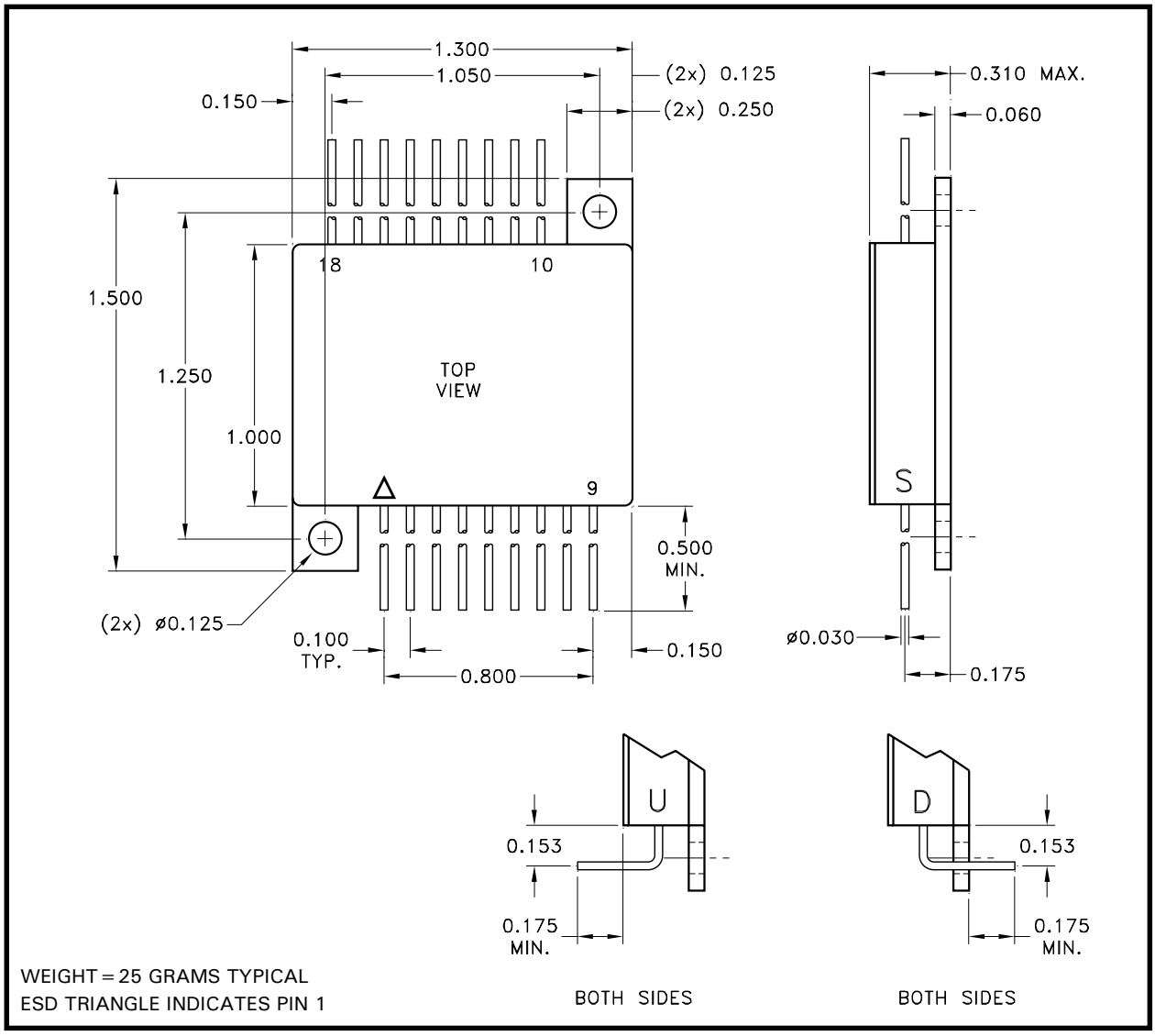
OUTPUT VOLTAGE SWING vs TEMPERATURE



SAFE OPERATING AREA



MECHANICAL SPECIFICATIONS



ALL DIMENSIONS ARE ±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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Contact MSK for MIL-PRF-38534 qualification status.