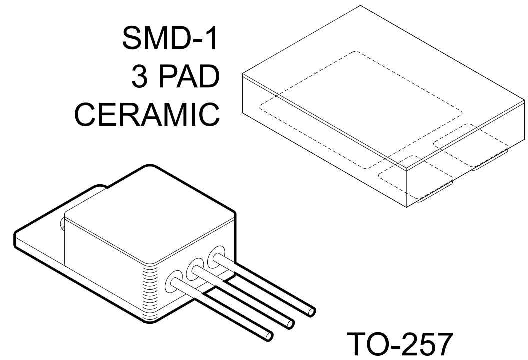
TTM Technologies
Time-To-Market Interconnect Solutions

1.5A, NEGATIVE ADJUSTABLE LINEAR REGULATOR

5173

FEATURES:

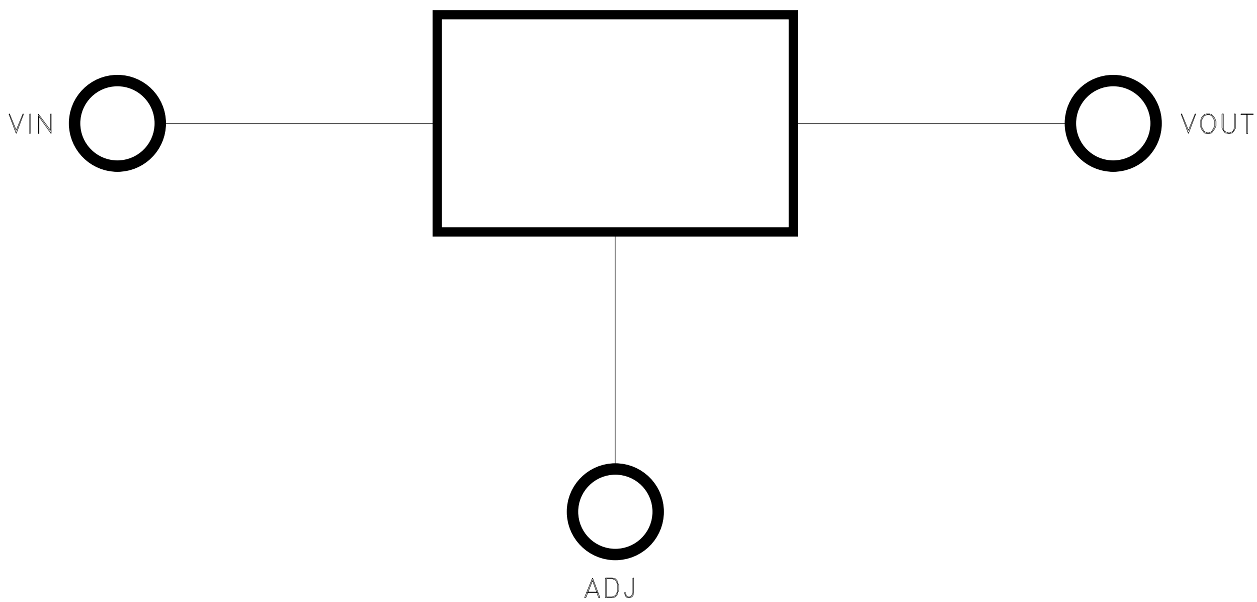
- Output Current Limit
- Internal Thermal Overload Protection
- Output Current to 1.5 Amps
- Adjustable Output using two External Resistors
- Available in 3 Lead Form Options: Straight, Up and Down (TO-257)
- Electrically Isolated Package (TO-257)
- Equivalent Rad Hard Device MSK5973RH
- Contact TTM Technologies for MIL-PRF-38534 Qualification Status



DESCRIPTION:

The MSK5173 is a 3-terminal negative adjustable regulator capable of supplying up to 1.5A of current. The output is adjustable using external resistors for a range of Vref to -27V. Excellent line and load regulation characteristics ensure accurate performance. The MSK5173 has full protection with current and thermal limiting. The MSK5173 is packaged in two space saving packages, the 3 pin power surface mount ceramic SMD-1 or the TO-257 package with 3 lead form options: straight, up and down.

EQUIVALENT SCHEMATIC



TYPICAL APPLICATIONS

- System Power Supplies
- Switching Power Supply Post Regulators
- Constant Voltage/Current Regulators
- High Efficiency Linear Regulators

PIN-OUT INFORMATION

TO-257		SMD-1	
1	ADJ	1	ADJ
2	VIN	2	VOUT
3	VOUT	3	VIN

PACKAGE = ISOLATED

ABSOLUTE MAXIMUM RATINGS ⑧

VIN	Input Voltage (VIN - VOUT)	30VDC
PD	Power Dissipation	Internally Limited
IOUT	Output Current	1.5A
TJ	Junction Temperature	+150°C
TST	Storage Temperature Range ⑨	-65°C to +150°C
TLD	Lead Temperature Range (10 Seconds Soldering)	300°C
TC	Case Operating Temperature Range	
	MSK5173	-55°C to +125°C
	MSK5173H	-55°C to +125°C

ELECTRICAL SPECIFICATIONS

Parameter	Test Conditions	Group A Subgroup	MSK5173H Min.	MSK5173H Typ.	MSK5173H Max.	MSK5173 Min.	MSK5173 Typ.	MSK5173 Max.	Units
Reference Voltage	3V ≤ (VIN - VOUT) ≤ 30V	1	-1.30	-1.25	-1.20	-1.35	-1.25	-1.15	V
	IOUT = 10mA	2, 3	-1.30	-	-1.20	-	-	-	V
Line Regulation	3V ≤ (VIN - VOUT) ≤ 30V	1	-0.02	0.002	+0.02	-0.02	0.002	+0.02	%/V
	IOUT = 10mA	2, 3	-0.05	-	+0.05	-	-	-	%/V
Adjust Pin Current	3V ≤ (VIN - VOUT) ≤ 30V	1	-	65	100	-	65	100	μA
	IOUT = 10mA	2, 3	-	-	100	-	-	-	μA
Adjust Pin Current Change	3V ≤ (VIN - VOUT) ≤ 30V	1	-5.0	0.2	+5.0	-5.0	0.2	+5.0	μA
	IOUT = 10mA	2, 3	-6.0	-	+6.0	-	-	-	μA
Load Regulation	VIN = -8, VOUT = -5V	1	-25	-	+25	-25	-	+25	mV
	10mA ≤ IOUT ≤ 1.5A	2, 3	-50	-	+50	-	-	-	mV
Current Limit ⑦	VIN = -10V	1	1.5	2.3	-	1.5	2.3	-	A
	VOUT = -5V	2, 3	1.5	-	-	-	-	-	A
Ripple Rejection ②	VOUT = -10V, F = 120HZ, Cadj = 10μF	4	66	-	-	66	-	-	dB
Minimum Load Current ②	(VIN - VOUT) = 30V	1	-	-	5	-	-	5	mA
Thermal Resistance ②	Junction to Case @ 125°C to -257 Package	-	-	5.0	6.7	-	5.0	6.7	°C/W
Thermal Resistance ②	Junction to Case @ 125°C SMD -1 Package	-	-	4.4	6.1	-	4.4	6.1	°C/W

NOTES:

① Output is decoupled to ground using 10μF low ESR tantalum capacitors and 0.1μF ceramic.
② Guaranteed by design but not tested. Typical parameters are representative of actual device performance but are for reference only.
③ All output parametyers are tested using a low duty cycle pulse to maintain TJ = TC.
④ Industrial grade and devices shall be tested to subgroup 1 unless otherwise specified.
⑤ Military grade devices ("H" suffix) shall be 100% tested to subgroups 1, 2 and 3.
⑥ Subgroup 1 TA = TC = +25°C
Subgroup 2 TA = TC = +125°C
Subgroup 3 TA = TC = -55°C
⑦ The output current limit function provides protection from transient overloads but it may exceed the maximum continuous rating. Continuous operation in current limit may damage the device.
⑧ Continuous operation at or above absolute maximum ratings may adversely effect the device performance and/or life cycle.
⑨ Internal solder reflow temperature is 180°C, do no exceed.

APPLICATION NOTES

OUTPUT VOLTAGE

The MSK5173 develops a nominal -1.25V reference voltage between the output and adjustment terminal. With a constant reference voltage drop across program resistor R1, a constant current flows through the output set resistor R2. Since the current from the adjustment terminal represents an error in the programmed output voltage, the MSK5173 was designed to minimize IADJ and make it very constant with line and load changes. To do this, all quiescent operating current is returned to the output establishing a minimum load current requirement. If there is insufficient load on the output, the output will rise. Figure 1 shows the output voltage calculations.

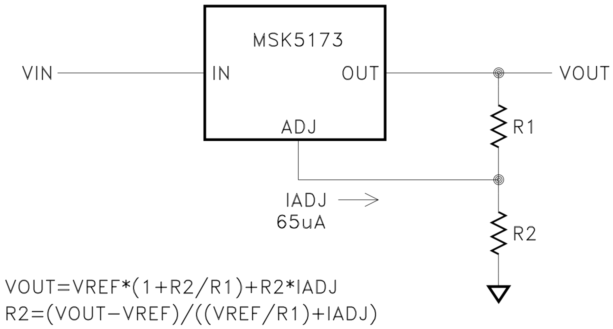


FIGURE 1

INPUT VOLTAGE

The minimum required input voltage for proper operation is VOUT+ Dropout voltage. See typical performance curves for dropout performance.

EXTERNAL CAPACITORS

Input bypassing with a 1uF tantalum in parallel with a 0.1uF ceramic on the input is suitable in most applications. To maximize transient response and minimize input supply transients more input capacitance can be added. The adjustment terminal can be bypassed to ground on the MSK5173 to improve ripple rejection. This bypass capacitor prevents ripple from being amplified at higher output voltages. The impedance of the adjust pin capacitor at the ripple frequency should be less than the value of R1. For most application a 10µF bypass capacitor will provide sufficient ripple rejection at any output level. Increases over 10µF do not appreciably improve the ripple rejection at frequencies above 120Hz. Output bypassing with 10µF low ESR tantalum in parallel with a 0.1µF ceramic attached as close to the regulator's output as possible is best. This will effectively lower the regulator output impedance, increase transient response and eliminate any oscillations. Any increase of the load capacitance larger than 10µF will merely improve the loop stability and output impedance. See Figure 3 for typical application schematic.

LOAD REGULATION

The MSK5173 is capable of providing extremely good load regulation but a few precautions are needed to obtain maximum performance. The current set resistor connected between the adjustment terminal and the output terminal should be tied directly to the output pin as close to the case of the regulator as possible rather than near the load. This eliminates package pin and trace drops from appearing effectively in series with the reference and degrading regulation. For example, if the regulator is set to -5V with 0.05Ω resistance between the regulator and the current set resistor, the output will droop 225mV at 1A due to package pin and trace resistance. The amount of droop can be calculated as follows: (VOUT at 5mA) - (1.250-(0.05Ω*IL))*(1+R2/R1). The ground of R2 can be returned near the ground of the load to provide remote ground sensing and improve load regulation. Figure 2A shows the effect of resistance between the regulator and 240Ω set resistor.

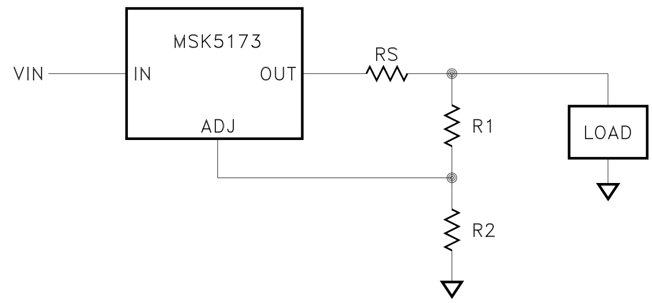


FIGURE 2A
(Degraded Regulation)

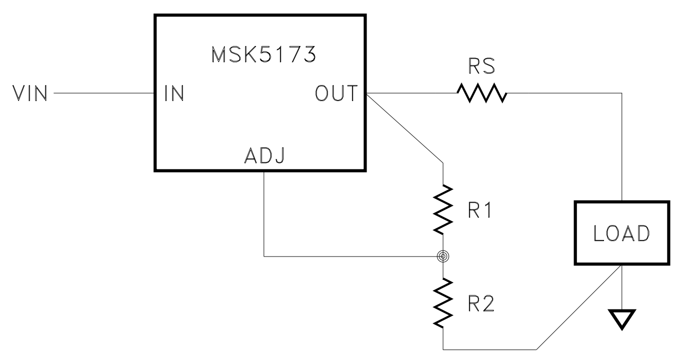
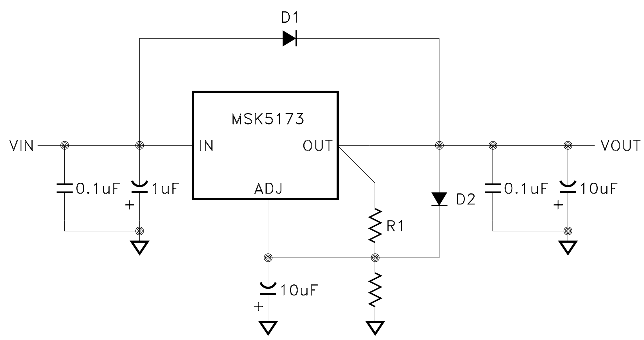


FIGURE 2B
(Best Case Regulation)

PROTECTION DIODES

When external capacitors are used with any IC regulator it is sometimes necessary to add protection diodes to prevent the capacitors from discharging through low current points into the regulator. Most 10μF capacitors have low enough internal series resistance to deliver 20A spikes when shorted. Although the surge is short, there is enough energy to stress MSK5173. When an output capacitor is connected to a regulator and the input is shorted or crowbarred, the output capacitor will discharge into the output of the regulator. The discharge current depends on the value of the capacitor, the output voltage of the regulator, and the rate of decrease of VIN. Figure 3 shows an MSK5173 with protection diodes included. D2 is only required if the adjust pin has external capacitance tied to it .



TYPICAL APPLICATION

FIGURE 3

HEAT SINKING

To determine if a heat sink is required for your application and if so, what type, refer to the thermal model and governing equation below.

Governing Equation:

$$T_J = P_D \times (R\theta_{JC} + R\theta_{CS} + R\theta_{SA}) + T_A$$

Where:

T_J = Junction Temperature
P_D = Total Power Dissipation
$R\theta_{JC}$ = Junction to Case Thermal Resistance
$R\theta_{CS}$ = Case to Heat Sink Thermal Resistance
$R\theta_{SA}$ = Heat Sink to Ambient Thermal Resistance
T_C = Case Temperature
T_A = Ambient Temperature
T_S = Heat Sink Temperature

Example:

This example demonstrates an analysis with the output set to -10V, where the output current is at 0.5 amp and the input is -15V.

Conditions for MSK5173:

VIN = -15V; I_{OUT} = 0.5A

1.) Assume 45° heat spreading model.
2.) Find regulator power dissipation:

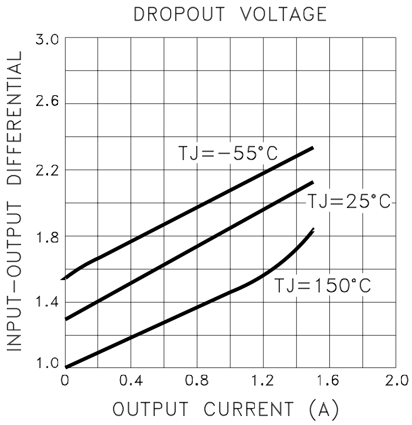
$$Pd = (V_{IN} - V_{OUT})(I_{OUT})$$
$$Pd = (15V-10V)(0.5A)$$
$$Pd = 2.5W$$

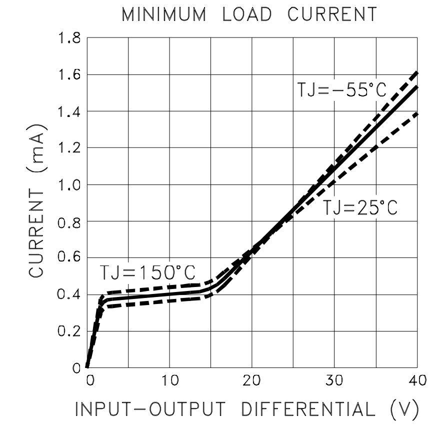
3.) For conservative design, set T_J = +125°C Max.
4.) For this example, worst case T_A = +90°C.
5.) $R\theta_{JC}$ = 6.7°C/W from the Electrical Specification Table.
6.) $R\theta_{CS}$ = 0.15°C/W for most thermal greases.
7.) Rearrange governing equation to solve for $R\theta_{SA}$:

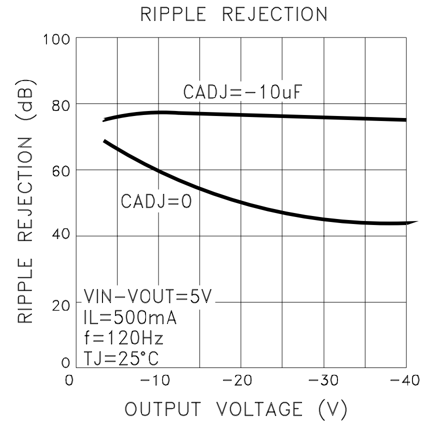
$$R\theta_{SA} = ((T_J - T_A)/P_D) - (R\theta_{JC}) - (R\theta_{CS})$$
$$= (125°C - 90°C)/2.5W - 6.7°C/W - 0.15°C/W$$
$$= 7.2°C/W$$

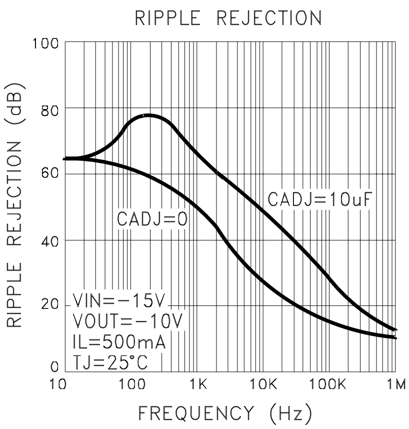
In this case the result is 7.2°C/W. Therefore, a heat sink with a thermal resistance of no more than 7.2°C/W must be used in this application to maintain regulator circuit junction temperature under 125°C.

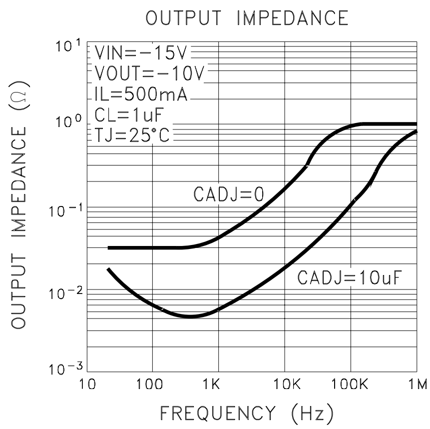
TYPICAL PERFORMANCE CURVES

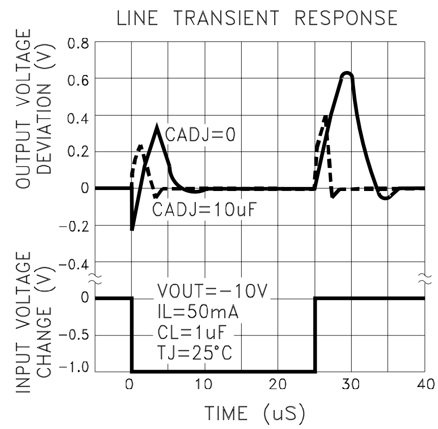


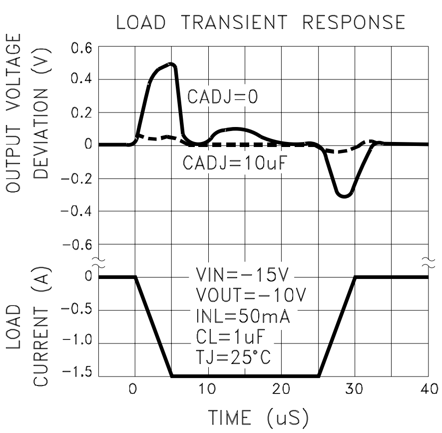


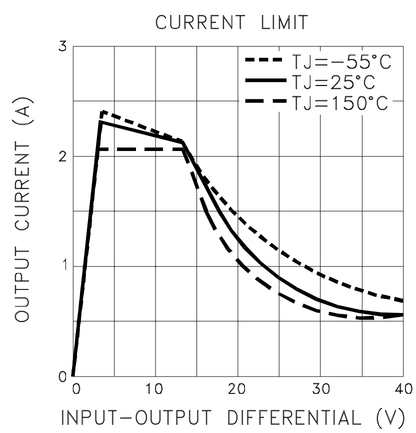


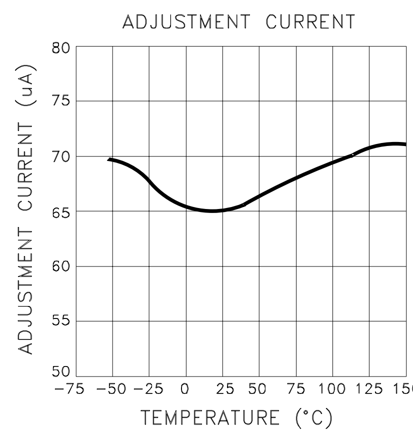




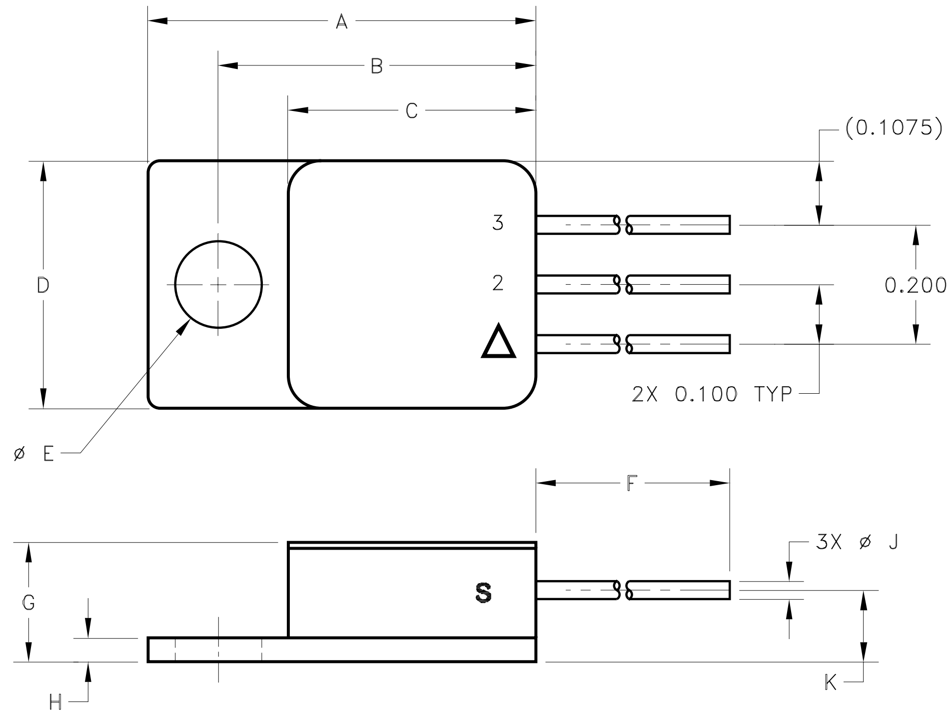


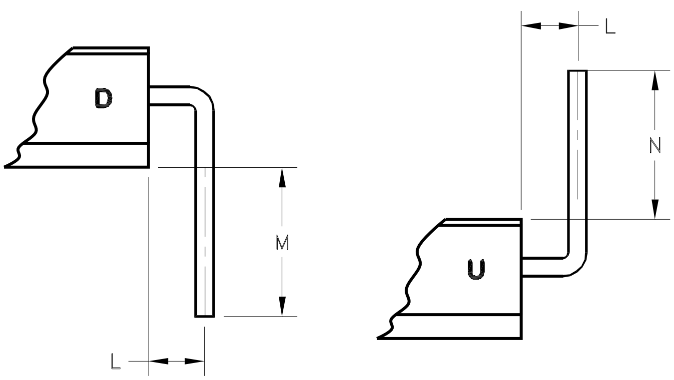






MECHANICAL SPECIFICATIONS





REF	MIN	MAX	REF	MIN	MAX
A	0.640	0.660	H	0.035	0.045
B	0.527	0.537	J	0.028	0.032
C	0.405	0.425	K	0.110	0.130
D	0.405	0.425	L	0.085	0.105
E	0.140	0.150	M	0.200	———
F	0.400	———	N	0.200	———
G	———	0.210			

ESD TRIANGLE INDICATES PIN 1
WEIGHT = 3.2 GRAMS TYPICAL

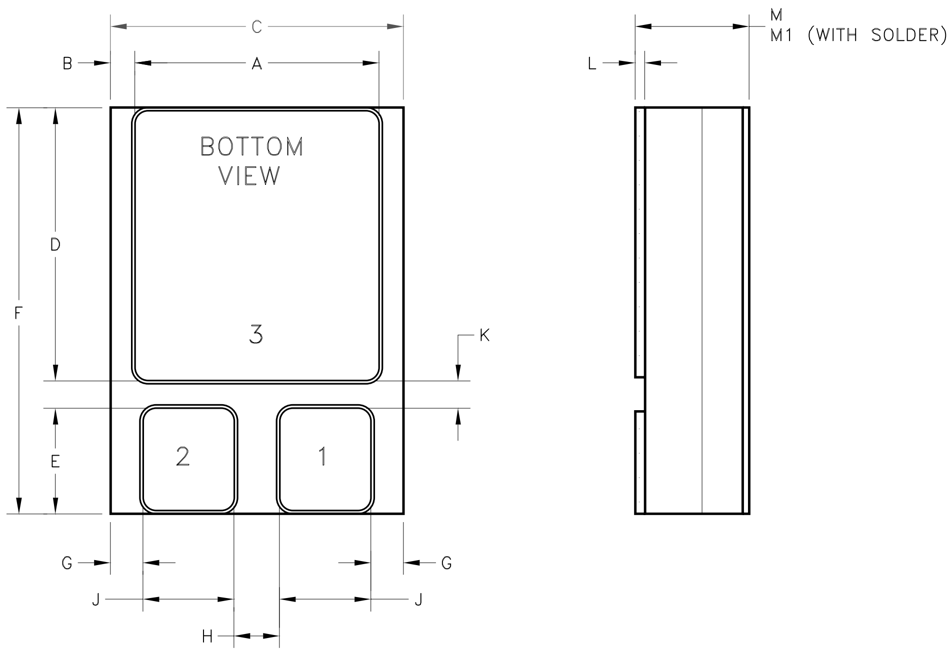
ALL DIMENSIONS ARE SPECIFIED IN INCHES

ORDERING INFORMATION

MSK5173 H U

- LEAD CONFIGURATIONS
  S = STRAIGHT; U = BENT UP; D = BENT DOWN
- SCREENING
  BLANK = INDUSTRIAL; H = MIL-PRF-38534 CLASS H;
- GENERAL PART NUMBER

The above example is a Class H regulator with leads bent up.



REF	MIN	MAX	REF	MIN	MAX
A	0.365	0.385	H	0.035	—
B	0.032	0.042	J	0.130	0.150
C	0.440	0.460	K	0.030	—
D	0.405	0.425	L	0.012	0.018
E	0.152	0.162	M	—	0.130
F	0.615	0.635	M1	—	0.135
G	0.045	0.055			

WEIGHT = 2.2 GRAMS TYPICAL

ALL DIMENSIONS ARE SPECIFIED IN INCHES

ORDERING INFORMATION

MSK5173 H L

- L — 3 PAD CERAMIC SMD-1 PACKAGE
- H — SCREENING
  BLANK = INDUSTRIAL; H = MIL-PRF-38534 CLASS H;
- MSK5173 — GENERAL PART NUMBER

The above example is a Class H regulator in the 3 Pad Ceramic Package.

REVISION HISTORY

REV	STATUS	DATE	DESCRIPTION
D	Released	01/16	Add internal note and update format
E	Released	04/23	Remove MIL-PRF-38535 and update company name and website