



**RAD HARD POSITIVE,
1.5 AMP, LOW DROPOUT
ADJ VOLTAGE REGULATOR**

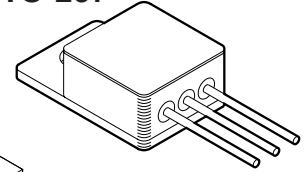
5970RH

FEATURES:

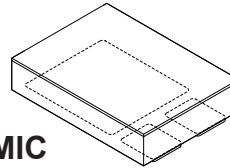


- Manufactured using Space Qualified RH1086 Die
- Total Dose Hardened to 100 Krads(Si) (Method 1019.7 Condition A)
- Low Dropout Voltage
- Internal Short Circuit Current Limit
- Output Voltage is Adjustable with 2 External Resistors
- Output Current Capability to 1.5 Amps
- Internal Thermal Overload Protection
- Non RAD Hard EDU devices available
- Available to DSCC SMD 5962R09211

TO-257



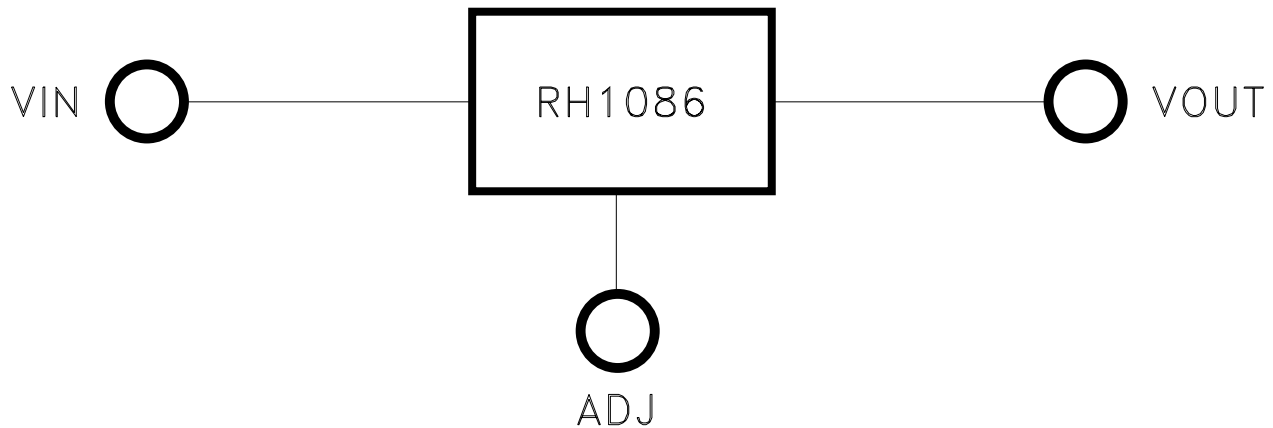
**SMD-1
3 PAD
CERAMIC**



DESCRIPTION:

The MSK5970RH offers low dropout voltage while offering radiation tolerance for space applications. This, combined with the low θ_{JC} , allows increased output current while providing exceptional device efficiency. Because of the increased efficiency, a small hermetic 3 pin package can be used providing maximum performance while occupying minimal board space. Output voltage is selected by the user through the use of 2 external resistors. Additionally, the regulator offers internal short circuit current and thermal limiting, which allows circuit protection and eliminates the need for external components and excessive derating. The MSK5970RH is packaged in two space saving options; 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

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

PIN-OUT INFORMATION

| TO-257 | SMD-1 |
|-----------------|----------------|
| 1 ADJ | 1 ADJ |
| 2 VOUT | 2 VIN |
| 3 VIN | 3 VOUT |
| CASE = ISOLATED | LID = ISOLATED |

and the Linear Technology logo are registered trademarks and RH1086 is a copyright of Linear Technology Corporation

ABSOLUTE MAXIMUM RATINGS

⑧

| | |
|--------------|--|
| $\pm V_{IN}$ | Input Voltage (WRT V_{OUT}).....25V |
| P_D | Power Dissipation.....Internally Limited |
| I_{OUT} | Output Current.....⑦.....1.5A |
| T_J | Junction Temperature.....+150°C |

| | |
|----------|--|
| T_{ST} | Storage Temperature Range.....⑪.....-65°C to +150°C |
| T_{LD} | Lead Temperature Range (10 Seconds).....300°C |
| T_C | Case Operating Temperature Range MSK5970RH.....-40°C to +85°C MSK5970EDU.....⑫.....-40°C to +85°C MSK5970K/HRH.....-55°C to +125°C ESD Rating.....3A |

ELECTRICAL SPECIFICATIONS

| Parameter | Test Conditions ③ ⑨ | Group A Subgroup | MSK5970K/HRH | | | MSK5970RH/EDU | | | Units |
|-------------------------|--|------------------|--------------|-------|-------|---------------|-------|-------|-------|
| | | | Min. | Typ. | Max. | Min. | Typ. | Max. | |
| Reference Voltage | $I_{OUT} = 10\text{mA}$ $V_{IN} = V_{OUT} + 3\text{V}$ | 1 | 1.238 | 1.250 | 1.262 | 1.225 | 1.250 | 1.270 | V |
| | | 2, 3 | 1.225 | 1.250 | 1.270 | - | - | - | V |
| | Post Irradiation | 1 | 1.205 | 1.250 | 1.270 | 1.205 | 1.250 | 1.270 | V |
| Dropout Voltage | $10\text{mA} \leq I_{OUT} \leq 1.5\text{A}$ $\Delta V_{OUT} = 1\%$ | 1 | - | 1.3 | 1.575 | - | 1.3 | 1.6 | V |
| Line Regulation | $I_{OUT} = 10\text{mA}$ | 1 | -0.5 | 0.1 | 0.5 | - | 0.1 | 0.6 | % |
| | $(V_{OUT} + 3\text{V}) \leq V_{IN} \leq (V_{OUT} + 15\text{V})$ | 2, 3 | -0.75 | 0.2 | 0.75 | - | - | - | % |
| Load Regulation | $V_{IN} = V_{OUT} + 3\text{V}$ | 1 | -1.0 | 0.2 | 1.0 | - | 0.2 | 2.0 | % |
| | $10\text{mA} \leq I_{OUT} \leq 1.5\text{A}$ | 2, 3 | -2.0 | 0.3 | 2.0 | - | - | - | % |
| Short Circuit Current ⑦ | $V_{IN} = V_{OUT} + 5\text{V}$ | 1 | 1.5 | 2.0 | - | 1.5 | 2.0 | - | A |
| Ripple Rejection ② | $I_{OUT} = 1.5\text{A}$; $C_{OUT} = 25\mu\text{F}$; $f = 120\text{Hz}$ | - | 60 | 75 | - | 60 | 75 | - | DB |
| Thermal Resistance ② | Junction to Case @ 125C TO-257 Package | - | - | 5.3 | 5.7 | - | 5.3 | 5.7 | °C/W |
| Thermal Resistance ② | Junction to Case @ 125C SMD-1 Package | - | - | 4.7 | 5.1 | - | 4.7 | 5.1 | °C/W |

NOTES:

- ① Output is decoupled to ground using 22 μF minimum low ESR capacitors unless otherwise specified.
- ② Guaranteed by design but not tested. Typical parameters are representative of actual device performance but are for reference only. Not applicable to post irradiation performance.
- ③ All output parameters are tested using a low duty cycle pulse to maintain $T_J = T_C$.
- ④ Industrial grade and devices shall be tested to subgroup 1 unless otherwise specified.
- ⑤ Military grade devices ("H" and "K" suffix) shall be 100% tested to subgroups 1,2 and 3.
- ⑥ Subgroup 1 $T_A = +25^\circ\text{C}$
 2 $T_A = +125^\circ\text{C}$
 3 $T_A = -55^\circ\text{C}$
- 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. For compliance with MIL-STD 883 revision C current density specifications, the MSK5970RH is derated to 1 Amp.
- ⑧ Continuous operation at or above absolute maximum ratings may adversely effect the device performance and/or life cycle.
- ⑨ Pre and Post irradiation limits at 25°C, up to 100Krad TID, are identical unless otherwise specified. Post irradiation performance is guaranteed by design with a 2X radiation design margin.
- ⑩ Reference DSCC SMD 5962R09211 for electrical specification for devices purchased as such.
- ⑪ Internal solder reflow temperature is 180°C, do not exceed.
- ⑫ MSK5970EDU does not use RAD Hard Die, Post Irradiation specifications are not applicable.

APPLICATION NOTES

BYPASS CAPACITORS

Minimum requirement for output capacitance is 10uF, low ESR tantalum. A 22uF low ESR (0.5-2 ohm) tantalum capacitor attached close to the regulator's output will ensure stability in most applications. This will effectively lower the regulator's output impedance, increase transient response and eliminate any oscillations that are normally associated with low dropout regulators. Additional bypass capacitors can be used at the remote load locations to further improve regulation. These can be either of the tantalum or the electrolytic variety. Unless the regulator is located very close to the power supply filter capacitor(s), a 4.7uF minimum low ESR (0.5-2 ohm) tantalum capacitor should also be added to the regulator's input. An electrolytic may also be substituted if desired. When substituting electrolytic in place of tantalum capacitors, a good rule of thumb to follow is to increase the size of the electrolytic by a factor of 10 over the tantalum value.

OUTPUT VOLTAGE

The MSK5970RH develops a 1.250 Volt reference between the output pin and the adjust pin. A resistor, R1, is placed between the output and adjust pins, causing current to flow through R1 and down through R2, setting the output voltage. R1 may be chosen to sink the minimum required load current of 10mA. Refer to Figure 1 for connections and VOUT calculation.

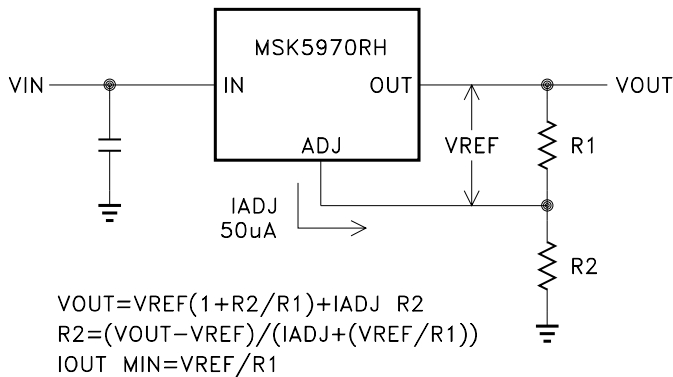


FIGURE 1

LOAD REGULATION

With a three-terminal device, it is not possible to provide true remote load sensing. The resistance of the connection to the load will limit the load regulation of the device. The best load regulation will be achieved when the top of the divider is connected to the pin as close to the case of the MSK5970RH as possible and the bottom of the divider as close to the load as possible. This will effectively reduce the effect of the parasitic line resistance on the load regulation of the device.

Refer to Figure 2 for proper connections.

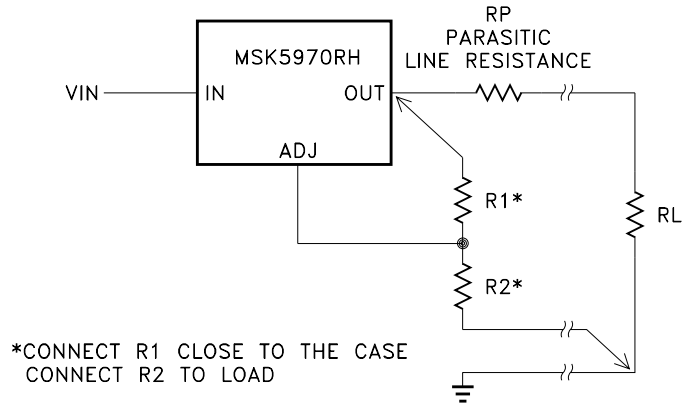


FIGURE 2

RIPPLE REJECTION

The typical curve for ripple rejection is shown with the adjust pin bypassed as shown in Figure 3. For proper bypassing and ripple rejection approaching the values of the curve, the impedance of the adjust pin capacitor at the ripple frequency should be less than the value of R1. The value of the adjust pin capacitor is a function of the input ripple frequency. For instance, if R1=100Ω, at 120Hz the adjust pin capacitor should be 25μF. At 10KHz only 0.22uF is required.

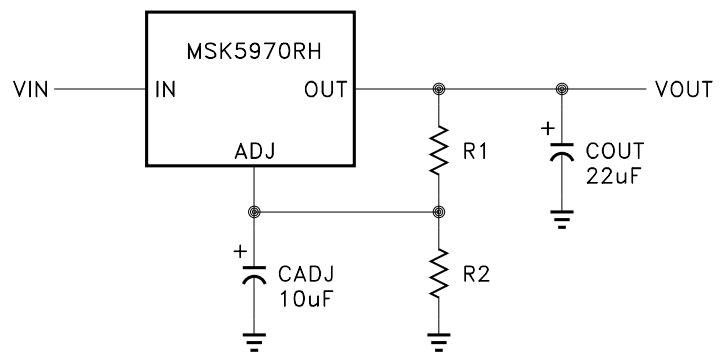


FIGURE 3

APPLICATION NOTES CONT'D

OVERLOAD SHUTDOWN

The regulator features both power and thermal overload protection. When the maximum power dissipation is not exceeded, the regulator will current limit slightly above its 1.5 amp rating. As the VIN-VOUT voltage increases, however, shutdown occurs in relation to the maximum power dissipation curve. If the device heats enough to exceed its rated die junction temperature due to excessive ambient temperature, improper heat sinking etc., the regulator also shuts down until an appropriate junction temperature is maintained. It should also be noted that in the case of an extreme overload, such as a sustained direct short, the device may not be able to recover. In these instances, the device must be shut off and power reapplied to eliminate the shutdown condition.

TOTAL DOSE RADIATION TEST PERFORMANCE

Radiation performance curves for TID testing have been generated for all radiation testing performed by MSK. These curves show performance trends throughout the TID test process and can be located in the MSK5970RH radiation test report. The complete radiation test report is available in the RAD HARD PRODUCTS section on the MSK website.

<http://www.mskennedy.com/store.asp?pid=9951&catid=19680>

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 the thermal calculations for the TO-257 package with the regulator operating at one-half of its maximum rated output current.

Conditions for MSK5970RH:

VIN = +8.0V; Iout = +0.75A

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

$$\begin{aligned} P_d &= (V_{IN} - V_{OUT})(I_{out}) \\ P_d &= (8-5)(0.75) \\ &= 2.25W \end{aligned}$$

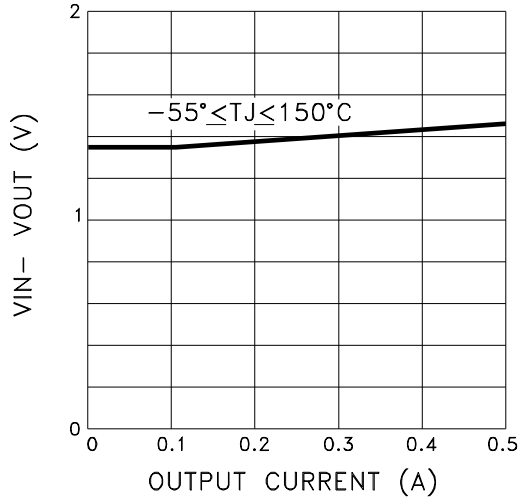
- 3.) For conservative design, set $T_j = +125^\circ\text{C}$ Max.
- 4.) For this example, worst case $T_a = +90^\circ\text{C}$.
- 5.) $R_{\theta jc} = 5.7^\circ\text{C/W}$ from the Electrical Specification Table.
- 6.) $R_{\theta cs} = 0.15^\circ\text{C/W}$ for most thermal greases.
- 7.) Rearrange governing equation to solve for $R_{\theta sa}$:

$$\begin{aligned} R_{\theta sa} &= ((T_j - T_a)/P_d) - (R_{\theta jc}) - (R_{\theta cs}) \\ &= (125^\circ\text{C} - 90^\circ\text{C}) / 2.25W - 5.7^\circ\text{C/W} - 0.15^\circ\text{C/W} \\ &= 9.7^\circ\text{C/W} \end{aligned}$$

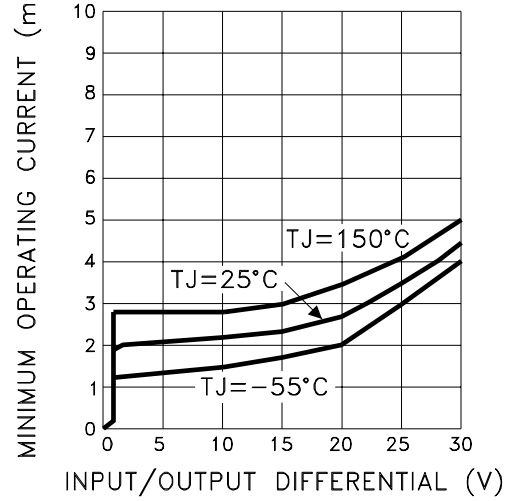
In this case the result is 9.7°C/W . Therefore, a heat sink with a thermal resistance of no more than 9.7°C/W must be used in this application to maintain regulator circuit junction temperature under 125°C .

TYPICAL PERFORMANCE CURVES

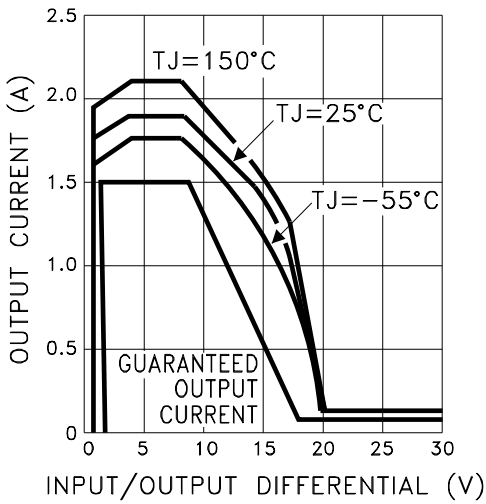
DROPOUT VOLTAGE vs. OUTPUT CURRENT



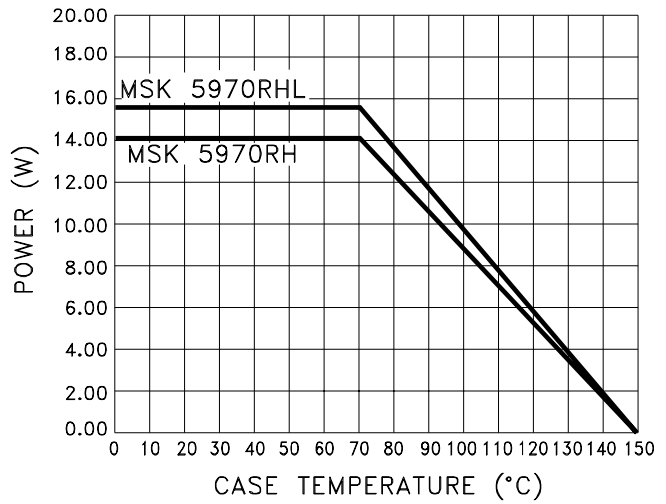
MINIMUM OPERATING CURRENT



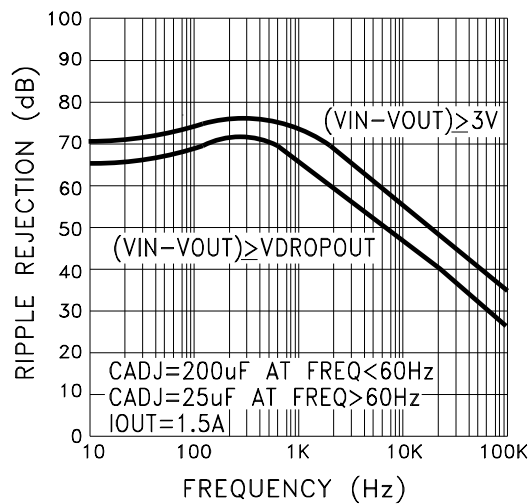
INTERNAL CURRENT LIMIT vs. VIN-VOUT



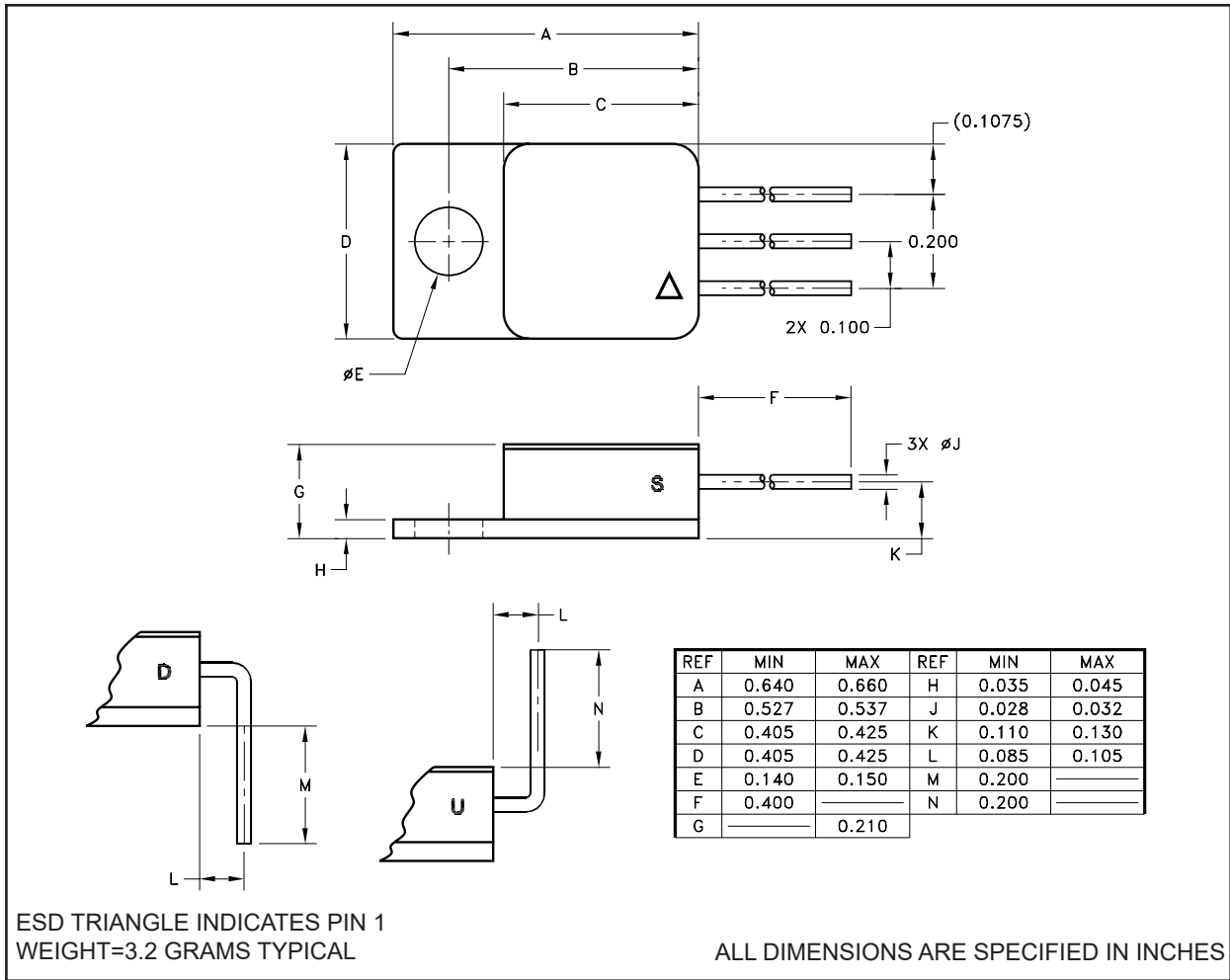
POWER DISSIPATION vs. TEMPERATURE



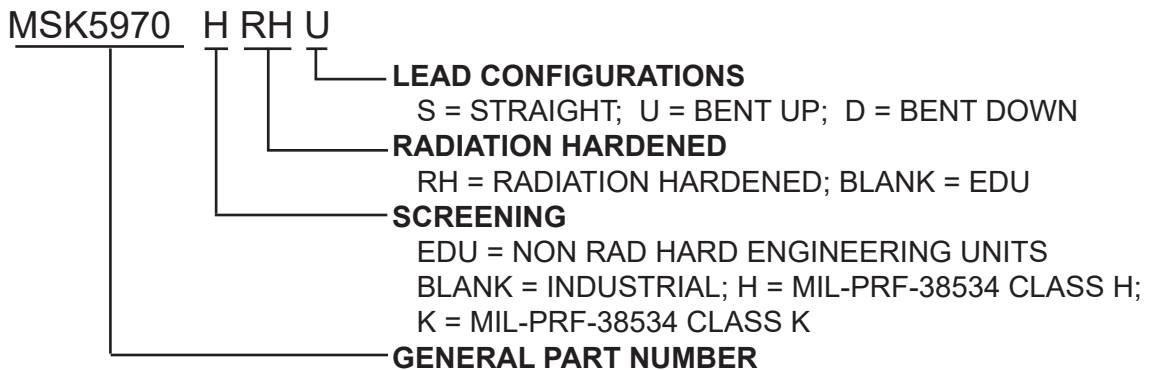
RIPPLE REJECTION vs. FREQUENCY



MECHANICAL SPECIFICATIONS



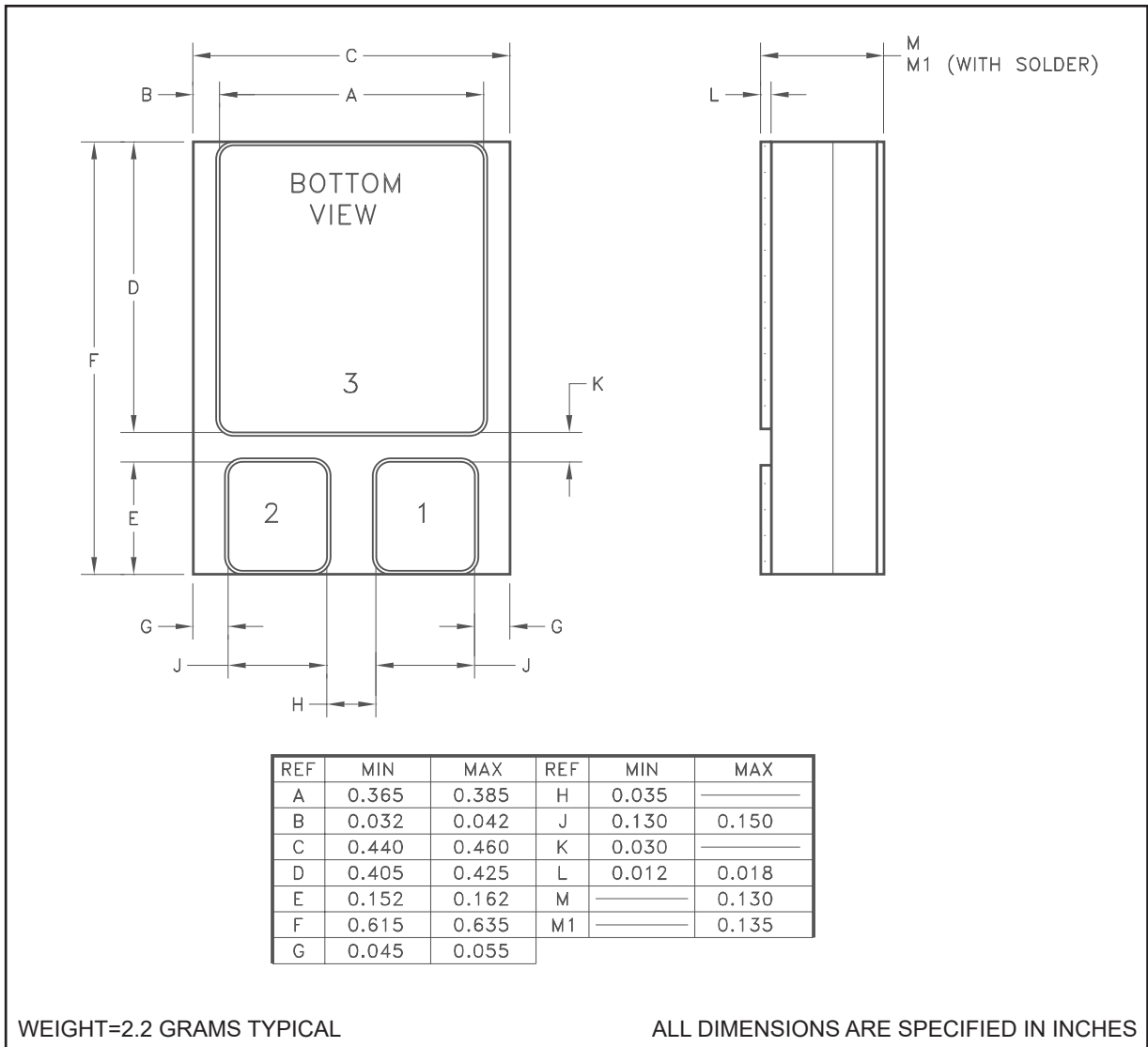
ORDERING INFORMATION



The above example is an adjustable Class K regulator with leads bent up. Ordering information for the 3 pad ceramic SMD-1 package is contained on the next page.

NOTE: See DSCC SMD 5962R09211 for DSCC part number options.

MECHANICAL SPECIFICATIONS



ORDERING INFORMATION

MSK5970 | **K** | **RH** | **L**
 ————|———|———|———
 |
 |———| **3 PAD CERAMIC SMD-1 PACKAGE**
 |———| **RADIATION HARDENED**
 |———| RH = RADIATION HARDENED; BLANK = EDU
 |———| **SCREENING**
 |———| EDU = NON RAD HARD ENGINEERING UNITS
 |———| BLANK = INDUSTRIAL; H = MIL-PRF-38534 CLASS H;
 |———| K = MIL-PRF-38534 CLASS K
 |———| **GENERAL PART NUMBER**

The above example is an adjustable Class K regulator.

NOTE: See DSCC SMD 5962R09211 for DSCC part number options.

REVISION HISTORY

| REV | STATUS | DATE | DESCRIPTION |
|-----|----------|-------|---|
| F | Released | 10/14 | Format update, add internal note and clarify mechanical specifications. |
| G | Released | 12/14 | Add case = isolated to pin out info and ESD rating. |
| H | Released | 08/17 | Add EDU device type. |
| J | Released | 09/17 | Update parameters to better correlate to manufacturer's pre and post rad specs. |

ANAREN, MSK Products
www.anaren.com/msk

The information contained herein is believed to be accurate at the time of printing. Anaren, MSK products reserves the right to make changes to its products or specifications without notice, however and assumes no liability for the use of its products.
Please visit our website for the most recent revision of this datasheet.