# Anaren® MSK PRODUCTS

RAD HARD POSITIVE, 1.5 AMP, LOW DROPOUT ADJ VOLTAGE REGULATOR
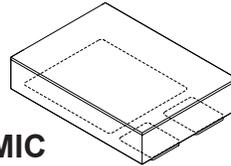
5970RH

FEATURES:

- Manufactured using *LT LINEAR TECHNOLOGY* 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
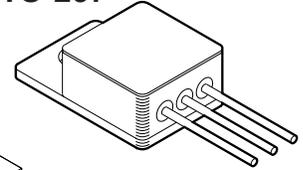
SMD-1 3 PAD CERAMIC

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

VIN — RH1086 — VOUT — ADJ
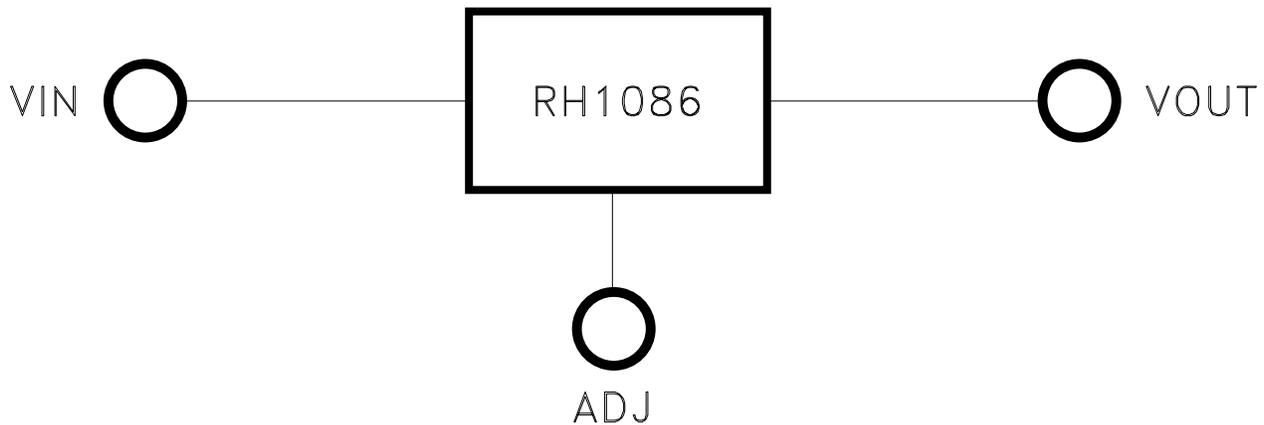
TYPICAL APPLICATIONS

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

PIN-OUT INFORMATION

TO-257

1	ADJ
2	VOUT
3	VIN
CASE = ISOLATED	

SMD-1

1	ADJ
2	VIN
3	VOUT
LID = ISOLATED	

8548-135 Rev. J 9/17

ABSOLUTE MAXIMUM RATINGS ⑧

±V$_{IN}$ Input Voltage (WRT VOUT.................................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$_{OUT}$ = 10mA VIN = VOUT +3V		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	10mA ≤ I$_{OUT}$ ≤ 1.5A △VOUT = 1%		1	-	1.3	1.575	-	1.3	1.6	V
Line Regulation	I$_{OUT}$ = 10 mA		1	-0.5	0.1	0.5	-	0.1	0.6	%
	(VOUT +3V) ≤ VIN ≤ (VOUT +15V)		2, 3	-0.75	0.2	0.75	-	-	-	%
Load Regulation	VIN = VOUT +3V		1	-1.0	0.2	1.0	-	0.2	2.0	%
	10mA ≤ I$_{OUT}$ ≤ 1.5A		2, 3	-2.0	0.3	2.0	-	-	-	%
Short Circuit Current ⑦	VIN = VOUT +5V		1	1.5	2.0	-	1.5	2.0	-	A
Ripple Rejection ②	I$_{OUT}$ = 1.5A; C$_{OUT}$ = 25µF; f = 120Hz		-	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 22µF 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 TJ = TC.

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°C
          2   T$_A$ = +125°C
          3   T$_A$ = -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. 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.

BYPASS CAPACITORS

Minimum requirement for output capacitance is 10uF, low ESR tantalum. A 22µF 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.
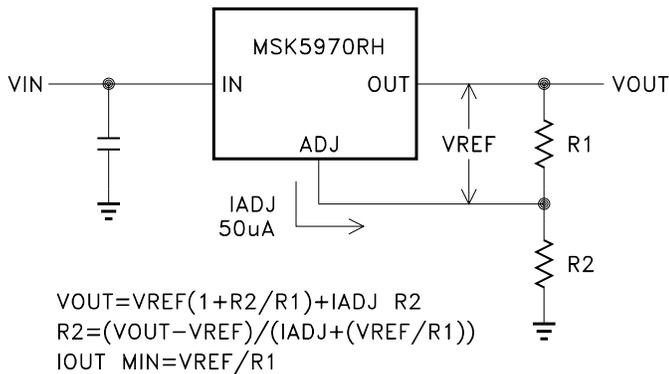

$$VOUT = VREF(1 + R2/R1) + IADJ \ R2$$
$$R2 = (VOUT - VREF)/(IADJ + (VREF/R1))$$
$$IOUT \ MIN = VREF/R1$$

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.
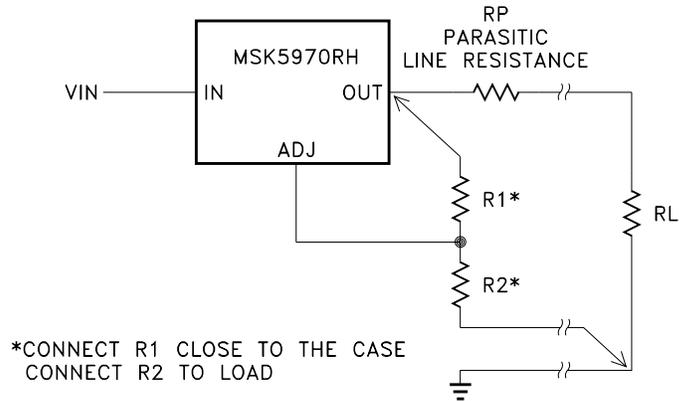
Refer to Figure 2 for proper connections.

*CONNECT R1 CLOSE TO THE CASE
 CONNECT R2 TO LOAD

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.
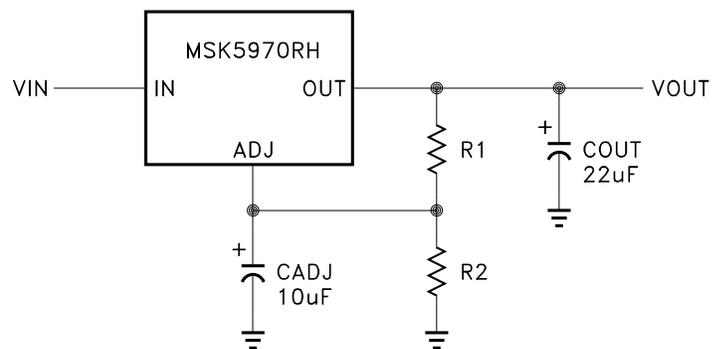

FIGURE 3

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 it's 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: $T_j = P_d \times (R_{\theta jc} + R_{\theta qcs} + R_{\theta sa}) + T_a$

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.
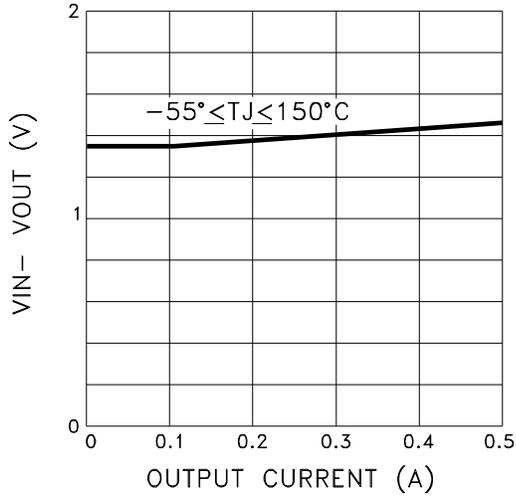2.) Find positive regulator power dissipation:

$$P_d = (VIN - VOUT)(Iout)$$
$$P_d = (8-5)(0.75)$$
$$= 2.25W$$

3.) For conservative design, set T_j = +125°C Max.
4.) For this example, worst case T_a = +90°C.
5.) $R_{\theta jc}$ = 5.7°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 $R_{\theta sa}$:

$$R_{\theta sa} = ((T_j - T_a)/P_d) - (R_{\theta jc}) - (R_{\theta cs})$$
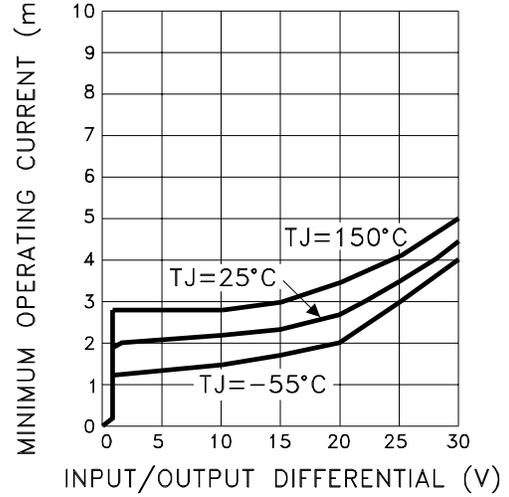$$= (125°C - 90°C) / 2.25W - 5.7°C/W - 0.15°C/W$$
$$= 9.7°C/W$$

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.

8548-135 Rev. J   9/17

TYPICAL PERFORMANCE CURVES

DROPOUT VOLTAGE vs. OUTPUT CURRENT

−55°≤TJ≤150°C

VIN− VOUT (V) vs. OUTPUT CURRENT (A)

MINIMUM OPERATING CURRENT

TJ=150°C
TJ=25°C
TJ=−55°C

MINIMUM OPERATING CURRENT (mA) vs. INPUT/OUTPUT DIFFERENTIAL (V)

INTERNAL CURRENT LIMIT vs. VIN−VOUT

TJ=150°C
TJ=25°C
TJ=−55°C

GUARANTEED
OUTPUT
CURRENT

OUTPUT CURRENT (A) vs. INPUT/OUTPUT DIFFERENTIAL (V)
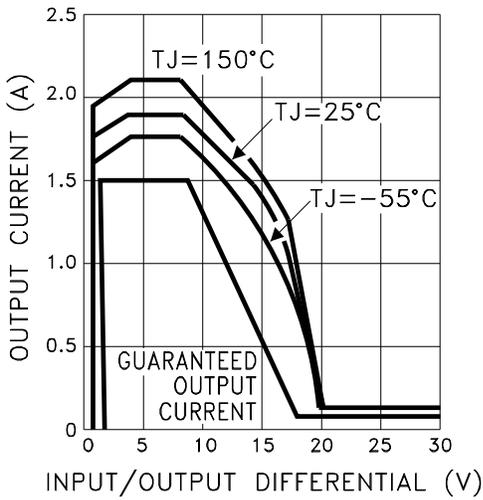
POWER DISSIPATION vs. TEMPERATURE

MSK 5970RHL
MSK 5970RH

POWER (W) vs. CASE TEMPERATURE (°C)
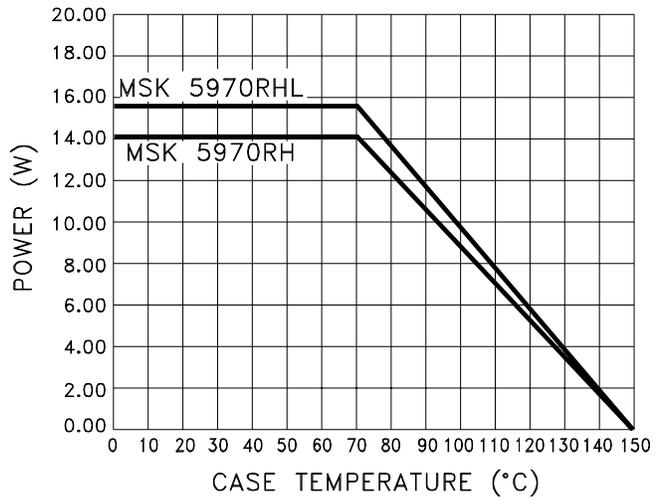
RIPPLE REJECTION vs. FREQUENCY

(VIN−VOUT)≥3V
(VIN−VOUT)≥VDROPOUT

CADJ=200uF AT FREQ<60Hz
CADJ=25uF AT FREQ>60Hz
IOUT=1.5A

RIPPLE REJECTION (dB) vs. FREQUENCY (Hz)

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

MSK5970 H RH U

LEAD CONFIGURATIONS
   S = STRAIGHT; U = BENT UP; D = BENT DOWN
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 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.

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

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