MIL-PRF-38534 CERTIFIED

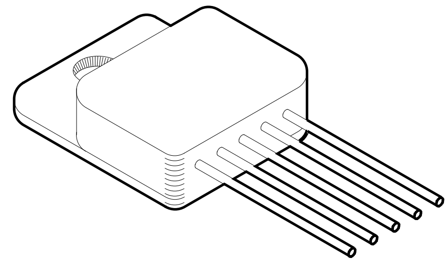
M.S.KENNEDY CORP. RAD HARD DUAL POS/NEG, 3 AMP, LOW DROPOUT FIXED VOLTAGE REGULATORS

5930RH SERIES

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

FEATURES:

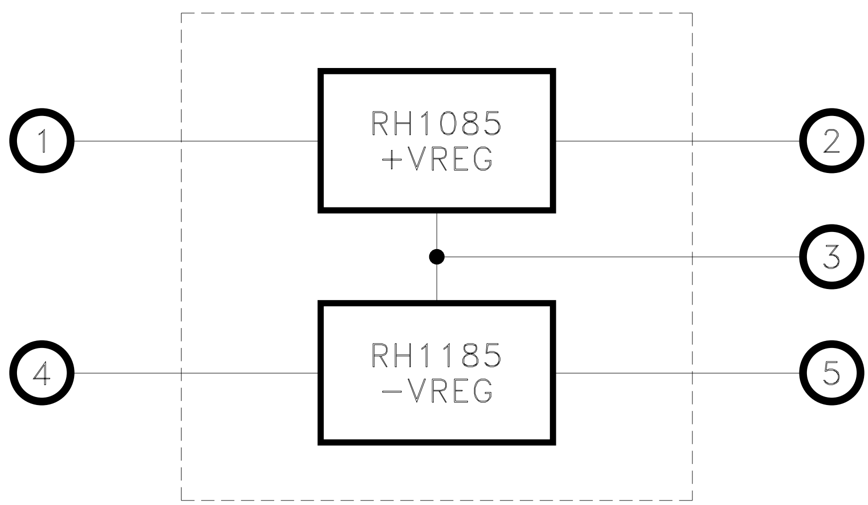
- Manufactured using LINEAR TECHNOLOGY Space Qualified RH1085 and RH1185 Die
- Total Dose Tested to 300 Krads(Si) (Method 1019.7 Condition A)
- Dual Low Dropout Voltage
- Internal Short Circuit Current Limit
- Output Voltages Are Internally Set To ± 1% Max
- Electrically Isolated Case
- Internal Thermal Overload Protection
- Many Output Voltage Combinations
- Alternate Package and Lead Form Configurations Available
- Alternate Output Voltages Available
- Contact MSK for MIL-PRF-38534 Qualification and Appendix G (Radiation) Status



DESCRIPTION:

The MSK 5930RH Series offers low dropout voltages on both the positive and negative regulators 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 5 pin package can be used providing maximum performance while occupying minimal board space. Output voltages are internally trimmed to ± 1% maximum resulting in consistent and accurate operation. Additionally, both regulators offer internal short circuit current and thermal limiting, which allows circuit protection and eliminates the need for external components and excessive derating.

EQUIVALENT SCHEMATIC



TYPICAL APPLICATIONS

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

PIN-OUT INFORMATION

1 +Vin
2 +Vout
3 GND
4 -Vin
5 -Vout

ABSOLUTE MAXIMUM RATINGS ⑨

$\pm V_{IN}$	Input Voltage (WRT V_{OUT})	±30V
P_D	Power Dissipation	Internally Limited
I_{OUT}	Output Current	±3A
T_J	Junction Temperature	+150°C
T_{ST}	Storage Temperature Range	-65°C to +150°C
T_{LD}	Lead Temperature Range (10 Seconds)	300°C
T_C	Case Operating Temperature	
	MSK 5930-5939RH	-40°C to +85°C
	MSK 5930K/H/E RH-5939K/H/E RH	-55°C to +125°C

ELECTRICAL SPECIFICATIONS

Parameter	Test Conditions ③ ⑪	Group A Subgroup	MSK 5930K/H/E RH SERIES Min.	Typ.	Max.	MSK 5930RH SERIES Min.	Typ.	Max.	Units
POSITIVE OUTPUT REGULATORS									
Output Voltage Tolerance	I_{OUT} = 0A; V_{IN} = V_{OUT} + 3V	1	-	0.1	1.0	-	0.1	2.0	%
		2,3	-	0.1	2.0	-	-	-	%
	Post Radiation	1	-	1.5	3.0	-	1.5	3.0	%
Dropout Voltage ②	0A≤I_{OUT}≤3A; ΔV_{OUT} = 50mV	1	-	1.3	1.5	-	1.3	1.6	V
Load Regulation	100mA≤I_{OUT}≤3A	1	-	0.2	1	-	0.2	2	%
	V_{IN} = V_{OUT} + 3V	2,3	-	0.3	2	-	-	-	%
Line Regulation	I_{OUT} = 0A	1	-	0.1	0.5	-	0.1	0.6	%
	(V_{OUT} + 3V)≤V_{IN}≤(V_{OUT} + 15V)	2,3	-	0.2	0.75	-	-	-	%
Quiescent Current	V_{IN} = V_{OUT} + 3V; I_{OUT} = 0A	1,2,3	-	10	15	-	10	15	mA
Short Circuit Current ②⑨	V_{IN} = V_{OUT} + 5V	-	3.2	4	-	3.0	4	-	A
Ripple Rejection ②	I_{OUT} = 3A; C_{OUT} = 25μF; f = 120Hz	-	60	75	-	60	75	-	dB
Thermal Resistance ②	JUNCTION TO CASE @ 125°C	-	-	2.9	3.2	-	2.9	3.2	°C/W
NEGATIVE OUTPUT REGULATORS ⑧									
Output Voltage Tolerance	I_{OUT} = 0A; V_{IN} = V_{OUT} + 3V	1	-	0.1	1.0	-	0.1	2.0	%
		2,3	-	0.1	2.5	-	-	-	%
	Post Radiation	1	-	1.0	2.0	-	1.0	2.0	%
Dropout Voltage ②	0A≤I_{OUT}≤3A; ΔV_{OUT} = 50mV	1	-	0.8	1.2	-	0.8	1.3	V
Load Regulation	V_{IN} = V_{OUT} + 3V	1	-	0.2	1	-	0.2	2	%
	100mA≤I_{OUT}≤3A	2,3	-	0.3	2	-	-	-	%
Line Regulation	I_{OUT} = 0A	1	-	0.1	0.5	-	0.1	0.6	%
	(V_{OUT} + 3V)≤V_{IN}≤(V_{OUT} + 15V)	2,3	-	0.2	0.75	-	-	-	%
Quiescent Current	V_{IN} = V_{OUT} + 3V; I_{OUT} = 0A	1,2,3	-	4.5	10	-	4.5	10	mA
Short Circuit Current ②	V_{IN} = V_{OUT} + 5V	-	3.0	3.5	-	3.0	3.5	-	A
Ripple Rejection ②	I_{OUT} = 3A; C_{OUT} = 25μF; f = 120Hz	-	60	75	-	60	75	-	dB
Thermal Resistance ②	JUNCTION TO CASE @ 125°C	-	-	3.3	3.6	-	3.3	3.6	°C/W

NOTES:

① Outputs are decoupled to ground using 33μF 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.
③ All output parameters are tested using a low duty cycle pulse to maintain T_J = T_C.
④ Industrial grade and "E" suffix 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 = T_C = +25°C
Subgroup 2 T_A = T_C = +125°C
Subgroup 3 T_A = T_C = -55°C
⑦ Please consult the factory if alternate output voltages are required.
⑧ Input voltage (V_{IN} = V_{OUT} + a specified voltage) is implied to be more negative than V_{OUT}.
⑨ For compliance with Mil-STD 833 revision C current density specifications, the MSK 5930RH series is derated to 2 Amps for the positive regulator.
⑩ Continuous operation at or above absolute maximum ratings may adversely effect the device performance and/or life cycle.
⑪ Pre and post irradiation limits, at 25°C, up to 100Krad TID, are identical unless otherwise specified.

PART NUMBER ⑦	OUTPUT VOLTAGES POSITIVE	NEGATIVE
MSK5930RH	+3.3V	-5.2V
MSK5931RH	+5.0V	-5.0V
MSK5932RH	+5.0V	-5.2V
MSK5933RH	+12.0V	-5.0V
MSK5934RH	+12.0V	-12.0V
MSK5935RH	+15.0V	-15.0V
MSK5936RH	+15.0V	-5.0V
MSK5937RH	+5.0V	-12.0V
MSK5938RH	+5.0V	-15.0V
MSK5939RH	+10.0V	-10.0V

APPLICATION NOTES

BYPASS CAPACITORS

For most applications a 33uF minimum, low ESR (0.5-2 ohm) tantalum capacitor should be attached as close to the regulator's output as possible. 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.

LOAD REGULATION

For best results the ground pin should be connected directly to the load as shown below, this effectively reduces the ground loop effect and eliminates excessive voltage drop in the sense leg. It is also important to keep the output connection between the regulator and the load as short as possible since this directly affects the load regulation. For example, if 20 gauge wire were used which has a resistance of about .008 ohms per foot, this would result in a drop of 8mV/ft at 1Amp of load current. It is also important to follow the capacitor selection guidelines to achieve best performance. Refer to Figure 1 for connection diagram.

Avoiding Ground Loops

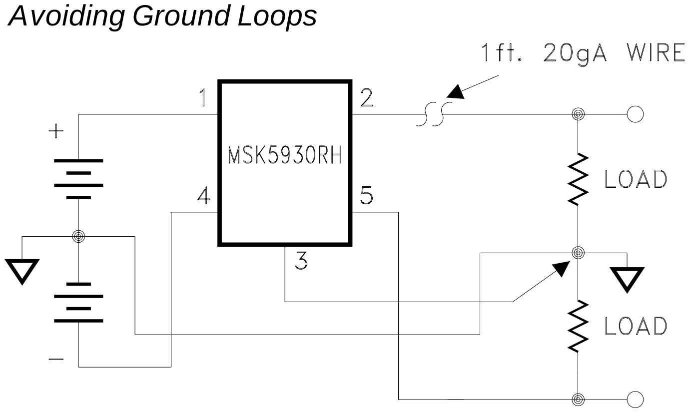


FIGURE 1

TOTAL DOSE RADIATION TEST PERFORMANCE

Radiation performance curves for TID testing have been generated for all radiation testing performed by MS Kennedy. These curves show performance trends throughout the TID test process and can be located in the MSK 5930RH radiation test report. The complete radiation test report will be available in the RAD HARD PRODUCTS section on the MSK website.

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

OVERLOAD SHUTDOWN

The regulators feature both power and thermal overload protection. When the maximum power dissipation is not exceeded, the regulators will current limit slightly above their 3 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 regulators also shutdown 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.

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: $Tj = Pd \times (R_{\theta}jc + R_{\theta}cs + R_{\theta}sa) + Ta$

WHERE
Tj = Junction Temperature
Pd = 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
Tc = Case Temperature
Ta = Ambient Temperature
Ts = Heat Sink Temperature

EXAMPLE:

This example demonstrates an analysis where each regulator is at one-half of its maximum rated power dissipation, which occurs when the output currents are at 1.5 amps each.

Conditions for MSK 5932RH:

Vin = ±7.0V; Iout = ±1.5A

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

Pd = (Vin - Vout)(Iout)
Pd = (7-5)(1.5)
= 3.0W

3.) For conservative design, set Tj = +125°C Max.
4.) For this example, worst case Ta = +90°C.
5.) $R_{\theta}jc$ = 3.6°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 $R_{\theta}sa$:

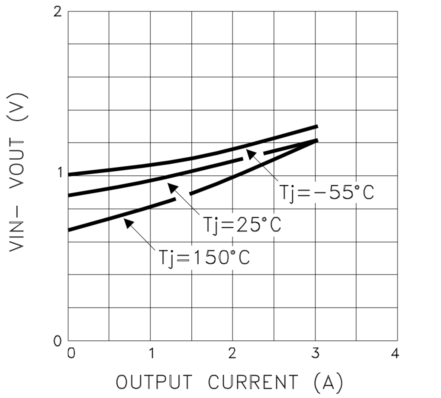
$R_{\theta}sa$ = ((Tj - Ta)/Pd) - ($R_{\theta}jc$) - ($R_{\theta}cs$)
= (125°C - 90°C)/3.0W - 3.6°C/W - 0.15°C/W
= 7.9°C/W

The same exercise must be performed for the positive regulator. In this case the result is 7.9°C/W. Therefore, a heat sink with a thermal resistance of no more than 7.9°C/W must be used in this application to maintain both regulator circuit junction temperatures under 125°C.

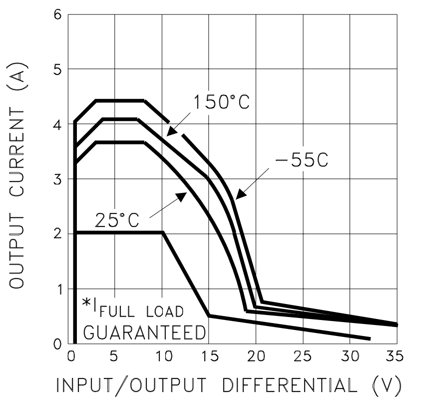
TYPICAL PERFORMANCE CURVES

POSITIVE REGULATORS

DROPOUT VOLTAGE vs. OUTPUT CURRENT

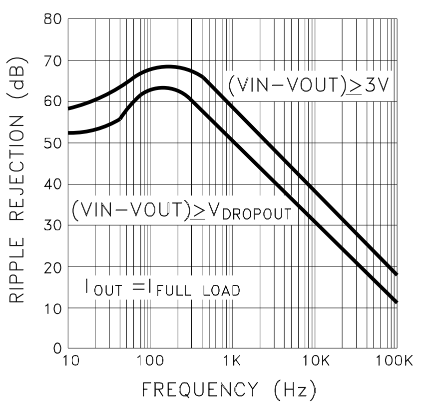


INTERNAL CURRENT LIMIT vs. VIN−VOUT

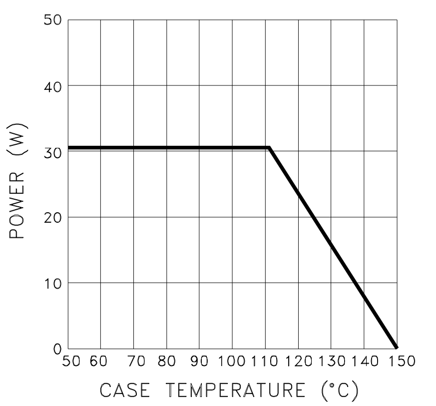


*REFERENCE NOTE 9 ON PAGE 2

RIPPLE REJECTION vs. FREQUENCY

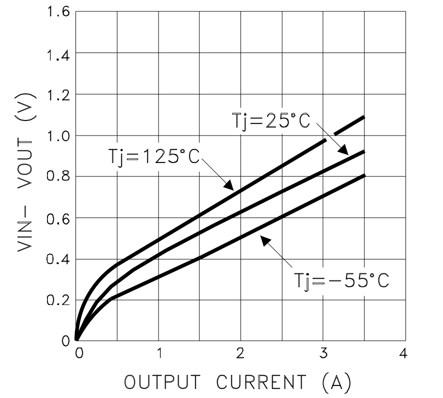


POWER DISSIPATION vs. TEMPERATURE

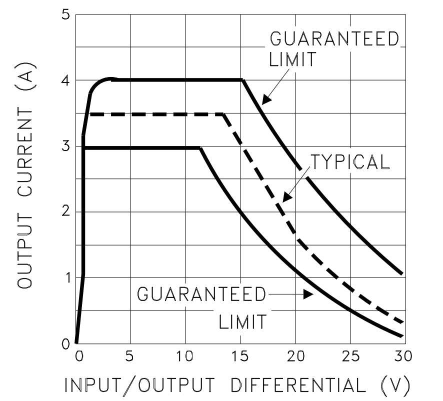


NEGATIVE REGULATORS

DROPOUT VOLTAGE vs. OUTPUT CURRENT



INTERNAL CURRENT LIMIT vs. VIN−VOUT



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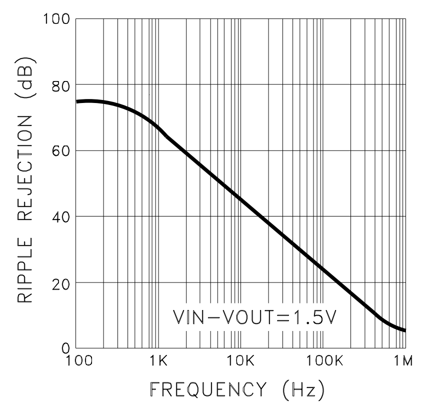
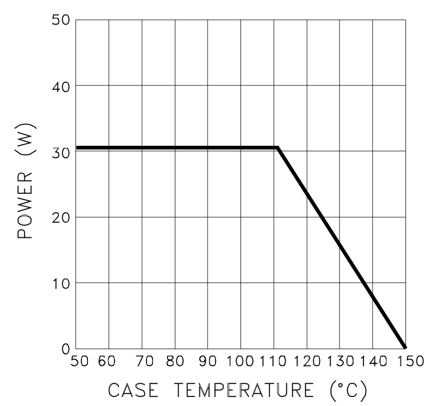
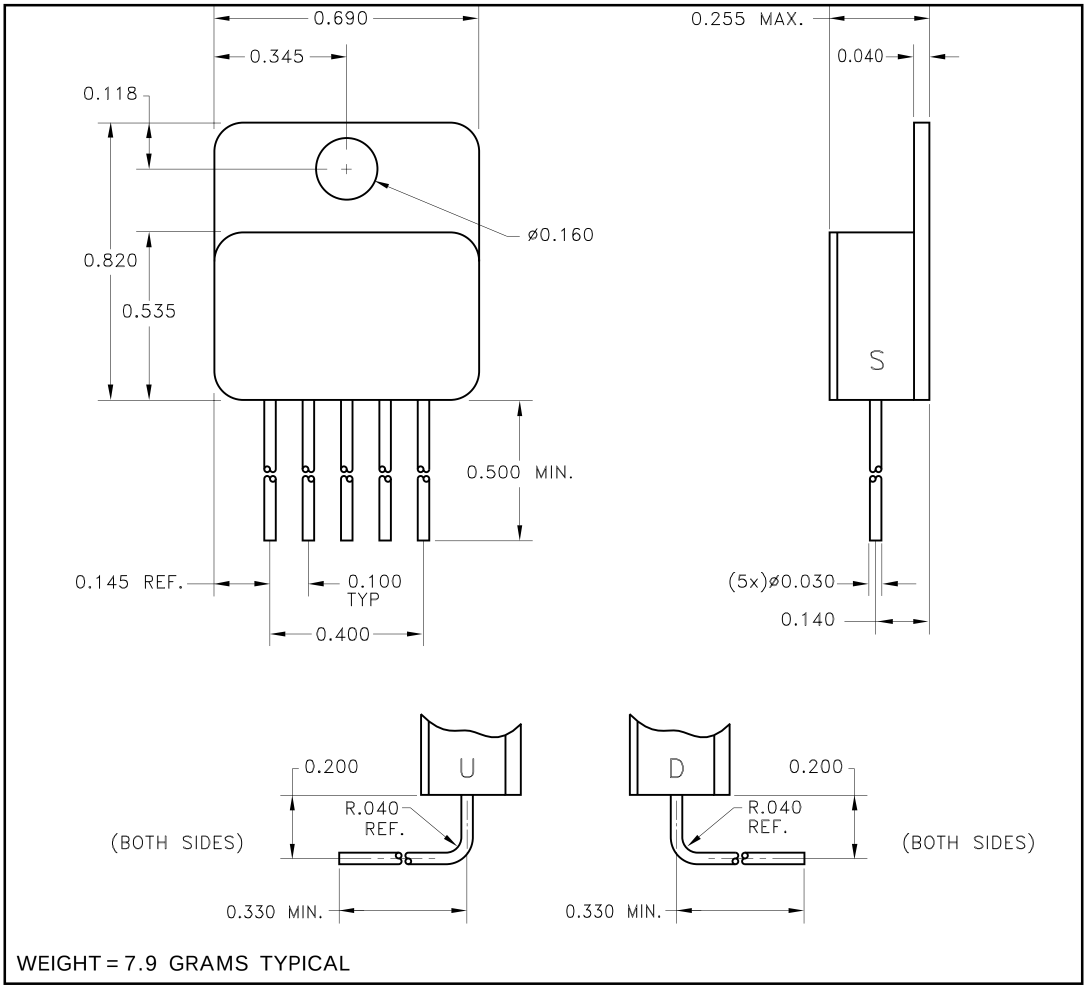


POWER DISSIPATION vs. TEMPERATURE



MECHANICAL SPECIFICATIONS



NOTE: ESD Triangle indicates Pin 1.

ALL DIMENSIONS ARE ± 0.010 INCHES UNLESS OTHERWISE LABELED

ORDERING INFORMATION

MSK5930 H RH U

- **LEAD CONFIGURATIONS** (U)
  S = STRAIGHT; U = BENT UP; D = BENT DOWN
- **RADIATION HARDENED** (RH)
- **SCREENING** (H)
  BLANK = INDUSTRIAL; E = EXTENDED RELIABILITY
  H = MIL-PRF-38534 CLASS H; K = MIL-PRF-38534 CLASS K
- **OUTPUT VOLTAGE (5930-5939)** (30)
  SEE PAGE 2 FOR PART NUMBERS & VOLTAGES
- **GENERAL PART NUMBER** (MSK59)

The above example is a +3.3V, -5.2V military regulator with leads bent up.

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