MIL-PRF-38534 CERTIFIED

M.S.KENNEDY CORP.

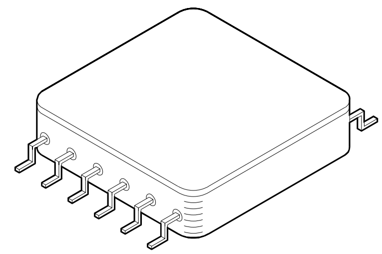
RAD TOLERANT ULTRA LOW DROPOUT ADJUSTABLE POSITIVE LINEAR REGULATOR

5900RH

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

FEATURES:

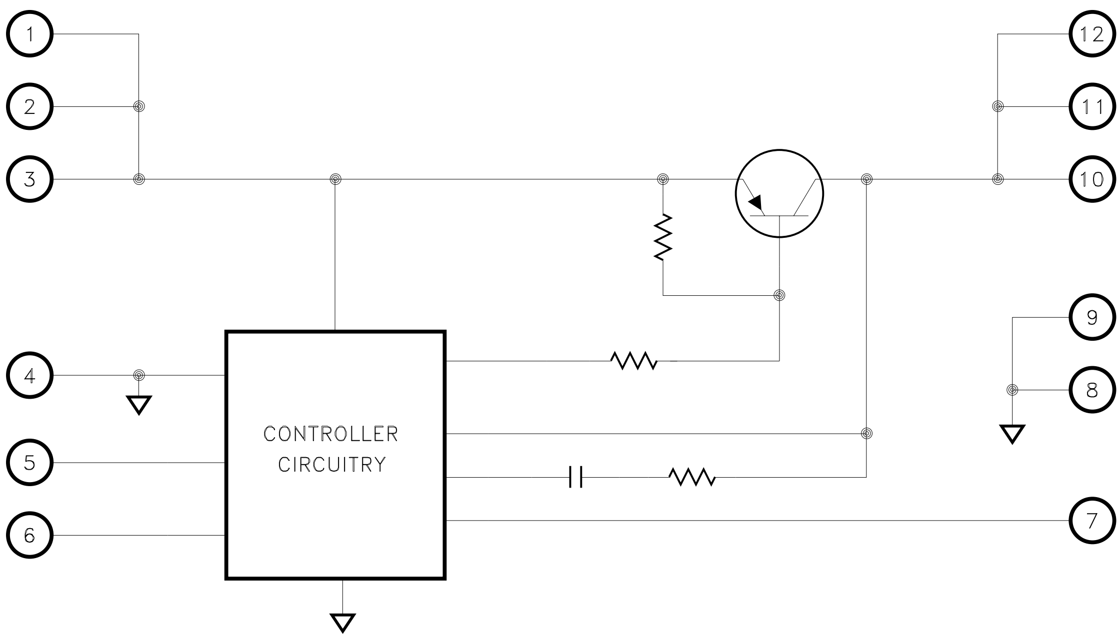
- Total Dose Tested to 300K RAD
- Ultra Low Dropout for Reduced Power Consumption
- External Shutdown/Reset Function
- Latching Overload Protection
- Adjustable Output Using Two External Resistors
- Output Current Limit
- Surface Mount Package
- Available to DSCC SMD # 5962-05220



DESCRIPTION:

The MSK 5900RH is a rad tolerant adjustable linear regulator capable of delivering 4.0 amps of output current. Typical dropout is only 0.30 volts with a 1.5 amp load. An external shutdown/reset function is ideal for power supply sequencing. This device also has latching overload protection that requires no external current sense resistor. The MSK 5900RH is radiation tolerant to 300K RAD and specifically designed for many space/satellite applications. The device is packaged in a hermetically sealed 12 pin flatpack that is lead formed for surface mount applications.

EQUIVALENT SCHEMATIC



TYPICAL APPLICATIONS

- Satellite System Power Supplies
- Switching Power Supply Post Regulators
- Constant Voltage/Current Regulators
- Microprocessor Power Supplies

PIN-OUT INFORMATION

1 V_{IN} A	12 V_{OUT} A
2 V_{IN} B	11 V_{OUT} B
3 V_{IN} C	10 V_{OUT} C
4 GND 1	9 GND 2
5 Latch	8 GND 2
6 Shutdown	7 FB

Rev. F 2/06

ABSOLUTE MAXIMUM RATINGS ⑩

- $+V_{IN}$ Supply Voltage . . . . +10V
- I_{OUT} Output Current ⑦ 4A
- T_C Case Operating Temperature Range
  - MSK5900RH K/H/E . . . . -55°C to +125°C
  - MSK5900RH . . . . -40°C to +85°C
- T_{ST} Storage Temperature Range -65°C to +150°C
- T_{LD} Lead Temperature Range . . . . 300°C (10 Seconds)
- P_D Power Dissipation . . . . See SOA Curve
- T_C Junction Temperature . . . . 150°C

ELECTRICAL SPECIFICATIONS

Parameter	Test Conditions ① ⑨	Group A	MSK5900K/H/E			MSK5900			Units
		Subgroup	Min.	Typ.	Max.	Min.	Typ.	Max.	
Input Voltage Range ② ⑧	10mA ≤ I_{OUT} ≤ 1.0A	1	2.8	-	7.5	2.8	-	7.5	V
		2,3	2.8	-	7.5	-	-	-	V
Feedback Voltage	10mA ≤ I_{OUT} ≤ 1.0A R1 = 187Ω	1	1.225	1.265	1.305	1.202	1.265	1.328	V
		2,3	1.225	-	1.305	-	-	-	V
Feedback Pin Current ②	V_{FB} = 1.265V 10mA ≤ I_{OUT} ≤ 1.0A	1,2,3	0	-	5.0	0	-	5.0	μA
Quiescent Current	V_{IN} = 7.5V	1	-	14	20	-	14	20	mA
	Not Including I_{OUT}	2,3	-	14	20	-	-	-	mA
Line Regulation	I_{OUT} = 10mA 2.8V ≤ V_{IN} ≤ 7.5V	1	-	±0.01	±0.50	-	0.01	±0.60	%V_{OUT}
	R1 = 187Ω	2,3	-	-	±0.50	-	-	-	%V_{OUT}
Load Regulation	10mA ≤ I_{OUT} ≤ 1.0A	1	-	±0.06	±0.80	-	0.06	±1.0	%V_{OUT}
		2,3	-	-	±0.80	-	-	-	%V_{OUT}
Dropout Voltage	Delta FB = 1% I_{OUT} = 1.0A	1	-	0.22	0.70	-	0.22	0.75	V
		2,3	-	0.26	0.70	-	-	-	V
Minimum Output Current ②	2.8V ≤ V_{IN} ≤ 7.5V	1	-	8	10	-	8	10	mA
	R1 = 187Ω	2,3	-	9	10	-	-	-	mA
Output Voltage Range ②	V_{IN} = 7.5V	-	1.5	-	6.8	1.5	-	6.7	V
Output Current Limit ⑦	V_{IN} = 4.4V V_{OUT} = 3.3V	1	1.5	1.75	2.0	1.3	1.75	2.2	A
		2,3	1.3	1.75	2.2	-	-	-	A
Shutdown Threshold	V_{OUT} ≤ 0.2V (OFF)	1	1.0	1.3	1.6	1.0	1.3	1.6	V
	V_{OUT} = Nominal (ON)	2,3	1.0	1.3	1.6	-	-	-	V
Shutdown Hysteresis	Difference between voltage	1	-	0.02	0.2	-	0.02	0.2	V
	threshold of V_{SDI} (ON) and V_{SDI} (OFF)	2,3	-	0.03	0.2	-	-	-	V
Ripple Rejection ②	f = 1KHz to 10KHz	4	20	-	-	20	-	-	dB
	10mA ≤ I_{OUT} ≤ 1.0A 1.0V = V_{IN}-V_{OUT}	5,6	20	-	-	-	-	-	dB
Phase Margin ②		4,5,6	30	70	-	30	70	-	degrees
Gain Margin ②		4,5,6	10	18	-	10	18	-	dB
Equivalent Noise Voltage ②	Referred to Feedback Pin	4,5,6	-	-	50	-	-	50	μV_{RMS}
Thermal Resistance ②	Junction to Case @ 125°C Output Device	-	-	6.9	7.5	-	6.9	7.8	°C/W

NOTES:

① Unless otherwise specified, V_{IN} = 5.0V, R1 = 1.62K, $V_{SHUTDOWN}$ = 0V and I_{OUT} = 10mA. See Figure 2.
② Guaranteed by design but not tested. Typical parameters are representative of actual device performance but are for reference only.
③ Industrial grade and "E" suffix devices shall be tested to subgroups 1 and 4 unless otherwise requested.
④ Military grade devices ("H" suffix) shall be 100% tested to subgroups 1,2,3 and 4.
⑤ Subgroup 5 and 6 testing available upon request.
⑥ Subgroup 1,4 T_C = +25°C
Subgroup 2,5 T_C = +125°C
Subgroup 3,6 T_A = -55°C
⑦ Output current limit is dependent upon the values of V_{IN} and V_{OUT}. See Figure 1 and typical performance curves.
⑧ Minimum V_{IN} at -55°C and I_{OUT} = 1.0A is 4.0V due to current limit circuitry.
⑨ Consult factory for post radiation limits.
⑩ Continuous operation at or above absolute maximum ratings may adversely effect the device performance and/or life cycle.

PIN FUNCTIONS

V_{IN} A,B,C - These pins provide power to all internal circuitry including bias, start-up, thermal limit and overcurrent latch. Input voltage range is 2.8V to 7.5V. All three pins must be connected for proper operation.

GND1 - Internally connected to input ground, these pins should be connected externally by the user to the circuit ground and the GND2 pins.

LATCH - The MSK 5900RH has a timed latch-off circuit which provides overcurrent protection. An overcurrent or output short condition will saturate the internal drive transistor. The time-out latch will then be triggered and turn off the regulator. The time-out period is determined by an external capacitor connected between the latch and GND pins. Once the overcurrent condition is removed, the latch can be reset by pulling the SHUTDOWN pin high, grounding the LATCH pin or cycling power off, then on. Under normal conditions, the voltage at the LATCH pin is zero. When the device is latched off, the voltage at the LATCH pin will be 1.6V at 25°C.

SHUTDOWN - There are two functions to the SHUTDOWN pin. It may be used to disable the output voltage or to reset the LATCH pin. To activate the shutdown/ reset functions the user must apply a voltage greater than 1.3V to the SHUTDOWN pin. The output voltage will turn on when the SHUTDOWN pin is pulled below the threshold voltage. If the SHUTDOWN pin is not used, it should be connected to ground.

FB - The FB pin is the inverting input of the internal error amplifier. The non-inverting input is connected to an internal 1.265V reference. This error amplifier controls the drive to the output transistor to force the FB pin to 1.265V. An external resistor divider is connected to the output, FB pin and ground to set the output voltage.

GND2 - Internally connected to output ground, these pins should be connected externally by the user to the circuit ground and the GND1 pins.

V_{OUT} A,B,C - These are the output pins for the device. All three pins must be connected for proper operation.

POWER SUPPLY BYPASSING

To maximize transient response and minimize power supply transients it is recommended that a 33μF minimum tantalum capacitor is connected between V_{IN} and ground. A 0.1μF ceramic capacitor should also be used for high frequency bypassing.

OUTPUT CAPACITOR SELECTION

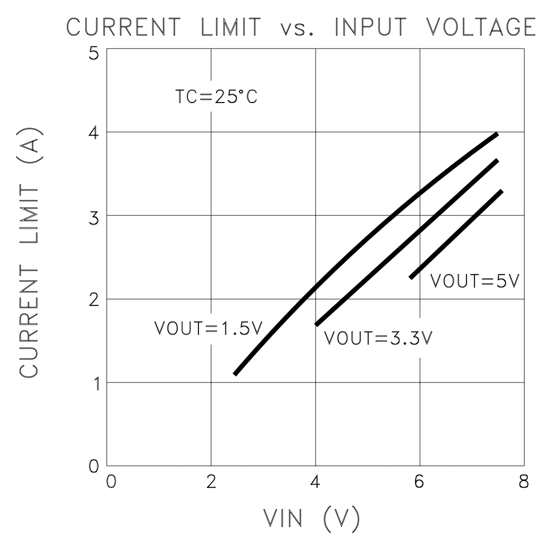
Typically, large bulk capacitance is required at the output of a linear regulator to maintain good load transient response. However, with the MSK 5900RH this is not the case. A 47μF surface mount tantalum capacitor in parallel with a 0.1μF ceramic capacitor from the output to ground should suffice under most conditions. If the user finds that tighter voltage regulation is needed during output transients, more capacitance may be added. If more capacitance is added to the output, the bandwidth may suffer.

OVERCURRENT LATCH-OFF/LATCH PIN CAPACITOR SELECTION

As previously mentioned, the LATCH pin provides over current/output short circuit protection with a timed latch-off circuit. The latch off time out is determined with an external capacitor connected from the LATCH pin to ground. The time-out period is equal to the time it takes to charge this external capacitor from 0V to 1.6V. The latch charging current is provided by an internal current source. This current is a function of input voltage and temperature (see latch charging current curve). For instance, at 25°C, the latch charging current is 7.2μA at V_{IN}=3V and 8μA at V_{IN}=7V.

In the latch-off mode, some additional current will be drawn from the input. This additional latching current is also a function of input voltage and temperature (see latching current curve).

FIGURE 1



The MSK 5900RH current limit function is directly affected by the input and output voltages. Figure 1 illustrates the relationship between V_{IN} and I_{CL} for three output voltages.

THERMAL LIMITING

The MSK 5900RH control circuitry has a thermal shutdown temperature of approximately 150°C. This thermal shutdown can be used as a protection feature, but for continuous operation, the junction temperature of the pass transistor must be maintained below 150°C. Proper heat sink selection is essential to maintain these conditions.

HEAT SINK SELECTION

To select a heat sink for the MSK 5900RH, the following formula for convective heat flow may be used.

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_A = Ambient Temperature

$$\text{Power Dissipation} = (V_{IN} - V_{OUT}) \times I_{OUT}$$

Next, the user must select a maximum junction temperature. The absolute maximum allowable junction temperature is 150°C. The equation may now be rearranged to solve for the required heat sink to ambient thermal resistance ($R_{\theta SA}$).

Example:

An MSK 5900RH is connected for $V_{IN} = +5V$ and $V_{OUT} = +3.3V$. I_{OUT} is a continuous 1A DC level. The ambient temperature is +25°C. The maximum desired junction temperature is +125°C.

$R_{\theta JC} = 7.5°C/W$ and $R_{\theta CS} = 0.15°C/W$ for most thermal greases

$$\text{Power Dissipation} = (5V - 3.3V) \times (1A) = 1.7\text{Watts}$$

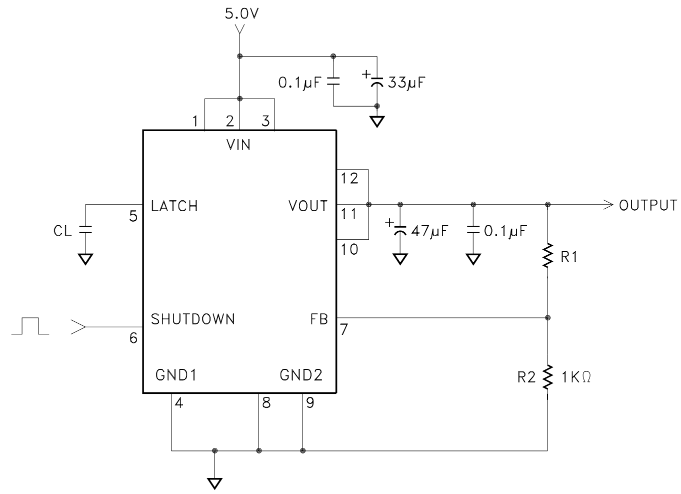
Solve for $R_{\theta SA}$:

$$R_{\theta SA} = \left[\frac{125°C - 25°C}{1.7W}\right] - 7.5°C/W - 0.15°C/W$$

$$= 51.2°C/W$$

In this example, a heat sink with a thermal resistance of no more than 51°C/W must be used to maintain a junction temperature of no more than 125°C.

TYPICAL APPLICATIONS CIRCUIT



$$V_{OUT} = 1.265(1 + R1/R2)$$

OUTPUT VOLTAGE SELECTION

As noted in the above typical applications circuit, the formula for output voltage selection is

$$V_{OUT} = 1.265\left[1 + \frac{R1}{R2}\right]$$

A good starting point for this output voltage selection is to set R2 = 1K. By rearranging the formula it is simple to calculate the final R1 value.

$$R1 = R2\left[\frac{V_{OUT}}{1.265} - 1\right]$$

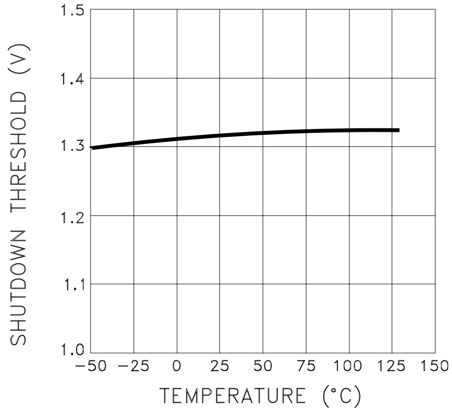
Table 1 below lists some of the most probable resistor combinations based on industry standard usage.

TABLE 1

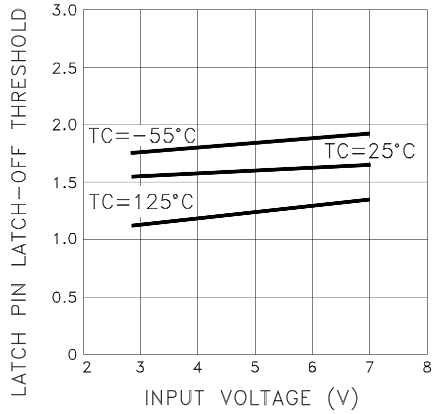
OUTPUT VOLTAGE (V)	R2 (Ω)	R1 (nearest 1%) (Ω)
1.5	1K	187
1.8	1K	422
2.0	1K	576
2.5	1K	976
2.8	1K	1.21K
3.3	1K	1.62K
4.0	1K	2.15K
5.0	1K	2.94K

TYPICAL PERFORMANCE CURVES

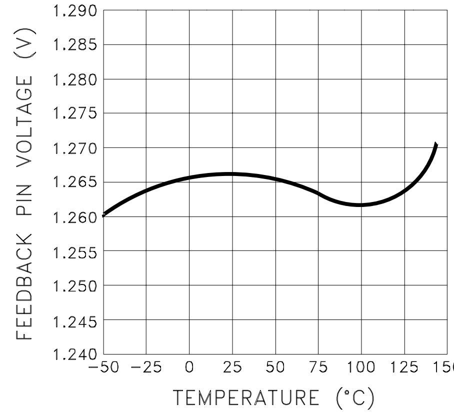
SHUTDOWN VOLTAGE THRESHOLD vs. TEMPERATURE



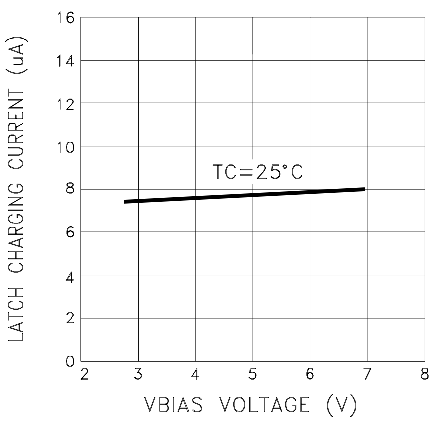
LATCH PIN LATCH−OFF THRESHOLD vs. INPUT VOLTAGE



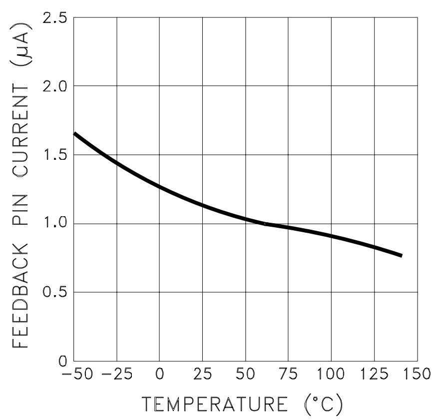
FEEDBACK PIN VOLTAGE vs. TEMPERATURE



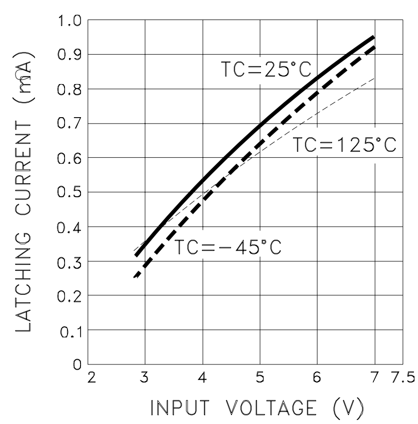
LATCH CHARGING CURRENT vs. VBIAS VOLTAGE



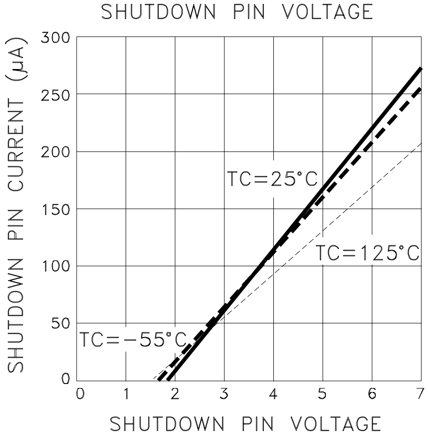
FEEDBACK PIN BIAS CURRENT vs. TEMPERATURE



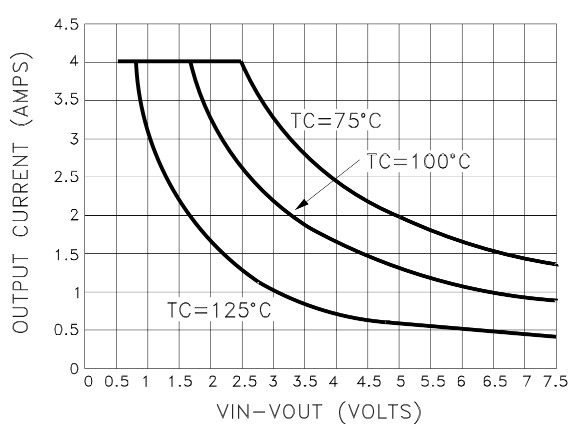
LATCHING CURRENT vs. INPUT VOLTAGE



SHUTDOWN PIN CURRENT vs. SHUTDOWN PIN VOLTAGE

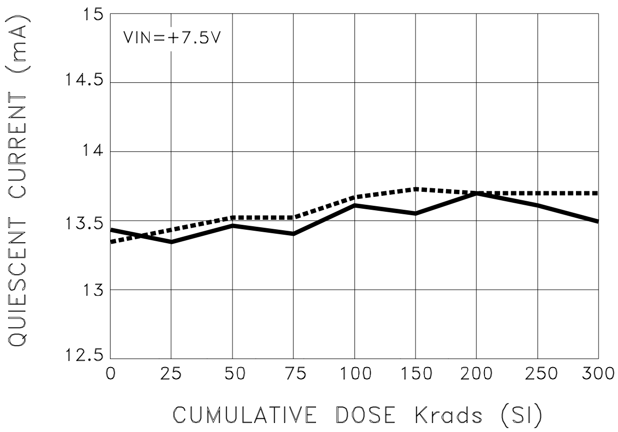


SOA OUTPUT CURRENT vs. VOLTAGE DROP

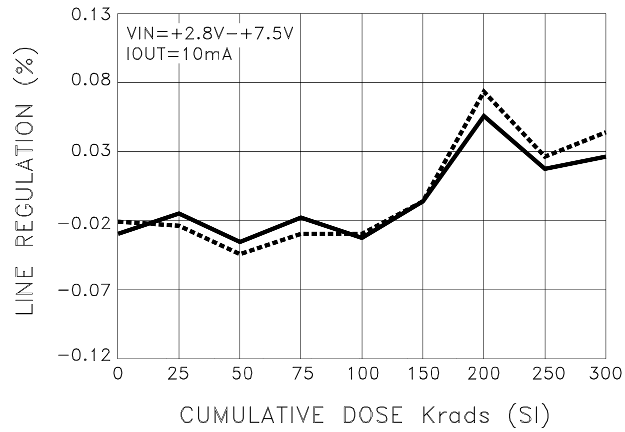


RADIATION PERFORMANCE CURVES

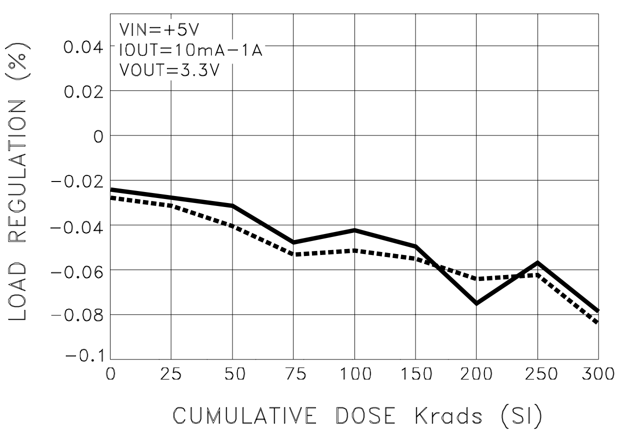
QUIESCENT CURRENT



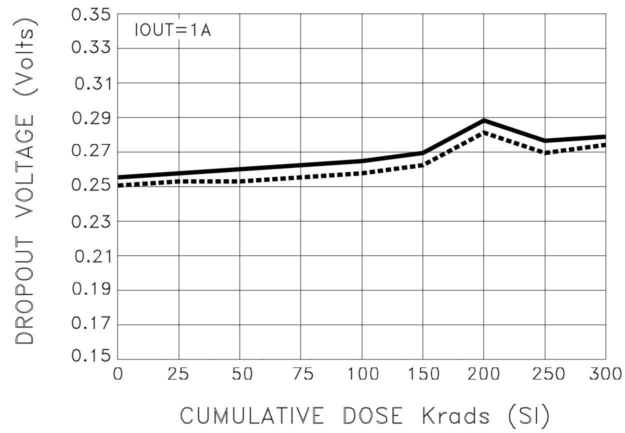
LINE REGULATION



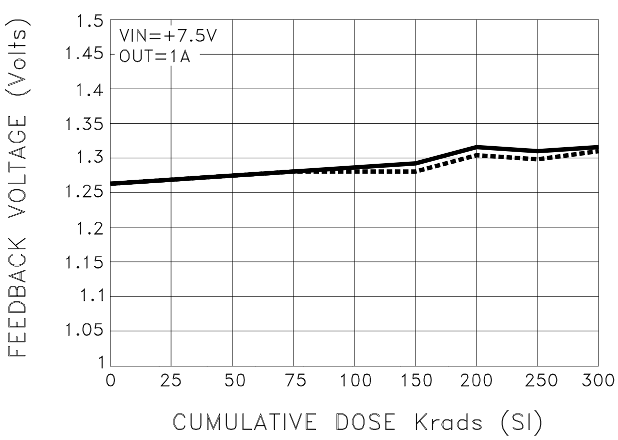
LOAD REGULATION



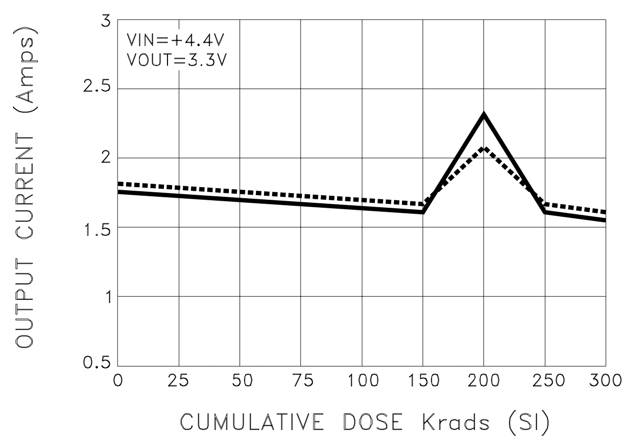
DROPOUT VOLTAGE



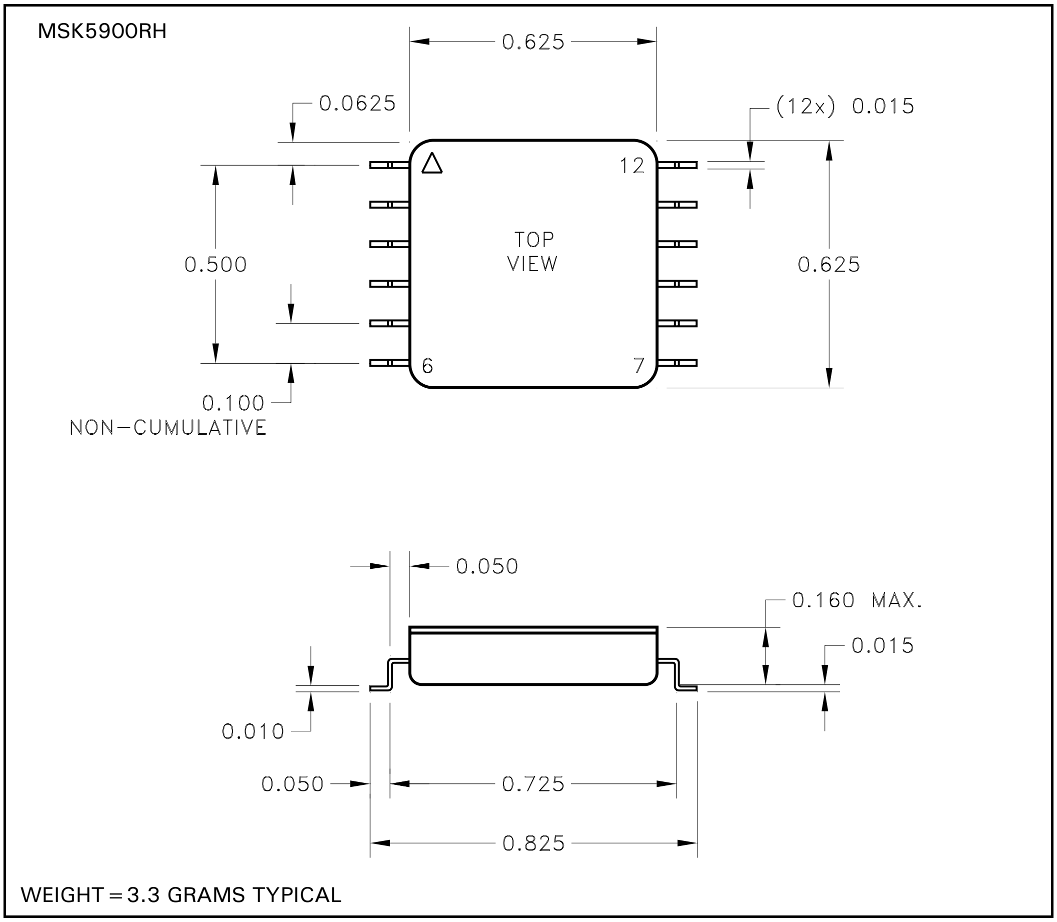
FEEDBACK VOLTAGE



OUTPUT CURRENT LIMIT



MECHANICAL SPECIFICATIONS



ALL DIMENSIONS ARE ±0.010 INCHES UNLESS OTHERWISE LABELED.
ESD Triangle indicates pin 1.

ORDERING INFORMATION

Part Number	Screening Level
MSK5900RH	INDUSTRIAL
MSK5900ERH	EXTENDED RELIABILITY
MSK5900HRH	MIL-PRF-38534 CLASS H
MSK5900KRH	MIL-PRF-38534 CLASS K
DSCC SMD	5962-05220

The above example is a Military grade hybrid.

NOTE: See DSCC SMD 5962-05220 for DSCC part number options.

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