MSK
M.S.KENNEDY CORP.

RAD TOLERANT ULTRA LOW DROPOUT ADJUSTABLE POSITIVE LINEAR REGULATOR
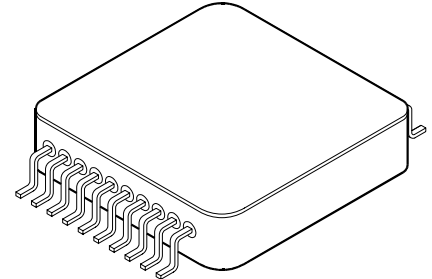# 5910RH

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 with Lead Forming
· Low Input Voltage for Maximum Efficiency
· Up to 5A Output Current
· Available to DSCC SMD #5962-05220

DESCRIPTION:

The MSK 5910RH is a rad tolerant adjustable linear regulator capable of delivering 5.0 amps of output current. The typical dropout is only 0.11 volts at 1 amp. 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 5910RH is radiation tolerant and specifically designed for many space/satellite applications. The device is packaged in a hermetically sealed 20 pin flatpack that can be lead formed for surface mount applications.

EQUIVALENT SCHEMATIC
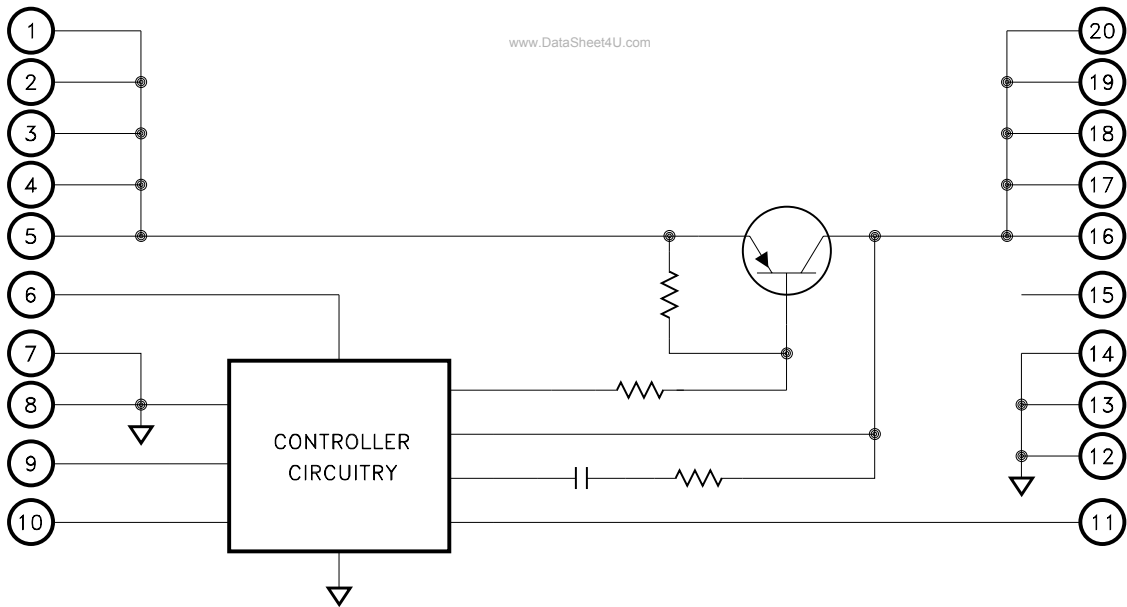
TYPICAL APPLICATIONS

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

PIN-OUT INFORMATION

1 VINA	20 VOUTE
2 VINB	19 VOUTD
3 VINC	18 VOUTC
4 VIND	17 VOUTB
5 VINE	16 VOUTA
6 VBIAS	15 NC
7 GND1	14 GND2
8 GND1	13 GND2
9 Latch	12 GND2
10 Shutdown	11 FB

Rev. I 3/06

ABSOLUTE MAXIMUM RATINGS [9]

+V_{BIAS} Bias Supply Voltage 10.0V
+V_{IN} Supply Voltage 10.0V
I_{OUT} Output Current [7] 5A
T_C Case Operating Temperature Range
MSK5910K/H/E RH . . . -55°C to +125°C
MSK5910RH . . . . -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 [8]	Test Conditions [1] [8]	Group A Subgroup	MSK5910K/H/E Min.	MSK5910K/H/E Typ.	MSK5910K/H/E Max.	MSK5910 Min.	MSK5910 Typ.	MSK5910 Max.	Units
Input Voltage Range [2]	10mA ≤ I_{OUT} ≤ 1.0A	1,2,3	2.0	-	7.5	2.0	-	7.5	V
Input Bias Voltage [2]	V_{BIAS} ≥ V_{IN}	1,2,3	2.8	5.0	7.5	2.8	5.0	7.5	V
Feedback Voltage	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	I_{IN} + I_{BIAS}, V_{BIAS} = V_{IN} = 7.5V Not including I_{OUT}	1,2,3	-	14	20	-	14	20	mA
Bias Current	V_{BIAS} = 7.5V	1,2,3	-	2	4	-	2	4	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}
	R1 = 976	2,3	-	-	±0.80	-	-	-	%V_{OUT}
Dropout Voltage	Delta FB = 1% I_{OUT} = 1.0A	1	-	0.11	0.40	-	0.11	0.45	V
		2,3	-	0.14	0.40	-	-	-	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	-	7.0	1.5	-	7.0	V
Output Current Limit [7]	V_{IN} = 2.5V V_{OUT} = 1.5V	1	3.2	3.6	4.0	3.2	3.6	4.0	A
		2,3	3.0	-	-	-	-	-	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 threshold of V_{SDI} (ON) and V_{SDI} (OFF)	1	-	0.02	0.2	-	0.02	0.2	V
		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]	I_{OUT} = 450mA	4,5,6	30	80	-	30	80	-	degrees
Gain Margin [2]	I_{OUT} = 450mA	4,5,6	10	30	-	10	30	-	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	-	-	7.3	8.4	-	7.3	9.0	°C/W

NOTES:

① Unless otherwise specified, V_{BIAS} = V_{IN} = 5.0V, R1 = 1.62K, $V_{SHUTDOWN}$ = 0V and I_{OUT} = 10mA. I_{OUT} is subtracted from I_Q measurement.
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 tested with a low duty cycle pulse to minimize junction heating and is dependent on the values of V_{IN}, V_{OUT} and case temperature. See Typical Performance Curves.
⑧ Contact factory for post radiation limits.
⑨ Continuous operation at or above absolute maximum ratings may adversely effect the device performance and/or life cycle.

PIN FUNCTIONS

VIN A,B,C,D,E - These pins provide the input power connection to the MSK 5910RH. This is the supply that will be regulated to the output. All five pins must be connected for proper operation.

VBIAS - This pin provides power to all internal circuitry including bias, start-up, thermal limit and overcurrent latch. VBIAS voltage range is 2.8V to 7.5V. VBIAS should be kept greater than or equal to VIN.

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 5910RH 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. Holding the latch pin low disables current limiting. 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.

VOUT A,B,C,D,E - These are the output pins for the device. All five pins must be connected for proper operation.

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 5910RH this is not the case. A $47\mu F$ surface mount tantalum capacitor in parallel with a $0.1\mu F$ 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.

POWER SUPPLY BYPASSING

To maximize transient response and minimize power supply transients it is recommended that a $33\mu F$ minimum tantalum capacitor is connected between VIN and ground. A $0.1\mu F$ ceramic capacitor should also be used for high frequency bypassing.

START UP OPTIONS

The MSK 5910RH starts up and begins regulating immediately when VBIAS and VIN are applied simultaneously. Applying VBIAS before VIN starts the MSK 5910RH up in a disabled or latched state. When starting in a latched state the device output can be enabled either by pulling the latch pin low to drain the latch capacitor or pulsing the shutdown pin high. The shutdown pulse duration is partially dependent upon the size of the latch capacitor and should be characterized for each application; 30uS is typically adequate for a 1uF latch capacitor at 25°C. A momentary high pulse on the shutdown pin can be achieved using the RC circuit below if VIN rises rapidly. The resistor and capacitor must be selected based on the required pulse duration, the rise characteristic of VIN and the shutdown pin threshold (see shutdown pin threshold and current curves).
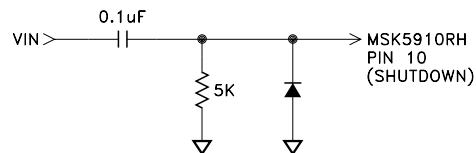
The shutdown pin can be held high and pulled low after VIN comes up or the latch pin held low and released after VIN comes up to ensure automatic startup when applying VBIAS before VIN. Either of the basic circuits below can be adapted to a variety of applications for automatic start up when VBIAS rises before VIN.
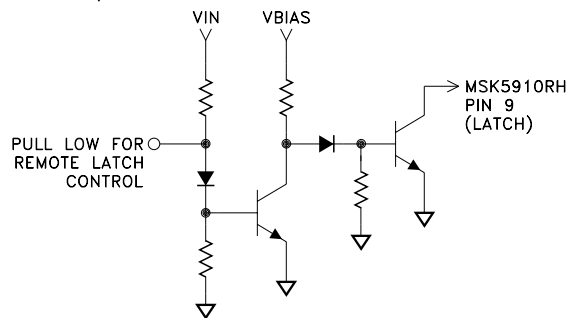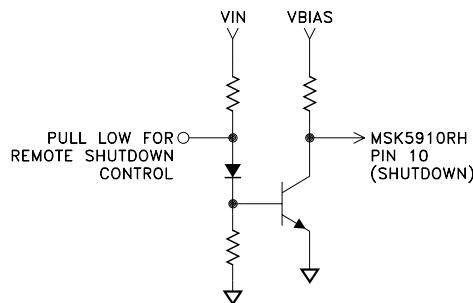
OVERCURRENT LATCH-OFF/LATCH PIN CAPACITOR SELECTION

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 bias voltage and temperature (see latch charging current curve). For instance, at 25°C, the latch charging current is $7.2\mu A$ at VBIAS = 3V and $8\mu A$ at VBIAS = 7V.

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

The MSK 5910RH current limit function is directly affected by the input and output voltages. Custom current limit is available; contact the factory for more information.

THERMAL LIMITING

The MSK 5910RH 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 5910RH, 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 5910RH 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.

$R_{\theta JC} = 8.5°C/W$ and $R_{\theta CS} = 0.15°C/W$ for most thermal greases

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

Solve for $R_{\theta SA}$:

$$R_{\theta SA} = \left[\frac{125°C \text{ - } 25°C}{1.7W}\right] \text{-}8.5°C/W \text{ - } 0.15°C/W$$

$$= 50.2°C/W$$

In this example, a heat sink with a thermal resistance of no more than 50°C/W must be used to maintain a junction temperature of no more than 125°C.

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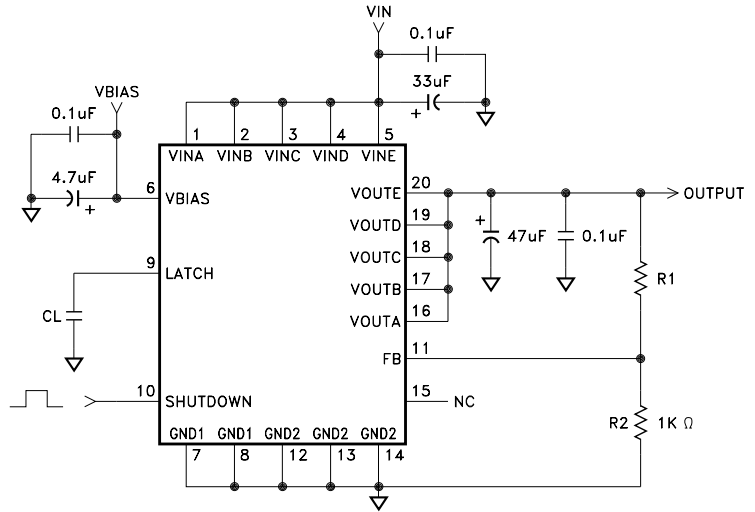
$$V_{OUT} = 1.265(1 + R1/R2)$$

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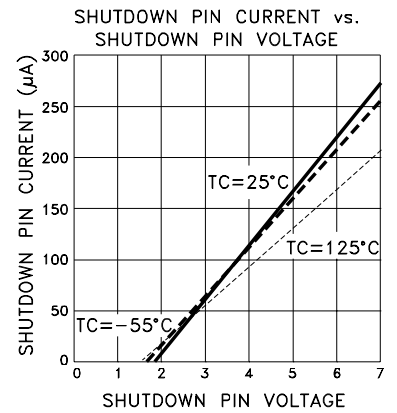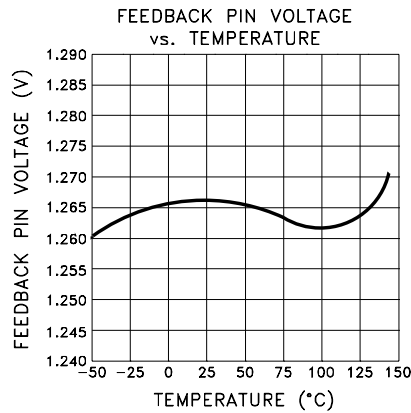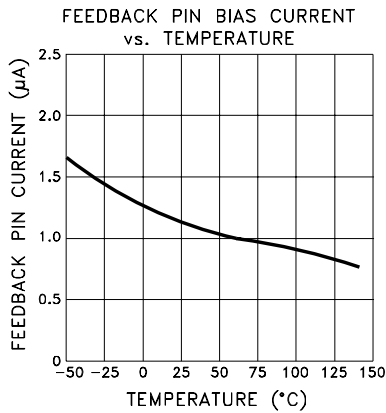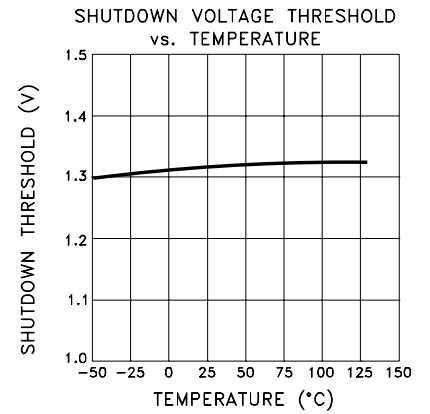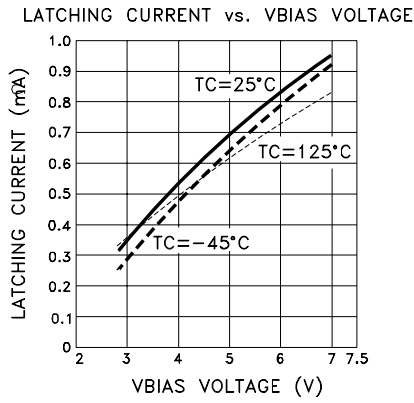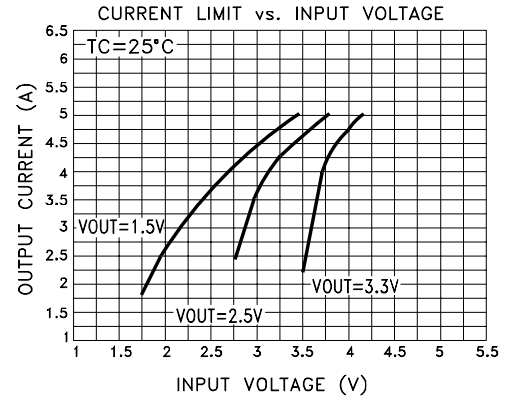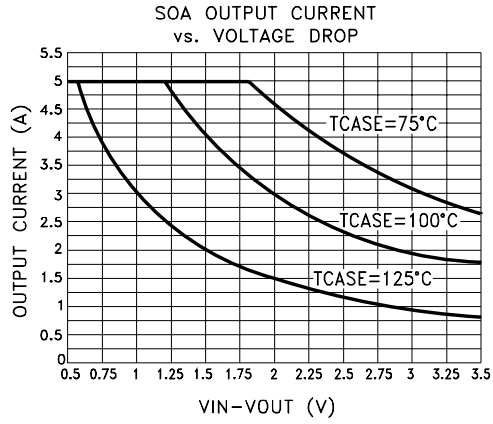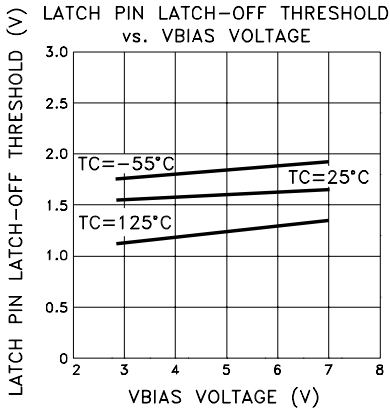
$$R1 = R2 \left[\frac{V_{OUT}}{1.265} \text{ -}1\right]$$

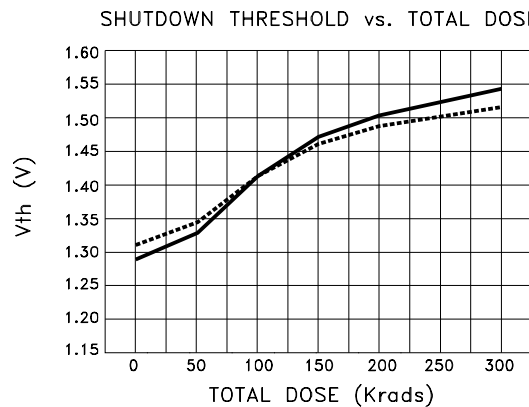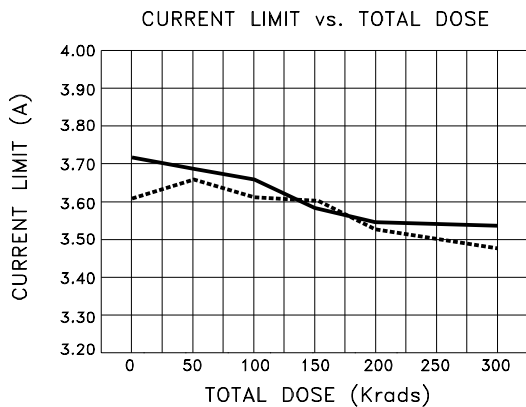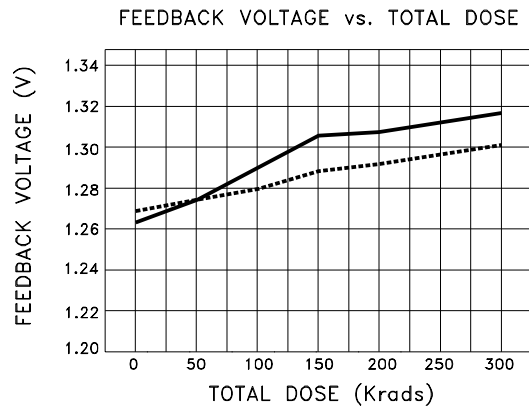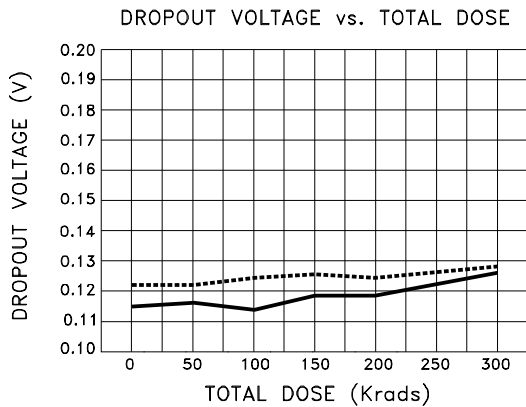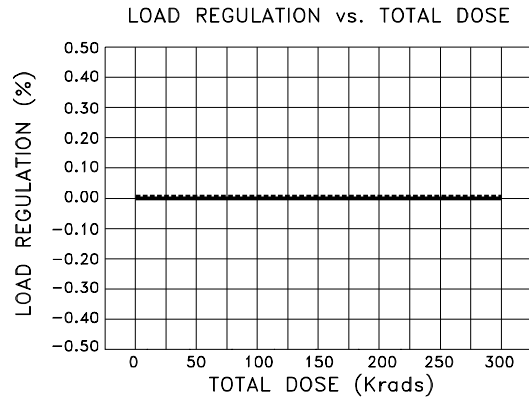Table 1 below lists some of the most probable resistor combinations based on industry standard usage.

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

LATCH PIN LATCH-OFF THRESHOLD vs. VBIAS VOLTAGE

SOA OUTPUT CURRENT vs. VOLTAGE DROP

CURRENT LIMIT vs. INPUT VOLTAGE

LATCHING CURRENT vs. VBIAS VOLTAGE

LATCH CHARGING CURRENT vs. VBIAS VOLTAGE

SHUTDOWN VOLTAGE THRESHOLD vs. TEMPERATURE

FEEDBACK PIN BIAS CURRENT vs. TEMPERATURE

FEEDBACK PIN VOLTAGE vs. TEMPERATURE

SHUTDOWN PIN CURRENT vs. SHUTDOWN PIN VOLTAGE

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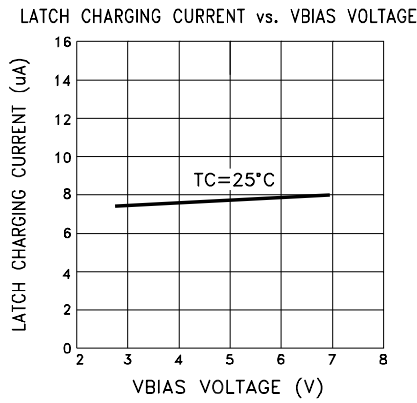
RADIATION PERFORMANCE CURVES

IQ vs. TOTAL DOSE

IQ (mA) vs. TOTAL DOSE (Krads)

BIAS CURRENT vs. TOTAL DOSE

BIAS CURRENT (mA) vs. TOTAL DOSE (Krads)

LINE REGULATION vs. TOTAL DOSE

LINE REGULATION (%) vs. TOTAL DOSE (Krads)

LOAD REGULATION vs. TOTAL DOSE

LOAD REGULATION (%) vs. TOTAL DOSE (Krads)

DROPOUT VOLTAGE vs. TOTAL DOSE

DROPOUT VOLTAGE (V) vs. TOTAL DOSE (Krads)

FEEDBACK VOLTAGE vs. TOTAL DOSE

FEEDBACK VOLTAGE (V) vs. TOTAL DOSE (Krads)

CURRENT LIMIT vs. TOTAL DOSE

CURRENT LIMIT (A) vs. TOTAL DOSE (Krads)

SHUTDOWN THRESHOLD vs. TOTAL DOSE

Vth (V) vs. TOTAL DOSE (Krads)

——— AVERAGE BIASED
·········· AVERAGE GND

MECHANICAL SPECIFICATIONS

0.087 REF.

0.625

0.625

(20x)0.015 ±0.005

0.081

0.625

0.500 MIN.

TOP VIEW

20

10

11

.050 TYP.

0.450

0.15 MAX.

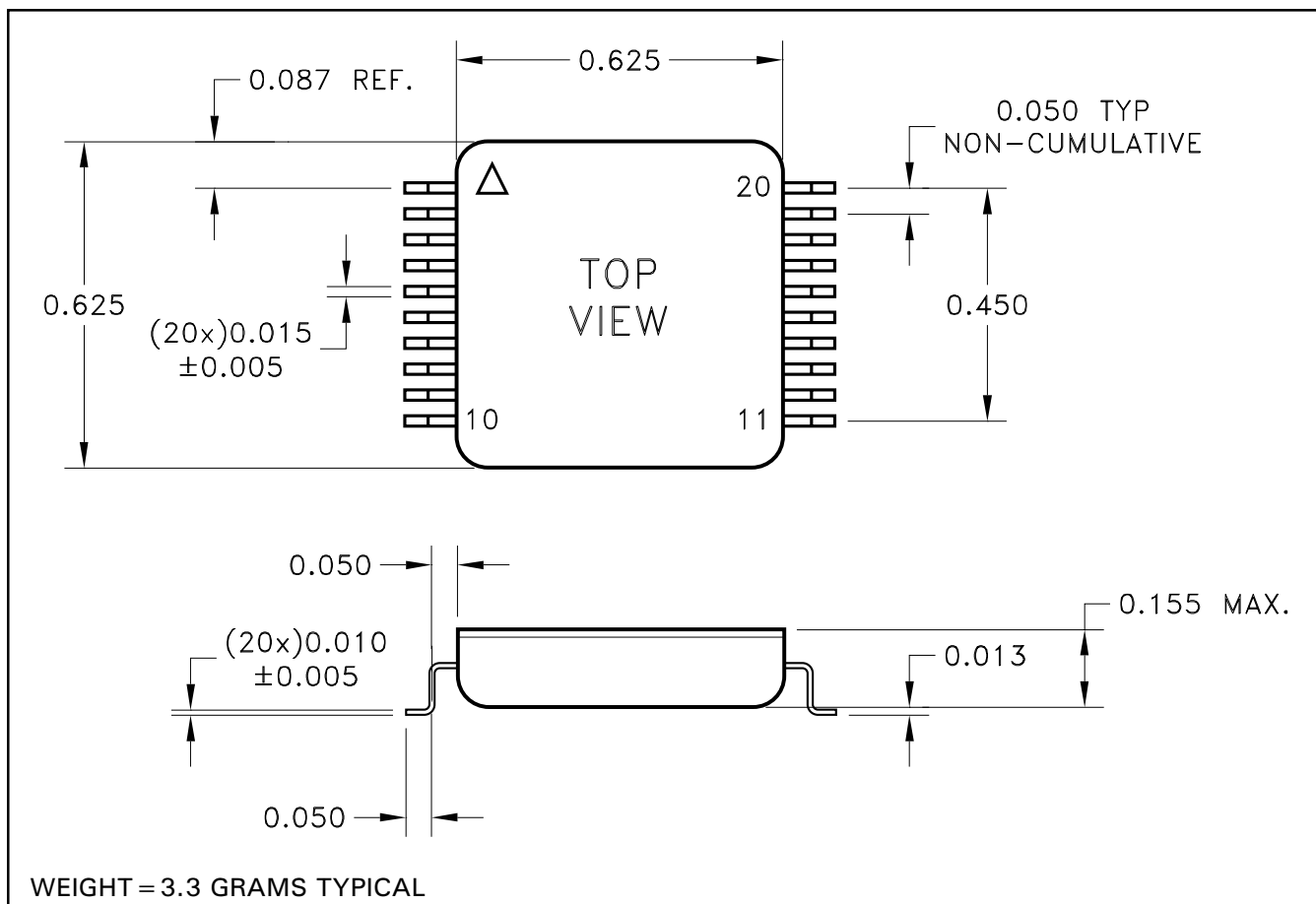(20x) 0.010 ±0.005

WEIGHT = 3.5 GRAMS TYPICAL

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

ORDERING INFORMATION

PART NUMBER	SCREENING LEVEL	LEADS
MSK5910RH	INDUSTRIAL	
MSK5910ERH	EXTENDED RELIABILITY	STRAIGHT
MSK5910HRH	MIL-PRF-38534 CLASS H	
MSK5910KRH	MIL-PRF-38534 CLASS K	
DSCC SMD	5962-05220	

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

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

ORDERING INFORMATION

PART NUMBER	SCREENING LEVEL	LEADS
MSK5910RHG	INDUSTRIAL	GULL WING
MSK5910ERHG	EXTENDED RELIABILITY	
MSK5910HRHG	MIL-PRF-38534 CLASS H	
MSK5910KRHG	MIL-PRF-38534 CLASS K	
DSCC SMD	5962-05220	

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

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