MIL PRF 38534 CERTIFIED

RAD TOLERANT ULTRA LOW DROPOUT ADJUSTABLE POSITIVE LINEAR REGULATOR

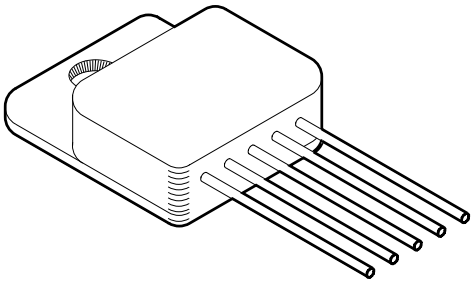
5921RH

M.S.KENNEDY CORP.

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

FEATURES:

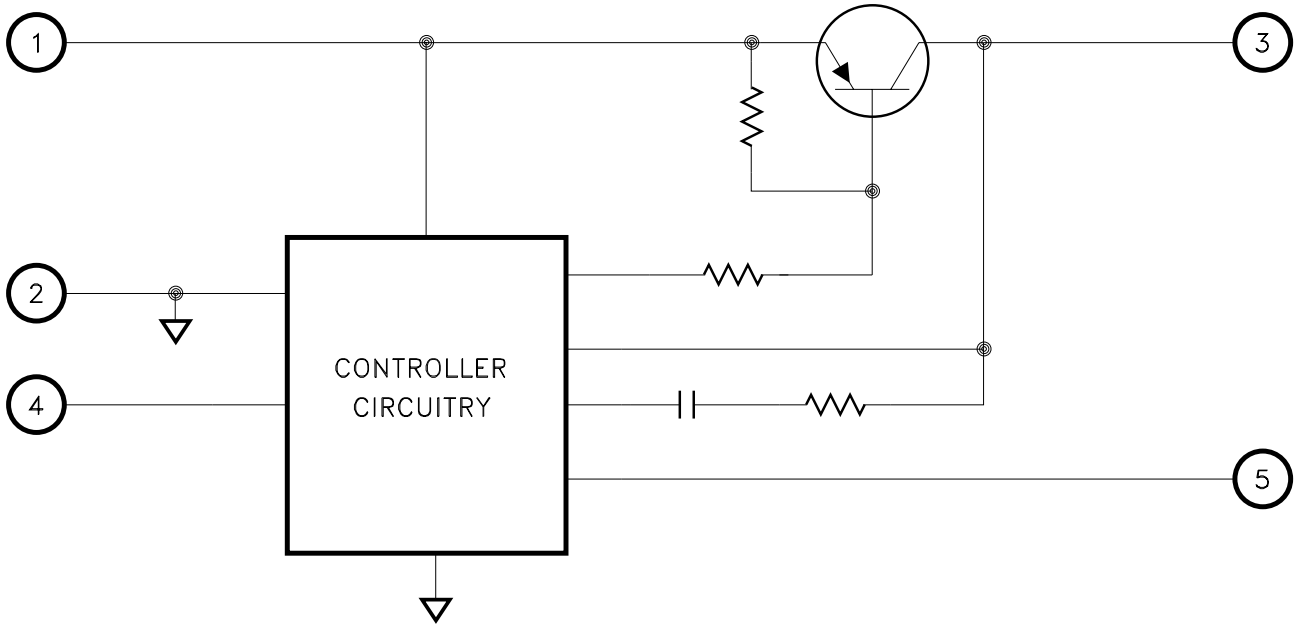
- Total Dose Tested to 300K RAD
- Ultra Low Dropout for Reduced Power Consumption
- External Shutdown
- Latching Overload Protection
- Adjustable Output Using Two External Resistors
- Output Current Limit
- Available in 3 Lead Form Options: Straight, Up and Down
- Available to DSCC SMD # 5962-05220



DESCRIPTION:

The MSK 5921RH is a rad tolerant adjustable linear regulator typically capable of delivering 5.0 amps of output current. The typical dropout is only 0.30 volts with a 3.0A load. An external shutdown function is ideal for power supply sequencing. This device also has latching overload protection that requires no external current sense resistor. The MSK 5921RH is radiation tolerant and specifically designed for space/satellite applications. The device is packaged in a hermetically sealed space efficient 5 pin SIP that is electrically isolated from the internal circuitry allowing for direct heat sinking.

EQUIVALENT SCHEMATIC



TYPICAL APPLICATIONS

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

PIN-OUT INFORMATION

1 VIN
2 GND
3 VOUT
4 SHUTDOWN
5 ADJUST

ABSOLUTE MAXIMUM RATINGS ⑧

$+V_{IN}$	Supply Voltage . . . . . +10V	T_{ST}	Storage Temperature Range -65°C to +150°C
I_{OUT}	Output Current ⑦ 5A	T_{LD}	Lead Temperature Range . . . . . 300°C
T_C	Case Operating Temperature Range		(10 Seconds)
	MSK5921K/H/E RH . . . -55°C to +125°C	P_D	Power Dissipation . . . . . See SOA Curve
	MSK5921RH . . . . . -40°C to +85°C	T_C	Junction Temperature . . . . . 150°C

ELECTRICAL SPECIFICATIONS

Parameter	Test Conditions ①⑪	Group A Subgroup	MSK5921K/H/E Min.	MSK5921K/H/E Typ.	MSK5921K/H/E Max.	MSK5921 Min.	MSK5921 Typ.	MSK5921 Max.	Units
Input Voltage Range ②	10mA ≤ I_{OUT} ≤ 1.0A	1	2.9		6.5	2.9		6.5	V
		2,3	2.9		6.5				V
Feedback Voltage	I_{OUT} = 3.0A 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} ≤ 3.0A	1,2,3	0		5.0	0		5.0	µA
Quiescent Current	V_{IN} = 6.5V	1		14	20		14	20	mA
	Not Including I_{OUT}	2,3		14	20				mA
Line Regulation ⑨	I_{OUT} = 50mA	1		±0.01	±0.50		0.01	±0.60	%V_{OUT}
	V_{OUT} + 0.4V ≤ V_{IN} ≤ I_{OUT} + 1.3V	2,3			±0.50				%V_{OUT}
Load Regulation ⑨	10mA ≤ I_{OUT} ≤ 3.0A	1		±0.06	±0.80		0.06	±1.0	%V_{OUT}
		2,3			±0.80				%V_{OUT}
Dropout Voltage ⑩	Delta FB = 1% I_{OUT} = 2.5A	1		0.22	0.40		0.22	0.45	V
		2,3		0.26	0.40				V
Minimum Output Current ②	2.8V ≤ V_{IN} ≤ 6.5V	1		8	10		8	10	mA
	R1 = 187Ω	2,3		9	10				mA
Output Voltage Range ②	V_{IN} = 6.5V		1.5		6.0	1.5		6.0	V
Output Current Limit ⑦	V_{IN} = 3.5V V_{OUT} = 2.5V	1	3.0	4.0	5.0	3.0	4.0	5.0	A
		2,3	3.0	4.0	5.0				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
Ripple Rejection ②	f = 120Hz	4	65			65			dB
	I_{OUT} = 50mA	5,6	65						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			2.2	4.0		2.2	4.0	°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 Continuous operation at or above absolute maximum ratings may adversely effect the device performance and/or life cycle.
⑨ V_{IN} shall be as specified or V_{IN} Min, whichever is greater.
⑩ Not applicable when V_{OUT} < V_{IN} Min dropout voltage maximum.
⑪ Consult factory for post radiation limits.

APPLICATION NOTES

PIN FUNCTIONS

VIN - This pin provides power to all internal circuitry including bias, start-up, thermal limit and overcurrent latch. Input voltage range is 2.9V to 6.5V.

GND - Internally connected to ground, this pin should be connected externally by the user to the circuit ground.

SHUTDOWN - There are two functions to the SHUTDOWN pin. It may be used to disable the output voltage or to reset a current latch condition. To activate the shutdown/reset functions the user must apply a voltage greater than 1.6V 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. It should be noted that with the shutdown pin tied to ground, a current latch condition can only be reset by cycling power off, then on.

VOUT - This is the output pin for the device.

ADJUST - The ADJUST 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 ADJUST pin to 1.265V. An external resistor divider is connected to the output, ADJUST pin and ground to set the output voltage.

OVERCURRENT LATCH

Overcurrent protection is provided by the MSK5921RH series through the use of a timed latch off circuit. The internal latch timeout is triggered by an overcurrent condition. To allow for start up surge currents, the timeout is approximately 5.5mS at 25°C. If the overcurrent condition remains at the end of the timeout cycle, the regulator will latch off until the latch is reset. The latch condition can be reset by pulling the shutdown pin high or cycling VIN off then back on. A thermal limit condition will trigger the latch with no time out delay.

INPUT POWER SUPPLY BYPASSING

To maximize transient response and minimize power supply transients it is recommended that a 100μF tantalum capacitor is connected between VIN and ground. A 0.1μF ceramic capacitor should also be used for high frequency bypassing.

OUTPUT CAPACITOR SELECTION

Output capacitors are required to maintain regulation and stability. A 220μF surface mount tantalum capacitor in parallel with a 1.0μF 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. ESR of the output capacitors should be maintained at 0.1Ω to 1Ω.

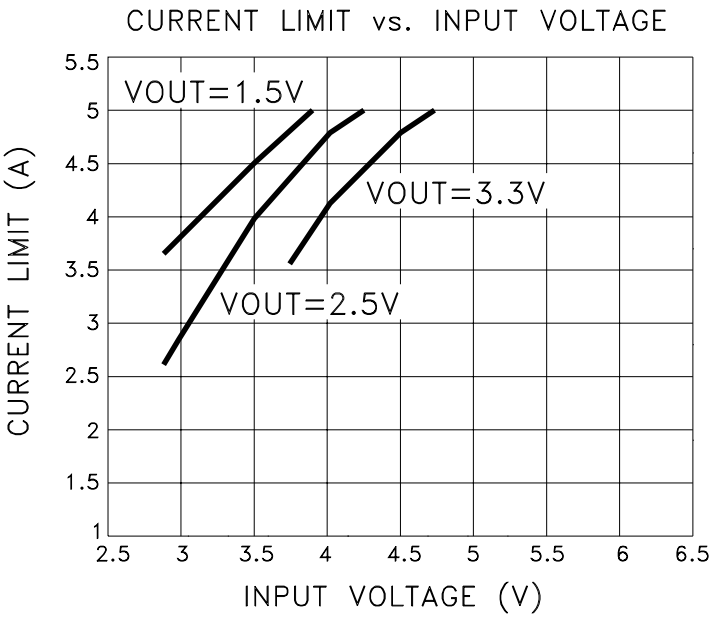


FIGURE 1

CURRENT LIMIT AND SOA

The MSK 5921RH current limit function is directly affected by the input and output voltages. Figure 1 illustrates the relationship between VIN and ICL for various output voltages. It is very important for the user to consult the SOA curve when using input voltages which result in current limit conditions beyond 4.5 Amps. When using input voltages which result in current limit above 4.5 Amps, the user must maintain output current within the SOA curve to avoid damage to the device. Note that 5 Amp maximum is due to current carrying capability of the internal wirebonds.

APPLICATION NOTES CONT.

THERMAL LIMITING

The MSK 5921RH 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 5921RH, 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

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

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 5921RH is connected for $V_{IN} = +3.3V$ and $V_{OUT} = +2.5V$. I_{OUT} is a continuous 3A DC level. The ambient temperature is +25°C. The maximum desired junction temperature is +125°C.

$R_{\theta JC} = 4.0°C/W$ and $R_{\theta CS} = 0.15°C/W$ for most thermal greases

$$\text{Power Dissipation} = (3.3V\text{-}2.5V) \times (3A)$$
$$= 2.4\text{Watts}$$

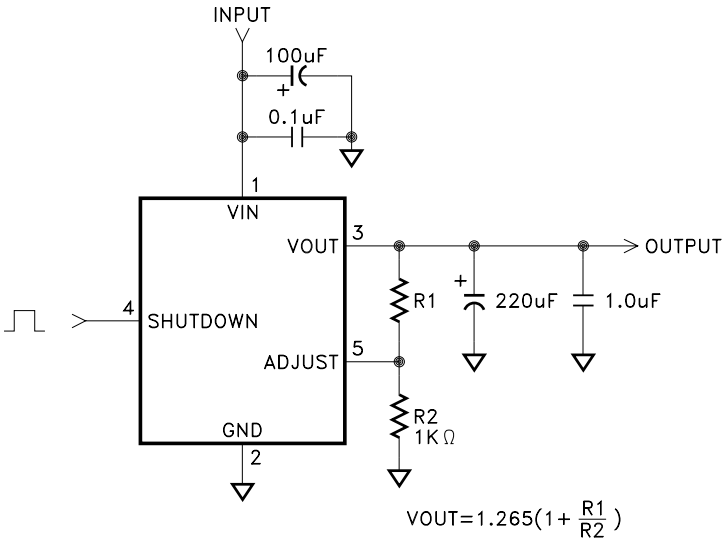
Solve for $R_{\theta SA}$:

$$R_{\theta SA} = \left[\frac{125°C - 25°C}{2.4W}\right] - 4.0°C/W - 0.15°C/W$$

$$= 36.5°C/W$$

In this example, a heat sink with a thermal resistance of no more than 36.5°C/W must be used to maintain a junction temperature of no more than 125°C.

TYPICAL APPLICATIONS CIRCUIT



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.

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

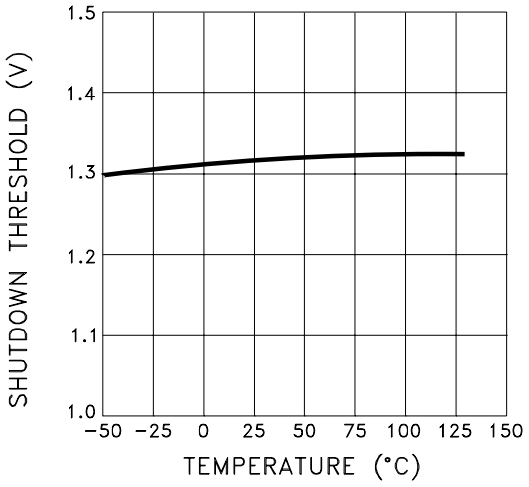
Table 1 below lists some of the most probable resistor combinations based on industry standard usage.

TABLE 1

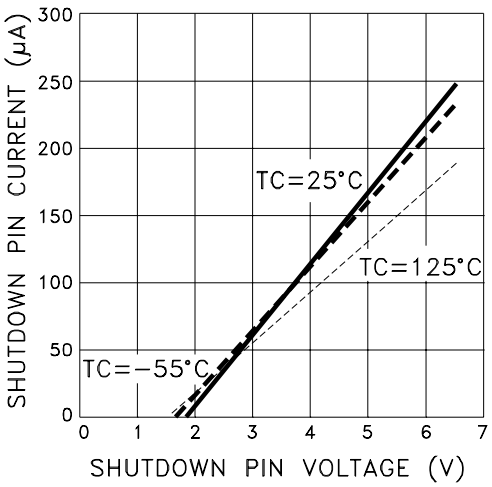
OUTPUT VOLTAGE (V)	R2 (Ω)	R1 (nearest 1%) (Ω)
1.5	1K	187
1.8	1K	422
2.0	1K	576
2.5	1K	976
2.8	1K	1.21K
3.3	1K	1.62K
4.0	1K	2.15K
5.0	1K	2.94K

TYPICAL PERFORMANCE CURVES

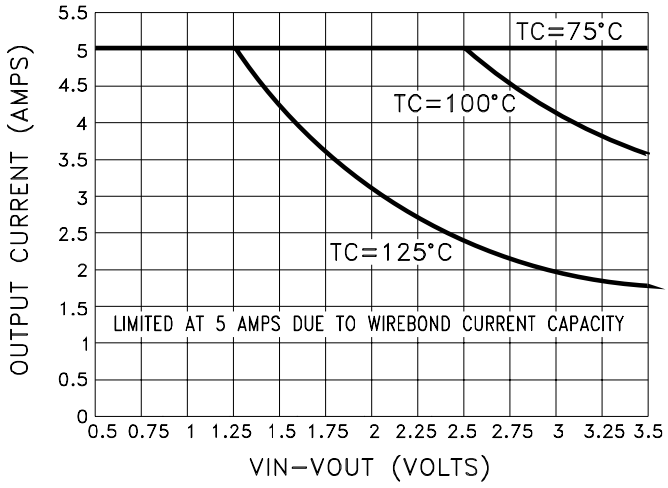
SHUTDOWN VOLTAGE THRESHOLD vs. TEMPERATURE



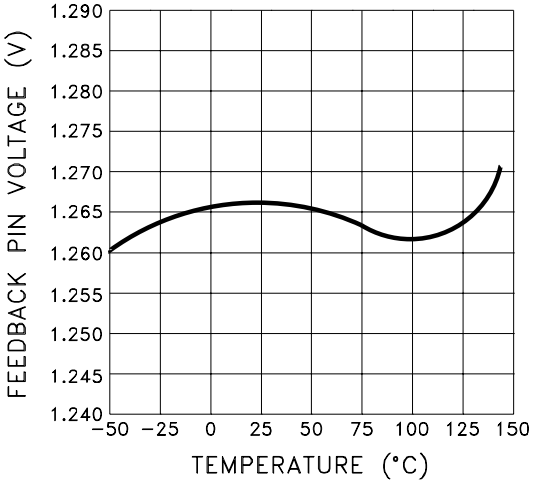
SHUTDOWN PIN CURRENT vs. SHUTDOWN PIN VOLTAGE



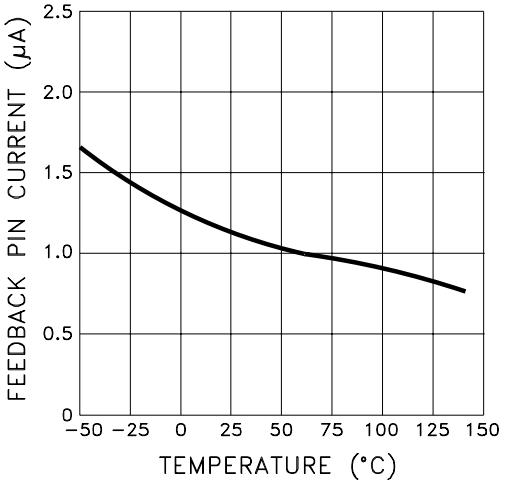
SOA OUTPUT CURRENT vs. VOLTAGE DROP



FEEDBACK PIN VOLTAGE vs. TEMPERATURE

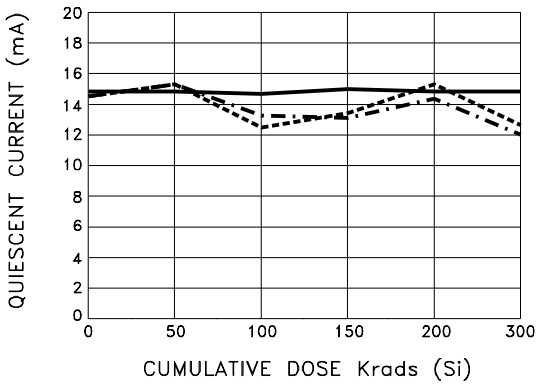


FEEDBACK PIN BIAS CURRENT vs. TEMPERATURE

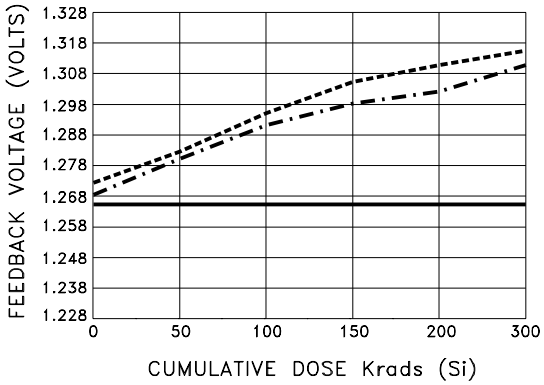


RADIATION PERFORMANCE CURVES

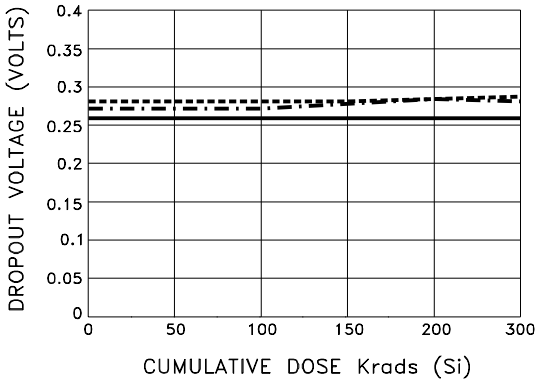
QUIESCENT CURRENT



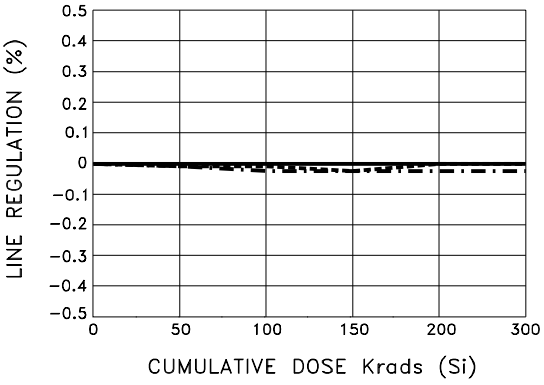
FEEDBACK VOLTAGE



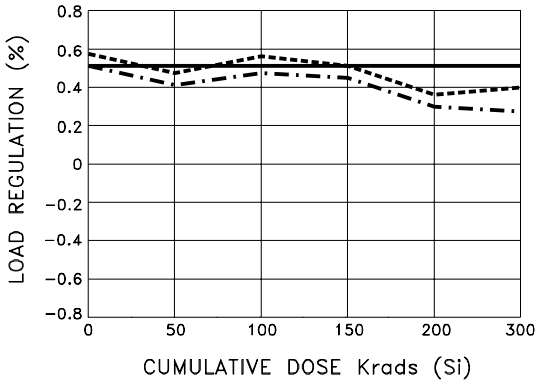
DROPOUT VOLTAGE



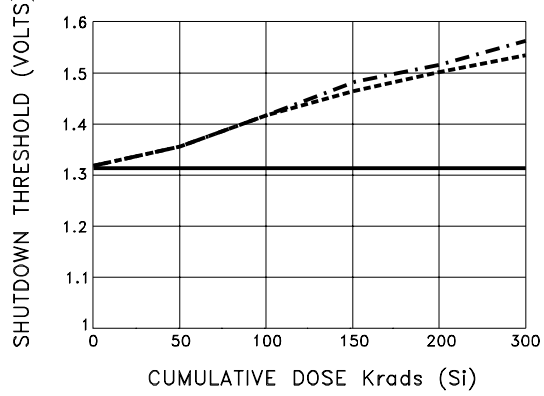
LINE REGULATION



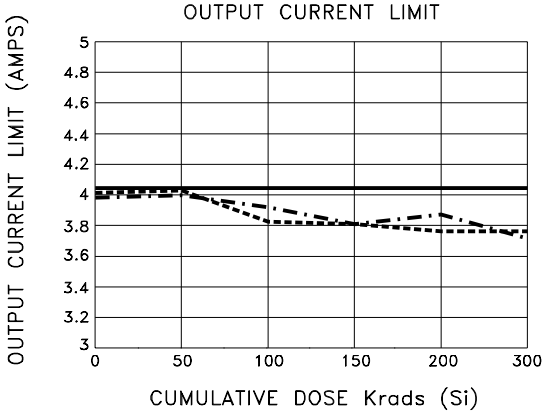
LOAD REGULATION

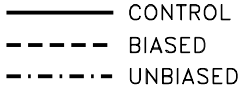


SHUTDOWN THRESHOLD



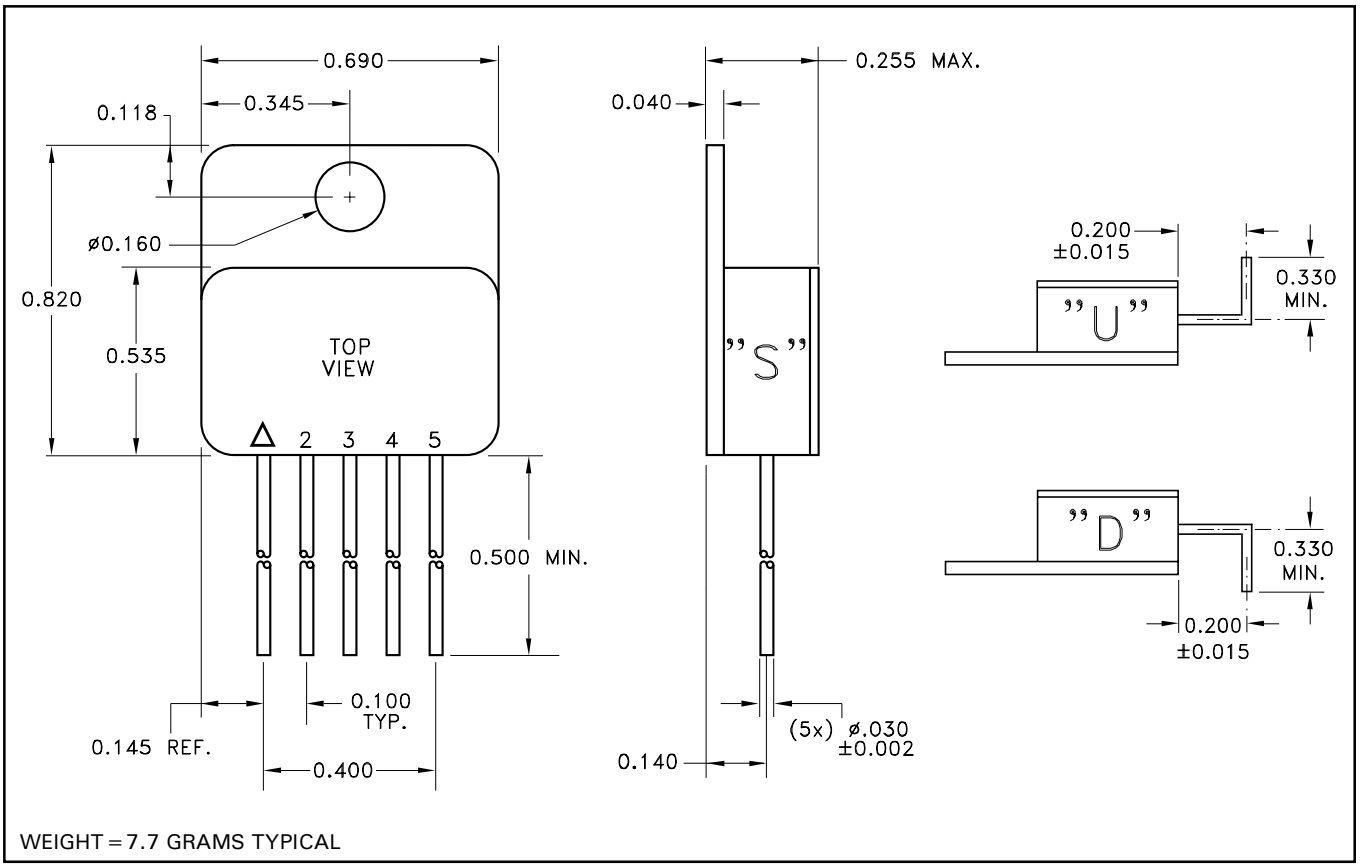
OUTPUT CURRENT LIMIT





NOTE: All radiation performance curve test conditions are in accordance with the electrical specifications table (page 2).

MECHANICAL SPECIFICATIONS



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

ORDERING INFORMATION

MSK5921 K RH U

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

RADIATION HARDENED

SCREENING
BLANK = INDUSTRIAL; E = EXTENDED RELIABILITY
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.

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

M.S. Kennedy Corp.
4707 Dey Road, Liverpool, New York 13088
Phone (315) 701-6751
FAX (315) 701-6752
www.mskennedy.com

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Please visit our website for the most recent revision of this datasheet.
Contact MSK for MIL PRF 38534 Class H, Class K and Appendix G (radiation) status.