



M.S.KENNEDY CORP.

**RAD TOLERANT,
HIGH SPEED,
BUFFER AMPLIFIER**

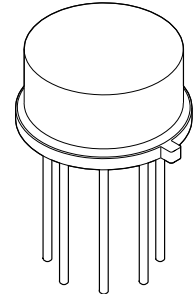
0002RH

4707 Dey Road Liverpool, N.Y. 13088

(315) 701-6751

FEATURES:

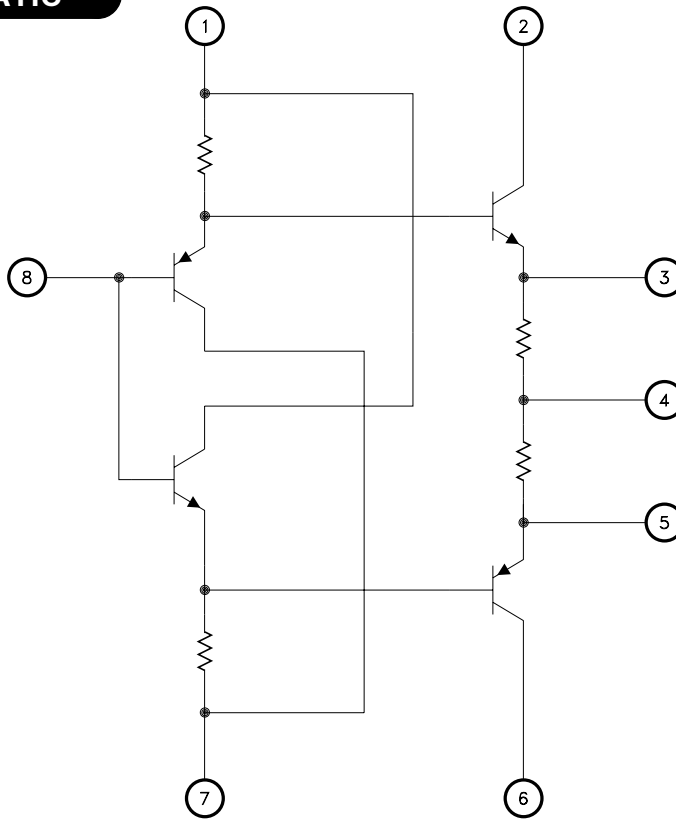
- Total Dose Tested to 300 Krads (Si)
- RAD Tolerant LH0002 Replacement
- High Input Impedance-180KΩ Min
- Low Output Impedance-10Ω Max
- Low Harmonic Distortion
- DC to 30 MHz Bandwidth
- Slew Rate is Typically 400 V/μS
- Operating Range from ±5V to ±20V
- Contact MSK for MIL-PRF-38534 Qualification Status and Appendix G (Radiation Status)



DESCRIPTION:

The MSK 0002RH is a general purpose current amplifier. It is the industry wide RAD tolerant replacement for the LH0002. The device is ideal for use with an operational amplifier in a closed loop configuration to increase current output. The MSK 0002RH is designed with a symmetrical output stage that provides low output impedances to both the positive and negative portions of output pulses. The MSK 0002RH is packaged in a hermetic 8 lead low profile TO-5 header and is specified over the full military temperature range.

EQUIVALENT SCHEMATIC



TYPICAL APPLICATIONS

- High Speed D/A Conversion
- 30MHz Buffer
- Line Driver
- Precision Current Source

PIN-OUT INFORMATION

1	V1 +	5	E4
2	V2 +	6	V2-
3	E3	7	V1-
4	Output	8	Input

ABSOLUTE MAXIMUM RATINGS ^⑤

$\pm V_{CC}$	Supply Voltage	$\pm 20V$
V_{IN}	Input Voltage	$\pm 20V$
P_d	Power Dissipation	600mW
T_c	Case Operating Temperature (MSK 0002K/H/E RH)	$-55^{\circ}C$ to $+125^{\circ}C$
	(MSK 0002RH)	$-40^{\circ}C$ to $+85^{\circ}C$

T_{ST}	Storage Temperature Range	$-65^{\circ}C$ to $+150^{\circ}C$
T_{LD}	Lead Temperature Range (10 Seconds)	$+300^{\circ}C$
T_J	Junction Temperature	$+175^{\circ}C$
θ_{JC}	Thermal Resistance @ $T_C = 125^{\circ}C$ Output Devices	$55^{\circ}C/W$

ELECTRICAL SPECIFICATIONS

Parameter	Test Conditions ^{①⑥}	Group A Subgroup	MSK 0002K/H/E RH ^④			MSK 0002RH			Units
			Min.	Typ.	Max.	Min.	Typ.	Max.	
Quiescent Current	$V_{IN} = 0V$ $R_S = 10K\Omega$ $R_L = 1.0K\Omega$	1	-	± 6.3	± 10	-	± 6.3	± 12	mA
Input Current	$R_S = 10K\Omega$ $R_L = 1.0K\Omega$	1	-	± 5	± 15	-	± 5	± 20	μA
		2,3	-	± 10	± 20	-	-	-	μA
Output Offset Voltage	$R_S = 300\Omega$ $R_L = 1.0K\Omega$	1	-	± 6	± 30	-	± 6	± 35	mV
		2,3	-	± 10	± 30	-	-	-	mV
Input Impedance ^③	$V_{IN} = 1.0V_{RMS}$ $R_S = 200K\Omega$ $R_L = 1K\Omega$ $f = 1.0KHz$	4	180	-	-	180	-	-	$K\Omega$
Output Impedance ^③	$V_{IN} = 1.0V_{RMS}$ $R_S = 10K\Omega$ $R_L = 50\Omega$ $f = 1.0KHz$	4	-	-	10	-	-	10	Ω
Output Voltage Swing	$R_L = 1.0K\Omega$ $f = 1.0KHz$	4	± 10	± 11	-	± 10	± 11	-	V _p
	$R_L = 100\Omega$ $\pm V_{CC} = \pm 15V$ $f = 1.0KHz$	4	± 9.5	-	-	± 9.5	-	-	V _p
Voltage Gain ^②	$V_{IN} = 3.0V_{PP}$ $f = 1.0KHz$ $R_S = 10K\Omega$ $R_L = 1.0K\Omega$	4	0.95	0.97	-	0.95	0.97	-	V/V
		5,6	0.92	-	-	-	-	-	V/V
Rise Time	$V_{OUT} = 2.5V_{PP}$ $f = 10KHz$ $R_S = 100\Omega$ $R_L = 50\Omega$	4	-	6	12	-	6	15	nS

NOTES:

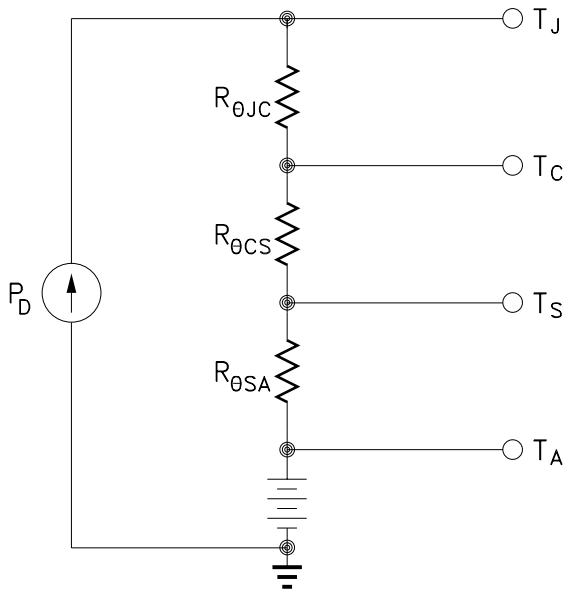
- ① Unless otherwise specified $\pm V_{CC} = \pm 12V_{DC}$, $R_L = 1K\Omega$.
- ② Subgroups 5 & 6 shall be tested as part of device initial characterization and after design and process changes. Parameter shall be guaranteed to the limits specified for subgroups 5 & 6 for all lots not specifically tested.
- ③ Devices shall be capable of meeting the parameter, but need not be tested.
- ④ Subgroup 1,4 $T_A = T_C = +25^{\circ}C$
Subgroup 2,5 $T_A = T_C = +125^{\circ}C$
Subgroup 3,6 $T_A = T_C = -55^{\circ}C$
- ⑤ Continuous operation at or above absolute maximum ratings may adversely effect the device performance and/or life cycle.
- ⑥ Consult factory for post radiation limits.

APPLICATION NOTES

HEAT SINKING

To determine if a heat sink is necessary for your application and if so, what type, refer to the thermal model and governing equation below.

Thermal Model:



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

$R_{\theta CS}$ = Heat Sink to Ambient Thermal Resistance

T_C = Case Temperature

T_A = Ambient Temperature

T_S = Sink Temperature

Example:

This example demonstrates a worst case analysis for the buffer output stage. This occurs when the output voltage is 1/2 the power supply voltage. Under this condition, maximum power transfer occurs and the output is under maximum stress.

Conditions:

$$V_{CC} = \pm 12VDC$$

$$V_o = \pm 6Vp \text{ Sine Wave, Freq.} = 1KHz$$

$$R_L = 100\Omega$$

For a worst case analysis we will treat the $\pm 6Vp$ sine wave as an 6 VDC output voltage.

1.) Find Driver Power Dissipation

$$\begin{aligned} PD &= (V_{CC} - V_o) (V_o / R_L) \\ &= (12V - 6V) (6V / 100\Omega) \\ &= 360mW \end{aligned}$$

2.) For conservative design, set $T_J = +125^\circ C$ Max.

3.) For this example, worst case $T_A = +80^\circ C$

4.) $R_{\theta JC} = 55^\circ C/W$ from MSK 0002RH Data Sheet

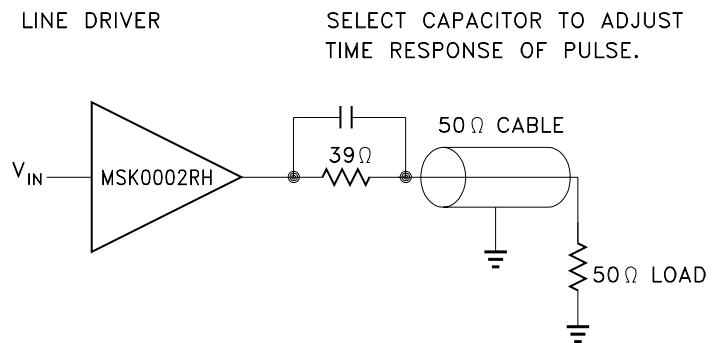
5.) $R_{\theta CS} = 0.15^\circ C/W$ for most thermal greases

6.) Rearrange governing equation to solve for $R_{\theta SA}$

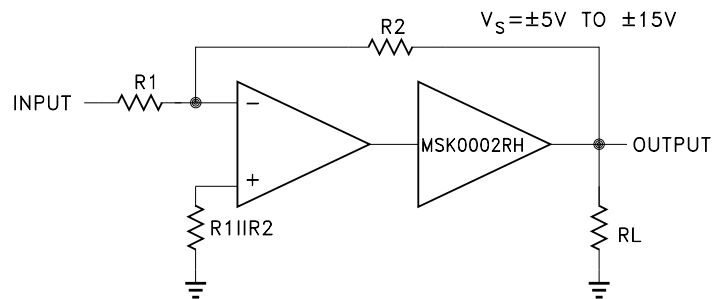
$$\begin{aligned} R_{\theta SA} &= ((T_J - T_A) / P_D) - (R_{\theta JC}) - (R_{\theta CS}) \\ &= ((125^\circ C - 80^\circ C) / 0.36W) - 55^\circ C/W - 0.15^\circ C/W \\ &= 125 - 55.15 \\ &= 69.9^\circ C/W \end{aligned}$$

This heat sink in this example must have a thermal resistance of no more than $69.9^\circ C/W$ to maintain a junction temperature of no more than $+125^\circ C$.

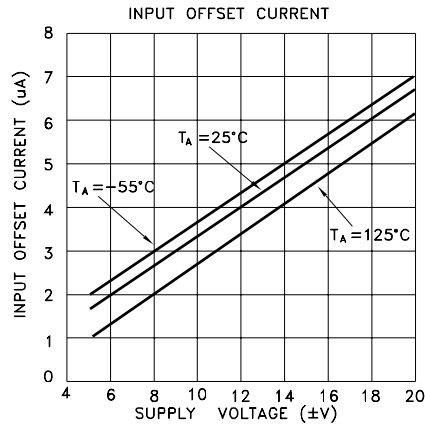
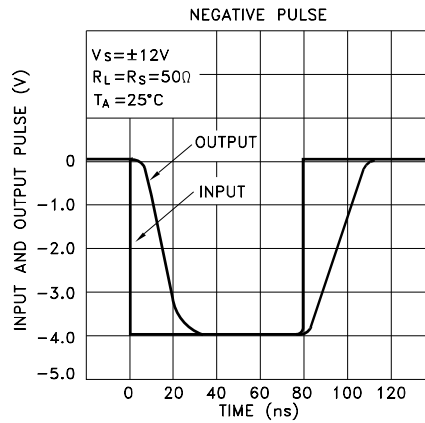
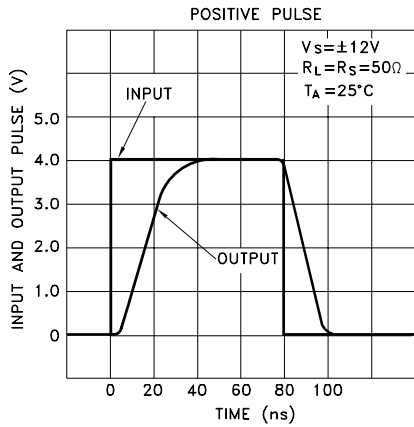
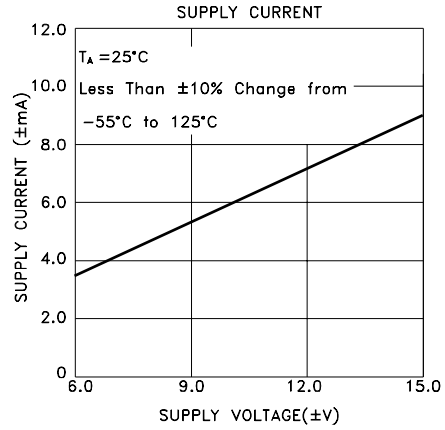
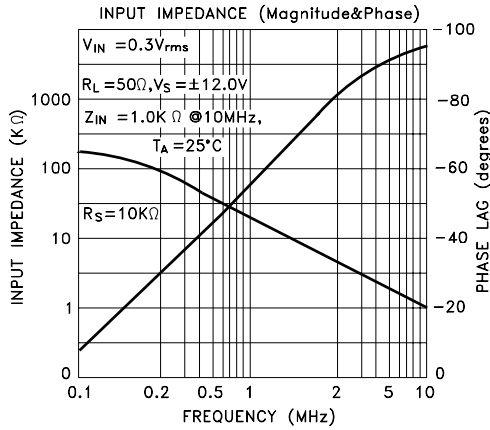
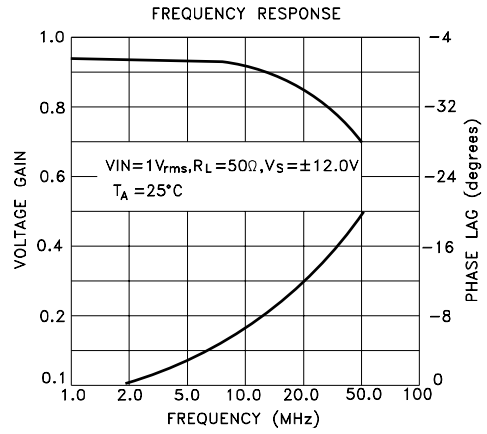
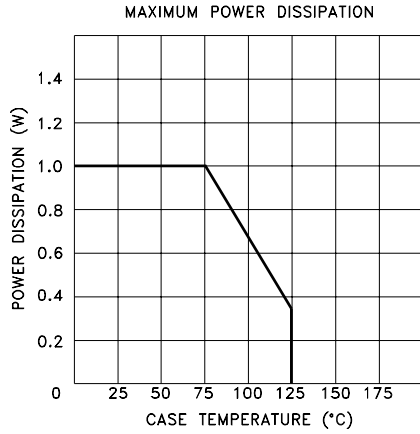
Typical Applications:



HIGH CURRENT OPERATIONAL AMPLIFIER

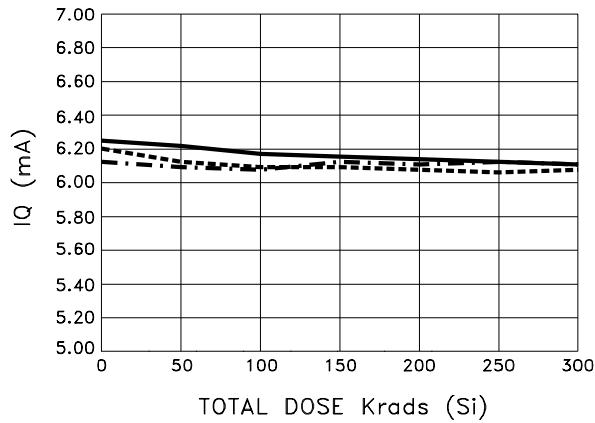


TYPICAL PERFORMANCE CURVES

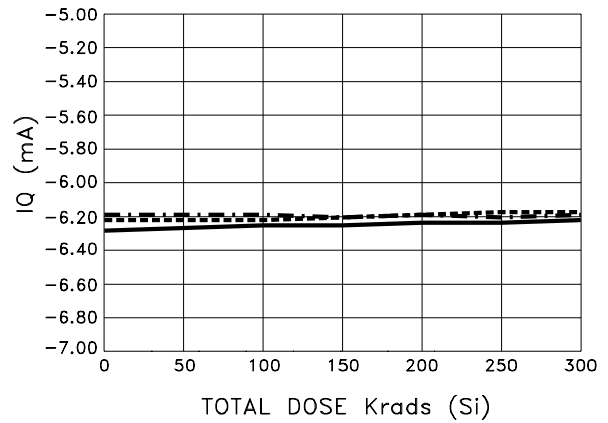


RADIATION CURVES

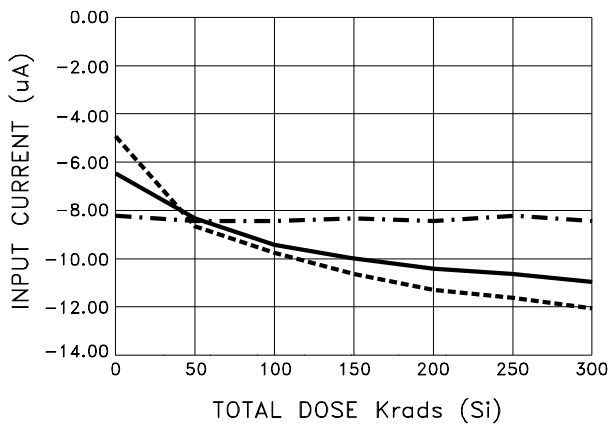
POSITIVE IQ vs TOTAL DOSE



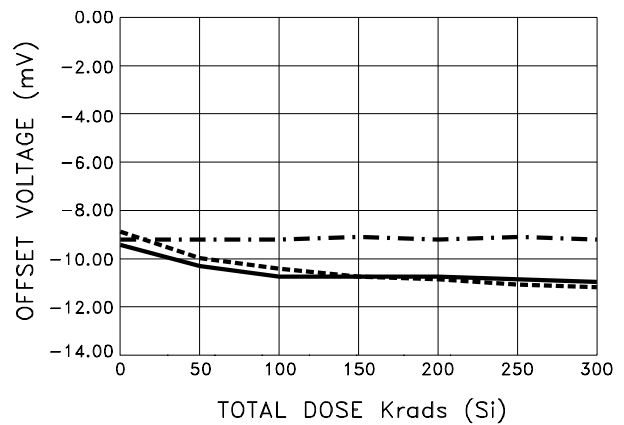
NEGATIVE IQ vs TOTAL DOSE



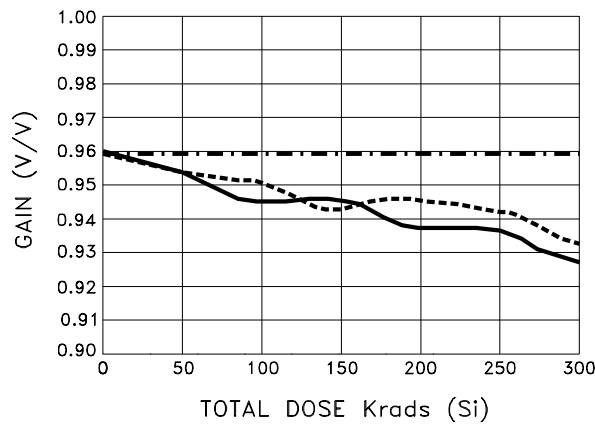
INPUT CURRENT vs TOTAL DOSE



OFFSET VOLTAGE vs TOTAL DOSE



GAIN vs TOTAL DOSE

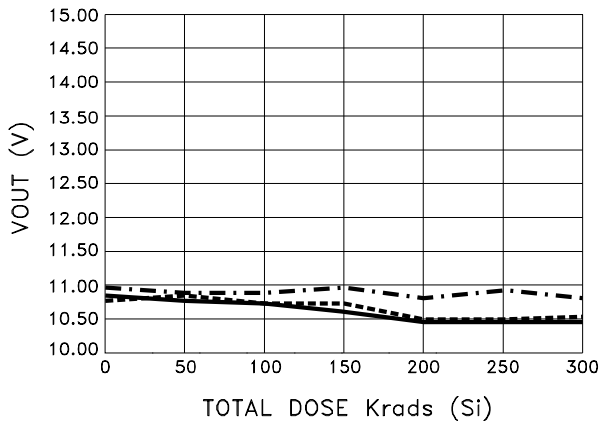


- AVG BIAS
- - - AVG GND
- · - · - CONTROL

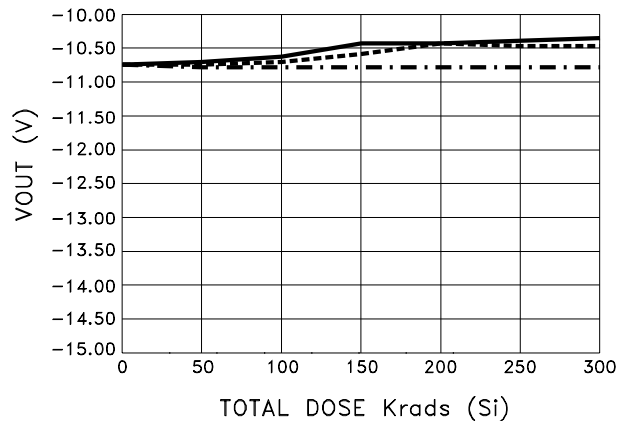
NOTE: All radiation curve test conditions are in accordance with the electrical specifications table (page 2). See RAD report for bias and dose rate.

RADIATION CURVES CONT'D

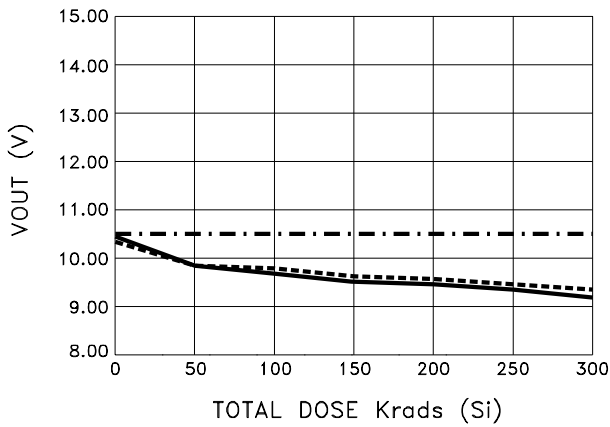
VOUT 1 POSITIVE vs TOTAL DOSE



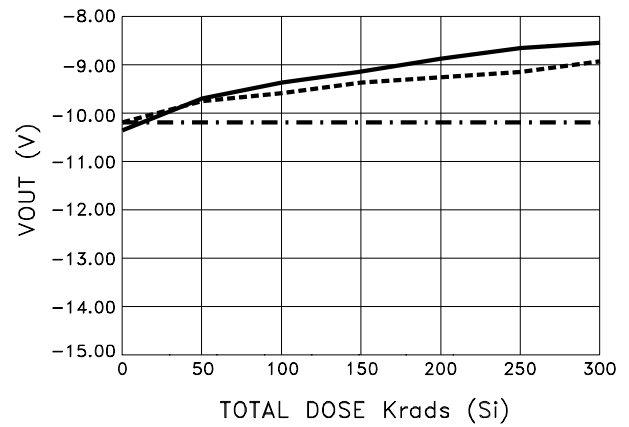
VOUT 1 NEGATIVE vs TOTAL DOSE



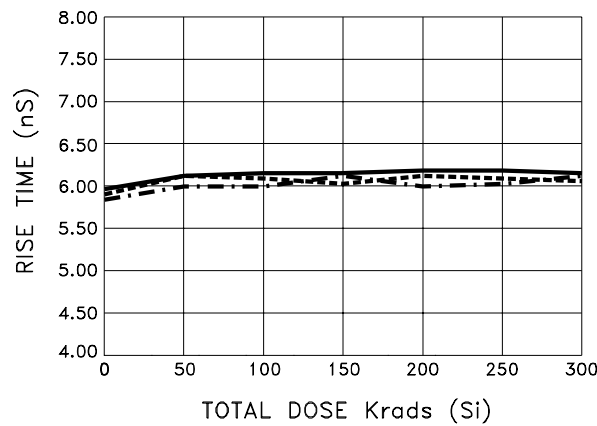
VOUT 2 POSITIVE vs TOTAL DOSE



VOUT 2 NEGATIVE vs TOTAL DOSE



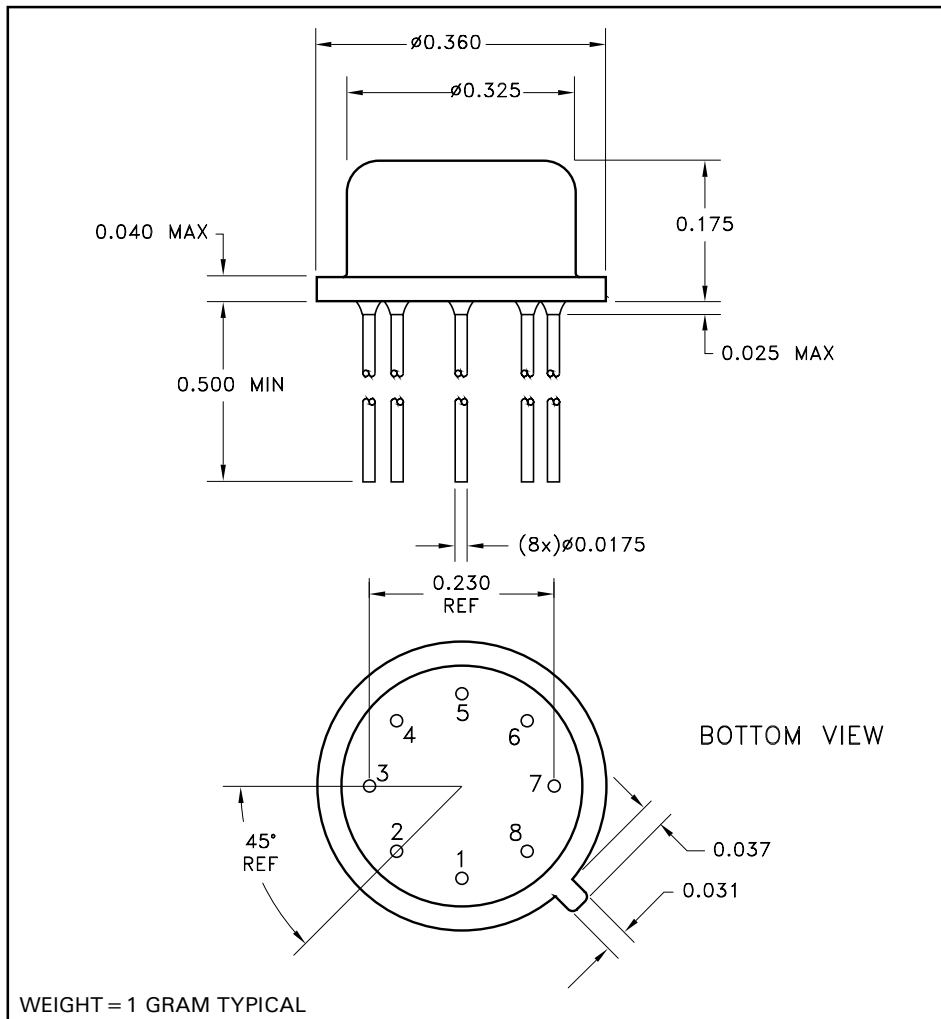
RISE TIME vs TOTAL DOSE



———— AVG BIAS
 - - - - - AVG GND
 - · - · - CONTROL

NOTE: All radiation curve test conditions are in accordance with the electrical specifications table (page 2). See RAD report for bias and dose rate.

MECHANICAL SPECIFICATIONS



ALL DIMENSIONS ARE ± 0.010 INCHES UNLESS OTHERWISE LABELED

ORDERING INFORMATION

Part Number	Screening Level
MSK0002RH	Industrial
MSK0002ERH	Extended Reliability
MSK0002HRH	MIL-PRF-38534 Class H
MSK0002KRH	MIL-PRF-38534 Class K

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Please visit our website for the most recent revision of this datasheet.

Contact MSK for MIL-PRF-38534 qualification status and Appendix G (radiation status)