



M.S.KENNEDY CORP.

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

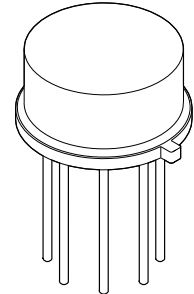
**0002RH**

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**FEATURES:**

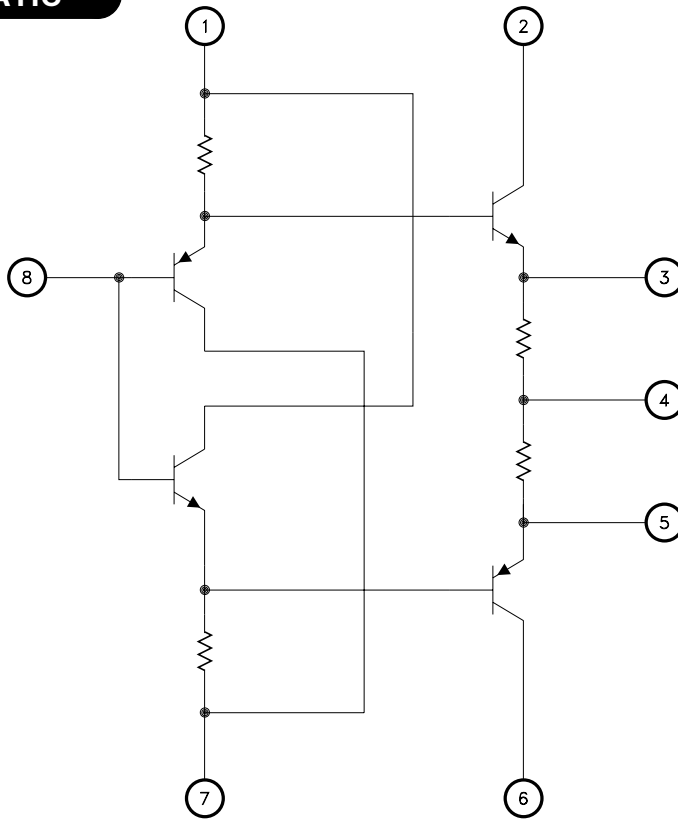
- Total Dose Tested to 300 Krads(Si) (Method 1019.7 Condition A)
- RAD Tolerant LH0002 Replacement
- High Input Impedance-180KΩ Min
- Low Output Impedance-10Ω Max
- Low Harmonic Distortion
- DC to 30 MHz Bandwidth
- Slew Rate is Typically 400 V/μS
- Operating Range from ±5V to ±20V
- Contact MSK for 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 <sup>⑤</sup>

$\pm V_{CC}$ Supply Voltage . . . . .	$\pm 20V$	$T_{ST}$ Storage Temperature Range . . . . .	$-65^{\circ}C$ to $+150^{\circ}C$
$V_{IN}$ Input Voltage . . . . .	$\pm 20V$	$T_{LD}$ Lead Temperature Range . . . . .	$+300^{\circ}C$ (10 Seconds)
$P_d$ Power Dissipation . . . . .	600mW	$T_J$ Junction Temperature . . . . .	$+175^{\circ}C$
$T_C$ Case Operating Temperature (MSK 0002K/H/E RH) . . . . .	$-55^{\circ}C$ to $+125^{\circ}C$	$\theta_{JC}$ Thermal Resistance @ $T_C = 125^{\circ}C$ Output Devices . . . . .	$55^{\circ}C/W$
(MSK 0002RH) . . . . .	$-40^{\circ}C$ to $+85^{\circ}C$		

## ELECTRICAL SPECIFICATIONS

Parameter	Test Conditions <sup>①</sup> <sup>⑥</sup>	Group A Subgroup	MSK 0002K/H/E RH <sup>④</sup>			MSK 0002RH			Units
			Min.	Typ.	Max.	Min.	Typ.	Max.	
Quiescent Current	$V_{IN} = 0V$ $R_S = 10K\Omega$ $R_L = 1.0K\Omega$	1	-	$\pm 6.3$	$\pm 10$	-	$\pm 6.3$	$\pm 12$	mA
Input Current	$R_S = 10K\Omega$ $R_L = 1.0K\Omega$	1	-	$\pm 5$	$\pm 15$	-	$\pm 5$	$\pm 20$	$\mu A$
		2,3	-	$\pm 10$	$\pm 20$	-	-	-	$\mu A$
	Post Radiation	1	-	-	$\pm 25$	-	-	$\pm 25$	$\mu A$
Output Offset Voltage	$R_S = 300\Omega$ $R_L = 1.0K\Omega$	1	-	$\pm 6$	$\pm 30$	-	$\pm 6$	$\pm 35$	mV
		2,3	-	$\pm 10$	$\pm 30$	-	-	-	mV
Input Impedance <sup>③</sup>	$V_{IN} = 1.0V_{RMS}$ $R_S = 200K\Omega$ $R_L = 1K\Omega$ $f = 1.0KHz$	4	180	-	-	180	-	-	K $\Omega$
Output Impedance <sup>③</sup>	$V_{IN} = 1.0V_{RMS}$ $R_S = 10K\Omega$ $R_L = 50\Omega$ $f = 1.0KHz$	4	-	-	10	-	-	10	$\Omega$
Output Voltage Swing	$R_L = 1.0K\Omega$ $f = 1.0KHz$	4	$\pm 10$	$\pm 11$	-	$\pm 10$	$\pm 11$	-	Vp
	$R_L = 100\Omega$ $f = 1.0KHz$	4	$\pm 9.5$	-	-	$\pm 9.5$	-	-	Vp
	Post Radiation	4	$\pm 8.4$	-	-	$\pm 8.4$	-	-	Vp
Voltage Gain <sup>②</sup>	$V_{IN} = 3.0V_{pp}$ $f = 1.0KHz$ $R_S = 10K\Omega$ $R_L = 1.0K\Omega$	4	0.95	0.97	-	0.95	0.97	-	V/V
		5,6	0.92	-	-	0.92	-	-	V/V
	Post Radiation	4	0.90	-	-	0.90	-	-	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:

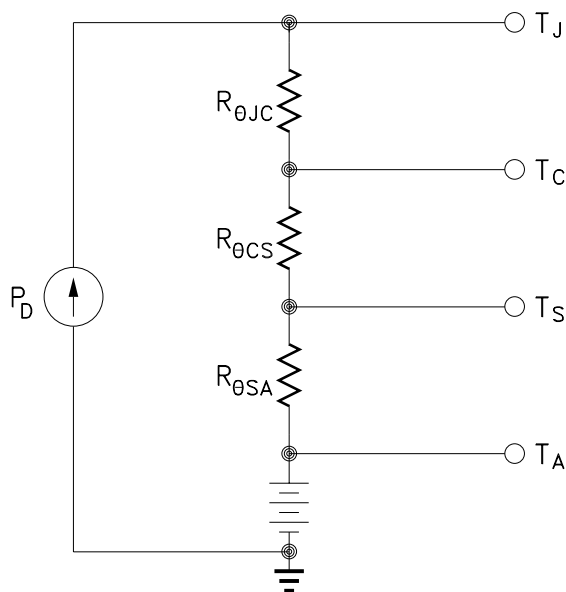
- ① Unless otherwise specified  $\pm V_{CC} = \pm 12V_{DC}$ ,  $R_L = 1K\Omega$ .
- ② Subgroups 5 & 6 shall be tested as part of device initial characterization and after design and process changes. Parameter shall be guaranteed to the limits specified for subgroups 5 & 6 for all lots not specifically 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 Pre and post irradiation limits at  $25^{\circ}C$ , up to 100Krad TID, are identical unless otherwise specified.

## 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

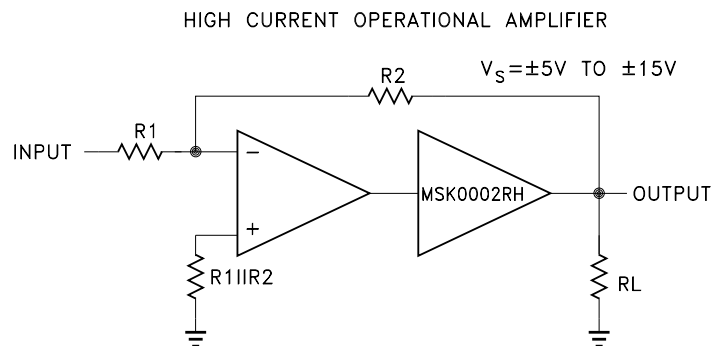
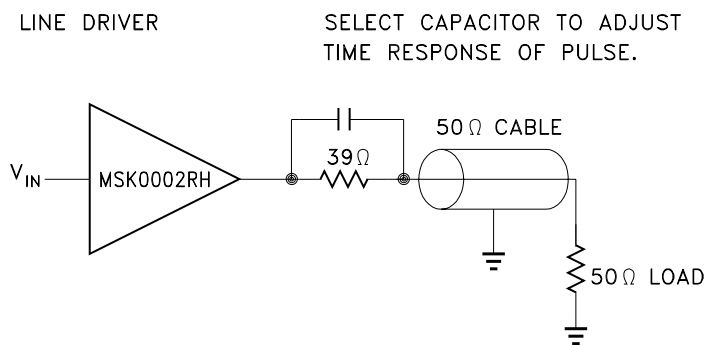
5.)  $R_{\theta CS} = 0.15^\circ C/W$  for most thermal greases

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:

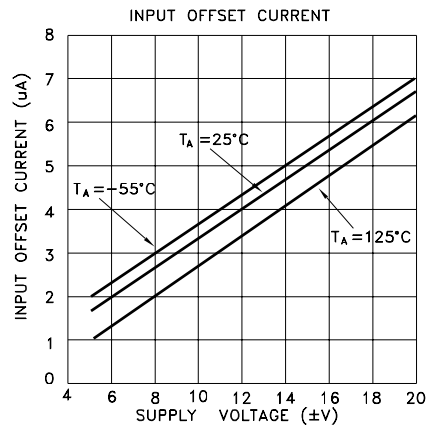
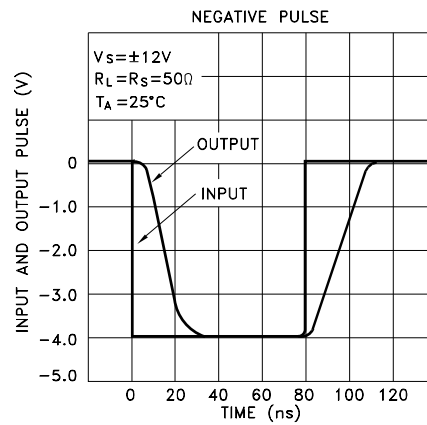
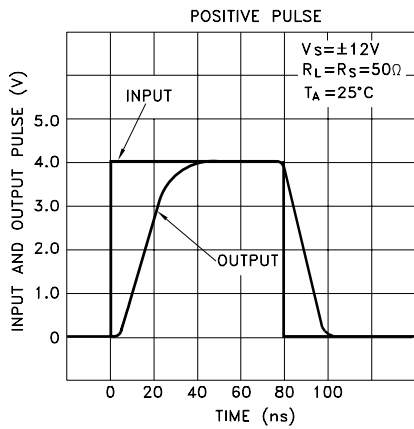
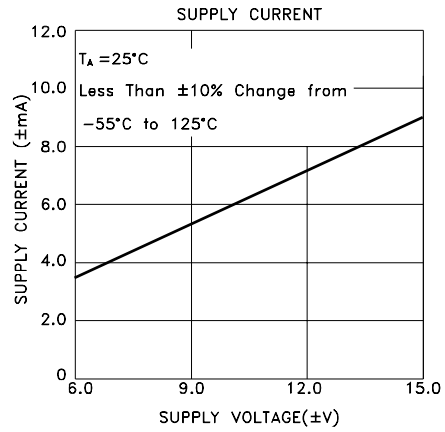
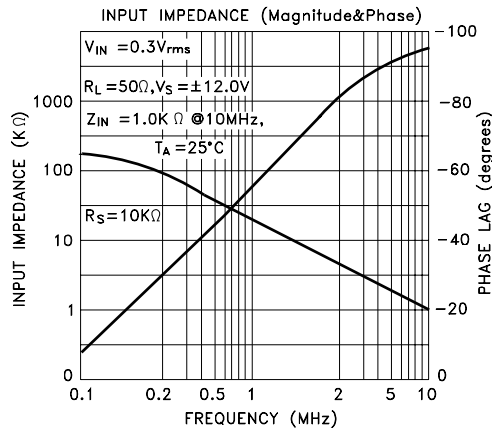
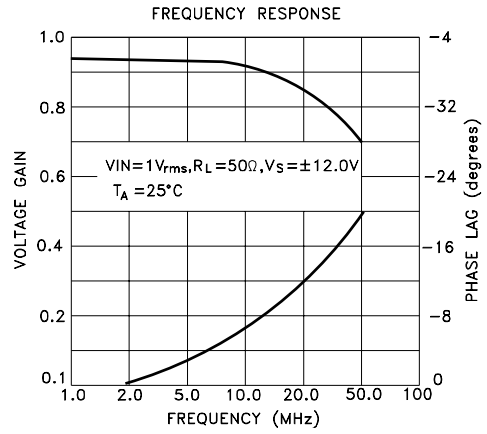
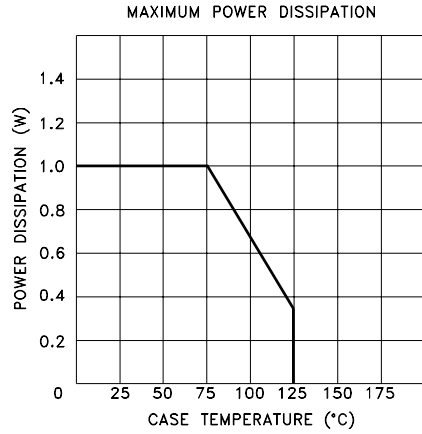


### TOTAL DOSE RADIATION TEST PERFORMANCE

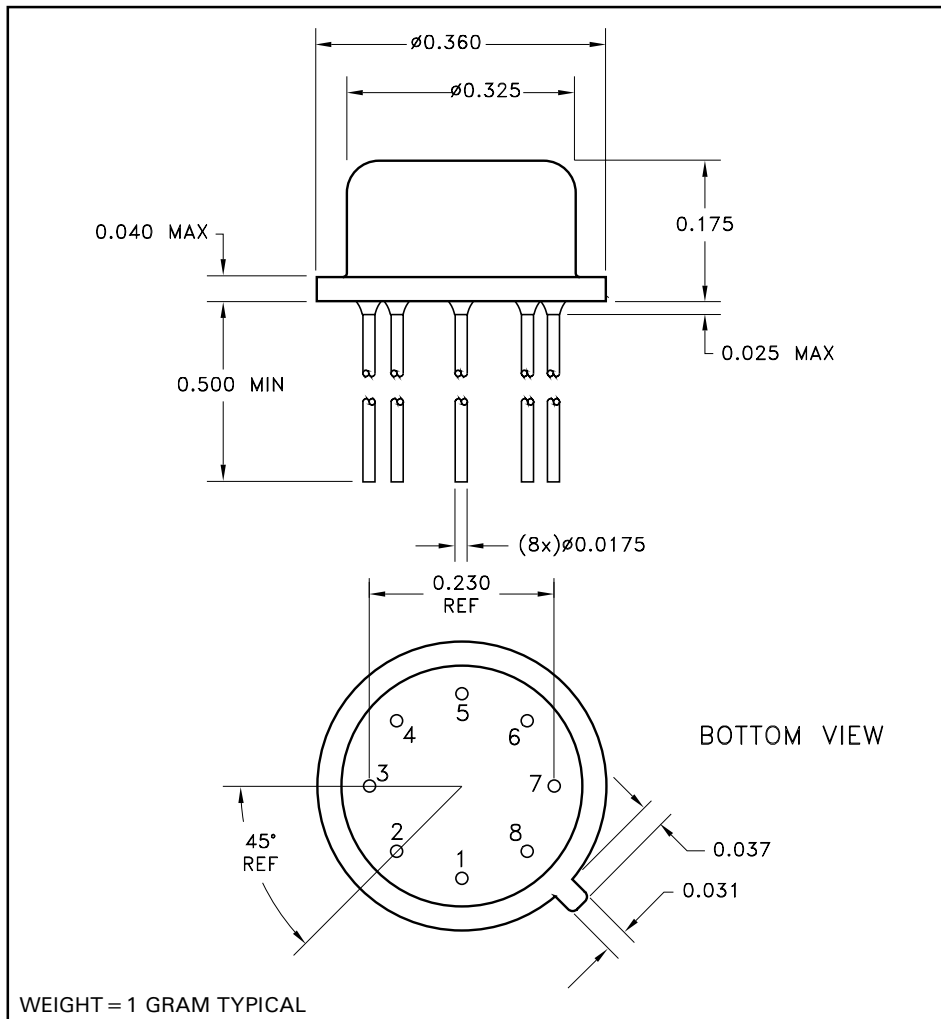
Radiation performance curves for TID testing have been generated for all radiation testing performed by MS Kennedy. These curves show performance trends throughout the TID test process and can be located in the MSK 0002RH radiation test report. The complete radiation test report is available in the RAD HARD PRODUCTS section on the MSK website.

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

# TYPICAL PERFORMANCE CURVES



## MECHANICAL SPECIFICATIONS



ALL DIMENSIONS ARE  $\pm 0.010$  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)