MIL-PRF-38534 & 38535 CERTIFIED FACILITY

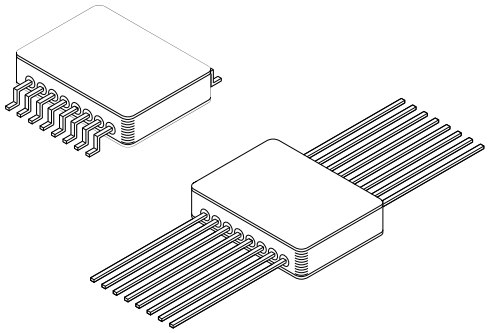
M.S.KENNEDY CORP.

RAD HARD QUAD PRECISION RAIL TO RAIL CURRENT SENSE AMP

496RH

FEATURES:

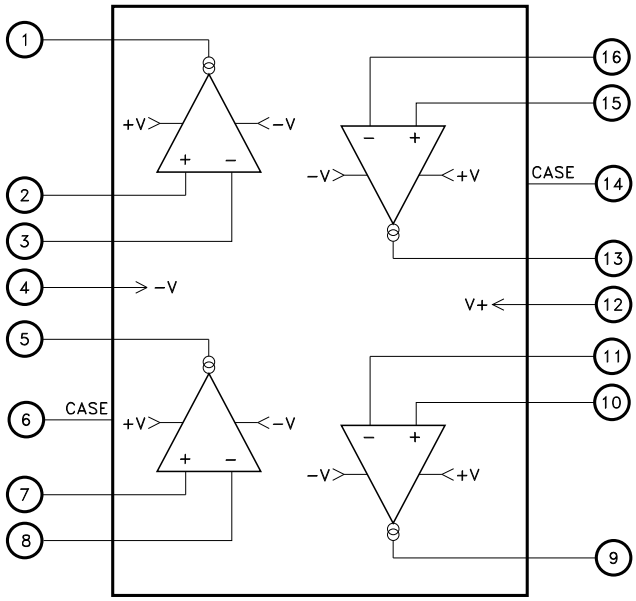
- Manufactured using LINEAR TECHNOLOGY RH6105 Dice
- Radiation Hardened to 100 Krad(Si) (Method 1019.7 Condition A)
- Low Dose Rate Hardened to 50 Krad(Si) (Method 1019.7 Condition D)
- Neutron Tested to $5X10^{11}$ n/cm² (Method 1017.2)
- Very Wide Input Common Mode Range
  - Extends 44V Above V- (Independent of V+)
  - Extends -0.3V Below V-
- Wide Power Supply Range: 2.85V to 36V
- Input Offset Voltage: 400μV Maximum
- Gain Accuracy: 1% Max
- Gain Configurable with External Resistors
- Operating Current: 195μA typ. per Amp
- Slew Rate: 2V/μs
- Sense Input Current When Powered Down: $<1\mu$A
- Full-Scale Output Current: 1mA Minimum
- Non-Rad Hard EDU's Available



DESCRIPTION:

The MSK496RH is a radiation hardened quad precision micropower current sense amplifier with a very wide input common mode range. With Over-the-Top® Technology, the MSK496RH is capable of sensing in high side or low side applications.This combined with external gain setting, and common mode and power supply rejection in excess of 100dB, make the MSK496RH well suited for a variety of current sensing applications. The MSK496RH is hermetically sealed in a 16 pin flat pack, and is available with straight or gull wing lead form.

EQUIVALENT SCHEMATIC



TYPICAL APPLICATIONS

- High Side or Low Side Current Sensing
- Current Monitoring on Positive or Negative Supply Voltages
- Battery Monitoring
- Fuse/MOSFET Monitoring
- Power Management

PIN-OUT INFORMATION

1	VOUT 1	16	-IN 4
2	+IN 1	15	+IN 4
3	-IN 1	14	CASE
4	V-	13	VOUT 4
5	VOUT 2	12	V+
6	CASE	11	-IN 3
7	+IN 2	10	+IN 3
8	-IN 2	9	VOUT 3

ABSOLUTE MAXIMUM RATINGS ⑨

Input Voltage (+IN, -IN to V-). . . .-9.5V to 44V
Differential Input Voltage. 44V
Total Supply Voltage from V-. 36V
Output Short Circuit Duration. . . . . Indefinite④

T_{ST} Storage Temperature Range. ⑫ . . . .-65°C to +150°C
T_{LD} Lead Temperature Range
(10 Seconds). . . . . .300°C
T_J Junction Temperature. . . . . .150°C
T_C Case Operating Temperature Range
MSK496KRH/HRH. . . . . .-55°C to +125°C
MSK496RH. . . . . .-40°C to +85°C
MSK496EDU . ⑪ . . . . . .-40°C to +85°C
ESD Rating. . . . . .Class 1B

ELECTRICAL SPECIFICATIONS

Parameter	Test Conditions ① ⑩		Group A Subgroup	MSK496KRH/HRH Min.	Typ.	Max.	MSK496RH/EDU Min.	Typ.	Max.	Units
Voltage Gain Error 1	V_{SENSE} = 25mV to 75mV		1	-1	0.1	1	-1	-	+1	%
			2,3	-1.5	0.1	1.5	-	-	-	%
Voltage Gain Error 2	V_{SENSE} = 25mV to 75mV		1,2,3	-4.25	-	+2.25	-4.25	-	+2.25	%
	V_S+ = 0	Post Irradiation	1	-4.5	-	+4.5	-4.5	-	+4.5	%
Input Offset Voltage 1	V_{SENSE} = 25mV, V_S+ = 12V		1	-0.4	-0.1	0.4	-0.4	-0.1	-0.4	mV
			2,3	-0.9	-	0.9	-	-	-	mV
		Post Irradiation Condition A	1	-1.0	-	1.0	-1.0	-	1.0	mV
		Post Irradiation Condition D	1	-2.0	-	1.0	-2.0	-	1.0	mV
Input Offset Voltage 2	V_{SENSE} = 5mV; V_S+ = 0V		1	-1	-0.3	1	-1	-0.3	1	mV
			2,3	-1.6	-	1.6	-	-	-	mV
		Post Irradiation	1	-1.2	-	1.2	-1.2	-	1.2	mV
Input Common Mode Rejection Ratio	V_{SENSE} = 5mV; V_S+ = 2.8V to 44V		4	100	120	-	100	120	-	dB
			5,6	95	-	-	-	-	-	dB
		Post Irradiation	4	90	-	-	90	-	-	dB
Power Supply Rejection Ratio	V_{SENSE} = 5mV; V+ = 2.85 to 36V		4	98	120	-	98	120	-	dB
			5,6	94	-	-	-	-	-	dB
		Post Irradiation	4	90	-	-	90	-	-	dB
Input Current ③	V_{SENSE} = 0V; V_S+ = 3V; A_V = 25		1,2,3	-	18	30	-	18	30	uA
	V_{SENSE} = 0V; V_S+ = 0V		-	-	-0.05	-	-	-0.05	-	uA
Input Offset Current ③	V_{SENSE} = 0V; V_S+ = 3V; A_V = 25		1,2,3	-	0.35	0.8	-	0.35	0.8	uA
	V_{SENSE} = 0V; V_S+ = 0V		-	-	0.1	-	-	0.1	-	uA
V+ Supply Current	V_{SENSE} = 0V; V_S+ = 3V; V+ = 36V		1,2,3	-	780	1800	-	780	1800	uA
Minimum Output Voltage	V_{SENSE} = 0mV; V_S+ = 44V; V+ = 36V		1,2,3	-	-	45	-	-	45	mV
Output High (Referred to V+)	V_{SENSE} = 120mV; A_V = 100; R_{OUT} = 10K		1,2,3	-	1.3	1.7	-	1.3	1.7	V
-3dB Bandwidth ③	V_{SENSE} = 50mV; A_V = 10V/V		-	-	100	-	-	100	-	kHz
Thermal Resistance (Each Amplifier) ②	Junction to Case @ 125°C		-	-	7.3	9.6	-	7.3	9.6	°C/W

NOTES:

① Unless otherwise specified; V+ = 12V, V- = 0V, V_S+ = 12V, R_{IN1} = R_{IN2} = 100Ω, R_{OUT} = 5K(A_V = 50), V_{SENSE} = (V_S+)-(V_S-).
② Guaranteed by design but not tested.
③ Typical parameters are representative of device performance but are for reference only.
④ A heat sink may be required to keep the junction temperature below absolute maximum ratings.
⑤ Industrial grade devices shall be tested to subgroup 1 and 4 unless otherwise specified.
⑥ Military grade devices ("H" and "K" suffix) shall be 100% tested to subgroups 1,2,3, and 4
⑦ Subgroup 5 & 6 testing available upon request.
⑧ Subgroup 1,4 TC = +25°C
Subgroup 2,5 TC = +125°C
Subgroup 3,6 TC = -55°C
⑨ Continuous operation at or above absolute maximum ratings may adversely affect the device performance and/or life cycle.
⑩ Pre and post irradiation limits at 25°C, up to 100 Krad(Si) TID (Condition A) and 50 Krad(Si) TID (Condition D), are identical unless otherwise specified.
⑪ MSK496EDU does not use Rad Hard die, post irradiation specifications are not applicable.
⑫ Internal solder reflow temperature is 180°C, do not exceed.

APPLICATION NOTES

PIN FUNCTIONS

-INx- The -IN pin is the negative input terminal of the sense amplifier. Voltages as high as 44V can be applied to the pin, relative to the negative supply pin V-.

+INx - The +IN pin is the positive input terminal of the sense amplifier. Voltages as high as 44V can be applied to the pin, relative to the negative supply pin V-.

V+ - The V^+ pin is the positive power supply for all amplifiers. Operational currents are sourced from this pin independent of the voltages on the -IN and +IN pins.

V- - The V- pin is the negative power supply for all amplifiers. Connect to the negative supply voltage or circuit ground for single supply opperation.

VOUTx - The VOUT pin is the output of the amplifier. The voltage at the output is a function of both the input differential ($V_{SENSE} \pm V_{OS}$), and the voltage gain R_{OUT}/R_{IN1}, for $R_{IN1} = R_{IN2}$. (See typical application ckt for more detail)

$VOUT = R_{OUT}/R_{IN} \times (V_{SENSE} \pm V_{OS})$

Set $R_{IN1} = R_{IN2}$ for best accuracy

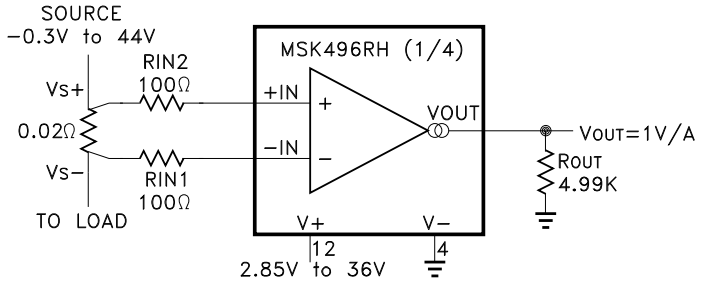
CASE - Pins 6 and 14 provide an electrical connection to the device package only. These pins are isolated from the internal circuit. Tie to a low impedance source or system ground to minimize coupling between amplifiers.

SENSE RESISTOR

Choose a R_{SENSE} resistor value just large enough to cover the application dynamic range to minimize power dissipation losses. The low 100μV typical offset voltage helps to maintain high resolution while minimizing power dissipation.

Kelvin connection of the input resistors to the sense resistor is recommended to minimize error in high current applications.

TYPICAL APPLICATION CKT



$$VOUT = \left((VS+)-(VS-)\right) \cdot \frac{R_{OUT}}{R_{IN}} ; A_V = \frac{R_{OUT}}{R_{IN}} ; R_{IN1} = R_{IN2} = R_{IN}$$

RADIATION TEST PERFORMANCE

Radiation performance curves have been generated for all radiation testing performed by MS Kennedy. These curves show performance trends throughout each test process and are located in the MSK196RH radiation test report. The complete radiation test report is available in the RAD HARD PRODUCTS section on the MSK website.

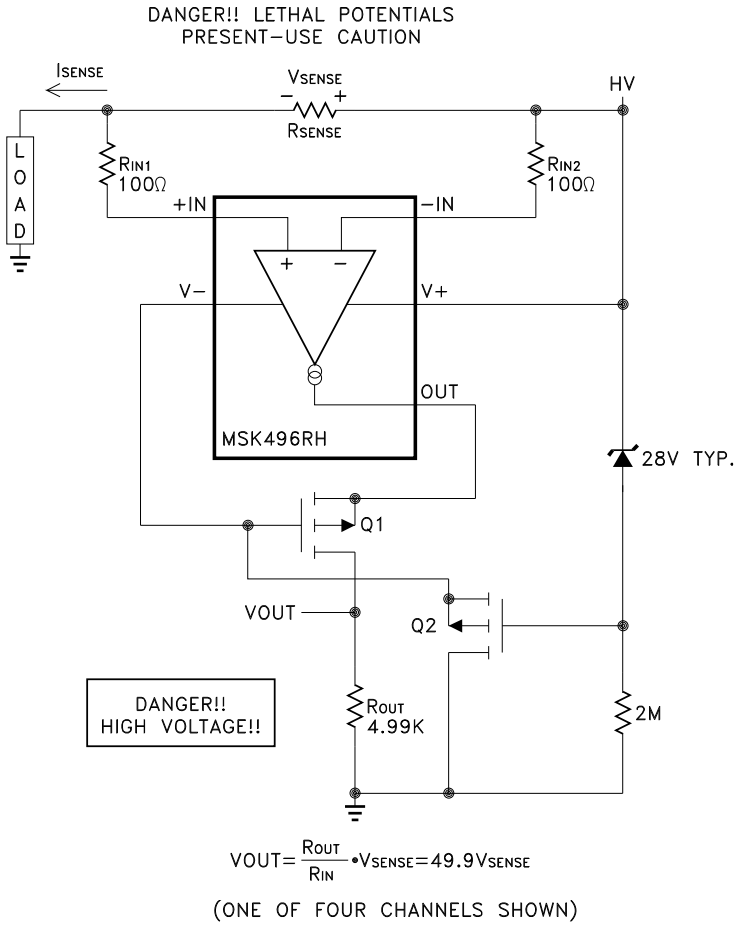
ADDITIONAL APPLICATION INFORMATION

For additional applications information, please reference Linear Technology Corporation's® LT6105 data sheet.

HIGH VOLTAGE SENSING

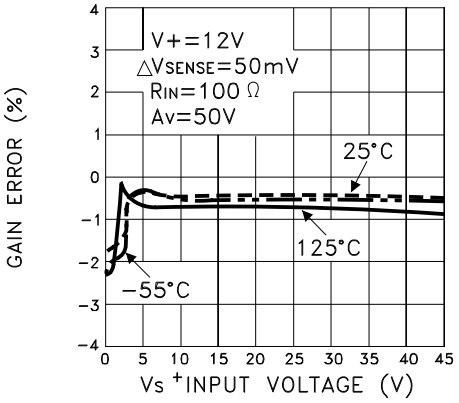
For high voltage applications, the MSK496RH can be used with external MOSFETs. The MOSFETs protect the device from the full potential of the high voltage supply. The high voltage supply is the positive rail of the device, and the Zener voltage minus the $V_{GS(on)}$ potential of Q2 determines the negative voltage rail for the device; $(V-) = (V+) - (V_Z - V_{GS})$. The device can safely sense current from 0.3V below the negative rail up to 44V above it independent of high voltage supply, and deliver a ground referenced signal via Q1. The values in the application circuit are provided for reference. They may need to be adjusted based on specific application requirements.

HIGH VOLTAGE SIMPLE CURRENT MONITOR

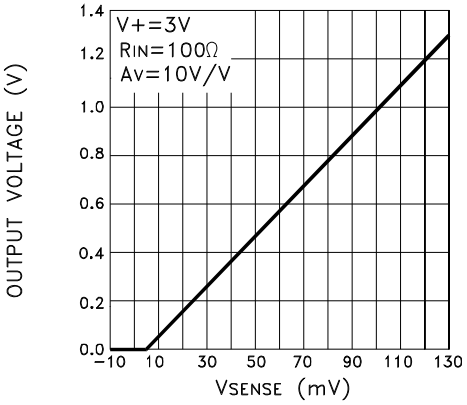


TYPICAL PERFORMANCE CURVES

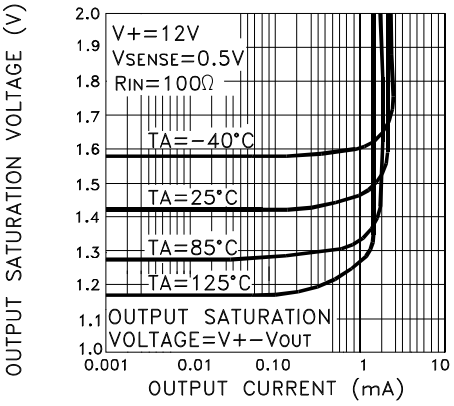
GAIN ERROR vs INPUT VOLTAGE



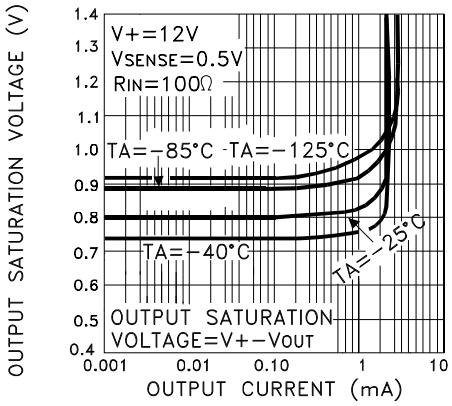
OUTPUT VOLTAGE vs VSENSE VOLTAGE; VS+=0V



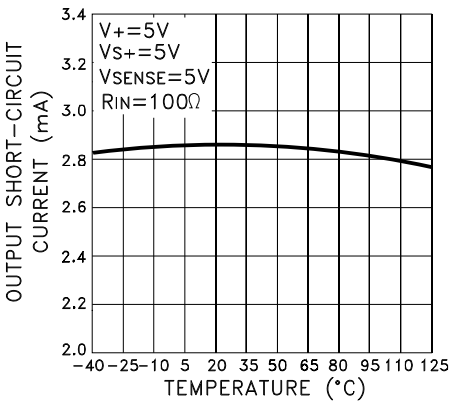
OUTPUT SATURATION VOLTAGE vs OUTPUT CURRENT Vs+=12V



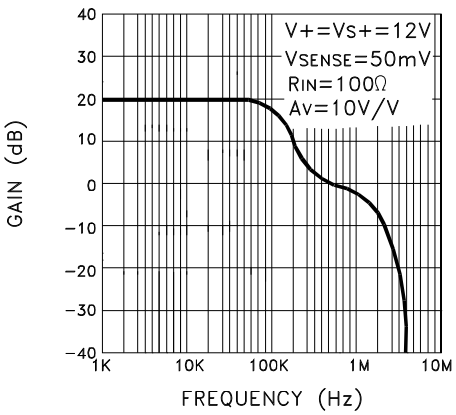
OUTPUT SATURATION VOLTAGE vs OUTPUT CURRENT Vs+=0.5V



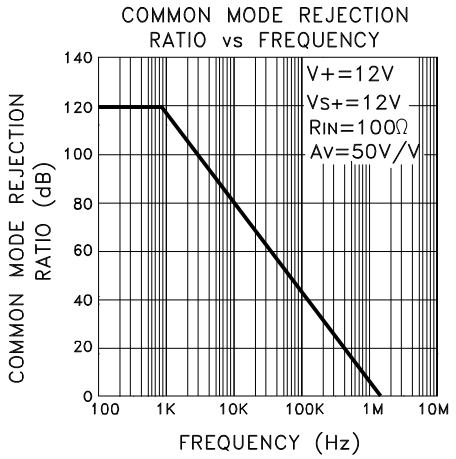
OUTPUT SHORT−CIRCUIT CURRENT vs TEMPERATURE



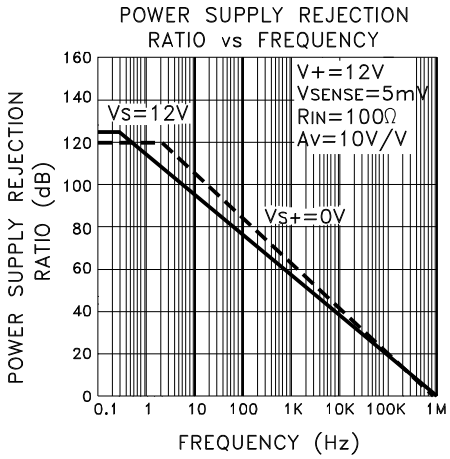
GAIN vs FREQUENCY



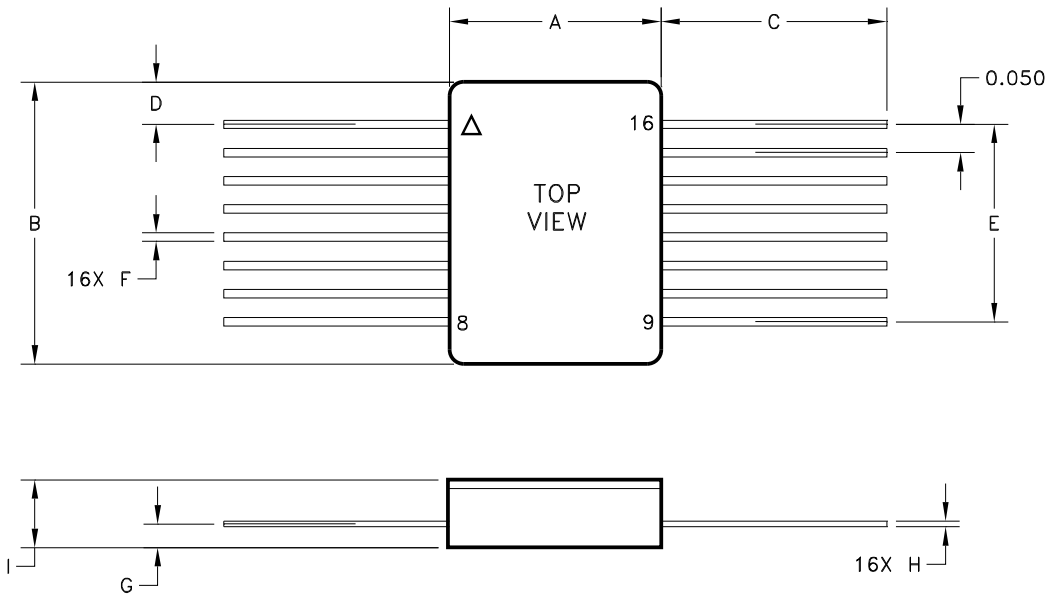
COMMON MODE REJECTION RATIO vs FREQUENCY



POWER SUPPLY REJECTION RATIO vs FREQUENCY



MECHANICAL SPECIFICATIONS



REF	MIN	MAX
A	0.365	0.385
B	0.490	0.510
C	0.400	———
D	0.075 REF	
E	0.345	0.355
F	0.012	0.018
G	0.032	0.052
H	0.008	0.012
I	———	0.115

ESD TRIANGLE INDICATES PIN 1
WEIGHT = 1.5 GRAMS TYPICAL

ALL DIMENSIONS ARE SPECIFIED IN INCHES

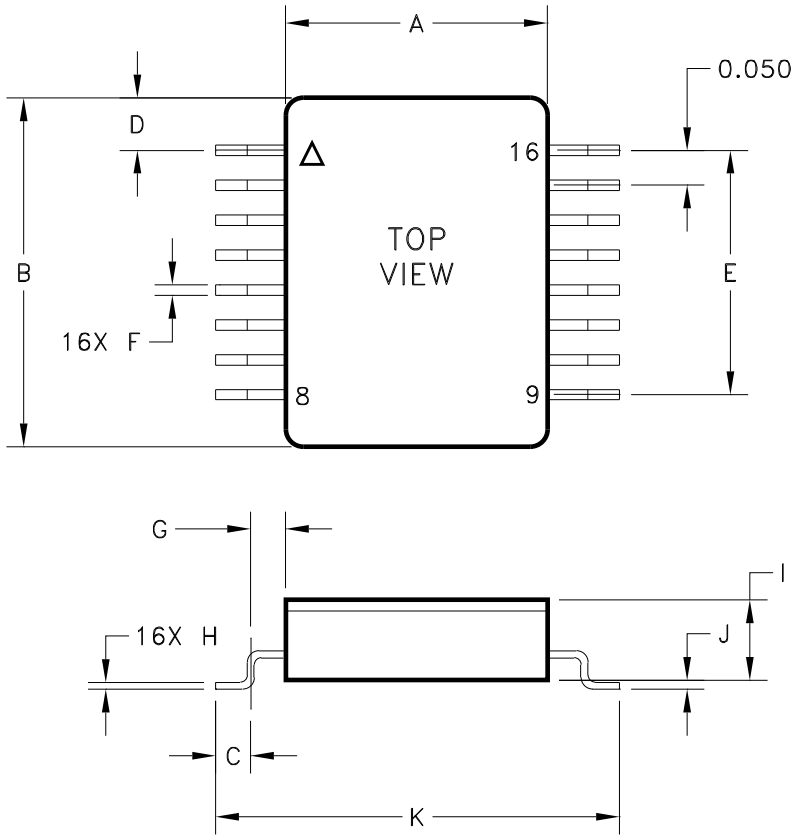
ORDERING INFORMATION

MSK496 K RH

LEAD CONFIGURATIONS
BLANK = STRAIGHT
RADIATION HARDENED
SCREENING
BLANK = INDUSTRIAL; H = MIL-PRF-38534 CLASS H;
K = MIL-PRF-38534 CLASS K
GENERAL PART NUMBER

The above example is a Class K screened device with straight leads.
For Non-Rad Hard engineering units, order MSK496EDU.

MECHANICAL SPECIFICATIONS



REF	MIN	MAX
A	0.365	0.385
B	0.490	0.510
C	0.045	0.055
D	0.075 REF	
E	0.345	0.355
F	0.012	0.018
G	0.050 REF	
H	0.008	0.012
I	———	0.115
J	0.008	0.018
K	0.550	0.600

NOTE: "J" IS MEASURED FROM BOTTOM OF PIN TO BOTTOM OF CASE.

ESD TRIANGLE INDICATES PIN 1
WEIGHT = 1.5 GRAMS TYPICAL

ALL DIMENSIONS ARE SPECIFIED IN INCHES

ORDERING INFORMATION

MSK496 K RH G

LEAD CONFIGURATIONS
G = GULL WING
RADIATION HARDENED
SCREENING
BLANK = INDUSTRIAL; H = MIL-PRF-38534 CLASS H;
K = MIL-PRF-38534 CLASS K
GENERAL PART NUMBER

The above example is a Class K screened device with gull wing lead form.
For Non-Rad Hard engineering units, order MSK496EDUG.

REVISION HISTORY

REV	STATUS	DATE	DESCRIPTION
F	Released	04/14	Add low dose rate test bullet and adjust VOS1 post rad specifications.
G	21078	05/14	Revise V+ supply current and shutdown input current typical values.
H	21116	06/14	Add ESD rating.
I	21374	10/14	Revise RθJC.

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