



M.S.KENNEDY CORP.


# RAD HARD DUAL PRECISION OP-AMP

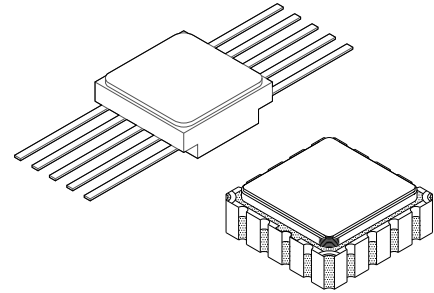
# 198RH

4707 Dey Road Liverpool, N.Y. 13088

(315) 701-6751

**FEATURES:**

- Manufactured using  Space Qualified RH1498 Die
- MIL-PRF-38535 Class V Processing & Screening
- Total Dose Tested to TBD Krads(Si) (Method 1019.7 Condition A)
- Rail - to - Rail Input and Output
- 800 $\mu$ V Max Vos from V+ to V-
- Gain - Bandwidth Product: 10MHz
- Slew Rate: 6V/uS Typical
- Low Supply Current per Amplifier: 1.7mA
- Stable for Capacitive Loads Up to 10,000pF
- Large Output Drive Current: 30mA
- Wide Supply Range: 4.5V to  $\pm$ 15V
- Available in Straight or Gull Wing Lead Form and LCCC
- Contact MSK for MIL-PRF-38535 Certification, Qualification and Radiation Status



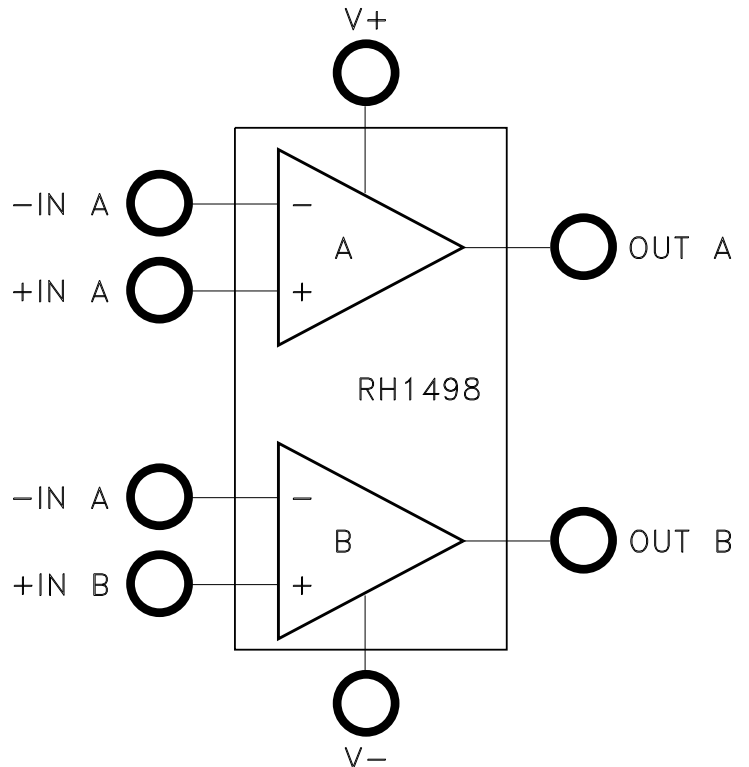
**DESCRIPTION:**

The MSK 198RH is a radiation hardened dual operational amplifier for use in space and severe military applications. This device offers rail-to-rail input and output, 10MHz gain-bandwidth product and 6V/uS slew rate. With a wide supply range of 4.5V to  $\pm$ 15V and drive current to 30mA, these op amps remain stable while driving capacitive loads up to 10,000pF. The MSK 198RH is an ideal solution when multiple robust precision amplifiers are required and board space is at a premium. The hermetically sealed MSK 198RH is offered in a 10 pin ceramic flat pack with straight or gull wing lead form and a leadless ceramic chip carrier package for meeting most surface mount applications.

**PIN-OUT INFORMATION**

FLAT PACK	LCCC
1 OUT A	1 OUT A
2 -IN A	2 NC
3 +IN A	3 -IN A
4 NC	4 NC
5 V-	5 +IN A
6 NC	6 NC
7 +IN B	7 V-
8 -IN B	8 NC
9 OUT B	9 +IN B
10 V+	10 NC
	11 -IN B
	12 NC
	13 OUT B
	14 NC
	15 V+
	16 NC

**EQUIVALENT SCHEMATIC**



**TYPICAL APPLICATIONS**

- Battery Powered Precision Instrumentation
- Driving A - to - D Converters
- Rail - to - Rail Buffer Amplifiers
- Low Voltage Signal Processing
- Active Filters

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## ABSOLUTE MAXIMUM RATINGS <sup>⑩</sup>

Total Supply Voltage (V+ to V-). . . . . 36V  
 Input Current . . . . . ±10mA  
 Output Short - Circuit Duration. . . . . Indefinite

T<sub>ST</sub> Storage Temperature Range. . . . . -65°C to +150°C  
 T<sub>LD</sub> Lead Temperature Range  
 (10 Seconds). . . . . 300°C  
 T<sub>J</sub> Junction Temperature. . . . . 150°C  
 T<sub>C</sub> Case Operating Temperature Range  
 MSK 198VRH. . . . . -55°C to +125°C  
 MSK 198RH. . . . . -40°C to +85°C

## ELECTRICAL SPECIFICATIONS

Parameter	Test Conditions <sup>⑪</sup> ①	Group A Subgroup	MSK 198VRH			MSK 198RH			Units
			Min.	Typ.	Max.	Min.	Typ.	Max.	
Input Offset Voltage		1	-800	-	800	-800	-	800	µV
		2,3	-1100	-	1100	-	-	-	µV
	Post Radiation	1	TBD	-	TBD	TBD	-	TBD	µV
Input Offset Voltage Match <sup>②</sup> <sup>③</sup>		1	0	-	1400	0	-	1400	µV
		2,3	0	-	1800	-	-	-	µV
Input Bias Current		1	-715	-	715	-715	-	715	nA
		2,3	-1200	-	1200	-	-	-	nA
	Post Radiation	1	TBD	-	TBD	TBD	-	TBD	nA
Input Bias Current Match <sup>②</sup> <sup>③</sup>		1	0	-	200	0	-	200	nA
		2,3	0	-	400	-	-	-	nA
Input Offset Current		1	0	-	70	0	-	70	nA
		2,3	0	-	300	-	-	-	nA
	Post Radiation	1	0	-	TBD	0	-	TBD	nA
Large Signal Voltage Gain	V <sub>OUT</sub> = -14.5V TO 14.5V R <sub>L</sub> = 10K	4	1000	-	-	1000	-	-	V/mV
		5,6	60	-	-	-	-	-	V/mV
	Post Radiation	4	TBD	-	-	TBD	-	-	V/mV
	V <sub>OUT</sub> = -10V TO 10V R <sub>L</sub> = 2K	4	500	-	-	500	-	-	V/mV
		5,6	25	-	-	-	-	-	V/mV
Post Radiation	4	TBD	-	-	TBD	-	-	V/mV	
Common Mode Rejection Ratio	V <sub>CM</sub> = -14.5V TO 14.5V	1,2,3	86	-	-	86	-	-	dB
		Post Radiation	1	TBD	-	-	TBD	-	-
CMMR Match <sup>②</sup>	V <sub>CM</sub> = -14.5V TO 14.5V	1,2,3	80	-	-	80	-	-	dB
		Post Radiation	1	TBD	-	-	TBD	-	-
Power Supply Rejection Ratio	V <sub>S</sub> = ±2.25V TO ±16V	1,2,3	88	-	-	88	-	-	dB
		Post Radiation	1	TBD	-	-	TBD	-	-
PSRR Match <sup>②</sup>	V <sub>S</sub> = ±2.25V TO ±16V	1,2,3	82	-	-	82	-	-	dB
		Post Radiation	1	TBD	-	-	TBD	-	-

## ELECTRICAL SPECIFICATIONS CONT'D

Parameter	Test Conditions <sup>⑪</sup> ①		Group A Subgroup	MSK 198VRH			MSK 198RH			Units
				Min.	Typ.	Max.	Min.	Typ.	Max.	
Output Voltage Swing (Low) <sup>④</sup> (V <sub>OUT</sub> -V <sub>-</sub> )	No Load		1,2,3	-	-	75	-	-	75	mV
		Post Radiation	1	-	-	TBD	-	-	TBD	mV
	ISINK = 1mA		1,2,3	-	-	150	-	-	150	mV
		Post Radiation	1	-	-	TBD	-	-	TBD	mV
	ISINK = 5mA		1,2,3	-	-	500	-	-	500	mV
		Post Radiation	1	-	-	TBD	-	-	TBD	mV
Output Voltage Swing (High) <sup>④</sup> (V <sub>+</sub> - V <sub>OUT</sub> )	No Load		1,2,3	-	-	25	-	-	25	mV
		Post Radiation	1	-	-	TBD	-	-	TBD	mV
	ISINK = 1mA		1,2,3	-	-	250	-	-	250	mV
		Post Radiation	1	-	-	TBD	-	-	TBD	mV
	ISINK = 5mA		1,2,3	-	-	800	-	-	800	mV
		Post Radiation	1	-	-	TBD	-	-	TBD	mV
Short-Circuit Current			1	± 15	-	-	± 15	-	-	mA
			2,3	± 7.5	-	-	-	-	-	mA
	Post Radiation		1	TBD	-	-	TBD	-	-	mA
Supply Current			1	-	-	5.0	-	-	5.0	mA
			2,3	-	-	6.0	-	-	-	mA
	Post Radiation		1	-	-	TBD	-	-	TBD	mA
Slew Rate	AV = -1, RL = 2K, VOUT = ± 10V		4	3.5	-	-	3.5	-	-	V/uS
	Measure at VOUT = ± 5V		4	TBD	-	-	TBD	-	-	V/uS
Input Voltage Range <sup>⑤</sup>			1	-15	-	15	-15	-	15	V
Input Noise Voltage <sup>⑤</sup>	0.1Hz to 10Hz		-	-	400	-	-	400	-	nVp-p
Input Noise Voltage Density <sup>⑤</sup>	f = 1kHz		-	-	12	-	-	12	-	nV/√Hz
Input Noise Current Density <sup>⑤</sup>	f = 1kHz		-	-	0.3	-	-	0.3	-	pA/√Hz
Gain-Bandwidth Product <sup>⑤</sup>	f = 100kHz		4	6.8	-	-	6.8	-	-	MHz
Thermal Resistance (MSK 198RH) <sup>⑤</sup>	Junction to Case @125°C		-	-	15.8	18.0	-	15.8	18.0	°C/W
Thermal Resistance (MSK 198RHL) <sup>⑤</sup>	Junction to Case @125°C		-	-	13.6	15.7	-	13.6	15.7	°C/W

### NOTES:

- ① Unless otherwise specified; V<sub>S</sub> = ± 15V, V<sub>CM</sub> = V<sub>OUT</sub> = 0V
- ② Matching parameters are the difference between amplifiers A and B.
- ③ Input Offset Voltage Match and Input Bias Current Match are not specified for post radiation.
- ④ Output Voltage swings are measured between the output and power supply rails.
- ⑤ Guaranteed by design but not tested. Typical parameters are representative of actual device performance but are for reference only.
- ⑥ Industrial grade devices shall be tested to subgroup 1 and 4 unless otherwise specified.
- ⑦ Military grade devices ("V" Suffix) shall be 100% tested to subgroups 1,2,3 and 4.
- ⑧ Subgroups 5 and 6 testing available upon request.
- ⑨ Subgroup 1, 4    TA = TC = +25°C  
Subgroup 2, 5    TA = TC = +125°C  
Subgroup 3, 6    TA = TC = -55°C
- ⑩ Continuous operation at or above absolute maximum ratings may adversely effect the device performance and/or life cycle.
- ⑪ Pre and Post irradiation limits at 25°C, to TBD TID, are identical unless otherwise specified.

# APPLICATION NOTES

## SINGLE TO DIFFERENTIAL ADC DRIVER

The circuit shown in Figure 1 utilizes the MSK 198RH to buffer and convert a single analog signal into an ADC with differential inputs. Some ADC's require an op amp to provide the appropriate gain and offset to match the signal to the input range of the ADC. An ADC may generate transient currents at their input due to the internal conversion circuit, and these currents need to be isolated from the signal source. The circuit in Figure 1 will provide a low impedance drive and absorb these currents. The first op amp offsets the input signal 1.25V while operating in unity gain. The output of the first op amp goes into the IN+ of the ADC and the inverting input of the second op amp. The second op amp inverts the signal around the 1.25VDC level applied to its non-inverting input and the output is connected to the IN- of the ADC. Optional filtering can be added to reduce high frequency noise from the ADC inputs if required.

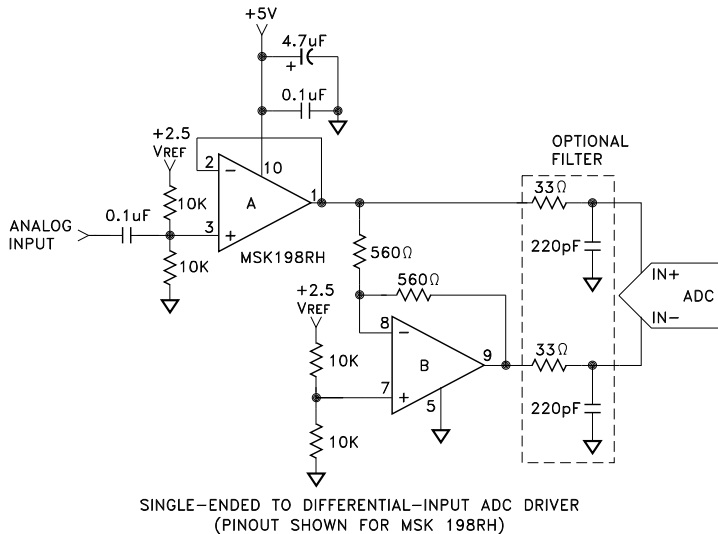
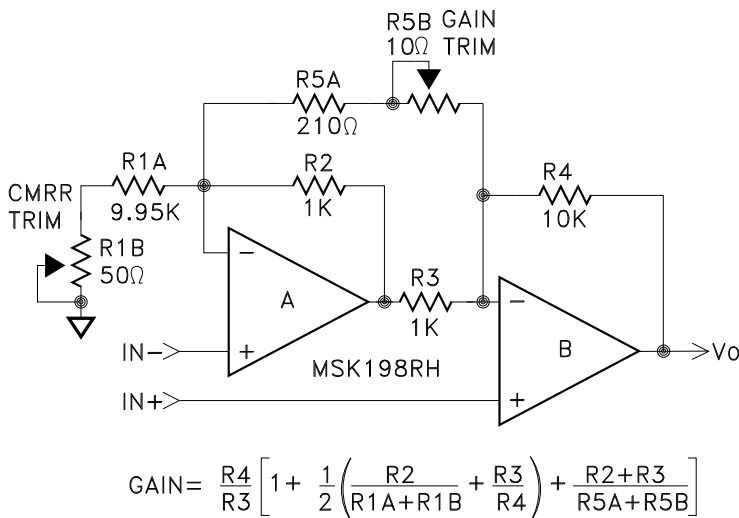


FIGURE 1

## INSTRUMENTATION AMPLIFIER

A simple low cost, low power consumption instrumentation amplifier can be designed with the MSK 198RH. Figure 2 shows a design that offers sensitivity trim for offset voltage, CMRR and gain. The circuit is configured for a differential input gain of 100.



INSTRUMENTATION AMPLIFIER

FIGURE 2

## 4th ORDER BUTTERWORTH FILTER

The wide bandwidth of the MSK 198RH is ideal for designing multi-order filter circuits. The circuit in Figure 3 shows a design that cascades two 2nd order filters as a 100KHz 4th order low pass filter. The design operates from a single supply. The filter offers a good compromise for low parts count and performance with minimal overshoot and ringing characteristics that a Butterworth filter offers.

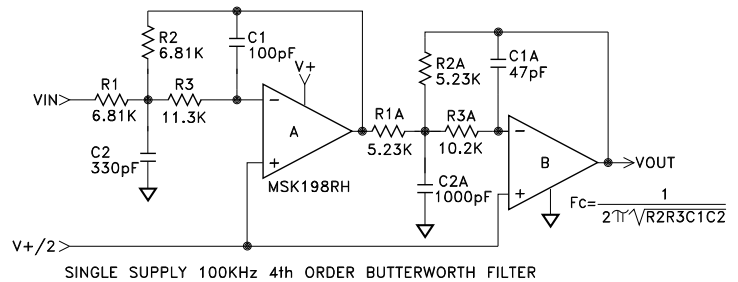


FIGURE 3

## TOTAL DOSE RADIATION TEST PERFORMANCE

Radiation performance curves for TID testing will be generated for all radiation testing performed by MS Kennedy. These curves show performance trends throughout the TID test process and will be located in the MSK 198RH radiation test report. The complete radiation test report will be available in the RAD HARD PRODUCTS section on the MSK website.

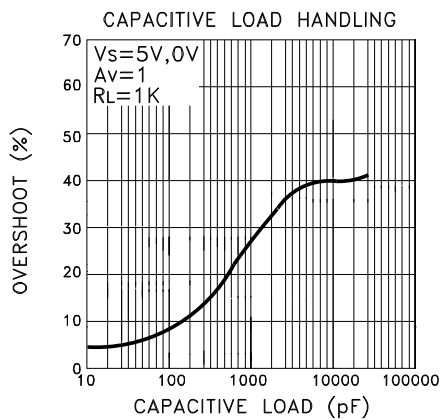
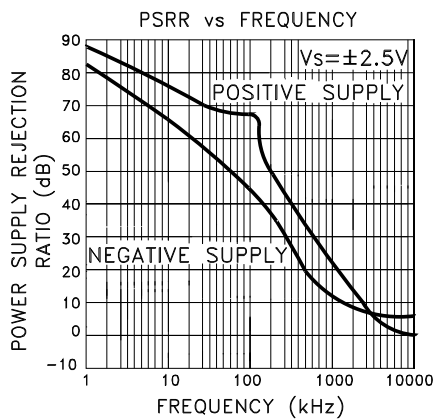
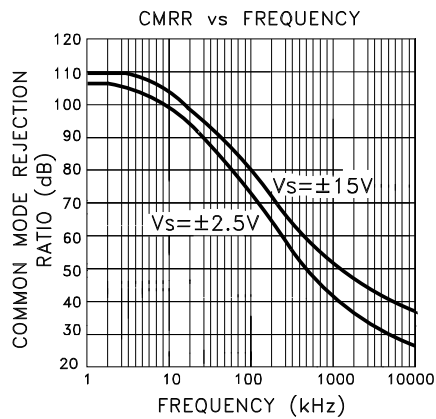
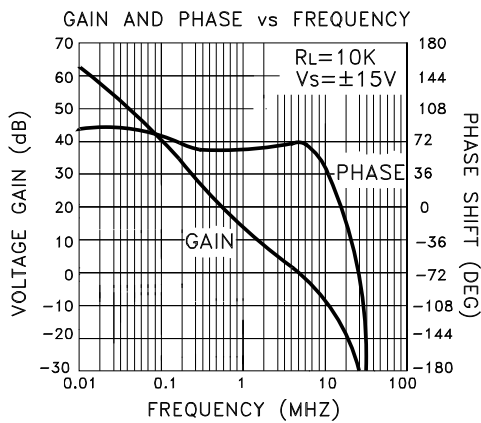
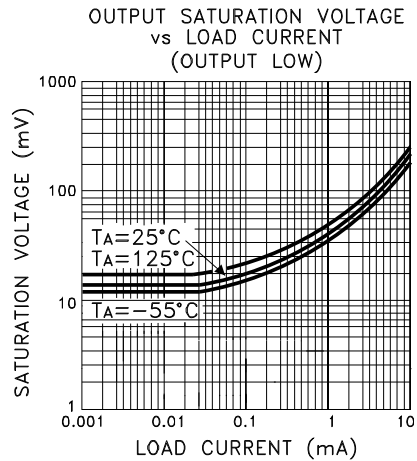
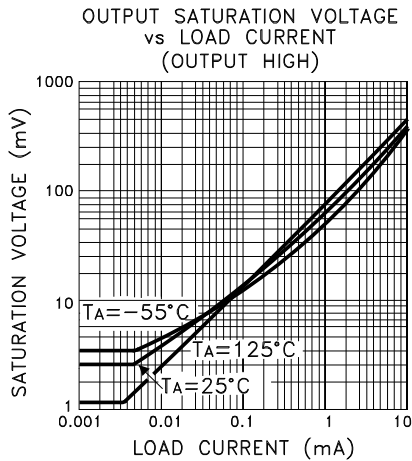
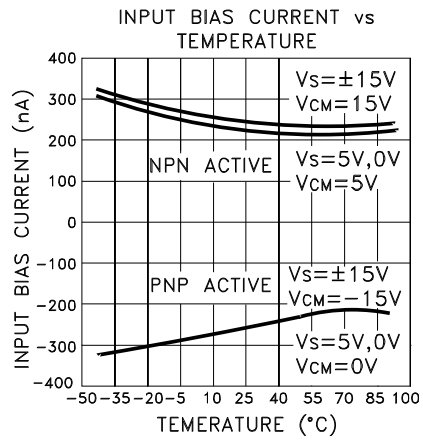
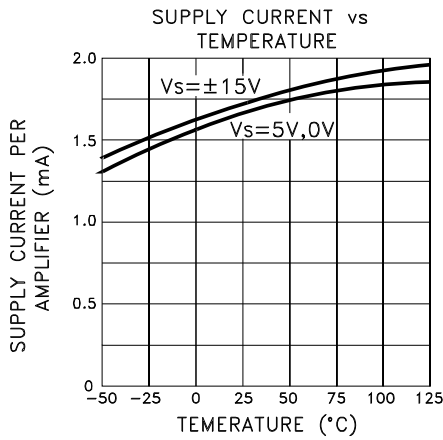
## ADDITIONAL APPLICATION INFORMATION

For additional applications information, please reference Linear Technology Corporation's® LT1498/1499 and RH1498 data sheets.

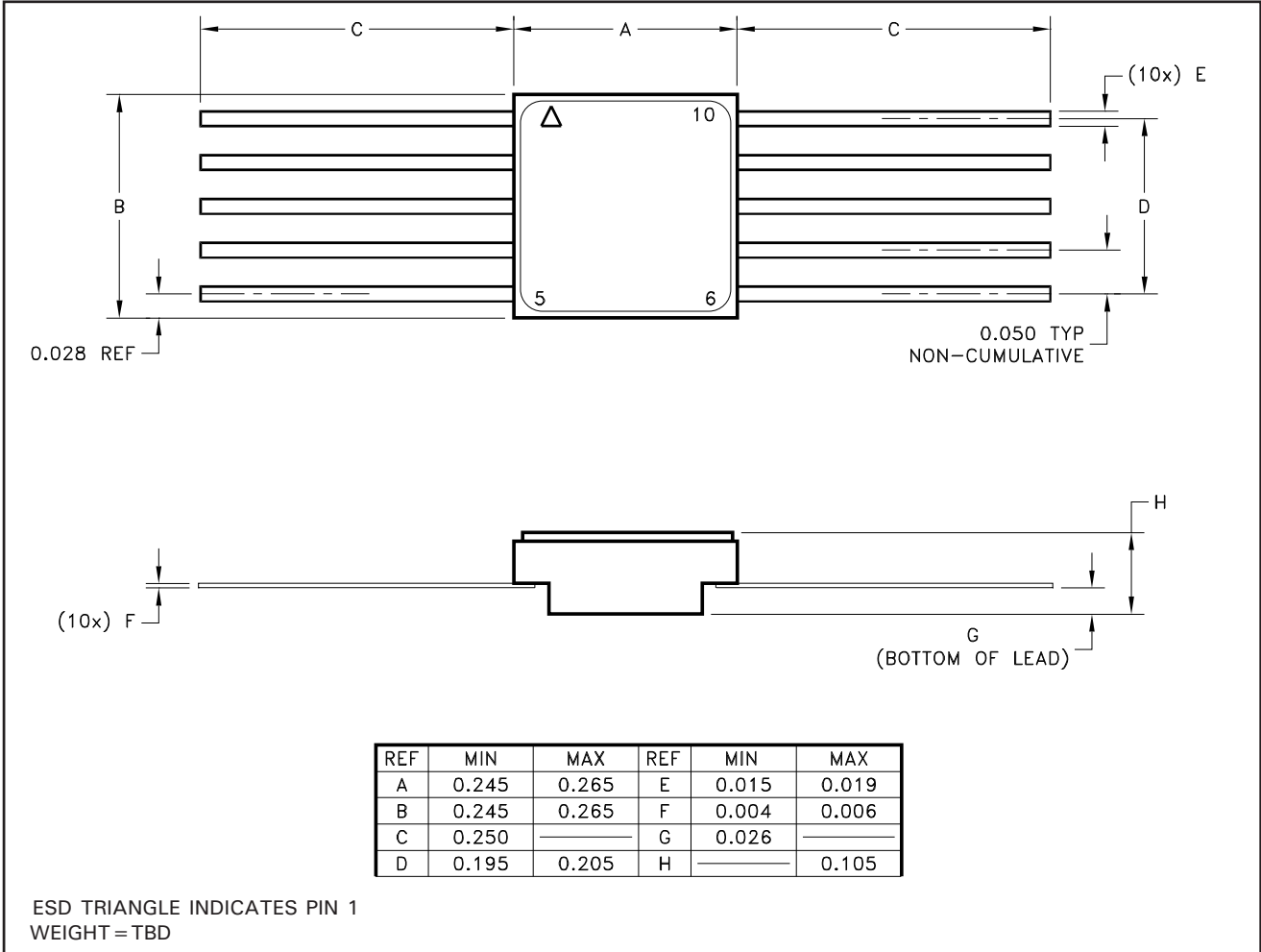
## DIE GLASSIVATION

For enhanced radiation tolerance the die has a glassivation thickness of 4KA and is not in accordance with MIL-PRF-38535.

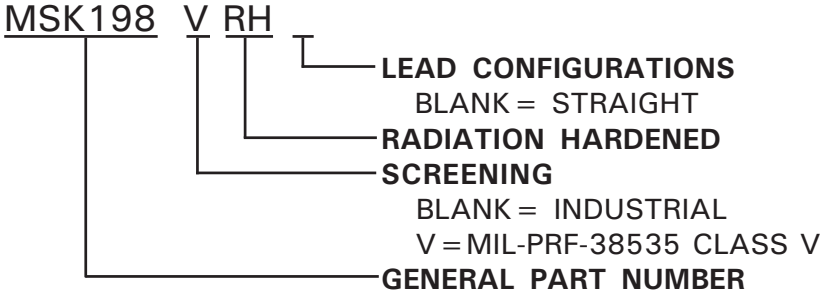
# TYPICAL PERFORMANCE CURVES



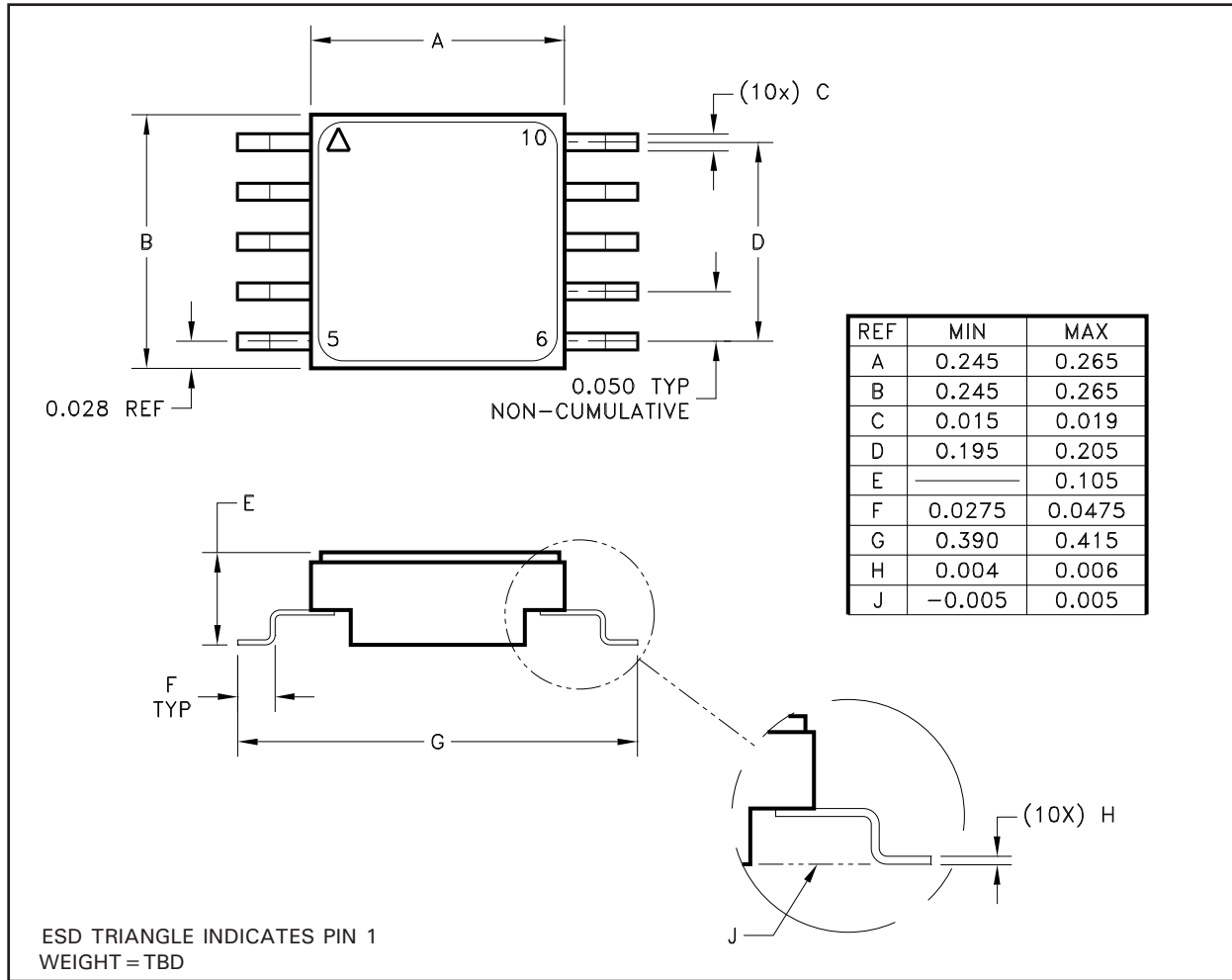
# MECHANICAL SPECIFICATIONS



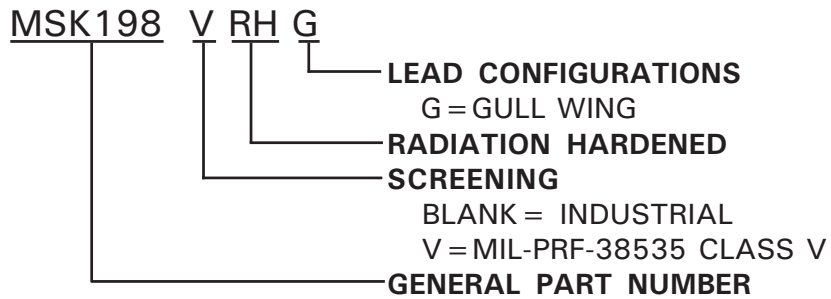
## ORDERING INFORMATION



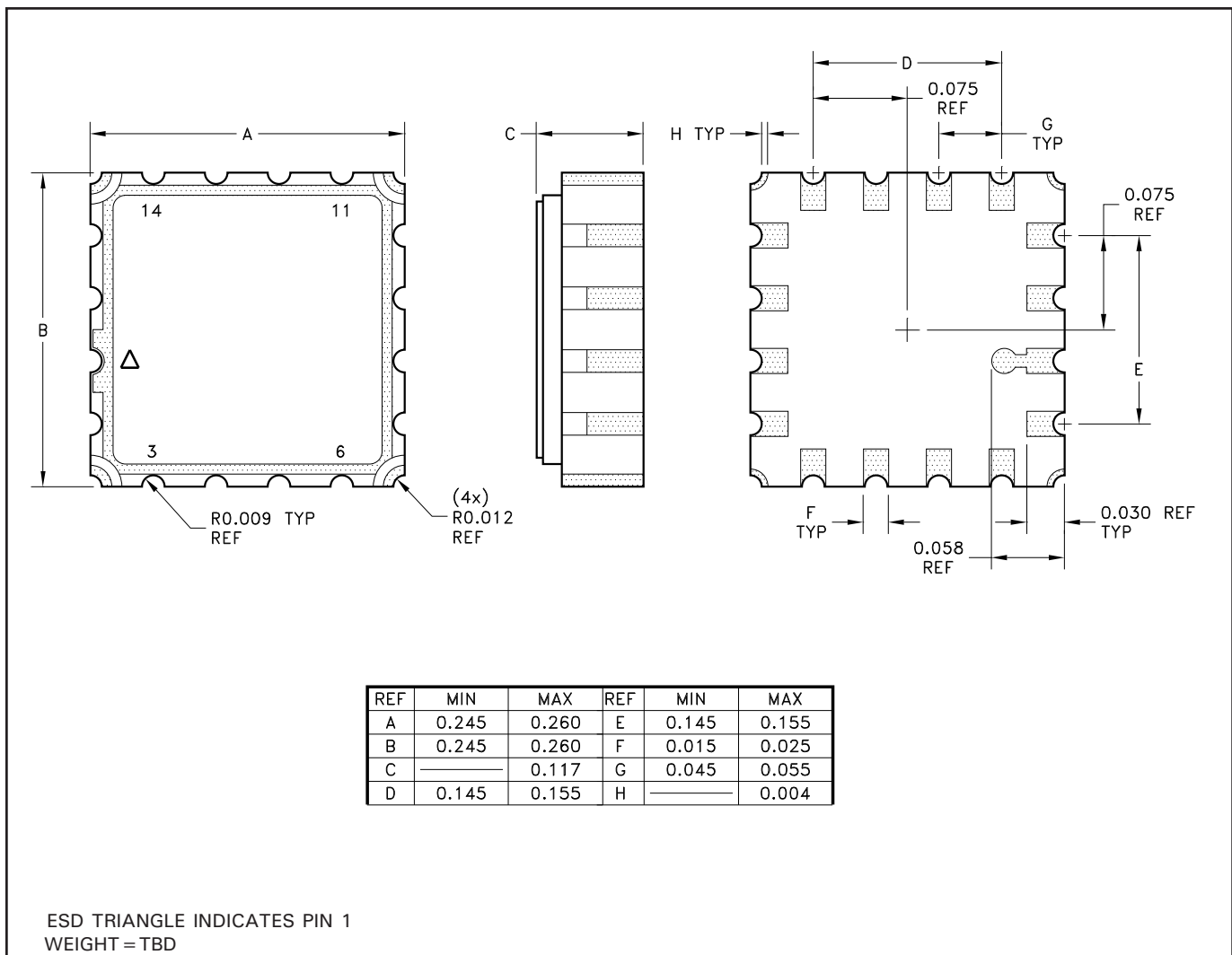
The above example is a Class V Dual Operational Amplifier with straight leads.



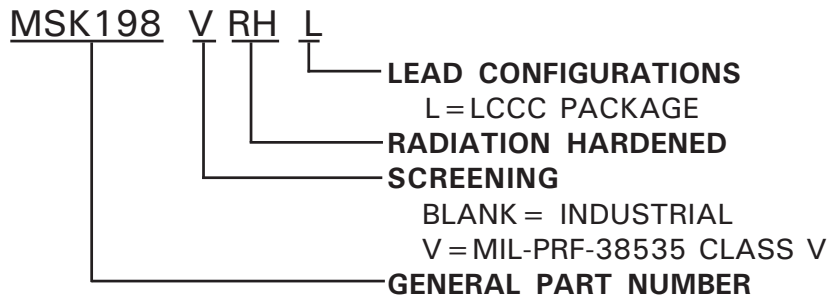
## ORDERING INFORMATION



The above example is a Class V Dual Operational Amplifier with gull wing lead form.



## ORDERING INFORMATION



The above example is a Class V Dual Operational Amplifier in an LCCC package.

**M.S. Kennedy Corp.**  
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Contact MSK for MIL-PRF-38535 Class V certification, qualification and radiation status.