


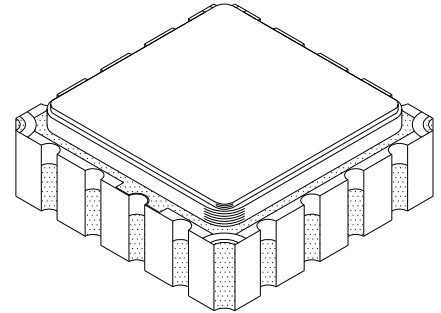


RAD HARD DUAL PRECISION OP-AMP

198RHL

FEATURES:

- Manufactured using  Space Qualified RH1498 Die
- MIL-PRF-38534 Class H & K Processing & Screening
- Total Dose Hardened to 100 Krads(Si) (Method 1019.7 Condition A)
- Rail - to - Rail Input and Output
- 800 μ V Max Vos from V+ to V-
- Gain - Bandwidth Product: 10MHz
- Slew Rate: 6V/ μ S 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
- Contact TTM Technologies for MIL-PRF-38534 Qualification and Radiation Status



DESCRIPTION:

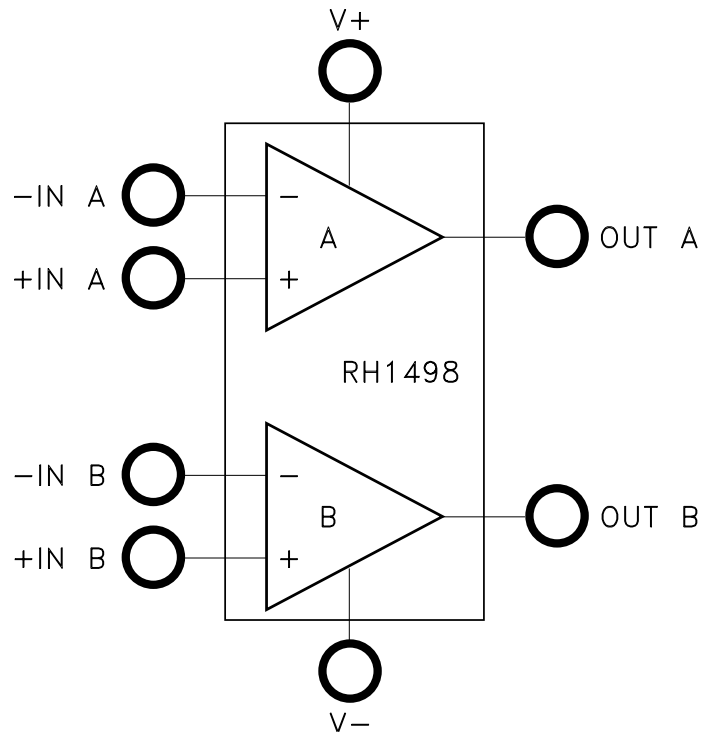
The MSK198RHL is a radiation hardened dual operational amplifier for use in space and severe military applications. This device offers rail-to-rail input and output, 10MHz gain-bandwidth product and 6V/ μ S slew rate. With a wide supply range of 4.5V to \pm 15V and drive current to 30mA, these op amps remain stable while driving capacitive loads up to 10,000pF. The MSK198RHL is an ideal solution when multiple robust precision amplifiers are required and board space is at a premium. The hermetically sealed MSK198RHL is offered in a leadless ceramic chip carrier package for surface mount applications.

PIN-OUT INFORMATION

- | | |
|----|----------|
| 1 | OUT A |
| 2 | NC |
| 3 | -IN A |
| 4 | NC |
| 5 | +IN A |
| 6 | NC |
| 7 | V- |
| 8 | CASE/LID |
| 9 | +IN B |
| 10 | NC |
| 11 | -IN B |
| 12 | NC |
| 13 | OUT B |
| 14 | NC |
| 15 | V+ |
| 16 | NC |

CASE; LID = PIN 8

EQUIVALENT SCHEMATIC



TYPICAL APPLICATIONS

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

ABSOLUTE MAXIMUM RATINGS ⁽¹⁰⁾

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

T_{ST} Storage Temperature Range..... -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
 MSK198K/H RHL..... -55°C to +125°C
 MSK198RHL..... -40°C to +85°C
 MSK198EDUL..... ⁽¹²⁾ -40°C to +85°C
 ESD Rating..... 2

ELECTRICAL SPECIFICATIONS

Parameter	Test Conditions ⁽¹¹⁾ ⁽¹⁾	Group A Subgroup	MSK198H/K RHL			MSK198RHL/EDUL			Units	
			Min.	Typ.	Max.	Min.	Typ.	Max.		
Input Offset Voltage		1	-800	-	800	-800	-	800	μV	
		2, 3	-1100	-	1100	-	-	-	μV	
Input Bias Current	Post Radiation	1	-950	-	950	-950	-	950	μV	
		1	-715	-	715	-715	-	715	nA	
Input Offset Current		2, 3	-1200	-	1200	-	-	-	nA	
	Post Radiation	1	-915	-	915	-915	-	915	nA	
Large Signal Voltage Gain		1	0	-	70	0	-	70	nA	
		2, 3	0	-	300	-	-	-	nA	
Common Mode Rejection Ratio ⁽⁵⁾	V _{OUT} = -14.5V TO 14.5V R _L = 10K	Post Radiation	1	0	-	100	0	-	100	nA
		4	1000	-	-	1000	-	-	V/mV	
CMMR Match ⁽²⁾ ⁽⁵⁾	V _{CM} = -14.5V TO 14.5V	5, 6	60	-	-	-	-	-	V/mV	
Power Supply Rejection Ratio	V _S = ±2.25V TO ±16V	4	500	-	-	500	-	-	V/mV	
PSRR Match ⁽²⁾	V _S = ±2.25V TO ±16V	1, 2, 3	70	-	-	70	-	-	dB	
Output Voltage Swing (Low) ⁽⁴⁾	No Load	1, 2, 3	70	-	-	70	-	-	dB	
	Post Radiation	1	-	-	75	-	-	75	mV	
(V _{OUT} - V ₋)	I _{SINK} = 1mA	1, 2, 3	-	-	150	-	-	150	mV	
	Post Radiation	1	-	-	100	-	-	100	mV	
Output Voltage Swing (High) ⁽⁴⁾	I _{SINK} = 5mA	1, 2, 3	-	-	500	-	-	500	mV	
	Post Radiation	1	-	-	500	-	-	500	mV	
(V ₊ - V _{OUT})	No Load	1, 2, 3	-	-	25	-	-	25	mV	
	Post Radiation	1	-	-	20	-	-	20	mV	
Short - Circuit Current	I _{SINK} = 1mA	1, 2, 3	-	-	250	-	-	250	mV	
	Post Radiation	1	-	-	150	-	-	150	mV	
Supply Current	I _{SINK} = 5mA	1, 2, 3	-	-	800	-	-	800	mV	
	Post Radiation	1	-	-	800	-	-	800	mV	
Slew Rate		1	±15	-	-	±15	-	-	mA	
		2, 3	±7.5	-	-	-	-	-	mA	
Input Voltage Range ⁽⁵⁾		Post Radiation	1	±10	-	-	±10	-	mA	
		1	-	-	5.0	-	-	5.0	mA	
Input Noise Voltage ⁽⁵⁾		2, 3	-	-	6.0	-	-	6.0	mA	
		4	3.5	-	-	3.5	-	-	V/μS	
Input Noise Voltage Density ⁽⁵⁾	A _V = -1, R _L = 2K, V _{OUT} = ±10V Measure at V _{OUT} = ±5V	Post Radiation	4	2.0	-	-	2.0	-	-	V/μS
		1	-15	-	15	-15	-	15	V	
Input Noise Current Density ⁽⁵⁾	0.1Hz to 10Hz	-	-	400	-	-	400	-	nVp-p	
	f = 1kHz	-	-	12	-	-	12	-	nV/√Hz	
Gain - Bandwidth Product ⁽⁵⁾	f = 1kHz	-	-	0.3	-	-	0.3	-	pA/√Hz	
	f = 100kHz	4	6.8	-	-	6.8	-	-	MHz	
Thermal Resistance ⁽⁵⁾	Junction to Case @ 125°C	-	-	13.6	16	-	13.6	16.5	°C/W	

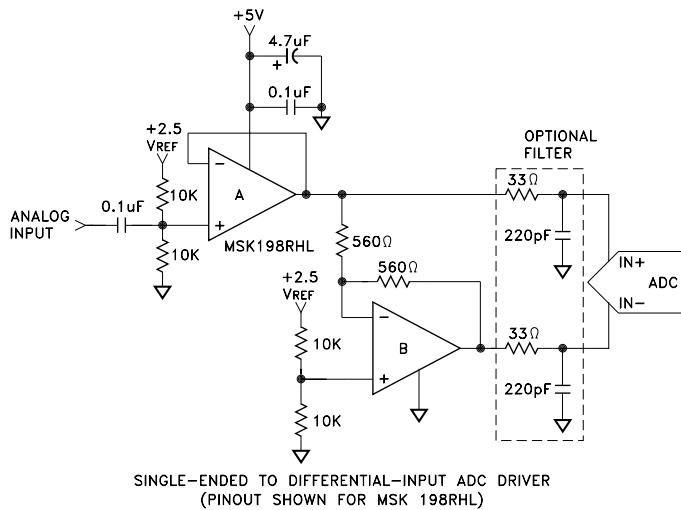
ELECTRICAL SPECIFICATIONS CONT'D

NOTES:

- ① Unless otherwise specified; $V_S = \pm 15V$, $V_{CM} = V_{OUT} = 0V$
- 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. Not applicable to Post Irradiation performance.
- ⑥ Industrial Grade devices shall be tested to Subgroup 1 and 4 unless otherwise specified.
- ⑦ Military Grade devices shall be 100% tested to Subgroups 1,2,3 and 4.
- ⑧ Subgroups 5 and 6 testing available upon request.
- ⑨ Subgroup 1, 4 $T_A = T_C = +25^\circ C$
Subgroup 2, 5 $T_A = T_C = +125^\circ C$
Subgroup 3, 6 $T_A = T_C = -55^\circ C$
- 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 $25^\circ C$, to 100K TID, are identical unless otherwise specified. Post Irradiation performance is guaranteed by design with a 2X radiation design margin.
- ⑫ MSK 198EDUL does not use RAD Hard Die, Post Irradiation specifications are not applicable.

SINGLE TO DIFFERENTIAL ADC DRIVER

The circuit shown in Figure 1 utilizes the MSK198RHL 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.

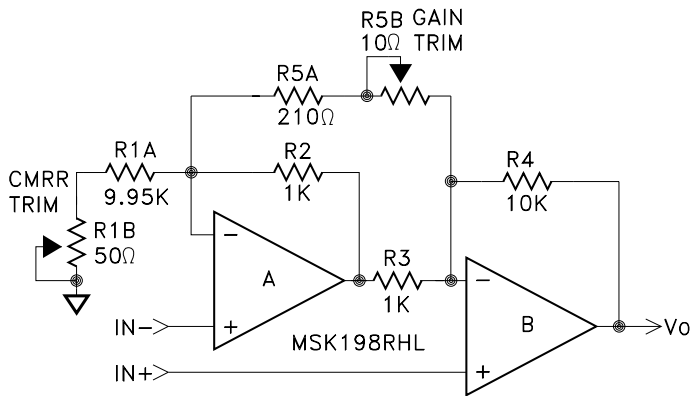


SINGLE-ENDED TO DIFFERENTIAL-INPUT ADC DRIVER (PINOUT SHOWN FOR MSK 198RHL)

FIGURE 1

INSTRUMENTATION AMPLIFIER

A simple low cost, low power consumption instrumentation amplifier can be designed with the MSK198RHL. 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.



$$GAIN = \frac{R4}{R3} \left[1 + \frac{1}{2} \left(\frac{R2}{R1A+R1B} + \frac{R3}{R4} \right) + \frac{R2+R3}{R5A+R5B} \right]$$

INSTRUMENTATION AMPLIFIER

FIGURE 2

4th ORDER BUTTERWORTH FILTER

The wide bandwidth of the MSK198RHL 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.

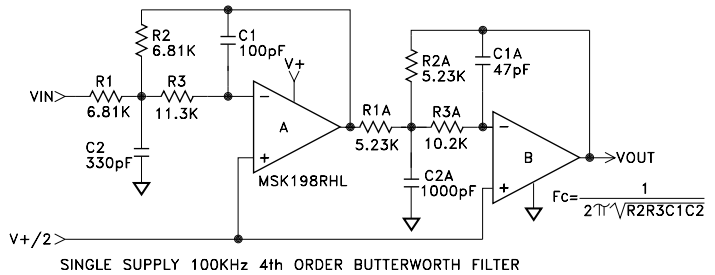


FIGURE 3

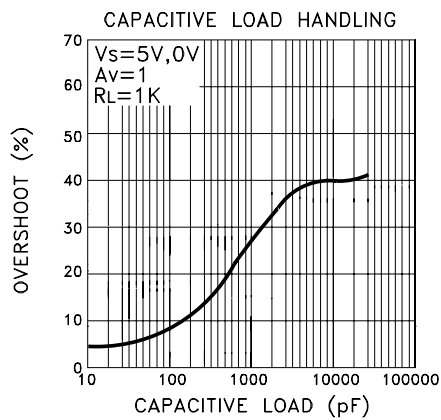
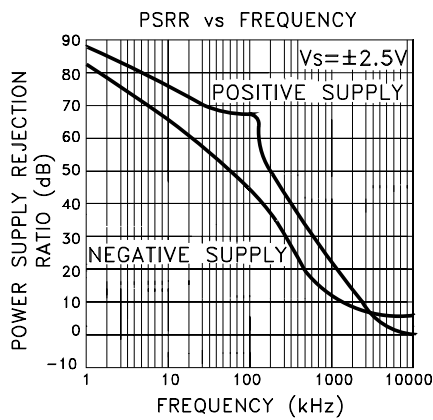
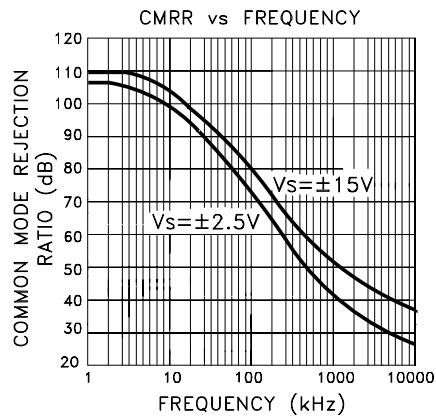
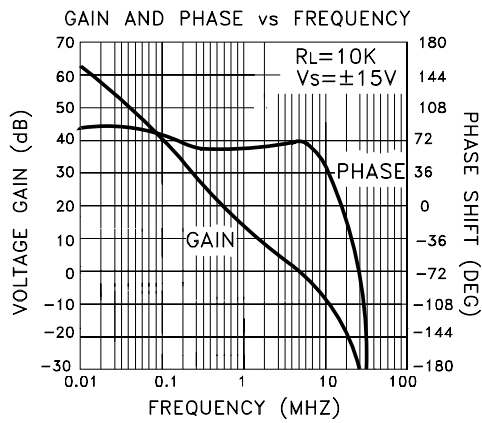
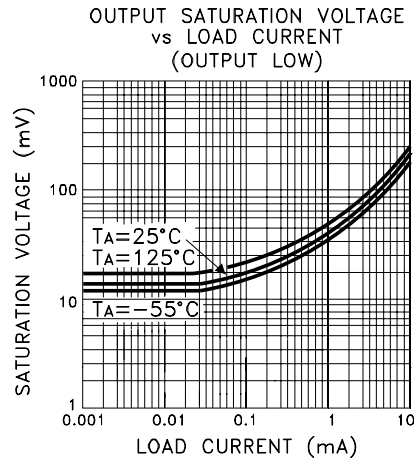
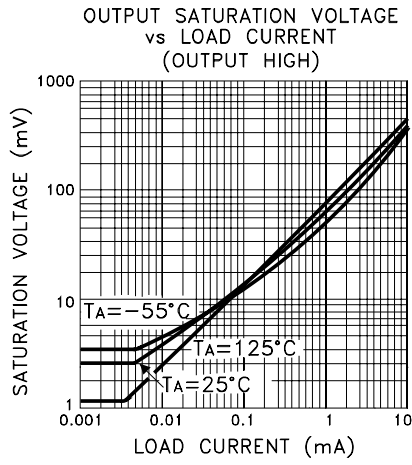
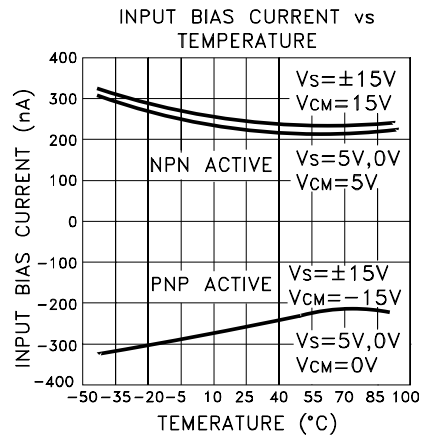
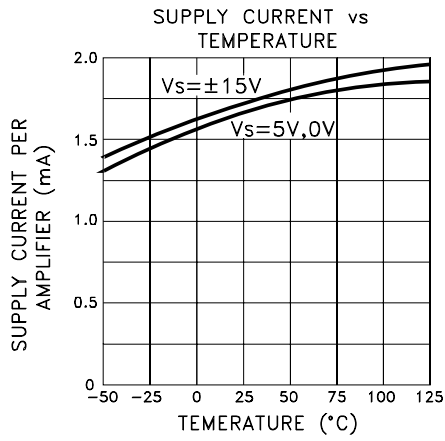
TOTAL DOSE RADIATION TEST PERFORMANCE

Radiation performance curves for TID testing will be generated for all radiation testing performed by TTM Technologies. These curves show performance trends throughout the TID test process and will be located in the MSK198RHL radiation test report. The complete radiation test report is available in the RAD HARD PRODUCTS section on the TTM Technologies website.

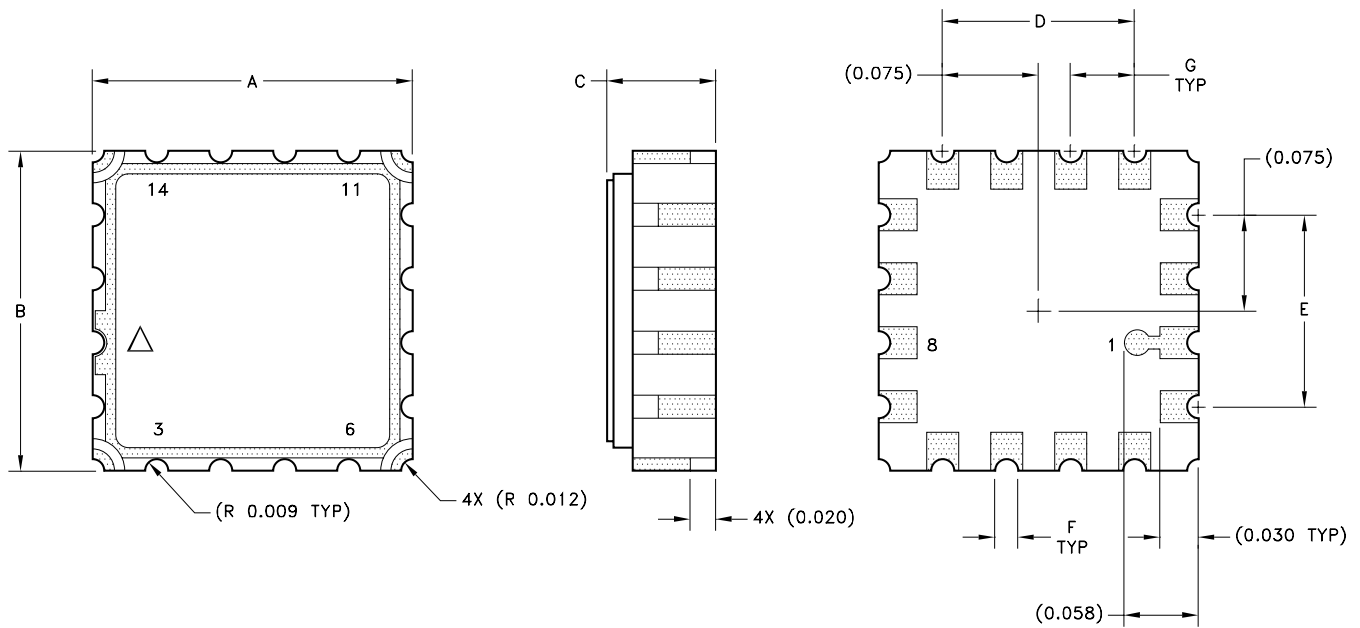
ADDITIONAL APPLICATION INFORMATION

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

TYPICAL PERFORMANCE CURVES



MECHANICAL SPECIFICATIONS



NOTE: PIN 8 IS CONNECTED TO PACKAGE LID.

REF	MIN	MAX
A	0.245	0.260
B	0.245	0.260
C		0.117
D	0.145	0.155
E	0.145	0.155
F	0.015	0.030
G	0.045	0.055

ESD TRIANGLE INDICATES PIN 1
WEIGHT=0.29 GRAMS TYPICAL

ALL DIMENSIONS ARE SPECIFIED IN INCHES

ORDERING INFORMATION

MSK198 K RH L

PACKAGE STYLE

L=LCCC PACKAGE

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 Dual Operational Amplifier in an LCCC package.

For Non-RAD Hard engineering units, order MSK 198EDUL.

REVISION HISTORY

REV	STATUS	DATE	DESCRIPTION
A	Released	01/15	Update format and add ESD rating.
B	Released	10/16	Add typical weight to mechanical specifications.
C	Released	09/17	Update parameters to better correlate to manufacturer's pre and post RAD specs.
D	Released	09/21	Remove MIL-PRF-38535
E	Released	11/23	Add MSK 198EDUL

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