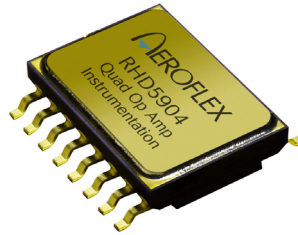


**RadHard-by-Design****RHD5904 Quad Operational Amplifier  
Instrumentation Amplifier with Enables**[www.aeroflex.com/RHDseries](http://www.aeroflex.com/RHDseries)

September 26, 2012

**FEATURES**

- Single power supply operation (3.3V to 5.0V) or dual power supply operation ( $\pm 1.65$  to  $\pm 2.5V$ )
- Radiation performance
  - Total dose:  $>1\text{Mrad(Si)}$ ; Dose rate = 50 - 300 rads(Si)/s
  - ELDRS Immune
  - SEL Immune  $>100\text{ MeV-cm}^2/\text{mg}$
  - Neutron Displacement Damage  $>10^{14}\text{ neutrons/cm}^2$
- High Speed
- Rail-to-Rail input and output range
- Enable pin to Enable/Disable amplifiers in pairs.
- Short Circuit Tolerant
- Full military temperature range
- Designed for aerospace and high reliability space applications
- Packaging – Hermetic ceramic SOIC
  - 16-pin, .417"L x .300"W x 0.105"Ht SOIC
  - Typical Weight 0.8 grams

**GENERAL DESCRIPTION**

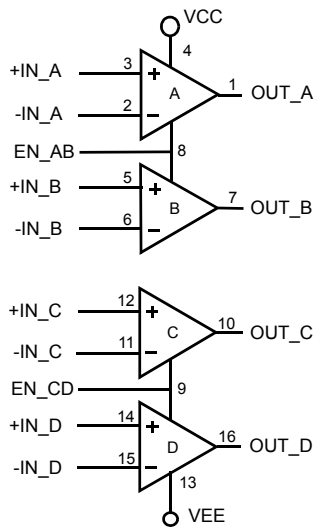
Aeroflex's RHD5904 is a radiation hardened, single supply, high speed, quad operational amplifier with enable in a 16-pin SOIC package. The RHD5904 design uses specific circuit topology and layout methods to mitigate total ionizing dose effects and single event latchup. These characteristics make the RHD5904 especially suited for the harsh environment encountered in Deep Space missions. It is guaranteed operational from  $-55^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ . Available screened in accordance with MIL-PRF-38534 Class K, the RHD5904 is ideal for demanding military and space applications.

**ORGANIZATION AND APPLICATION**

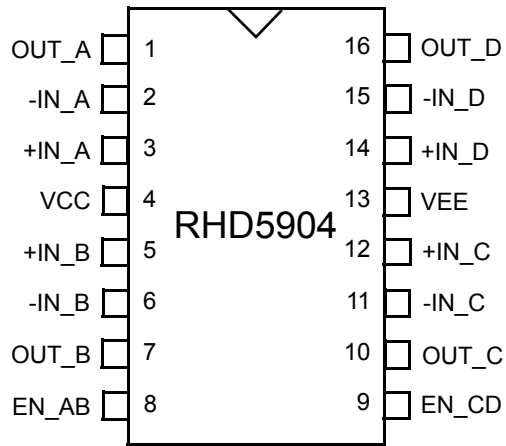
The RHD5904 amplifiers are capable of rail-to-rail input and outputs. Performance characteristics listed are for general purpose operational 5V CMOS amplifier applications. The amplifiers will drive substantial resistive or capacitive loads and are unity gain stable under normal conditions. Resistive loads in the low kohm range can be handled without gain derating and capacitive loads of several nF can be tolerated. CMOS device drive has a negative temperature coefficient and the devices are therefore inherently tolerant to momentary shorts, although on chip thermal shutdown is not provided. All inputs and outputs are diode protected.

The devices will not latch with SEU events to above  $100\text{ MeV-cm}^2/\text{mg}$ . Total dose degradation is minimal to above  $1\text{Mrad(Si)}$ . Displacement damage environments to neutron fluence equivalents in the mid  $10^{14}$  neutrons per  $\text{cm}^2$  range are readily tolerated. There is no sensitivity to low-dose rate (ELDRS) effects. SEU effects are application dependant.

The RHD5904 is configured with enable/disable control. Pairs of amplifiers are put in a power-down condition with their outputs in a high impedance state. Several useful operational amplifier configurations are supported where more than one amplifier can feed an output with others disabled.



**FIGURE 1: BLOCK DIAGRAM**



**16-Pin SOIC**

**FIGURE 2: PACKAGE PIN-OUT**

**Notes:**

1. Package and lid are electrically isolated from signal pads.
2. EN\_AB enables amplifiers A & B. EN\_CD enables amplifiers C & D.

## ABSOLUTE MAXIMUM RATINGS

Parameter	Range	Units
Case Operating Temperature Range	-55 to +125	°C
Storage Temperature Range	-65 to +150	°C
Junction Temperature	+150	°C
Supply Voltage V <sub>CC</sub> - V <sub>EE</sub>	+6.0	V
Input Voltage	V <sub>CC</sub> +0.4 V <sub>EE</sub> -0.4	V
Lead Temperature (soldering, 10 seconds)	300	°C
Thermal Resistance, Junction to Case, $\theta_{jc}$	7	°C/W
ESD Rating	2.0	KV
Power @ 25°C	200	mW

NOTICE: Stresses above those listed under "Absolute Maximums Rating" may cause permanent damage to the device. These are stress rating only; functional operation beyond the "Operation Conditions" is not recommended and extended exposure beyond the "Operation Conditions" may affect device reliability.

## RECOMMENDED OPERATING CONDITIONS

Symbol	Parameter	Typical	Units
+V <sub>CC</sub>	Power Supply Voltage	3.3 to 5.0	V
V <sub>CM</sub>	Input Common Mode Range	V <sub>CC</sub> to V <sub>EE</sub>	V

## ELECTRICAL PERFORMANCE CHARACTERISTICS

(T<sub>C</sub> = -55°C TO +125°C, +V<sub>CC</sub> = +5.0V -- UNLESS OTHERWISE SPECIFIED)

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Input Offset Voltage	V <sub>OS</sub>		-2		2	mV
Input Offset Current	I <sub>OS</sub>		-10		10	pA
Input Bias Current	I <sub>B</sub>		-20		20	pA
Input Offset TempCo $\frac{\mu V}{C}$	V <sub>I</sub> OST				10	$\mu V/C$
Common Mode Rejection Ratio	CMRR		70			dB
Power Supply Rejection Ratio	PSRR		70			dB
Output Voltage High	V <sub>OH</sub>	R <sub>OUT</sub> = 3.6 Kohms to GND	4.9			V
Output Voltage Low	V <sub>OL</sub>	R <sub>OUT</sub> = 3.6 Kohms to V <sub>CC</sub>			0.1	V
Short Circuit Output Current $\frac{mA}{2}$	I <sub>O(SINK)</sub>	V <sub>OUT</sub> to V <sub>CC</sub>	-63			mA
	I <sub>O(SOURCE)</sub>	V <sub>OUT</sub> to V <sub>EE</sub>			45	mA
Slew Rate	SR	R <sub>L</sub> = 8K	2.5			V/ $\mu S$
Open Loop Gain $\frac{dB}{2}$	A <sub>OL</sub>	No Load	100			dB
Unity Gain Bandwidth	U <sub>GBW</sub>	R <sub>L</sub> = 10K	5			MHz

## ELECTRICAL PERFORMANCE CHARACTERISTICS (continued)

(T<sub>C</sub> = -55°C TO +125°C, +V<sub>CC</sub> = +5.0V -- UNLESS OTHERWISE SPECIFIED)

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Input Voltage - Enable (EN_AB, EN_CD)	V <sub>HI</sub>	High (Enabled)	70% V <sub>CC</sub> - V <sub>EE</sub>			V
	V <sub>LO</sub>	Low (Disabled)			30% V <sub>CC</sub> - V <sub>EE</sub>	V
Input Current - Enable (EN_AB, EN_CD)	I <sub>EN</sub>				100	nA
Quiescent Supply Current	I <sub>CCQ</sub>	All Amplifiers Enabled, No Load			5.5	mA
		All Amplifier Disabled			1	uA
Channel Separation <u>2/</u>		R <sub>L</sub> = 2K, f = 1.0KHz	90			dB
Input-Referred Voltage Noise <u>2/</u>	e <sub>n</sub>	F = 1 kHz			TBD	V <sub>r</sub> /√Hz
Phase Margin <u>2/</u>	Φ <sub>m</sub>		TBD			Deg

Notes:

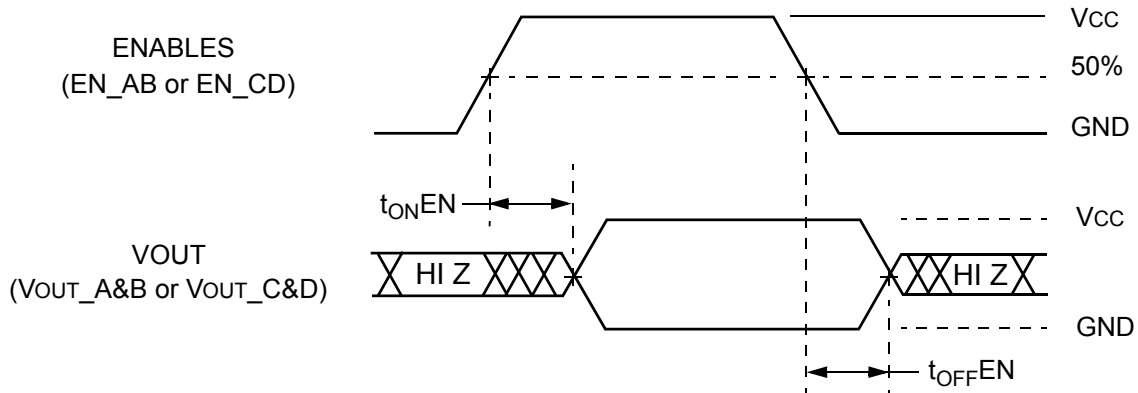
1/ Specification derated to reflect Total Dose exposure to 1 Mrad(Si) @ +25°C.

2/ Not tested. Shall be guaranteed by design, characterization, or correlation to other test parameters.

## SWITCHING CHARACTERISTICS

(T<sub>C</sub> = -55°C TO +125°C, +V<sub>CC</sub> = +5.0V -- UNLESS OTHERWISE SPECIFIED)

Parameter	Symbol	Conditions	Min	Max	Units
Output Delay (Enabled)	t <sub>ONEN</sub>			100	ns
Output Delay (Disabled)	t <sub>OFFEN</sub>			100	ns



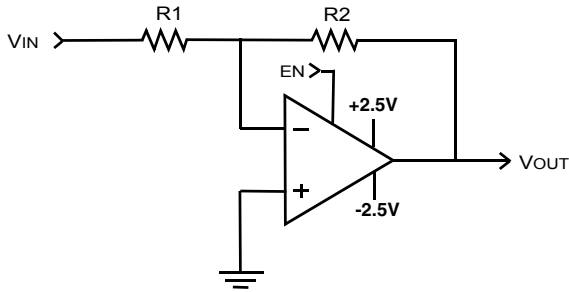
**FIGURE 3: RHD5904 SWITCHING DIAGRAM**

# RHD5904 QUAD OPERATIONAL AMPLIFIER APPLICATION NOTES

## APPLICATION NOTE 1: DUAL POWER SUPPLY AMPLIFIER

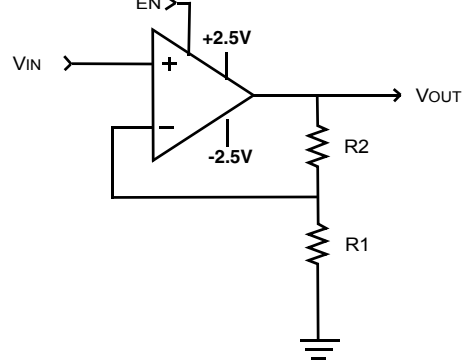
### Inverting Amplifier

$$V_{OUT} = -V_{IN} \left( \frac{R_2}{R_1} \right)$$



### Non Inverting Amplifier

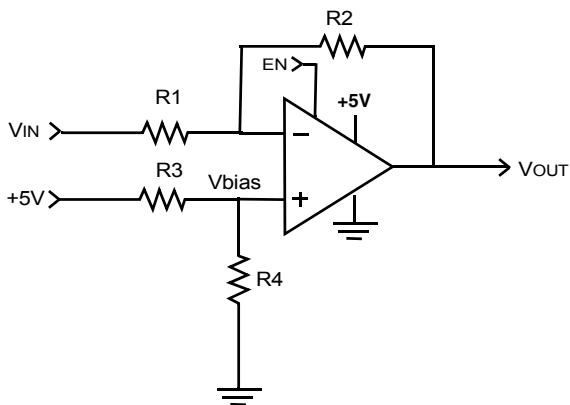
$$V_{OUT} = V_{IN} \left( 1 + \frac{R_2}{R_1} \right)$$



## APPLICATION NOTE 2: SINGLE POWER SUPPLY AMPLIFIER

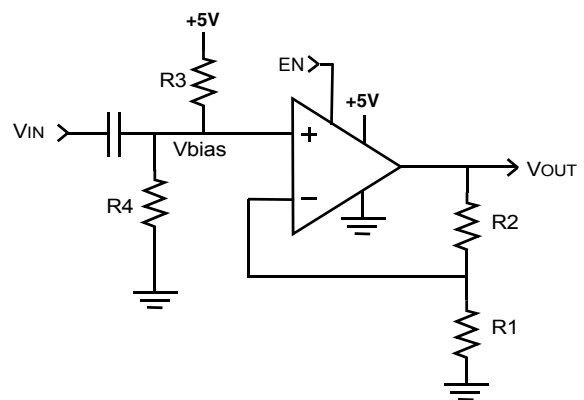
### Inverting Amplifier

$$V_{OUT} = -V_{IN} \left( \frac{R_2}{R_1} \right)$$



### Non Inverting Amplifier

$$V_{OUT} = V_{IN} \left( 1 + \frac{R_2}{R_1} \right)$$

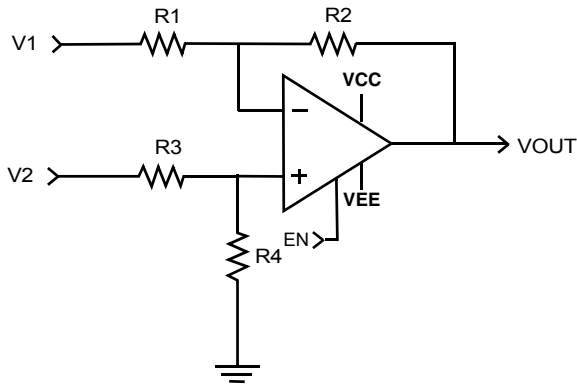


Note: For  $V_{OUT}$  DC @ mid range of common mode voltage range,  $V_{BIAS} = 2.5 / (1 + R_2/R_1)$ ,  $V_{BIAS} = +5 * R_4 / (R_3 + R_4)$

### APPLICATION NOTE 3: DIFFERENTIAL INPUT AMPLIFIER

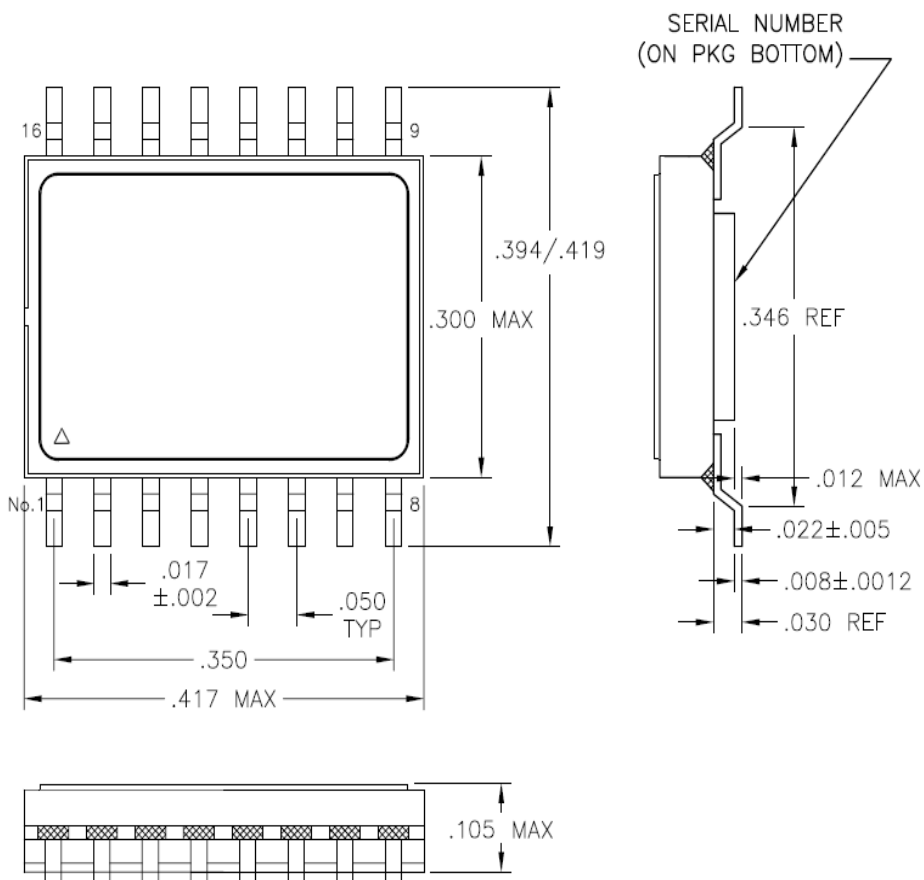
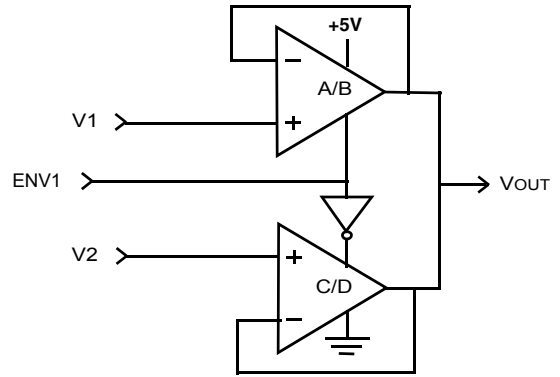
#### Differential Input Amplifier

$$V_{OUT} = \left( V_2 \left( \frac{R_4}{R_3 + R_4} \right) \left( 1 + \frac{R_2}{R_1} \right) \right) - \left( V_1 \frac{R_2}{R_1} \right)$$



### APPLICATION NOTE 4: MULTIPLE AMPLIFIERS

#### Multiple Amplifiers - Selectable Output



**FIGURE 4: PACKAGE OUTLINE**

## ORDERING INFORMATION

Model	DSCC SMD #	Screening	Package
RHD5904-7	-	Commercial Flow, +25°C testing only	16-pin SOIC Package
RHD5904-S	-	Military Temperature, -55°C to +125°C Screened in accordance with the individual Test Methods of MIL-STD-883 for Space Applications	
RHD5904-201-1S	5962-1024104KXC	DSCC SMD Pending	
RHD5904-201-2S	5962-1024104KXA		
RHD5904-901-1S	5962H1024104KXC	DSCC SMD and Radiation Certification Pending	
RHD5904-901-2S	5962H1024104KXA		

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**PLAINVIEW, NEW YORK**  
Toll Free: 800-THE-1553  
Fax: 516-694-6715

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Tel: 805-778-9229  
Fax: 805-778-1980

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Fax: 603-888-4585

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Tel: 949-362-2260  
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[www.aeroflex.com](http://www.aeroflex.com)    [info-ams@eroflex.com](mailto:info-ams@eroflex.com)

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