PA74R

Radiation Tolerant Power Dual Operational Amplifiers

RoHS COMPLIANT

FEATURES

- Wide Common Mode Range — Includes negative supply
- Wide Supply Voltage Range
  - Single supply: 5V to 40V
  - Split supplies: ±2.5V to ±20V
- High Output Current — 3A
- Single Event Effect (SEE) Testing - 46.1 MeV.cm^2/mg
- Total Ionizing Dose (TID) Testing - 50krad (Si)

APPLICATIONS

- Fine Steering & Deformable Mirrors
- Laser Gimbals
- Voice Coils
- Solenoids

DESCRIPTION

The amplifier design consists of dual monolithic input and output stages to achieve the desired input and output characteristics of the PA74R. The input stage utilizes a dual power op amp on a single chip monolithic that drives the output stages. The output stages are configured in a non-inverting unity gain buffer configuration. The output stages of the amplifier are also compensated for stability. The PA74R dual amplifiers are designed with both monolithic and hybrid technologies providing a cost-effective solution for applications requiring multiple amplifiers per board or bridge mode configurations. Both amplifiers are internally compensated but are not recommended for use as unity gain followers.

This dual hybrid circuit utilizes a beryllia (BeO) substrate, thick film resistors, ceramic capacitors and monolithic amplifiers to maximize reliability and power handling capability, minimize size and give top performance. Ultrasonically bonded aluminum wires provide reliable interconnections at all operating temperatures. The 8-Pin TO-3 package is hermetically sealed and electrically isolated. The use of compressible isolation washers voids the warranty.

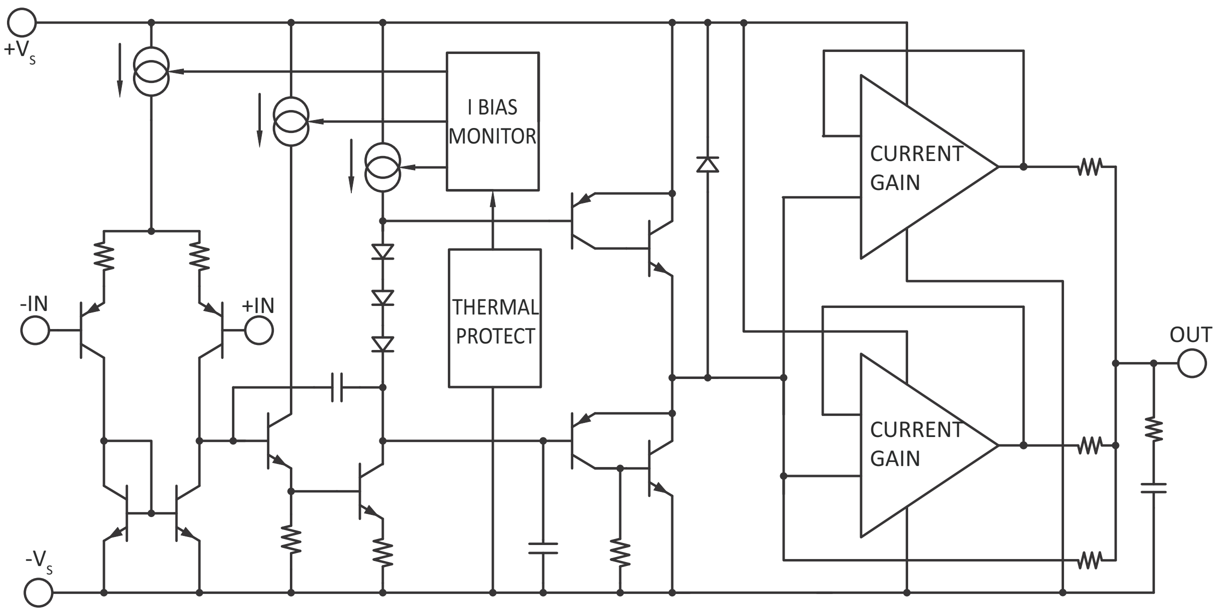
APEX RAD TOLERANT OVERVIEW

As an Apex radiation tolerant device, PA74R has been tested to “M/883” compliance. Additional testing for radiation tolerance includes:

- Particle Impact Noise Detection (PIND) Testing
- Single Event Effect (SEE) Testing: 46.1 MeV.cm^2/mg, Xenon heavy ion
- Enhanced Low Dose Rate Sensitivity (ELDRS) Testing: Dosage: 50 krad (Si)
- High-Dosage Radiation (HDR) Testing: Dosage: 50 krad (Si)

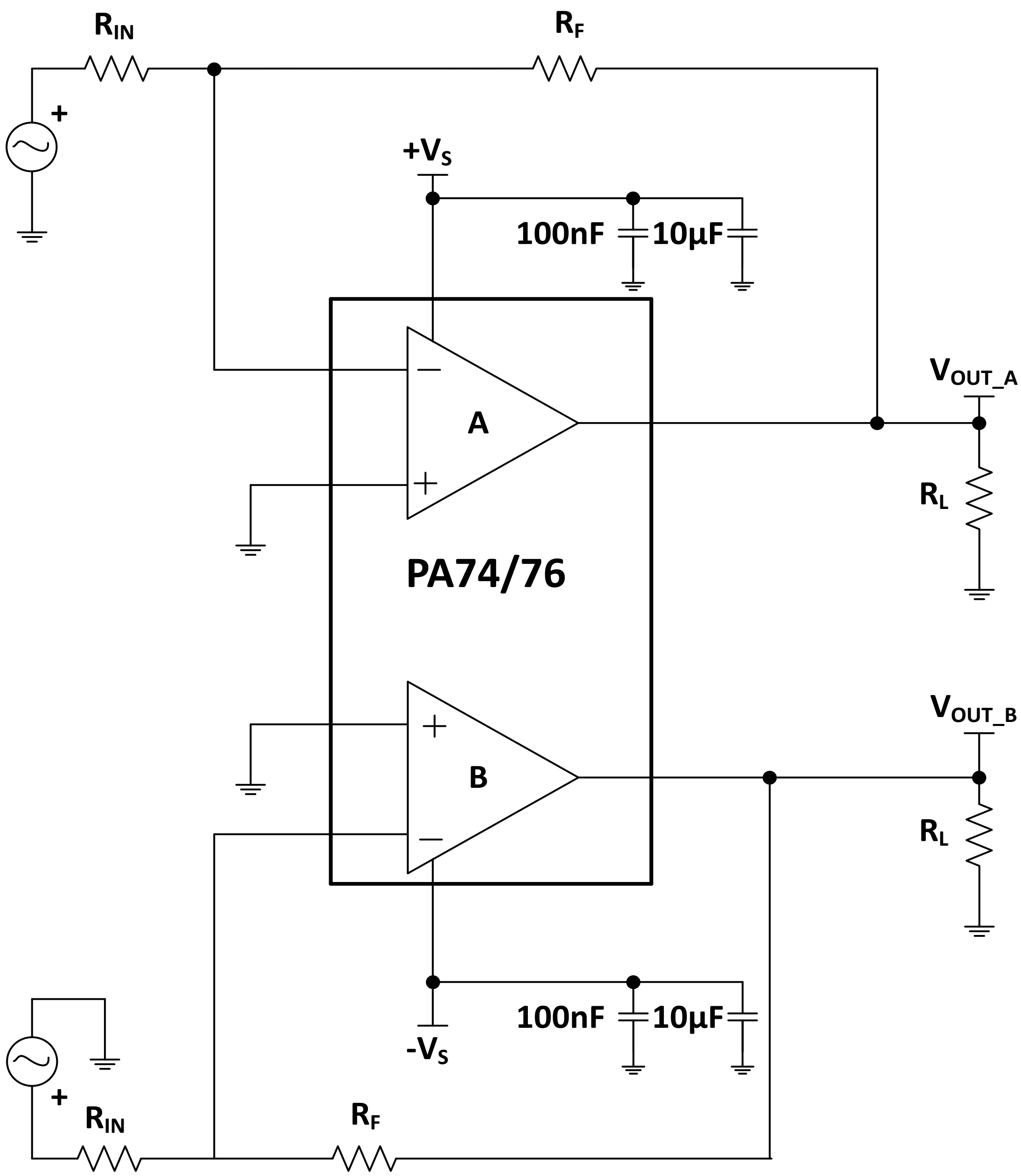
Apex radiation tolerant devices are considered “Class-H”, or radiation-tolerant. These devices do not satisfy the requirements for “Class-K” or radiation-hardened devices.

Figure 1: Equivalent Schematic



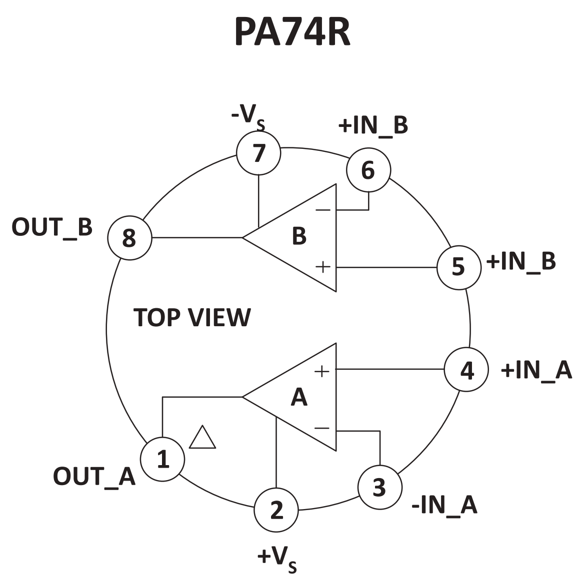
TYPICAL CONNECTION

Figure 2: Typical Connection



PINOUT AND DESCRIPTION TABLE

Figure 3: External Connections



PA74R

Pin Number	Name	Description
1	OUT_A	The output for channel A. Connect this pin to load and to the feedback resistors.
2	+Vs	The positive supply rail for both channels.
3	-IN_A	The inverting input for channel A.
4	+IN_A	The non-inverting input for channel A.
5	+IN_B	The non-inverting input for channel B.
6	-IN_B	The inverting input for channel B.
7	-Vs	The negative supply rail for both channels.
8	OUT_B	The output for channel B. Connect this pin to load and to the feedback resistors.

SPECIFICATIONS

Unless otherwise noted, the following conditions apply: $\pm V_S = \pm 15V$, $T_C = 25°C$.

ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Min	Max	Units
Supply Voltage, total	$+V_s$ to $-V_s$	5	40	V
Output Current	I_O		SOA	
Power Dissipation, internal (per amplifier)	P_D		36	W
Power Dissipation, internal (both amplifiers)	P_D		60	W
Input Voltage, differential	$V_{IN\ (Diff)}$		$\pm V_S$	V
Input Voltage, common mode	V_{cm}		$+V_S$, $-V_S$ – 0.5V	V
Temperature, pin solder, 10s max.			350	°C
Temperature, junction [1]	T_J		150	°C
Temperature Range, storage		-65	+150	°C
Operating Temperature Range, case	T_C	-55	+125	°C

1. Long term operation at the maximum junction temperature will result in reduced product life. Derate internal power dissipation to achieve high MTTF.

CAUTION The internal substrate contains beryllia (BeO). Do not break the seal. If accidentally broken, do not crush, machine, or subject to temperatures in excess of 850°C to avoid generating toxic fumes.

INPUT

Parameter	Test Conditions	PA74			PA74R			Units
		Min	Typ	Max	Min	Typ	Max	
Offset Voltage, initial[1]			1.5	10		0.79		mV
Offset Voltage vs. Temperature	Full temp range		20			*		µV/°C
Bias Current, initial[1]			0.10	0.50		0.90		µA
Common Mode Range	Full temp range	$-V_S$		$+V_S$–1.3	*		*	V
Common Mode Rejection, DC[1]	Full temp range	60	70			94		dB
Power Supply Rejection[1]	Full temp range	60	90		*	*		dB
Channel Separation	I_{OUT} = 1A, F = 1 kHz	50	70		*	*		dB

1. Typical values are based on a sample of PA74Rs that underwent radiation testing, reflecting the average of the biased and unbiased HDR data at 50krad. These values provide a general overview of performance; however, the full PA74R Radiation Report should be consulted prior to flight.

GAIN

Parameter	Test Conditions	PA74			PA74R			Units
		Min	Typ	Max	Min	Typ	Max	
Open Loop Gain[1]	Full temp range	89	100			103		dB
Gain Bandwidth Product	A_V = 40dB	0.9	1.4			1.2		MHz
Power Bandwidth	$V_{O(P-P)}$ = 28V		13.6			*		kHz

1. Typical values are based on a sample of PA74Rs that underwent radiation testing, reflecting the average of the biased and unbiased HDR data at 50krad. These values provide a general overview of performance; however, the full PA74R Radiation Report should be consulted prior to flight.

OUTPUT

Parameter	Test Conditions	PA74			PA74R			Units
		Min	Typ	Max	Min	Typ	Max	
Current, peak		2.5			*			A
Slew Rate		0.5	1.4			1.6		V/µs
Voltage Swing[1]	Full temp range, I_O = 100mA	|VS|±1.1	|VS|±0.9			|VS|±0.8		V
Voltage Swing	Full temp range, I_O = 1A	|VS|±2.0	|VS|±1.7		*	*		V
Voltage Swing[1]	I_O = 2.5A	|VS|±3.5	|VS|±2.9			*		V

1. Typical values are based on a sample of PA74Rs that underwent radiation testing, reflecting the average of the biased and unbiased HDR data at 50krad. These values provide a general overview of performance; however, the full PA74R Radiation Report should be consulted prior to flight.

POWER SUPPLY

Parameter	Test Conditions	PA74			PA74R			Units
		Min	Typ	Max	Min	Typ	Max	
Voltage, VSS [1]			30	40		*	*	V
Current, quiescent, total[2]			18	40		11		mA

1. +VS and -VS denote the positive and negative supply rail respectively. VSS denotes the total rail-to-rail supply voltage.
2. Typical values are based on a sample of PA74Rs that underwent radiation testing, reflecting the average of the biased and unbiased HDR data at 50krad. These values provide a general overview of performance; however, the full PA74R Radiation Report should be consulted prior to flight.

THERMAL

Parameter	Test Conditions	PA74			PA74R			Units
		Min	Typ	Max	Min	Typ	Max	
Resistance, junction to case								
DC, single amplifier	F < 60 Hz		3.2	3.5		*	*	°C/W
DC, both amplifiers [1]	F < 60 Hz		1.9	2.1		*	*	°C/W
AC, single amplifier	F > 60 Hz		2.4	2.6		*	*	°C/W
AC, both amplifiers [1]	F > 60 Hz		1.4	1.6		*	*	°C/W
Resistance, junction to air			30			*		°C/W
Temperature Range, case	Meets full range specs	-25		+85	-55		+125	°C

1. Rating applies when power dissipation is equal in the two amplifiers.

Note: * The specifications were not measured under radiation. In a non-radiation environment, the PA74 parameters reflect the behavior of the PA74R. However, in a radiation environment, the PA74R specifications marked with an asterisk (excluding thermal specifications) are likely to deviate from the PA74 specifications.

TYPICAL PERFORMANCE GRAPHS (PA74)

Figure 4: Normalized Quiescent Current vs. Case Temperature

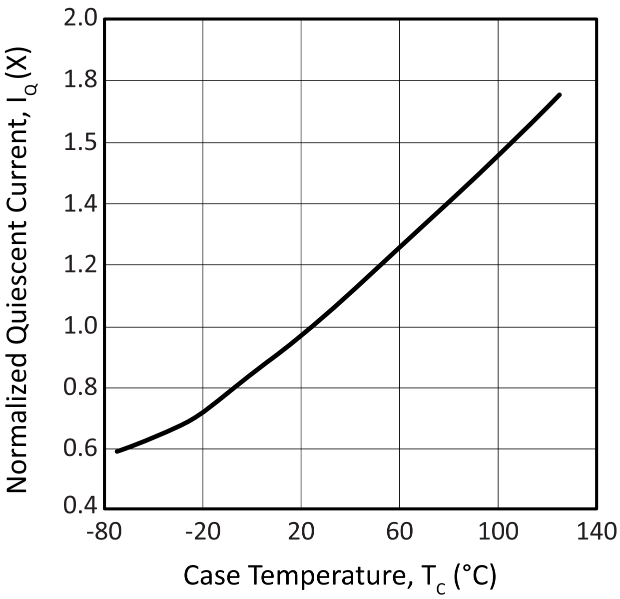


Figure 5: Normalized Quiescent Current vs. Supply Voltage

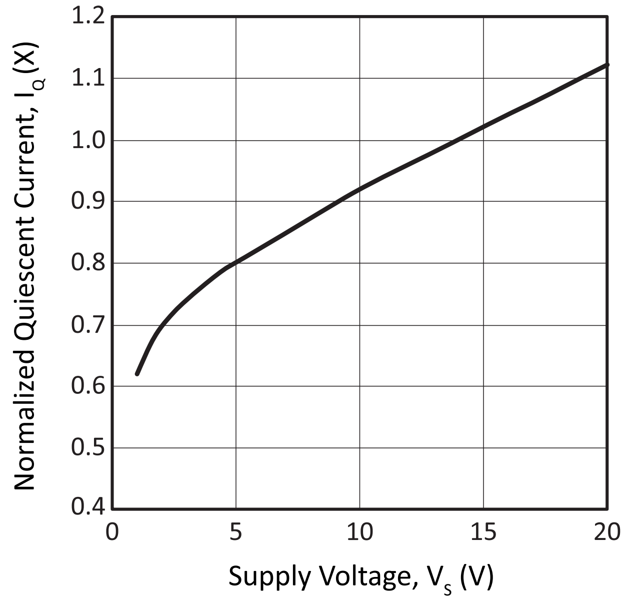


Figure 6: Output Voltage Swing

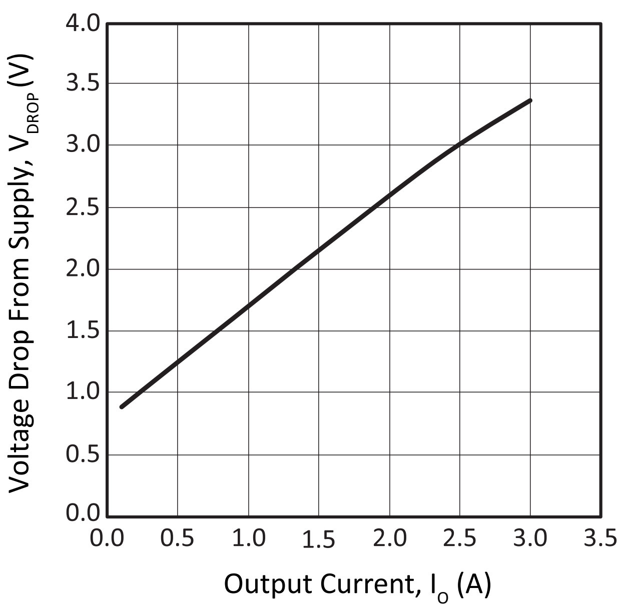


Figure 7: Pulse Response

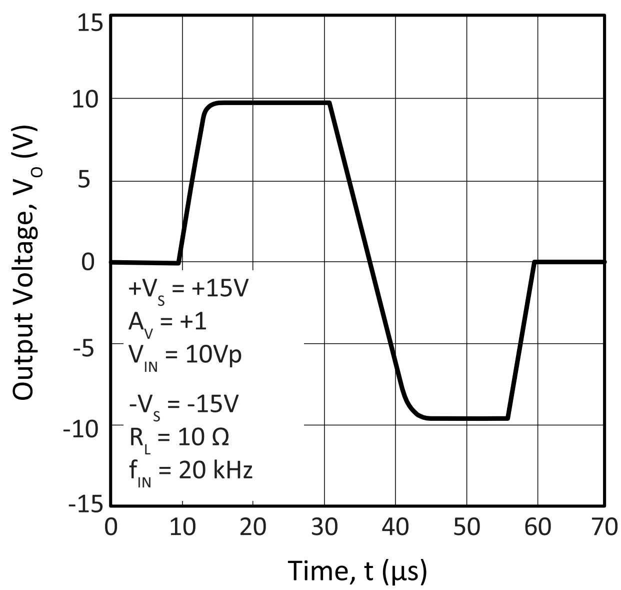


Figure 8: Pulse Response

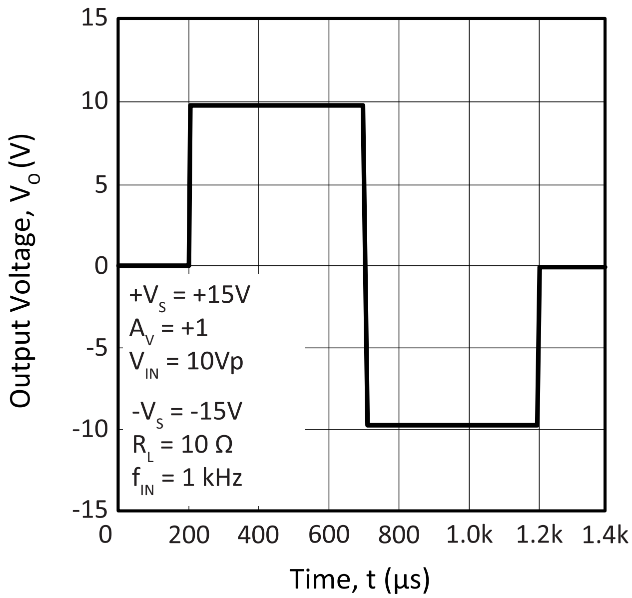


Figure 9: I_B vs Temperature

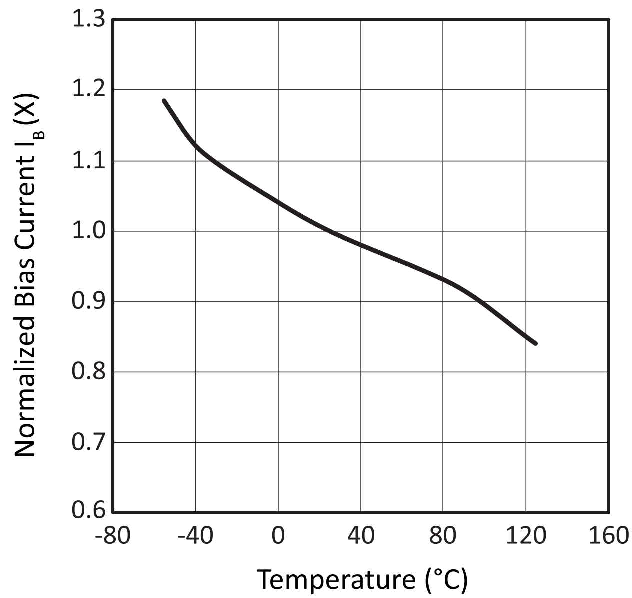


Figure 10: Phase vs Frequency

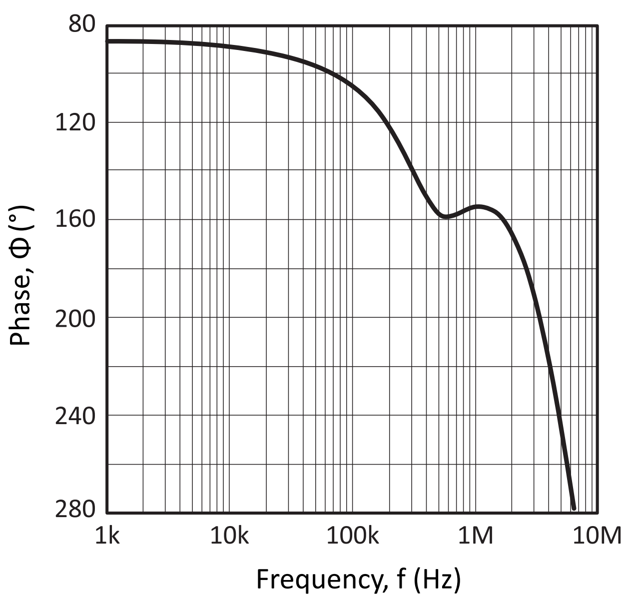


Figure 11: Voltage Gain vs Frequency

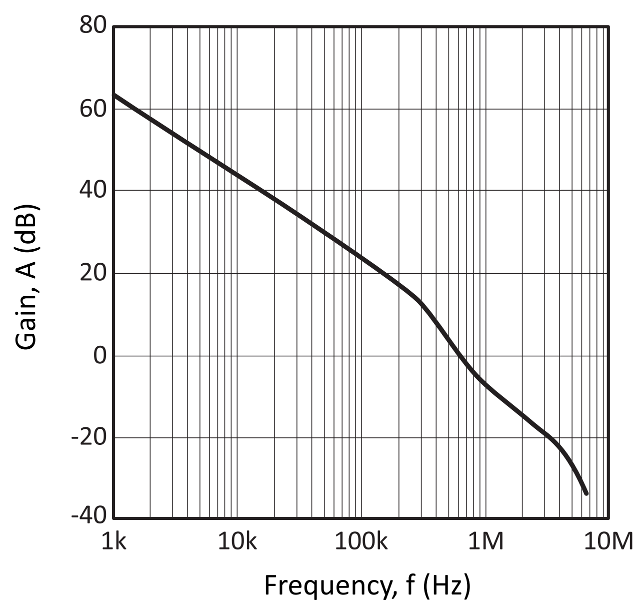


Figure 12: V_{OS} vs Temperature

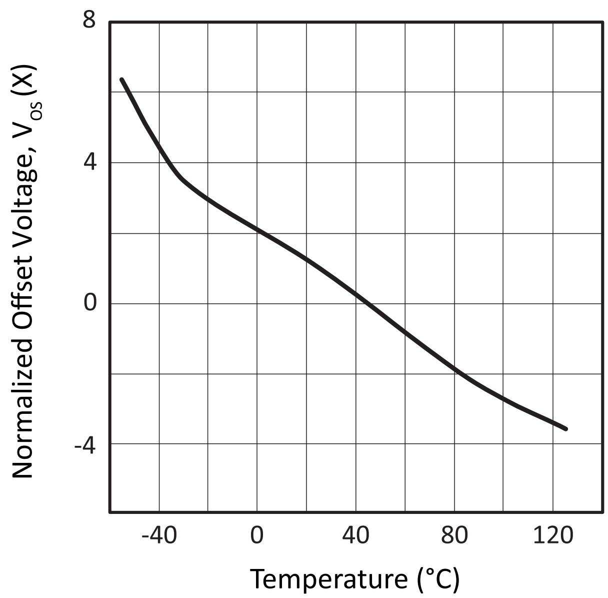
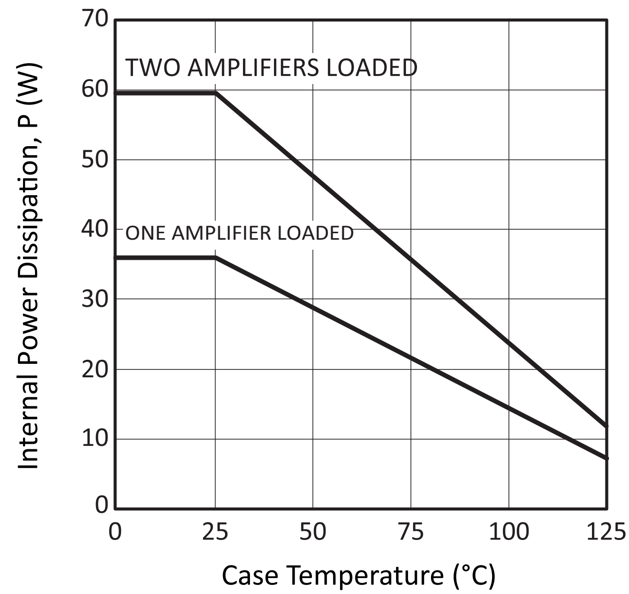


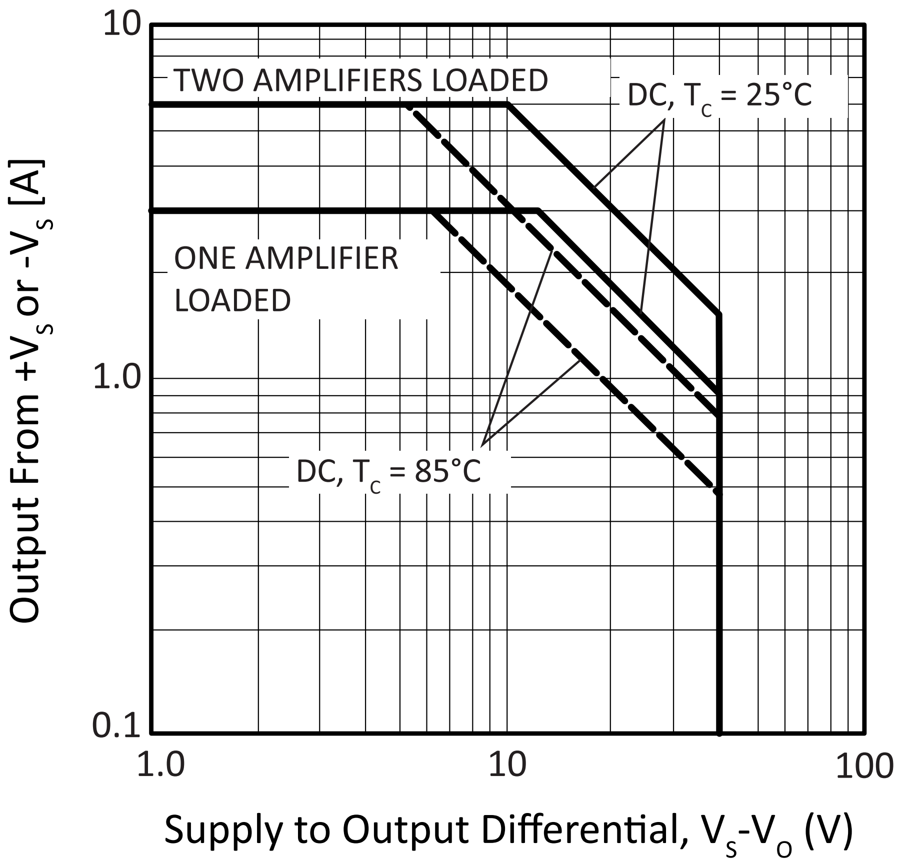
Figure 13: Power Derating



SAFE OPERATING AREA (SOA)

The SOA curves combine the effect of all limits for this power op amp. For a given application, the direction and magnitude of the output current should be calculated or measured and checked against the SOA curves. This is simple for resistive loads but more complex for reactive and EMF generating loads.

Figure 14: SOA



GENERAL

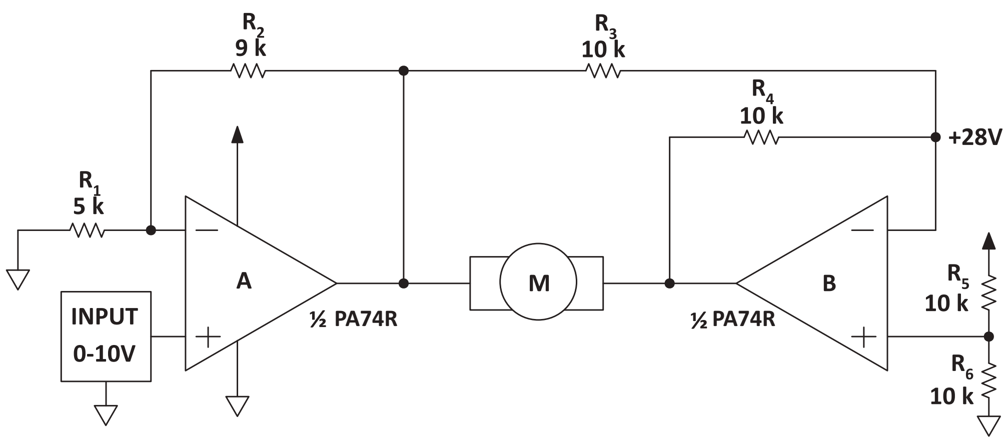
Please read Application Note 1 "General Operating Considerations" which covers stability, supplies, heat sinking, mounting, current limit, SOA interpretation, and specification interpretation. Visit www.apexanalog.com for Apex Microtechnology's complete Application Notes library, Technical Seminar Workbook, and Evaluation Kits.

TYPICAL APPLICATION

R1 and R2 set up amplifier A in a non-inverting gain of 2.8. Amp B is set up as a unity gain inverter driven from the output of amp A. Note that amp B inverts signals about the reference node, which is set at mid-supply (14V) by R5 and R6. When the command input is 5V, the output of amp A is 14V. Since this is equal to the reference node voltage, the output of amp B is also 14V, resulting in 0V across the motor. Inputs more positive than 5V result in motor current flow from left to right (see Figure 15). Inputs less positive than 5V drive the motor in the opposite direction.

The amplifiers are especially well-suited for this application. The extended common mode range allows command inputs as low as 0V. Its superior output swing abilities let it drive within 2V of supply at an output current of 2A. This means that a command input that ranges from 0.714V to 9.286V will drive a 24V motor from full scale CCW to full scale CW at up to ±2A. A single power op amp with an output swing capability of Vs –6 would require ±30V supplies and would be required to swing $48V_{P-P}$ at twice the speed to deliver an equivalent drive.

Figure 15: Typical Application (Bidirectional Speed Control from a Single Supply)



STABILITY CONSIDERATIONS

All monolithic power op amps use output stage topologies that present special stability problems. This is primarily due to non-complementary (both devices are NPN) output stages with a mismatch in gain and phase response for different polarities of output current. It is difficult for the opamp manufacturer to optimize compensation for all operating conditions.

THERMAL CONSIDERATIONS

Thermal grease or an Apex Microtechnology TW03 thermal washer, R_{CS} = 0.1 to 0.2°C/W, are the only recommended thermal interfaces for the PA74R. Internal power dissipation increases directly with frequency, therefore it is critical to sufficiently heat sink the PA74R. Even unloaded the PA74R can dissipate up to 3 watts while running at higher frequencies.

LOSS CONSIDERATIONS FOR PARALLEL CONFIGURATION

The PA74R utilizes a parallel configuration to achieve the desired current output requirements. The parallel configuration inherently creates internal losses due to circulating currents. The circulating currents generate power losses through the current sharing resistors when delivering current to the load.

SUPPLY CURRENT

The parallel configuration used in the PA74R also generates supply currents while high voltage sign waves are seen at the output. Listed below are the supply currents expected while running at a particular frequency and when $V_O \approx$ 15Vpp, note that the outputs are not loaded.

Frequency	Supply Current
100 Hz	18mA
1 kHz	20mA
5 kHz	32mA
10 kHz	50mA
15 kHz	75mA

SATURATION OPERATION

The parallel configuration used in the PA74R is sensitive to operation in the saturation region. The PA74R may exhibit large peak currents; this is mainly due to thermal protection limitations.

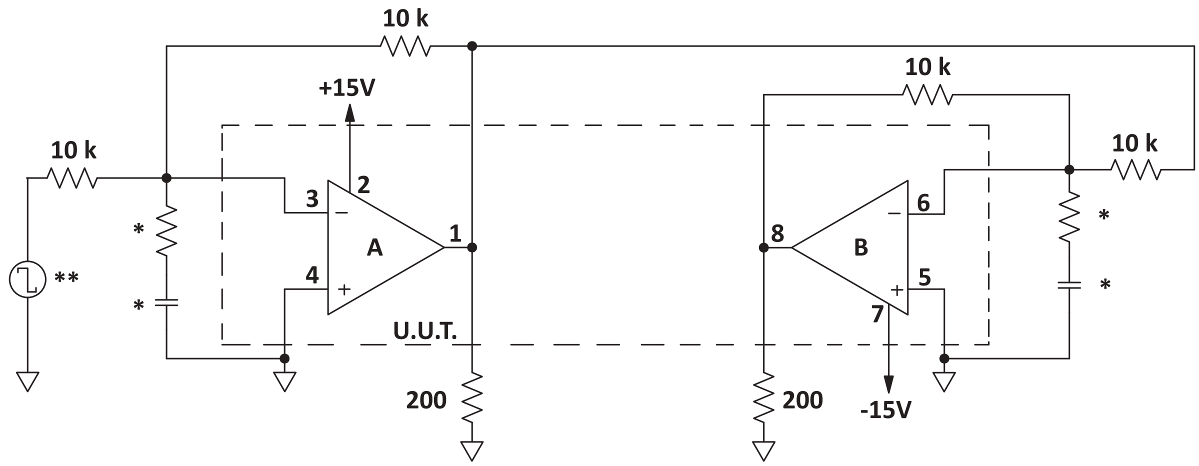
TABLE 4 GROUP A INSPECTION

SG	Parameter	Symbol	Temp.	Power	Test Conditions	Min	Max	Units
1	Quiescent Current	I_Q	25°C	±15	V_{IN} = 0, A_V = 100		30	mA
1	Input Offset Voltage	V_{OS}	25°C	±2.5	V_{IN} = 0, A_V = 100		10	mV
1	Input Offset Voltage	V_{OS}	25°C	±15	V_{IN} = 0, A_V = 100		10	mV
1	Input Offset Voltage	V_{OS}	25°C	±20	V_{IN} = 0, A_V = 100		14	mV
1	Input Bias Current, +IN	$+I_B$	25°C	±15	V_{IN} = 0		1000	nA
1	Input Bias Current, –IN	$-I_B$	25°C	±15	V_{IN} = 0		1000	nA
1	Input Offset Current	I_{OS}	25°C	±15	V_{IN} = 0		500	nA
3	Quiescent Current	I_Q	–55°C	±15	V_{IN} = 0, A_V = 100		30	mA
3	Input Offset Voltage	V_{OS}	–55°C	±2.5	V_{IN} = 0, A_V = 100		14	mV
3	Input Offset Voltage	V_{OS}	–55°C	±15	V_{IN} = 0, A_V = 100		14	mV
3	Input Offset Voltage	V_{OS}	–55°C	±20	V_{IN} = 0, A_V = 100		18	mV
3	Input Bias Current, +IN	$+I_B$	–55°C	±15	V_{IN} = 0		1000	nA
3	Input Bias Current, –IN	$-I_B$	–55°C	±15	V_{IN} = 0		1000	nA
3	Input Offset Current	I_{OS}	–55°C	±15	V_{IN} = 0		500	nA
2	Quiescent Current	I_Q	125°C	±15	V_{IN} = 0, A_V = 100		40	mA
2	Input Offset Voltage	V_{OS}	125°C	±2.5	V_{IN} = 0, A_V = 100		15	mV
2	Input Offset Voltage	V_{OS}	125°C	±15	V_{IN} = 0, A_V = 100		15	mV
2	Input Offset Voltage	V_{OS}	125°C	±20	V_{IN} = 0, A_V = 100		19	mV
2	Input Bias Current, +IN	$+I_B$	125°C	±15	V_{IN} = 0		1000	nA
2	Input Bias Current, –IN	$-I_B$	125°C	±15	V_{IN} = 0		1000	nA
2	Input Offset Current	I_{OS}	125°C	±15	V_{IN} = 0		500	nA
4	Output Voltage, I_O = 2A	V_O	25°C	±9.5	R_L = 3 Ω	6.0		V
4	Output Voltage, I_O = 100mA	V_O	25°C	±11	R_L = 100 Ω	9.9		V
4	Output Voltage, I_O = 1A	V_O	25°C	±4.8	R_L = 3 Ω	2.8		V
4	Stability/Noise	E_N	25°C	±15	R_L = 500 Ω, A_V = 1 C_L = 1.5nF		1.0	mV
4	Crosstalk	XTLK	25°C	±15	R_L = 3 Ω	50		dB
4	Slew Rate	SR	25°C	±15	R_L = 500 Ω	0.5		V/µs
4	Open Loop Gain	A_{OL}	25°C	±15	R_L = 500 Ω, F = 10 Hz	75		dB
4	Common Mode Rejection	CMR	25°C	±17	R_L = 500 Ω, V_{CM} = ±14V	60		dB

SG	Parameter	Symbol	Temp.	Power	Test Conditions	Min	Max	Units
6	Output Voltage, I_O = 2A	V_O	–55°C	±9.5	R_L = 3 Ω	6.0		V
6	Output Voltage, I_O = 100mA	V_O	–55°C	±11	R_L = 100 Ω	9.9		V
6	Output Voltage, I_O = 1A	V_O	–55°C	±4.8	R_L = 3 Ω	2.8		V
6	Stability/Noise	E_N	–55°C	±15	R_L = 500 Ω, A_V = 1, C_L = 1.5nF		1.0	mV
6	Slew Rate	SR	–55°C	±15	R_L = 500 Ω	0.5		V/µs
6	Open Loop Gain	A_{OL}	–55°C	±15	R_L = 500 Ω, F = 10 Hz	75		dB
6	Common Mode Rejection	CMR	–55°C	±17	R_L = 500 Ω, V_{CM} = ±14V	60		dB
5	Output Voltage, I_O = 1A	V_O	125°C	±4.8	R_L = 3 Ω	2.8		V
5	Output Voltage, I_O = 100mA	V_O	125°C	±11	R_L = 100 Ω	9.9		V
5	Output Voltage, I_O = 750mA	V_O	125°C	±4.0	R_L = 3 Ω	2.25		V
5	Stability/Noise	E_N	125°C	±15	R_L = 500 Ω, A_V = 1, C_L = 1.5nF		1.0	mV
5	Slew Rate	SR	125°C	±15	R_L = 500 Ω	0.5		V/µs
5	Open Loop Gain	A_{OL}	125°C	±15	R_L = 500 Ω, F = 10 Hz	75		dB
5	Common Mode Rejection	CMR	125°C	±17	R_L = 500 Ω, V_{CM} = ±14V	60		dB

BURN IN CIRCUIT

Figure 16: Burn in Circuit

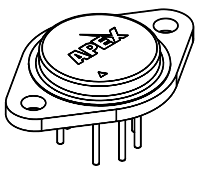


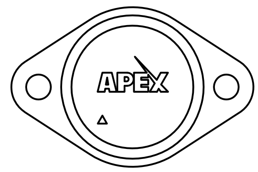
* These components are used to stabilize device due to poor high frequency characteristics of burn in board.
** Input signals are calculated to result in internal power dissipation of approximately 2.1W at case temperature = 125°C

PACKAGE OPTIONS

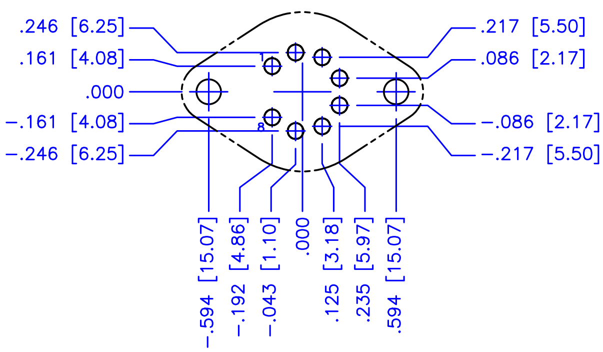
Part Number	Apex Package Style	Description
PA74	CE	8-pin TO-3 (Dual Op Amp)
PA74R	CE	8-pin TO-3 (Dual Op Amp)

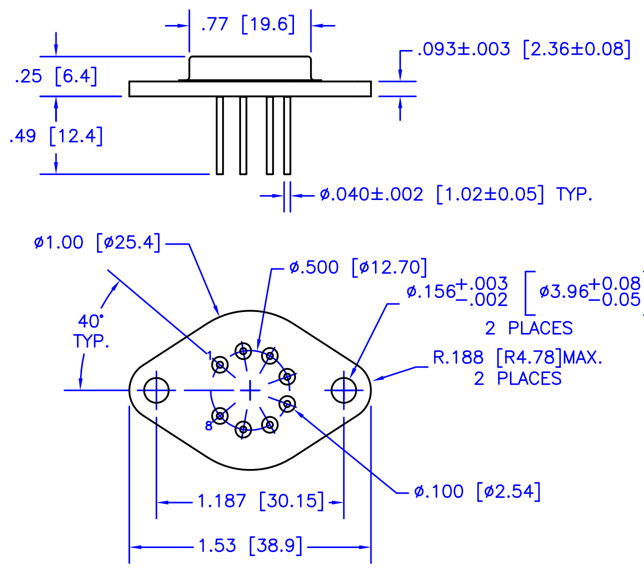
PACKAGE STYLE CE





Ordinate dimensions for CAD layout





NOTES:

1. Dimensions are inches & [mm].
2. Triangle printed on lid denotes pin 1.
3. Header flatness within pin circle is .0005” TIR, max.
4. Header flatness between mounting holes is .0015” TIR, max.
5. Standard pin material: Solderable nickel−plated Alloy 52.
6. Header material: Nickel−plated cold−rolled steel.
7. Welded hermetic package seal
8. Isolation: 500 VDC any pin to case.
9. Package weight: .53 oz [15 g]

NEED TECHNICAL HELP? CONTACT APEX SUPPORT!

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