Document PAS065
Doc Revision A1 – 07/08/08

PAS 9419/AO
ENGINEERING SPECIFICATION

10 CHANNEL 24 VOLT, 500 mA
AMPLIFIER CARD
PCB Revision A (07/08/08)

Additional copies of this manual or other Precision Analog Systems (PAS) literature may be obtained from:

Precision Analog Systems Co.
1021 SW 75th Avenue
Plantation, Florida 33317
Phone: (954) 587-0668
E-mail: inquiry@precisionanalog.com

The information in this document is subject to change without notice.

PAS makes no warranty of any kind with regard to this material, including, but not limited to, the implied warranties of merchantability and fitness for a particular purpose. Although extensive editing and reviews are performed before release, PAS assumes no responsibility for any errors that may exist in this document. No commitment is made to update or keep current the information contained in this document.

PAS does not assume any liability arising out of the application or use of any product or circuit described herein, nor is any license conveyed under any patent rights or any rights of others.

PAS assumes no responsibility resulting from omissions or errors in this manual, or from the use of information contained herein.

PAS reserves the right to make any changes, without notice, to this product to improve reliability, performance, function or design.

All rights reserved.

Specification release updates from rev A preliminary (03/29/07) to rev A1 (07/08/08)

10 Channel 24 Volt 500 mA Amplifier Card

TABLE OF CONTENTS

10 Channel 24 Volt 500 mA Amplifier Card

LIST OF TABLES

I. INTRODUCTION

GENERAL DESCRIPTION

The PAS 9419/AO provides ten high power amplifier circuits on a 6U format card. This amplifier is pin compatible with the first 10 channels of the PAS 9716/AO and PAS 9816/AO, 16 channel, 16-bit Analog Output cards. By using the combination of these two cards, a VME based analog output system can be constructed that will supply up to 24 Volts and 500 mAmps of output current per channel.

The maximum current and voltage that can be delivered by the amplifiers is primarily determined by the amplifiers power dissipation. Power in the amplifier is dependent on supply voltage and load impedance. These amplifiers are set up for a maximum output voltage of 24 Volts and an output current of 500 mA. Power supply voltage is set to 28 Volts to limit the drop across the amplifier to 4 Volts at maximum voltage and current. This still produces 2 Watts of power in each amplifier.

In order to dissipate this power, each amplifier has an individual aluminum heat sink. Addition heat sinking is provided by 1.5 square inch pads at each amplifier on the component side of the board, and a solid copper plane on the back of the PCB. For more information on power dissipation, refer to section IV of this specification.

Custom versions of this board can be provided with gain and output drive tailored to the application.

D sub-miniature 37-position female connectors are used to bring the signals into and out of the amplifier circuits. These connectors are mounted through the cards front panel.

A third two-position connector is located between the DB 37s, and it is used to connect to the 28 Volt power supply. Two LEDs are also provided at the front panel, and they are controlled by two lines in the upper D-sub connector.

Card Features: PAS 9419/AO-000

Number of Channels	10
Output Voltage	0 to 24 Volts (typ.)
Output Current	500 mAmps (typ.)
Input Voltage	0 to10 Volts (typ.)
Gain	2.4
External Power Supply	+28 VDC
Slew Rate	10 Volts / uSec. (typ.)
Gain-Bandwidth Product	1 MHz (typ.)
Status Indicators	2 front panel LEDs are driven by the PAS 9716 Digital Outs (Requires VME backplane connection)
Size	6U format, 160 mm x 233 mm
Input / Output Connectors	2 ea. DB 37 female
Power Supply Connector	2 position shrouded header (Amp Mate-N-Lock P/N 794120-1)

II. SPECIFICATIONS

Electrical Specifications: PAS 9419/AO-000

Number of Channels	10 Analog Outputs
Output Voltage Range	0 to 24 Volts
Output Current	500 mAmps
Output Current Limit	600 mA
Input Voltage Range	0 to +10 Volts
Voltage Gain	+ 2.4
Input Impedance	17 K ohm (typ.)
Zero Error (Note 1)	520 mV (typ.), 600 mV (max)
Gain Error	± 0.1 % FS, (adjustable to zero)
Slew Rate	10 V / uSec (typ.)
Output Voltage Swing	Vs - 2 V (min.) @ I out = 500 mA
Card Power Requirements	+ 28 Volts DC @ 200 mAmp (no Load) @ 5.2 Amps (Full Load)

Environmental Specifications

Operating Temperature Range (with forced air cooling)	0 to 70º C
Storage Temperature Range	-20 to 85º C
Junction Temperature	125º C (max)
Thermal Resistance (junction to air)	10º C / Watt (typ.)
Relative Humidity Range	20% to 95%, non-condensing
Board Environmental Protection	Conformal Coating

Physical Specifications

Dimensions	Form factor: Double (160 mm x 233 mm)
Weight	12 oz. (typ.)
Connectors	2 ea. DB37 female, (Analog Input and Output connectors) 1 ea. 2 pin shrouded header (External power connector)

Note 1: The cards output will not swing all the way to ground, because it is operated from a single supply. Once the card's input reaches approximately 300 mV, the output voltage tracks the input at a gain of 2.4. As an example. 500 mV of input voltage will produce an output of 1.20 Volts.

Ordering Information

The PAS 9419/AO card is structured to be available in several different configurations that are defined by dash numbers. Each dash number has three digits defined as XYZ. Each digit defines a certain feature of the card as shown in the table below

X = 0; Front Panel DB37 I/O

Y = 0; 28 Volt DC Power

Z = 0; Gain = 2.4

The only version documented at this time is the PAS 9419/AO-000. This dash number defines front panel I/O connectors, + 28 Volt DC power and gain of 2.4. Other versions can be tailored to future applications.

Jumpers and Indicators

The 9419/AO card contains 10 soldered in jumpers and two LED indicators. The 10 jumper wires are used to connect the output of the amplifier directly to the output connector. In future applications surface mount resistors can be installed in place of the jumper wires to provide higher output impedance.

Two LEDs are provided at the boards front panel to be used as general purpose indicators. These LEDs require power from a VME bus connection in order to operate. One side of each LED is connected to the VME +5 Volts. The other side is connected to one of the lower two pins in the P3 connector (defined in Table 3). Connecting these pins to ground will cause the respective LED to turn on.

Connector Definitions

Two 96 position DIN connectors can be installed on the back plane end of the board and connect to the VME bus to bring in + 5 Volts. This voltage is used to power the LEDs. The board also jumpers through the bus grant and interrupt acknowledge signals using these connectors. On the –000 version of the board these connectors are not installed.

Two DB37 female connectors are installed through the board's front panel to provide access to the ten analog output channels and the two digital outputs. The pin out of these connectors is defined in Table 2 on the following page.

A two position Mate-N-Lock connector is provided at the front panel, and located between the two DB37 connectors. This connector is used to bring in external power to the amplifiers. The housing for mating to this connector is Amp P/N 1-480393-1, and the crimp-on sockets is P/N 60619-1. The part number of the board power connector is 794120-1.

The pin out of this connector is defined below.

TABLE 1

2 Position Power Connector (P5)

1	Positive Power Supply	Bottom Terminal
2	Power Supply Ground	Top Terminal

TABLE 2

DB37 Connectors (P3 and P4)

		19	AGND
AGND	37		
		18	CH0H
AGND	36		
		17	CH1H
AGND	35		
		16	CH2H
AGND	34		
		15	CH3H
AGND	33		
		14	CH4H
AGND	32		
		13	CH5H
AGND	31		
		12	CH6H
AGND	30		
		11	CH7H
AGND	29		
		10	CH8H
AGND	28		
		9	CH9H
AGND	27		
		8	N/C
AGND	26		
		7	N/C
AGND	25		
		6	N/C
AGND	24		
		5	N/C
AGND	23		
		4	N/C
AGND	22		
		3	N/C
AGND	21		
		2	LED1
AGND	20		
		1	LED2

P3 is the input connector and P4 is the output connector. The same signal names are used in the input and output connectors. Example; CH0H input is P3 pin 18, and CH0H output is P4 pin 18. The LED1 and LED2 signals are only connected in P3.

III. CIRCUIT DESCRIPTION

The PAS 9419/AO card contains 10 high power amplifier circuits. Cards are configured to provide a gain of 2.4 with an output current drive of 500 mAmps. Output current and voltage range will be increased significantly when compared with a standard analog output card.

The amplifiers used on this board are OPA548's, manufactured by Texas Instruments/Burr-Brown. The OPA548 is a high-voltage / high-current operational amplifier ideal for driving a wide variety of loads. A laser-trimmed monolithic integrated circuit provides excellent low-level signal accuracy and high output voltage and current.

The OPA548 is internally protected against over-temperature conditions and circuit overloads. This design also uses the user-selected current limit to limit the output current to 600 mA.

The OPA548's are packaged in TI's DDPAK-7 and soldered to heat sink pads on the PCB. The heat sink pads are electrically connected to the low side of the power supply, which is ground in this application. All the heat sink pads are thermally connected to a solid ground plane on the bottom side of the printed circuit board, using plated through vias. Extruded aluminum heat sinks are also mounted on the top side of the board at each device. Using these three heat sink techniques, provides a thermal resistance of 8 to 10º C per Watt from junction to air. The maximum junction temperature of the amplifier is 125º C, and the maximum operating temperature is 70º C. This translates into a maximum rise of 55º C from junction to ambient or 5.5 Watts in the amplifier, times 10º C per Watt temperature rise. For more information on power dissipation refer to the following section.

All of the amplifier circuits have gain adjustments. A calibration procedure is provided on the page 13, and describes how to make these adjustments.

IV. POWER DISSIPATION AND POWER SUPPLY REQUIREMENTS

In order to calculate the power dissipated by the amplifiers, the quiescent power is added to the power dissipated by the output driver circuit; as shown in the following expression; P (Total) = P (Quiescent) + P(Output Stage)

The maximum quiescent power will occur when the power supply voltage is at its maximum of +28 Volts. The amplifiers quiescent current is 20 mA which will produce 28 Volts x 20 mA = 560 mW of quiescent power.

The maximum load current the amplifier is guaranteed to output is 500 mA. With a +28 Volt power supply and a 4 Volt drop across the output stage, the output voltage is +24 Volts. The minimum load resistance is 24 Volts divided by 500 mA = 48 ohms. The maximum power dissipation in the amplifier occurs when the output voltage is half the power supply voltage. As the output voltage increases from this point, the voltage across the amplifier decreases. As the output voltage decreases from this point, the current through the amplifier and the load decreases.

When the amplifier is driving this load to 24 Volts, it is delivering 12 Watts of power to the load, and the amplifier is dissipating 2 Watts. When the amplifier is driving the load to half the power supply voltage, both the amplifier and the load are dissipating 4.08 Watts of power. This calculation is shown in the following equation; 14 Volts x 14 Volts divided by 48 ohms = 4.08 Watts. In this example the total power in the amplifier is 560 mW + 4080 mW = 4640 mW, = 4.64 Watts.

The output amplifiers use heat sinks that provide a junction to air thermal resistance of 10° C/W. The junction temperature of the amplifier should never exceed 125° C, and is calculated by adding the ambient temperature to the temperature rise caused by the power dissipation. The following expression defines this temperature: $T_J = T_A + P_D \Theta_{JA}$. In the case of this example with an ambient temperature of 70° C, the junction temperature would be; T_J = 70° + (4.64 Watts x 10° C/W) = 116.4° C. This is below the maximum junction temperature, so it is safe to operate the amplifier under these conditions.

V. CALIBRATION PROCEDURE
PAS 9419/AO-000

Install the PAS 9419/AO card in a VME chassis or a similar 6U X 160 mm eurocard chassis. Connect the external 28 Volt power supply and allow the card to stabilize for approximately two minutes.

Offset Voltage Check

Connect each input signal to ground, either using a shorting connector or a programmable voltage source set to zero Volts. Observe the individual output channels with a Voltmeter and verify each channel has less than 600 mV of offset. Typically the offset voltage will be 520 mV. See note 1 on page 7.

Gain Adjustment

Drive each of the input signals to 10.00 Volts, and adjust each of the gain pots so that all outputs are at 24.000 Volts. The gain adjustment pots are defined in the table below.

TABLE 3

Gain Potentiometers

CH #	Gain Pot
0	R6
1	R13
2	R20
3	R27
4	R34
5	R41
6	R48
7	R55
8	R62
9	R69