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PAS 9417/AO
ENGINEERING SPECIFICATION

16 CHANNEL +/- 40 VOLT, 50 mA
AMPLIFIER CARD
PBC Revision A1 (08/31/09)

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16 Channel +/- 40 Volt 50 mA Amplifier Card

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16 Channel +/- 40 Volt 50 mA Amplifier Card

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I. INTRODUCTION

GENERAL DESCRIPTION

The PAS 9417/AO provides sixteen high power amplifier circuits on a 6U format card. This amplifier is pin compatible with the PAS 9716/AO, 16 channel, 16-bit Analog Output card. By using the combination of these two cards, a VME based analog output system can be constructed that will supply up to +/- 35 volts and up to 50 mAmps of output current.

This card is designed to allow either on-board power supplies or external power supplies. The card also has the option of connecting the amplifier's input and output signals either to the P2 backplane connector or to a pair of DB37 connectors at the front panel. When the front panel connections are used, the pin definitions are compatible with the PAS 9716/AO, 16 Channel, 16 bit, VME analog output card. The ordering information section provides information on the versions of the card that are available.

The maximum current and voltage that can be delivered by the amplifiers is primarily determined by the amplifier's power dissipation. This is dependent on supply voltage and load impedance. Custom versions of this board can be provided with gain and output drive tailored to the application.

Card Features: PAS 9417/AO

Number of Channels	16
Output Voltage	+/- 24 Volts (typ.), +/- 35 Volts (max.)
Output Current	+/- 50 mAmps (typ.)
Input Voltage	+/- 10 Volts (typ.)
Gain on –000 and -110	2.4
Gain on -101	2.7 on ch 0-7, 5.0 on ch 8-15
External Power Supply	+/-10 VDC (min.), +/- 40 VDC (max.)
Slew Rate	7 Volts / uSec. (typ.)
Gain-Bandwidth Product	1.8 MHz (typ.)
Status LEDs	2 front panel LEDs are driven by the PAS 9716 Digital Outs (Front panel option)
Size	6U format, 160 mm x 233 mm
Input / Output Connectors	2 ea. DB 37 female (Front panel Option)
Power Supply Connector	6 position shrouded header (Molex) (Front panel option)

II. SPECIFICATIONS

Electrical Specifications: PAS 9417/AO-000

Number of Channels	16 Analog Outputs
Output Voltage	+/- 25Volts (typ.)
Output Current	+/- 50 mAmps (min.)
Output Resistance -000	100 ohms (On board resistor in series with amp output)
Output Resistance –101,-110	Zero ohms in series with the OPA452
Gain –000, -110	2.4
Output Resistance –101,-110	Zero ohms in series with the OPA452
Gain -101	2.7 on ch 0-7, 5.0 on ch 8-15
Input Voltage	+/- 10 Volts (typ.)
Zero Error	+/- 5 mV, (adjustable to zero)
Gain Error	+/- 0.1 % FS, (adjustable to zero)
Slew Rate	7 V / uSec (typ.)
Output Voltage Swing	+/- Vs-4 Volts (min.) @ I out = 50 mAmps
Card Power Requirements	
(VME Bus)	+ 5 Volts @ 700 mA (No Load)
	+ 5 Volts @ 6 Amps (Full Load)
(External Power Supply	+/- 10 VDC to +/- 40 VDC
Option)	@ +/- 100 mAmp (No Load)
	@ +/- 900 mAmp (Full Load)

Environmental Specifications

Operating Temperature Range	0 to 55 degrees C.
Storage Temperature Range	-20 to 85 degrees C.
Junction Temperature	125 degrees C. (max.)
Thermal Resistance	
(junction to air)	25 degrees C. / Watt (typ.)
Relative Humidity Range	20% to 80%, non-condensing

Physical Specifications

Dimensions	Form factor: Double (160 mm x 233 mm)
Weight	32 oz. (typ)
Connectors	2 ea. DB37 female,
(Front Panel Options)	(Analog Input and Output connectors)
	1 ea. 6 pin shrouded header
	(External power connector)
	Mating connector, Molex P/N 50-57-9406

Ordering Information

The PAS 9417/AO card is 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; P2 I/O Connections

X = 1; Front Panel DB37 I/O

Y = 0; +/- 30 Volt on-board DC to DC Converters

Y = 1; No on-board DC to DC Converters

Z = 0; Gain = 2.4

Z = 1; Gain = 2.7 on Ch 0-7, Gain = 5.0 on Ch 8-15

The only three versions documented at this time are the PAS 9417/AO-000, -101 an -110. The dash 000 defines P2 I/O, on-board +/- 30 Volt DC-DC converters and gain of 2.4. The dash 101 defines front panel I/O, on-board +/- 30 Volt Dc-DC converters, gain of 2.7 on Ch 0-7, and gain of 5.0 on Ch 8-15. The dash 110 defines front panel I/O, No on-board +/- 30 Volt DC-DC converters and gain of 2.4. Other versions can be tailored to future applications.

Jumpers and Indicators

The 9417/AO card contains 32 soldered in jumpers and two LED indicators. All of the jumpers have three pins, and provide two possible jumper locations. Pin 1 of each jumper strip is defined with a square pad in the PC board layout.

These jumpers are used to select whether the amplifier signals are connected to the front panel connectors or to the P2 backplane connector. When the jumpers are in position 1 to 2, the amplifiers are connected to the front panel connectors. When the jumpers are in position 2 to 3 the amplifiers are connected to the P2 connector.

Two LEDs are provided at the front panel to indicate the board's status. These LEDs are steered by the DO1 and DO2 signals from the 9716 Analog Output card. If the amplifier is not wired directly to the AO card, then the LEDs will be driven by the signals that are wired to pins 1 and 2 of P3. LEDs are only available on cards that use front panel I/O connections.

Connector Definitions

Two 96 position DIN connectors are installed on the back plane end of the board and connect to the VME bus to bring in +/- 5 Volts. This voltage is used for the input to the DC to DC power supplies. The board also jumpers through the bus grant and interrupt acknowledge signals using these connectors.

Input and output signals to and from the amplifiers can be connected to the P2 backplace connector, through soldered in jumpers. The pin out of this connector is defined in Table 1 below.

TABLE 1
P2 CONNECTOR DEFINITIONS A AND C ROWS

AMP IN0	C1	A1	AGND
AMP IN1	C2	A2	AGND
AMP IN2	C3	A3	AGND
AMP IN3	C4	A4	AGND
AMP IN4	C5	A5	AGND
AMP IN5	C6	A6	AGND
AMP IN6	C7	A7	AGND
AMP IN7	C8	A8	AGND
AMP IN8	C9	A9	AGND
AMP IN9	C10	A10	AGND
AMP IN10	C11	A11	AGND
AMP IN11	C12	A12	AGND
AMP IN12	C13	A13	AGND
AMP IN13	C14	A14	AGND
AMP IN14	C15	A15	AGND
AMP IN15	C16	A16	AGND
AMP OUT0	C17	A17	AGND
AMP OUT 1	C18	A18	AGND
AMP OUT2	C19	A19	AGND
AMP OUT3	C20	A20	AGND
AMP OUT4	C21	A21	AGND
AMP OUT5	C22	A22	AGND
AMP OUT6	C23	A23	AGND
AMP OUT7	C24	A24	AGND
AMP OUT8	C25	A25	AGND
AMP OUT9	C26	A26	AGND
AMP OUT10	C27	A27	AGND
AMP OUT11	C28	A28	AGND
AMP OUT12	C29	A29	AGND
AMP OUT13	C30	A30	AGND
AMP OUT14	C31	A31	AGND
AMP OUT15	C32	A32	AGND

Two optional DB37 female connectors are installed through the board's front panel to provide access to the sixteen analog output channels and the two digital outputs. The pin out of these connectors is defined in Table 3 on the following page.

An optional six-position Molex header 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 mating connector to this header is Molex P/N 50-57-9406, and the crimp on pin P/Ns are 16-02-1114 or 16-02-1125.

The pin out of this connector is defined below. When DC to DC converters are used only the ground pin is connected.

TABLE 2

P5 (6 Position Molex Header)

1	Positive Power Supply
2	Power Supply Ground
3	Negative Power Supply
4	N/C
5	N/C
6	N/C

TABLE 3

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	CH10H
AGND	26		
		7	CH11H
AGND	25		
		6	CH12H
AGND	24		
		5	CH13H
AGND	23		
		4	CH14H
AGND	22		
		3	CH15H
AGND	21		
		2	DO1
AGND	20		
		1	DO2

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.

III. CIRCUIT DESCRIPTION

The PAS 9417/AO-000 card contains 16 high power amplifier circuits. Cards are configured to provide a gain of 2.4 with an output current drive of 50 mAmps. Output current and voltage range will be increased significantly when compared with a standard analog output card. Versions of this card with other gain values are also available.

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

The amplifiers used on this card are high voltage monolithic MOSFET operational amplifiers. They deliver performance features previously only found in hybrid designs, while increasing reliability. The amplifier part number is OPA452, and they are built by Texas Instruments.

The OPA452 is packaged in TI's DDPAC-7 and mounted with heat sinks. This package with the heat sink has a typical thermal resistance of 25 °C per Watt from junction to air, and the device has a maximum junction temperature of 125° C. Based on these parameters, the amplifier will dissipate a maximum of 2.6 Watts, and should typically be operated at 2.00 Watts or less.

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 power will occur when the power supply voltage is at its maximum of +/- 40 Volts. The amplifiers quiescent current is 6 mA which will produce 80 Volts x 6 mA = 480 mW of quiescent power. When the amplifiers are operated with the on-board +/- 30 Volt power supplies, the quiescent power is 60 Volts x 6 mA = 360 mW.

The maximum load current the amplifier is guaranteed to output is 50 mA. With +/- 40 Volt power supplies and a 4 Volt drop across the output stage, the output voltage is +/- 36 Volts, and the minimum load resistance is 36 Volts divided by 50 mA = 720 ohms. The maximum power dissipation in the amplifier occurs at 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 36 Volts, it is delivering 1.8 Watts of power to the load, and the amplifier is dissipating 200 mW. When the amplifier is driving the load to half the power supply voltage, both the amplifier and the load are dissipating 555 mWatts of power. This calculation is shown in the following equation; 20 Volts x 20 Volts divided by 720 ohms = 555 mWatts. In this example the total power in the amplifier is 480 mW + 555 mW = 1035 mW.

The output amplifiers use heat sinks that provide a junction to air thermal resistance of 25° 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 60° C, the junction temperature would be; T_J = 60° + (1.035 Watts x 25° C/W) = 86° C. This is below the maximum junction temperature, so it is safe to operate the amplifier under these conditions.

When the amplifiers are operated from the on-board +/- 30 Volt power supplies, the maximum output voltage is approximately +/- 26 Volts. At 50 mAmps of output current, this translates into a minimum load resistance of 520 ohms. At half the power supply voltage, the output power in the amplifier is 15 Volts x 15 Volts divided by 520 ohms = 432 mW. The total power is 432 mW + 360 mW = 792 mW. This puts the maximum junction temperature at about 20° above ambient.

V. CALIBRATION PROCEDURE

PAS 9417/AO -000 and -101 Setup

Install the PAS 9417/AO card in a VME chassis in order to provide + 5 Volt power to the on-board DC to DC converters. Allow the card to stabilize for approximately two minutes.

Offset Adjustment

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 adjust the zero pot on each channel for zero Volts. The offset adjustment pots are defined in the table on page 14.

Gain Adjustment -000

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 on page 14.

Gain Adjustment –101

Drive each of the input signals to 5.00 Volts, and adjust gain pots on channels 0 through 7 to 13.500 Volts. Adjust gain pots on channels 8 through 15 to 25.000 Volts. The gain adjustment pots are defined in the on page 14.

PAS 9417/AO -110 Setup

Connect a 5 Volt power supply to the backplane connector P1 of the card, or connect the 5 Volt power supply to the lands of the P2 connector. PAS made this connection using red and black wire soldered into the P2. +5V is connected to P2-32 using red insulated wire. Ground is connected to P2-31 using black insulated wire.

Connect external power supplies to P5 to supply amplifier power. PAS used a +/- 24 Volt DC supply to power the amplifiers. This limits the output swing to approximately +/- 20 Volts.

Offset Adjustment

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 adjust the zero pot on each channel for zero Volts. The offset adjustment pots are defined in the table below.

Gain Adjustment –110

Drive each of the input signals to 8.00 Volts, and adjust each of the gain pots so that all outputs are at 19.200 Volts. The gain adjustment pots are defined in the table below.

TABLE 4

Gain and Offset Potentiometers

CH #	Offset Pot	Gain Pot
0	R4	R7
1	R12	R15
2	R20	R23
3	R28	R31
4	R36	R39
5	R44	R47
6	R52	R55
7	R60	R63
8	R68	R71
9	R76	R79
10	R84	R87
11	R92	R95
12	R100	R103
13	R108	R111
14	R116	R119
15	R124	R127