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Radstone AOP-1
User Guide

Revision -
Publication No. HH681AOP1

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February 1996

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Printing History

Revision	Rev -	Rev A	Rev B	Rev C	Rev D	Rev E	Rev F
Date	2/96						

Related Documents

VMEBus Specification ANSI/IEEE Std 1014-1987

IEEE Std 1101.2-1992 Mechanical Core Specifications for Conduction-Cooled Eurocards.

PMV 68 BITE 3.0 User Manual Pub. No. HH681BITE3

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Chapter 1 - Introduction

Scope

This manual describes the Radstone AOP-1 Analog Output Board. It includes a full description of the features of the AOP-1 and provides instructions on how to configure, install and operate the board. Example programs are included to illustrate the use of the board in a standard VMEbus system.

Conventions

This manual adopts the following conventions throughout:

Bits are numbered from 0 to *n*, where 0 is the least significant bit and *n* the most significant.

Signal names follow the ANSI/IEEE Std. 1014 - 1987.

Signal names ending in (*) are active low, all others are active high.

GND and V_{CC} mean zero volt and five volt supply rails.

"longword", "word" and "byte", are taken to mean a thirty-two bit word, a sixteen bit word and an eight bit word respectively.

The $ prefix indicates hexadecimal values.

Radstone AOP-1

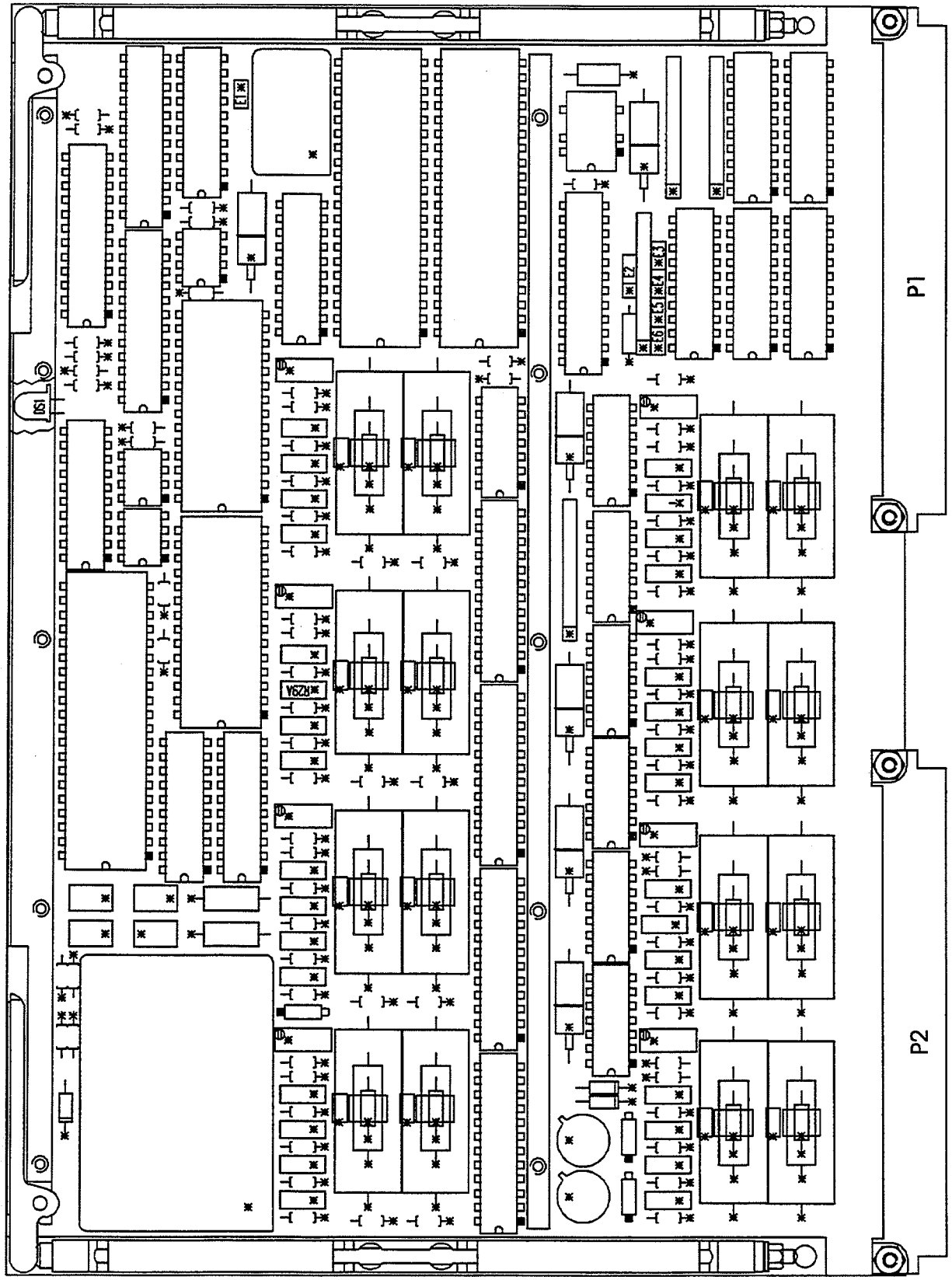
The AOP-1 Analog Output Board interfaces directly to the VMEbus and provides the user with 8 analog output channels.

The main features of the AOP-1 are:

- 8 bipolar analog output channels
- 12 bit Conversion range
- Analog output section electrically isolated from VMEbus
- Output voltage range -10V to +10V : for 10mA maximum current per channel
- Low pass output filter on each output
- VME A24:D16 slave
- 2 additional power supply outputs, +12.7V @ 50mA, -12.7V @ 50mA
- Comprehensive Built In Test (BIT)

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Figure 1.1 board layout



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Mechanical Overview

AOP-1 modules are available in five electrically compatible build styles. The five build styles have two basic mechanical configurations - Convection-cooled in accordance with IEEE Std. 1014-1987 and Conduction-cooled in accordance with IEEE Std 1101.2-1992.
Convection-cooled boards include:

Standard — **AOP-1S**
Extended Temperature — **AOP-1X**
Rugged Air-Cooled — **AOP-1RA**

Conduction-cooled boards include:

Rugged Conduction-cooled — **AOP-1RC**
Tactical — **AOP-1T**

A brief description of each build style follows:

Standard — AOP-1S

Intended for use in benign environments, the AOP-1S also provides the ideal cost effective method of complete system development. The S-style assembly comprises a double-Eurocard size printed wiring board with high quality commercial grade (plastic encapsulated) components. As software compatibility throughout the build styles is absolute, a system intended for final implementation in a severe tactical environment can be developed and debugged at low cost, switching over to target style only in the final stages of system integration.

Extended Temperature — AOP-1X

As AOP-1S, but conformally coated and 100% tested in manufacture to provide an extended operating range.

Rugged Air-cooled — AOP-1RA

RA-style boards are intended for applications that have extended temperature, shock and vibration requirements, but can be served by conventional, forced-air cooled, racking systems. These rugged boards comprise a double-Eurocard size printed wiring board fitted with wide temperature range, industrial grade components and are conformally coated as standard.

Rugged Conduction-cooled — AOP-1RC

Designed primarily for use in sealed ATR chassis and other conduction-cooled environments the RC-style board features wide temperature range, industrial grade devices, an integral thermal management layer and incorporates a central stiffening bar for additional strength. Cooling is achieved through conduction of heat from the thermal management layer to the cold wall of the rack to which the boards are secured by screw driven wedgelocks. RC-style boards are 100% temperature characterised and conformally coated during manufacture. AOP-1RC is mechanically compliant with IEEE Std. 1101.2-1992.

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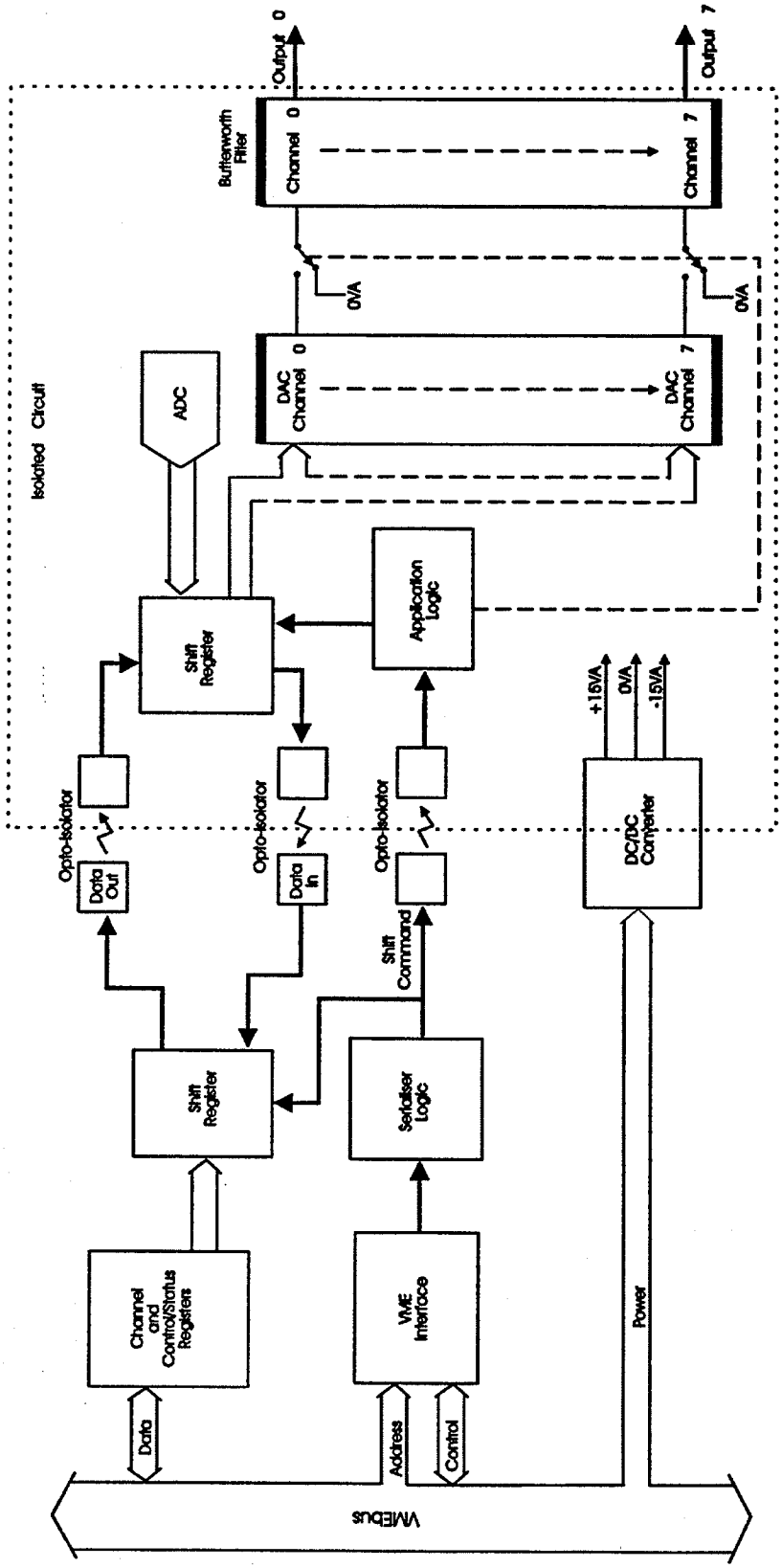
Tactical — AOP-1T

The AOP-1T complies with the most stringent military design rules and represents the highest level of reliability and environmental resistance available. T-style boards are mechanically identical to RC-style but feature extended operating and storage temperature range through use of MIL-STD-454 qualified components. T-style boards are designed to withstand environmental extremes of temperature, shock and vibration and comply fully with IEEE Std. 1101.2-1992. Careful attention to design detail ensures that the T-style remains compatible with standard commercial VMEbus racks.

All five styles fully support the power and versatility of the VMEbus, so no matter how large or diversified your project, absolute compatibility is assured at all stages of development.

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Figure 1.2 - AOP-1 Block Diagram



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AOP-1 Functional Overview

The AOP-1 Analog Output Board is supplied as a single 6U VMEbus card, and is electrically and mechanically compliant with the VMEbus specification.

The AOP-1 provides 8 single-ended analog output channels each containing a second order, low-pass, Butterworth output filter and an output override switch. Optical Isolation of the VMEbus from all Outputs insulates the bus and the user's valuable system components from the effects of accidental application of large voltages. This feature makes the AOP-1 ideally suited to mission critical, rugged and industrial applications where a high degree of bus isolation is required. All analog outputs are accessible via VME connector P2.

The analog outputs are programmed by writing to one of eight data registers. Writing a 12 bit word (11 data bits + sign bit) to any of these 8 data registers results in a voltage output from the Digital to Analog Converter (DAC) associated with that output channel. The voltage at the output of the DAC will assume a value proportional to the 11 data bits and a polarity equivalent to the sign bit.

The DAC outputs first pass through an analog switch which provides an override facility, then feed a Butterworth filter. The output override switch is software programmable and is provided to isolate the outputs. The switch removes the programmed DAC voltage from the output, forcing the output instead to 0 Volts.

The switch has two purposes: it is asserted at power up so as to provide a known startup voltage for each channel; it can also be asserted during normal use, allowing some limited BIT (Built In Test) function to occur, without the need to physically remove the user's equipment. The switch is programmed through a single write only word.

An on board ADC is included which can be used to measure voltages at 14 different locations on the card. The ADC provides a simple BIT facility. The ADC is programmed through a single write only word.

There are no main control or status registers since the function of the board is simple, however there are two extra facilities which provide the following:

1. A SYSFAIL status visual indicator (LED)
2. A VME SYSFAIL signal

A single read/write register is used as both a control and a status register for these extra facilities. There are 2 active bits which can be set as required, or read so as to determine the current state.

The SYSFAIL LED indicator on the front panel illuminates RED on initial power up and can be set or cleared by an appropriate VME access to the control register. Typically a VME master is instructed at power up to access each VME card and to carry out a BIT function on each. A working card will then have its SYSFAIL LED extinguished, a failing card will have its VME SYSFAIL signal asserted. The status of the LED and SYSFAIL signal are recorded in the status register.

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Memory Map

The AOP-1 memory map occupies 32K locations in the VMEbus standard address space as illustrated below.

Figure 1.3 - AOP-1 General Memory Map

Base Address + $0	Output Channel 0
Base Address + $2	Output Channel 1
Base Address + $4	Output Channel 2
Base Address + $6	Output Channel 3
Base Address + $8	Output Channel 4
Base Address + $A	Output Channel 5
Base Address + $C	Output Channel 6
Base Address + $E	Output Channel 7
Base Address + $10	Mask Register
Base Address + $12	ADC Register
Base Address + $14	Unused
Base Address + $20	Control/Status Reg
Base Address + $22	Unused
Base Address + $7FFF	

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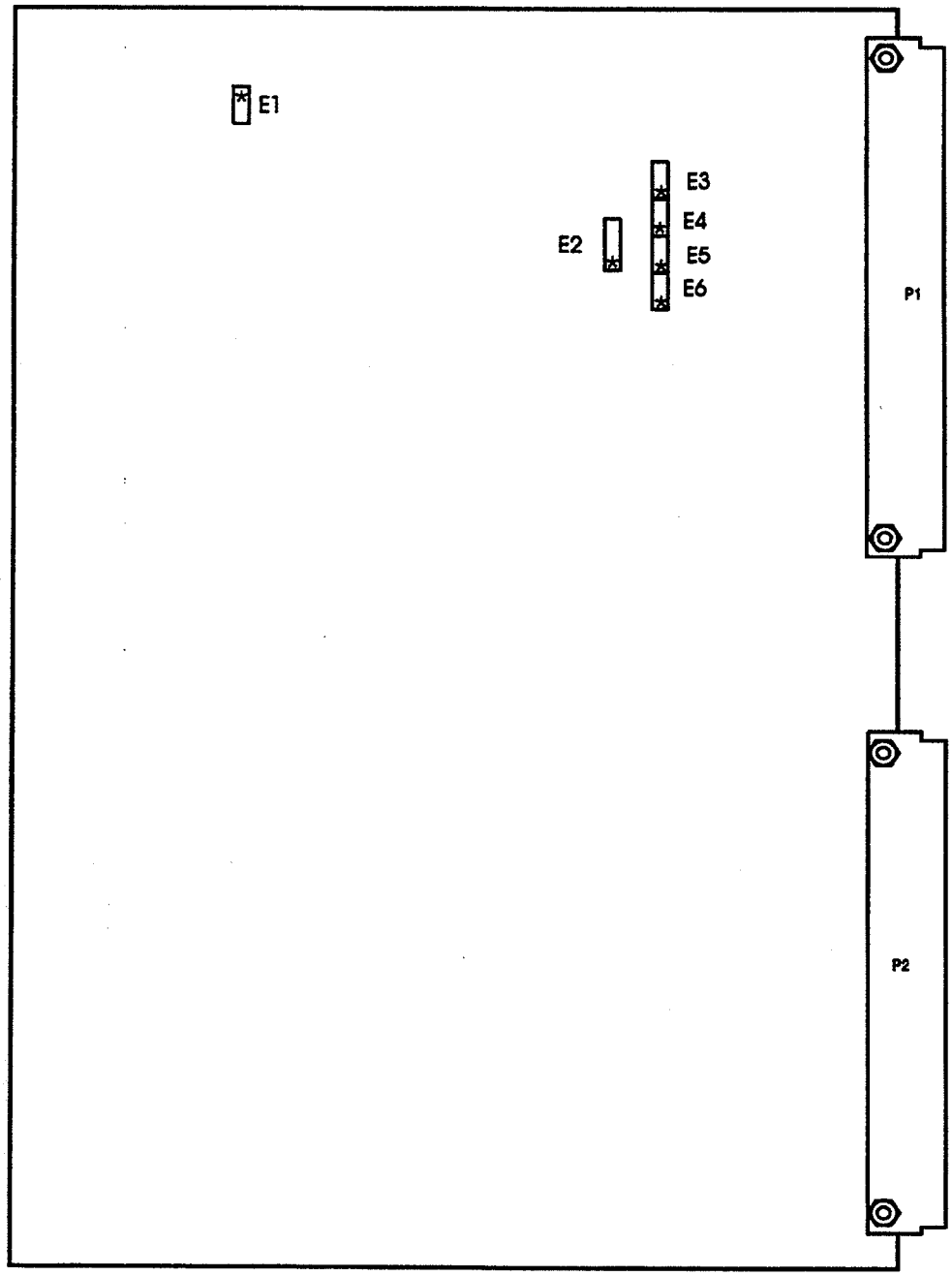
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Chapter 2 - Hardware Configuration

Preparing the Board

The AOP-1 is sensitive to the build up of static electricity and normal anti-static precautions should be observed when unpacking or handling the board.

Figure 2.1 - Jumper Location



* Indicates pin 1

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User Definable Options

The AOP-1 Analog Output Board has one user definable option (base address decode) which is selected using a series of jumpers. Boards are shipped from the factory with the default configuration as indicated below:

Table 2.1 - Default Settings

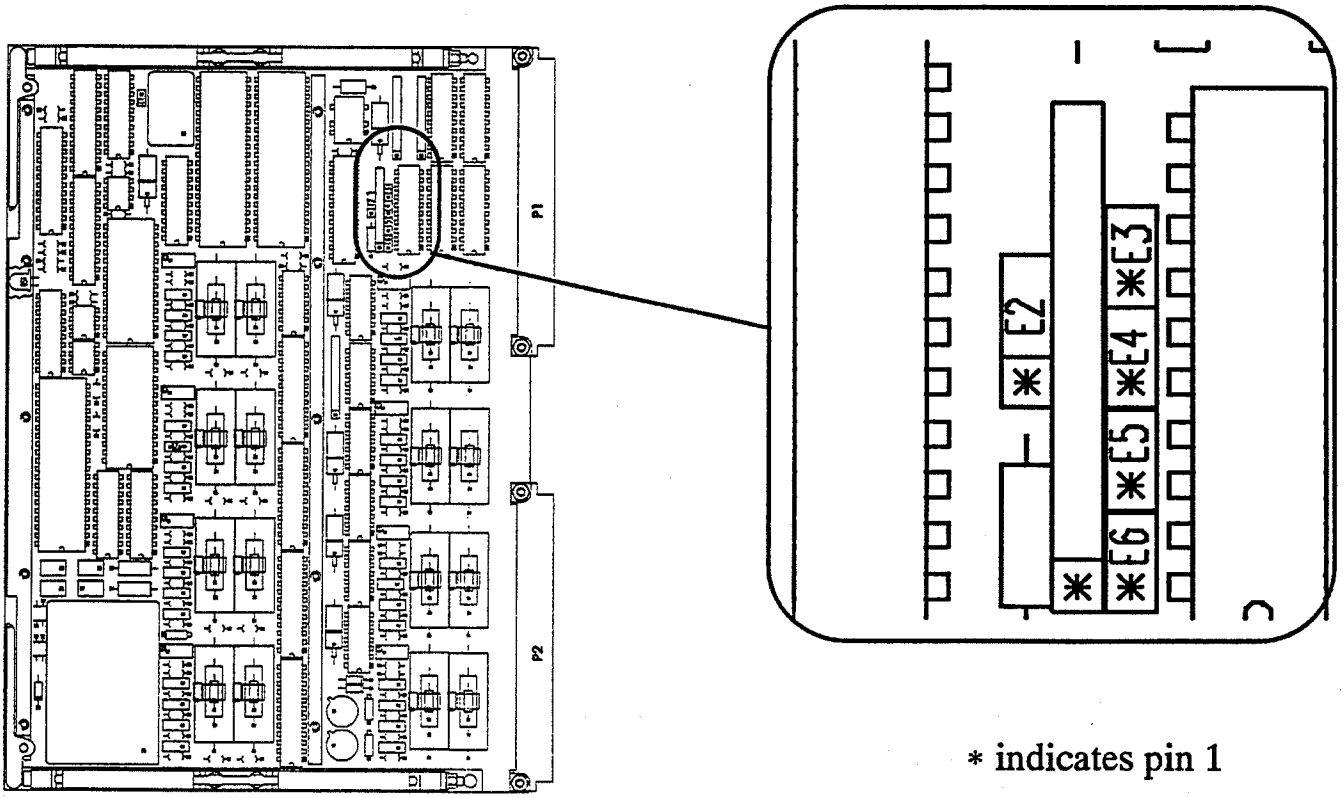
E3, E4 E5, E6	all OUT	Memory Map Base Address Selection	Standard Addressing - $F00000
E2	OUT	Reserved	Not fitted
E1	IN	Reserved for Factory use	Always fitted

Changing the Base Address

Jumpers E3 to E6

The AOP-1 occupies 32k consecutive byte locations in the VMEbus address map. It may be located on any 1Mbyte boundary within the standard address space of the VMEbus.

Figure 2.2 - Jumpers E3 to E6



* indicates pin 1

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Table 2.2 shows how the configuration of jumpers is used to alter the base address of the AOP-1. Removing a jumper sets the corresponding address bit to one (1). Inserting a jumper sets the corresponding address bit to zero (0).

The jumpers correspond to the following address lines:

E3 - A23
E6 - A22
E5 - A21
E4 - A20

Table 2.2 - Summary of Base Address Options

LOC3 E3	LOC2 E6	LOC1 E5	LOC0 E4	Base Address
out	out	out	out	$F00000
out	out	out	in	$E00000
out	out	in	out	$D00000
out	out	in	in	$C00000
out	in	out	out	$B00000
out	in	out	in	$A00000
out	in	in	out	$900000
out	in	in	in	$800000
in	out	out	out	$700000
in	out	out	in	$600000
in	out	in	out	$500000
in	out	in	in	$400000
in	in	out	out	$300000
in	in	out	in	$200000
in	in	in	out	$100000
in	in	in	in	$000000

In Table 2.2, the term **in** refers to a grounding (connection to 0V) of the relevant LOC pin.

Example : To select a Base Address of $400000

Fit jumpers E3, E5, E4 on the AOP-1 card.

Alternatively, the user may configure the address of the card via a backplane connection to P2. Removing the on-board links E3 to E6 and grounding the relevant LOC0 to LOC3 pin via the P2 connections selects the VMEbus address selection.

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Example: To select a Base Address of $700000

Ground (connect to 0V) LOC3. Leave LOC0 to LOC2 unconnected. The pinout of the LOC pins is as follows

LOC0 - P2 pin A4
LOC1 - P2 pin C4
LOC2 - P2 pin A2
LOC3 - P2 pin C2

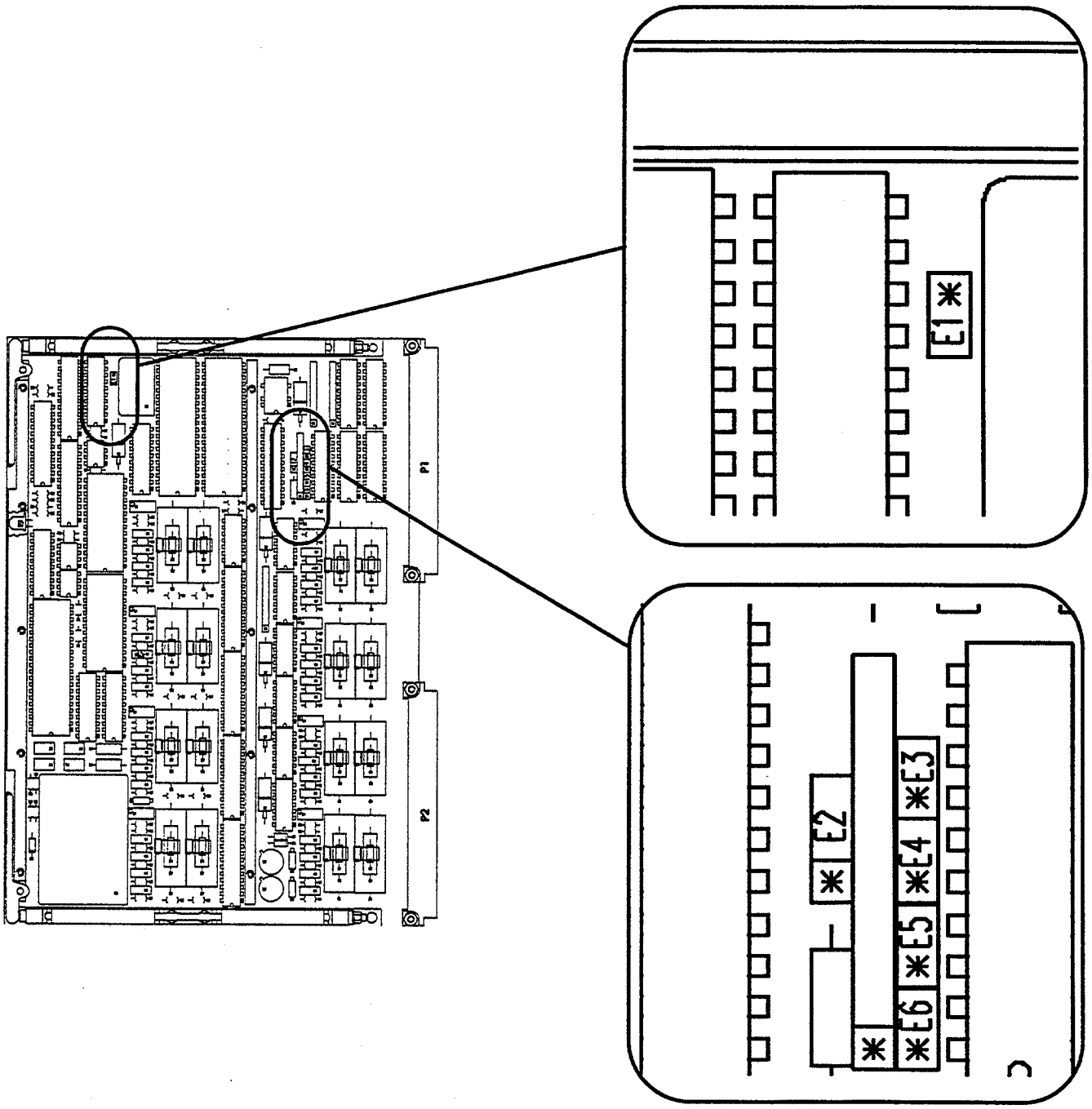
Jumpers E1 & E2

Jumper E1 - 2 pin jumper - is used for factory testing and ***should always be fitted*** in the users environment. Removal of this jumper will cause incorrect operation of the unit.

Jumper E2 - 3 pin jumper - is used in factory testing and ***should not be fitted*** by the user under any circumstances. Fitting this jumper could damage the VMEbus interface.

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Figure 2.3 - Jumper E2



* indicates pin 1

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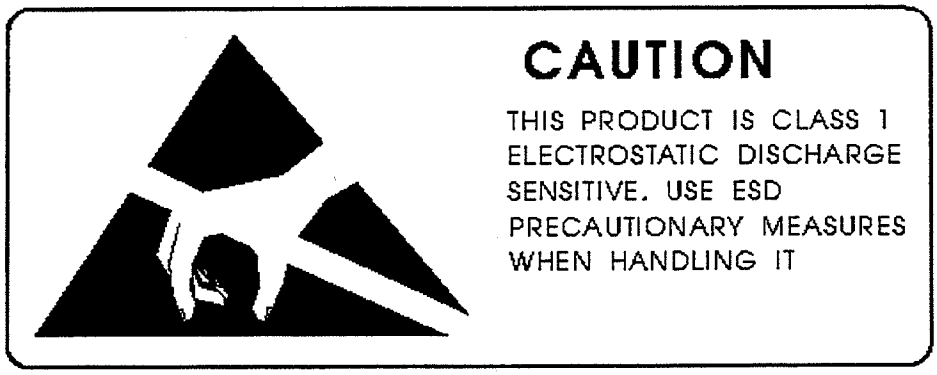
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Chapter 3 - Cables and Connections

Connecting the AOP-1

Ensure that power to the VMEbus system is turned off before installing the AOP-1. The AOP-1 is sensitive to the build-up of static electricity, therefore normal anti-static precautions should be observed when handling the board.



Communication between the AOP-1 and the VMEbus is performed via the P1 Connector on the rear of the board.

To install the AOP-1 in the VMEbus system, carefully align connectors P1 and P2 with the corresponding J1 and J2 connectors on the VMEbus backplane and press firmly home.

Finally, tighten the wedgelocks, or front panel lock screws, to secure the board in the rack.

The 8 channels of analog output are accessed via the VME backplane P2 connector.

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Connector Pin Assignments

The 96-way P1 connector on the AOP-1 mates with the J1 connector on the VMEbus backplane.

Table 3.1 - Connector P1 Pin Assignment

Pin	(a)	(b)	(c)
1	D00	BBSY	D08
2	D01	BCLR*	D09
3	D02	ACFAIL*	D10
4	D03	BG0IN*	D11
5	D04	BG0OUT*	D12
6	D05	BG1IN*	D13
7	D06	BG1OUT*	D14
8	D07	BG2IN*	D15
9	GND	BG2OUT*	GND
10	SYSCLK	BG3IN*	SYSFAIL*
11	GND	BG3OUT*	BERR*
12	DS1*	BR0*	SYSRESET*
13	DS0*	BR1*	LWORD*
14	WRITE*	BR2*	AM5
15	GND	BR3*	A23
16	DTACK*	AM0	A22
17	GND	AM1	A21
18	AS*	AM2	A20
19	GND	AM3	A19
20	IACK*	GND	A18
21	IACKIN*	SERCLK(1)	A17
22	IACKOUT*	SERDAT*(1)	A16
23	AM4	GND	A15
24	A07	IRQ7*	A14
25	A06	IRQ6*	A13
26	A05	IRQ5*	A12
27	A04	IRQ4*	A11
28	A03	IRQ3*	A10
29	A02	IRQ2*	A09
30	A01	IRQ1*	A08
31	-12V	+5V STDBY	+12V
32	+5V	+5V	+5V

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Analog Output Connections

Eight analog output/0Volt signal pairs are available from the 96 way P2 connector along with the two secondary supplies and the fan control.

Table 3.2 - Analog Output Connections

Pin	(a)	(b)	(c)
1	GND	N/C	GND
2	LOC2	N/C	LOC3
3	GND	N/C	GND
4	LOC0	N/C	LOC1
5	N/C	N/C	N/C
6	RESERVED	N/C	RESERVED
7	N/C	N/C	N/C
8	N/C	N/C	N/C
9	N/C	N/C	N/C
10	N/C	N/C	N/C
11	N/C	N/C	N/C
12	N/C	N/C	N/C
13	N/C	N/C	N/C
14	N/C	N/C	N/C
15	N/C	N/C	N/C
16	N/C	N/C	N/C
17	N/C	N/C	N/C
18	N/C	N/C	N/C
19	N/C	N/C	N/C
20	N/C	N/C	N/C
21	N/C	N/C	N/C
22	P12VLTS	N/C	N12VLTS
23	N/C	N/C	N/C
24	N/C	N/C	N/C
25	OP0	N/C	OP4
26	0VA	N/C	0VA
27	OP1	N/C	OP5
28	0VA	N/C	0VA
29	OP2	N/C	OP6
30	0VA	N/C	0VA
31	OP3	N/C	OP7
32	0VA	N/C	0VA

P2 Signal Definitions

GND is 0 Volts with respect to (w.r.t.) the VMEbus signals.
OP0 to OP7 are the analog output signals for channels 0 to 7.
0VA is 0 Volts w.r.t. the analog outputs OP0 to OP7, 0VA is also electrically isolated from GND.
P12VLTS is a power output. It provides +12.7 Volts w.r.t. 0VA.
N12VLTS is a power output. It provides -12.7 Volts w.r.t. 0VA.
LOC0 to LOC3 are the base address select pins.
N/C indicates no connection to the AOP-1 card.

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Chapter 4 - Software Configuration

Introduction

The AOP-1 occupies 32kbyte consecutive VMEbus locations however only the first 17 are used:

Figure 4.1 - Memory Map

Base Address + $0	Output Channel 0
Base Address + $2	Output Channel 1
Base Address + $4	Output Channel 2
Base Address + $6	Output Channel 3
Base Address + $8	Output Channel 4
Base Address + $A	Output Channel 5
Base Address + $C	Output Channel 6
Base Address + $E	Output Channel 7
Base Address + $10	Mask Register
Base Address + $12	ADC Register
Base Address + $14	Unused
Base Address + $20	Control/Status Reg
Base Address + $22	Unused
Base Address + $7FFF	

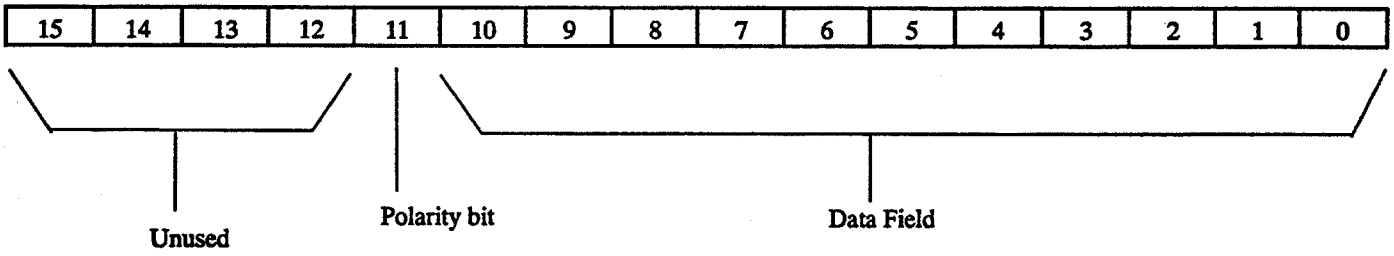
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Programming The Output Channels

Any output channel can be programmed simply by writing a right aligned 12 bit word to its appropriate VME address. Provided the mask bit in the Mask Register has been programmed to enable the outputs this 12 bit value will be seen as a voltage output on the appropriate P2 connecter pin.

Since the output voltage is bipolar, the 12 bit word includes a polarity bit.

Figure 4.2 - Output Channel Word Format



The data will be written into the output channel DAC aproximately 20 µsec after being written into the channels VME address. However as the Butterworth filter smoothes output voltage steps and provides for a controlled voltage transition, the outputs at the P2 edge connector may take up to 13ms to reach the programmed voltage.

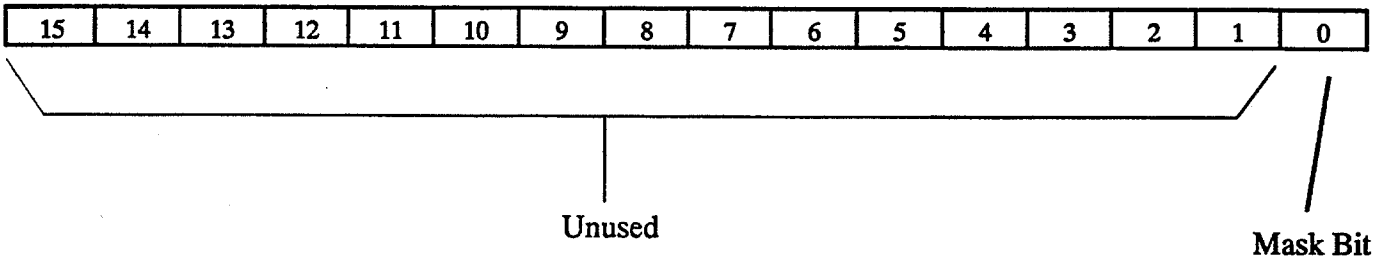
POLARITY bit	If set to logic 0, will create a positive voltage If set to logic 1, will create a negative voltage	
DATA FIELD	Creates increasingly more positive (or less negative) output for an increasing value (from 0 to $7FF)	
EXAMPLE WORDS	$0000	creates 0.000 Volts at the output
	$07FF	creates +9.99512 Volts at the output
	$0800	creates -10.000 Volts at the output
	$0FFF	creates -0.00488 Volts at the output

Reading an Output Channel register results in a transfer of the on-board ADC data. Details of this operation can be found in Chapter 6.

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Programming the Mask Register

Figure 4.3 - Mask Register



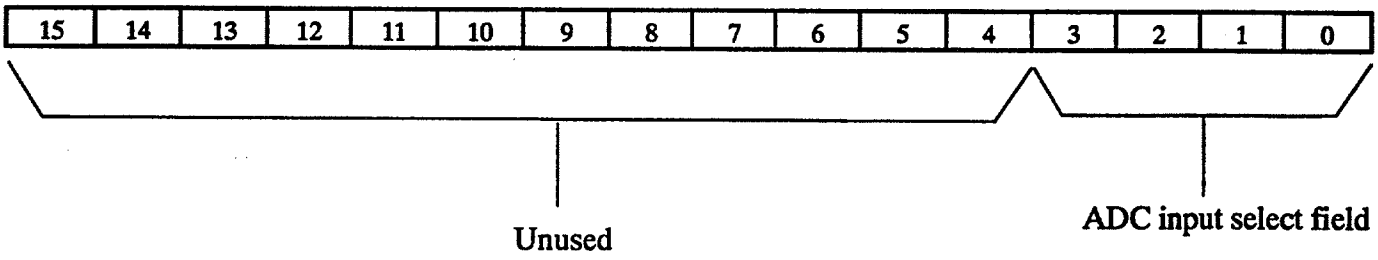
MASK BIT — If set to logic 0, will remove the output mask and allow the analog outputs to resume their programmed voltage states.
If set to logic 1, will assert the output mask and tie all the analog outputs to 0 Volts, regardless of the values programmed into the Output Channels.

The Mask Register does not have a readback facility. Data read from the Mask Register will be meaningless.

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Programming the ADC register

Figure 4.4 - ADC Register



ADC input select field
- If set to $0, will select Channel 0 Output as the input to the ADC
- If set to $1, will select Channel 1 Output as the input to the ADC
- If set to $2, will select Channel 2 Output as the input to the ADC
- If set to $3, will select Channel 3 Output as the input to the ADC
- If set to $4, will select Channel 4 Output as the input to the ADC
- If set to $5, will select Channel 5 Output as the input to the ADC
- If set to $6, will select Channel 6 Output as the input to the ADC
- If set to $7, will select Channel 7 Output as the input to the ADC
- If set to $8, will select DAC 0 & DAC 1 as the input to the ADC
- If set to $9, will select DAC 2 & DAC 3 as the input to the ADC
- If set to $A, will select DAC 4 & DAC 5 as the input to the ADC
- If set to $B, will select DAC 6 & DAC 7 as the input to the ADC
- If set to $C, will select +5 Volts as the input to the ADC
- If set to $D, will select 0 Volts as the input to the ADC

Writing to the ADC register will perform one of two functions:

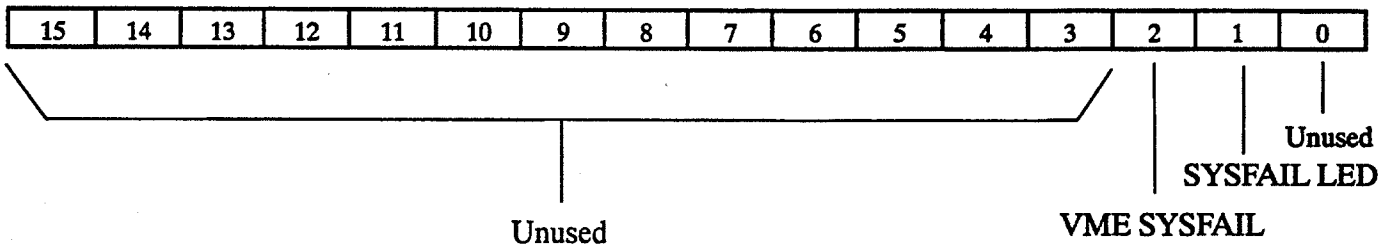
It will initiate an ADC sample.
It will set up the ADC input multiplexer from the 4 bit, ADC input select field (see above).

The ADC Register does not have a readback facility. Data read from this Register will be meaningless.

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Programming the Control/Status Register

Figure 4.5 - Control/Status Register



Bits 1 and 2 of the least significant three bits of the word are written into the register as follows:

BIT 1 = FAIL control bit (Drives red BITE FAIL LED)
writing 0 turns LED off
writing 1 turns LED on

BIT 2 = SYSFAIL control bit (Drives VME SYSFAIL signal)
writing 0 turns SYSFAIL signal off
writing 1 turns SYSFAIL signal on

Register Read:

Bits 0 and 3 to 15 should be ignored.

Bits 1 and 2 return state of each control bit as follows:

BIT 1 = FAIL control bit (1 indicates FAIL LED is lit)

BIT 2 = SYSFAIL control bit (1 indicates SYSFAIL is asserted)

Note, following power up, (ie VME signal SYSRESET asserted) the bits are defined as follows:

FAIL LED bit is ON
SYSFAIL bit is OFF

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Chapter 5 - Operating Instructions

The AOP-1 operates as a VME slave device only.

Programming Output Voltages

Outputs can be programmed with or without the Mask bit being set, however the outputs will not attain their expected value until the Mask is removed.

The 8 output channels are programmed by writing a 12 bit value to the relevant Output Register. A delay will be observed on the output voltage level as a filter (one in each output circuit) removes high frequency signals.

The outputs will continue to vary each time a new number is written to its VME register, however, it is possible to disconnect all the outputs and drive them from 0 Volts instead. This would be done when changes to the output channels would provide undesirable voltage changes to the user equipment, yet are unavoidable (e.g. at power up) or are needed for test purposes. Disabling the outputs is achieved using the Mask bit. The Mask bit switches all 8 outputs on at the same time, or all 8 outputs off at the same time.

Measuring specified voltage points on the board

An on board ADC allows voltage measurements to be carried out for monitoring board analog activity. The measureable points include the 8 output channels (measured at the P2 edge connector), the analog 0 Volts and the analog 5 Volts. The Mask switch will obviously prevent meaningful measurement of the outputs when it is set to disable them, therefore 4 additional measureable points have been created which allow access directly to the outputs of each DAC. These voltages form the 4 extra measureable points available to the ADC. In the ADC input select list shown in Chapter 5, these 4 points are listed as:

DAC 0 and DAC 1
DAC 2 and DAC 3
DAC 4 and DAC 5
DAC 6 and DAC 7

A pair of DACs are linked by two resistors of identical value. Their junction provides a central voltage point, and it is this junction which provides the ADC input. The voltage measured at these points will be controlled by 2 DACs instead of one. As an example assume both DAC 0 and DAC 1 were programmed to -5 Volts. If the ADC were set to measure their junction voltage its reading would relate to -5 Volts, similarly if both DAC 0 and DAC 1 were programmed to +5 Volts the ADC measuring their junction voltage would give a reading which would relate to +5 Volts, however if either DAC 0 or DAC 1 were then programmed to -5 Volts the ADC measuring their junction voltage would give a reading which would relate to 0 Volts. It is suggested that if a particular DAC output needs to be measured, its complement DAC in the pair is programmed to 0 Volts. The output to be measured will then be related to its programmed voltage.
Using the ADC circuit requires some care. The following steps should be used exactly as shown (any variation may corrupt the reading).

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Step 1 - Determine the required point to be measured and create the ADC data word from the input select list (see Chapter 5).
Step 2 - Write ADC data word into the ADC register. (This will channel the ADC input to the required measurement point).
Step 3 - Wait at least 20 µsec. (This will let the multiplexers and other circuits settle down).
Step 4 - Write ADC data word again into the ADC register. (This will start a conversion process).
Step 5 - Wait at least 20 µsec. (To allow time for the conversion to complete).
Step 6 - Write to any Output Channel. (This will latch the converted data into the shift register ready to be transferred back to the non isolated logic).
Step 7 - Write again to any Output Channel. (This will transfer the converted data back and allow it to be read).
Step 8 - Read any Output Channel.

The Most Significant 4 bits of the 16 bit word read back in step 8 should be ignored, since the ADC provides only 12 bits of relevant data. The ADC does not provide accurate measurements, however it can be used to show relative changes in the outputs (the +5 Volt and 0 Volt options are more accurate). Since the ADC values read back are relative the maximum and minimum values will need to be determined before using the ADC. They may even vary between the 8 output channels. The maximum is found by measuring the output channel programmed with $7FF. The minimum is found by measuring the output channel programmed with $800.

Note: If the ADC is to be used, it is necessary to remember the data written out to the port used in Steps 6 and 7, and use this data to write with otherwise the output channel in question will corrupt.

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Chapter 6 - Built In Test (BIT)

This chapter provides information about BITE V3 configuration and fail data. Refer to BITE V 3.0 User Manual Pub. No. HH681BITE3 for further information.

The AOP-1 BIT package comprises a register test, a DAC test and an output test. All tests run in initial BIT mode only.

Configuration Data

The AOP-1 test uses 5 longwords of configuration data. Four are the fixed usage BIT test masks and the slave processor timeout value. The final word contains the base address of the card under test.

Table 6.1 - Configuration Data Test

Configuration Data Word	Meaning	
0	AOP-1 test ignore mask. Bits set to ignore test as follows:	
	Bit	**Test**
	0	Register test
	1	Output test
	2	DAC test
1	AOP-1 test serious fail mask. The bit allocation is as above.	
2	AOP-1 test fatal fail mask. The bit allocation is as above.	
3	AOP-1 slave processor time-out count.	
4	AOP-1 under test, base address.	

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Fail Data

Register Tests

The register test checks access to the AOP-1 board and tests the bits used in the control register.
Register test reports: Mask_Code = 0001

Table 6.2 - Fail Data Tests

Fail_Code	Meaning
100	Write access of AOP-1 card check.
110	Read access of AOP-1 card checking status read.
120	Write/Read access check with inverse status.
130	Write/Read access check using default status.

fail_data[0] = Expected status to be read.

fail_data[1] = Status read.

fail_data[2] = Address of control register used for test.

Output Tests

The output tests check 0V is output by all 8 channels of the AOP-1 card while in BIT mode.

Output tests reports: Mask_Code = 0002

Table 6.3 - Output Tests

Fail_Code	Meaning
100	Write access of AOP-1 card turning on the BIT LED.
110	Write access of AOP-1 card setting up BIT mode.
120	Check of 0V output on each channel.
130	Restore card to normal operation (turn off BIT mode).

fail_data[0] = Expected output.

fail_data[1] = Output read.

fail_data[2] = Channel under test.

fail_data[3] = Address of control register used for test.

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DAC Tests

The DAC test checks access to the AOP-1 board and tests the DAC outputs for 0V, maximum and minimum voltage outputs. These values are tested by reading the ADC while the card is in BIT mode. The ADC reading for 0V is compared with readings of the 2 other output values.

DAC test reports: Mask_Code = 0004

Table 6.4 - DAC Tests

Fail_Code	Meaning
100	Write access of AOP-1 card turning on the BIT LED.
110	Write access of AOP-1 card setting up the BIT mode.
120	Check that ADC outputs not under test remain unchanged.
130	Check ADC output for channel under test maximum output.
140	Check that ADC outputs not under test remain unchanged.
150	Check ADC output for channel under test minimum output.
160	Restore card to normal operation (turn off BIT mode).

fail_data[0] = ADC read during test.

fail_data[1] = Output under test.

fail_data[2] = Zero voltage reading from test card.

fail_data[3] = Reading made when test voltage applied.

fail_data[4] = Address of control register used for test.

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Chapter 7 - Specifications

Common Specifications

This section details the specifications of the AOP-1.

VME Interface

Board Type		Slave
Addressing Modes		Standard A24
Data Transfers		Word D16 Byte D08 (odd or even)
Data Transfer Rate		3.6Mbytes/s
DSA low to DTACK low DSA high to DTACK high		250ns 150ns
Signal Drive Current Signal Loads		per ANSI/IEEE Std. 1014-1987 per ANSI/IEEE Std. 1014-1987

Output Characteristics

Number of Channels		8 single-ended
Output Voltage Range	(each channel)	-10V to +10V
Output Current	(each channel)	10mA max
Field to bus isolation		250V dc

Transfer Characteristics

Output Resolution	(each channel)	10 bits
Output Response Time	(each channel)	limited by Butterworth filter characteristics cutoff frequency 80Hz ±10% (-3dB)

Accuracy

Output Precision	(each channel)	<15mV
Output Offset	(each channel)	<5mV

Analog Supply Outputs

Minimum Voltage	+12 Volts, -12 Volts
Maximum Output Current	50mA

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Electrical

Two 96-way DIN41612 compatible connectors that mate with rack mounted backplane connectors form the electrical connection to the board.

Current Consumption

Typical	+5V ± 5% @ 1.2 A
	± 12V ± 5% @ 300mA per rail

Voltage Supply Requirements

+5V ±0.25V DC total excursion, including all transients.
V ripple (5V) = 50mV RMS (max) contained within the total excursion.
+12V and –12V ±1V DC total excursion, including all transients.

Safety Requirements

Do not exceed the maximum rated input voltages or apply reversed bias to the assembly. If such conditions occur, toxic fumes may be produced due to the destruction of components.

Mechanical

Weight

The appproximate weights of the AOP-1 are:

Standard	500g (18oz)
Extended temp	500g (18oz)
Rugged Air-cooled	620g (22oz)
Rugged Conduction-cooled	700g (25oz)
Tactical	700g (25oz)

Dimensions

Figures 7.1 and 7.2 show board dimensions in millimetres, with (inches) for general guidance only. The build standard of the AOP-1 is compatible with ANSI/IEEE Std 1014-1987 VMEbus Double Eurocard Standard. This allows the assembly to be fitted in any commercial VMEbus development chassis.

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Figure 7.1 VME Dimensions for Convection-cooled Boards

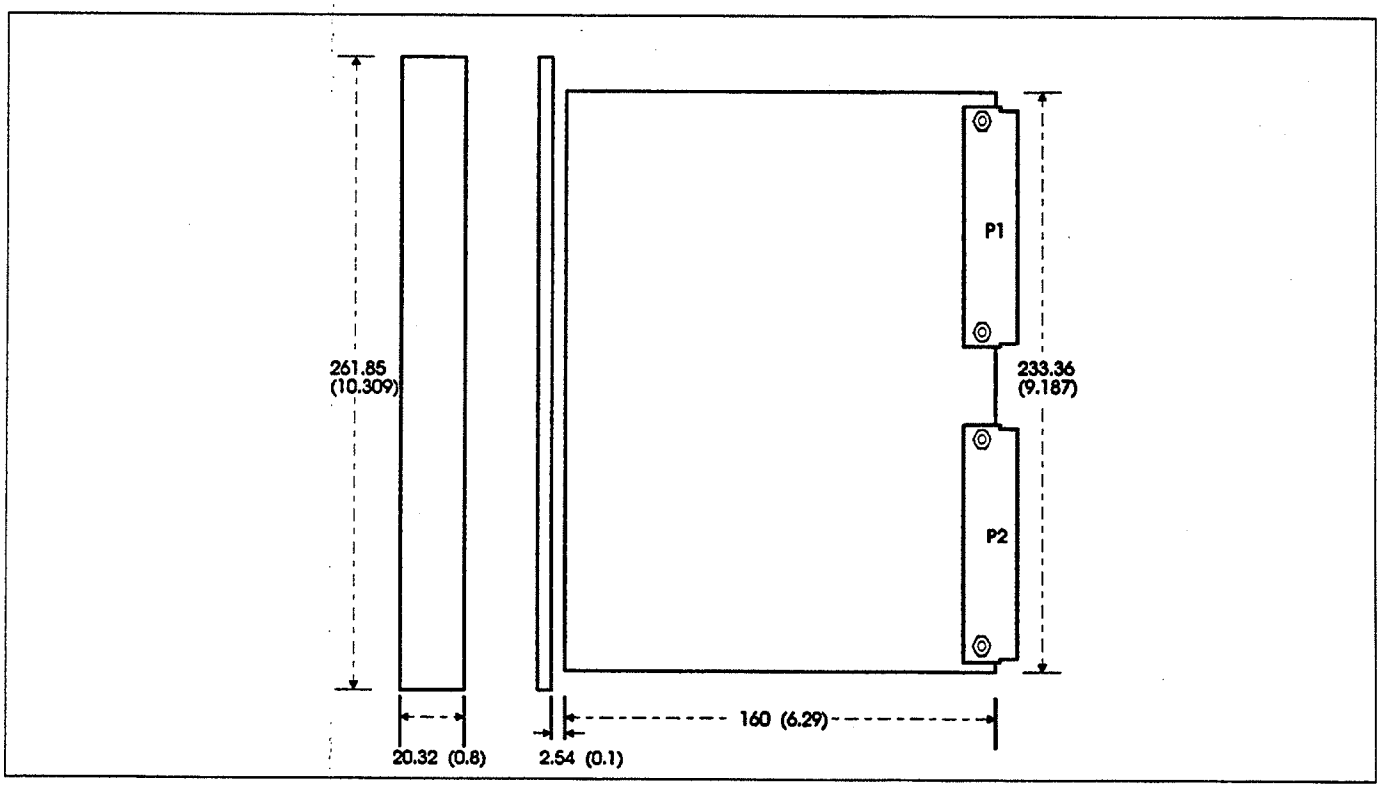
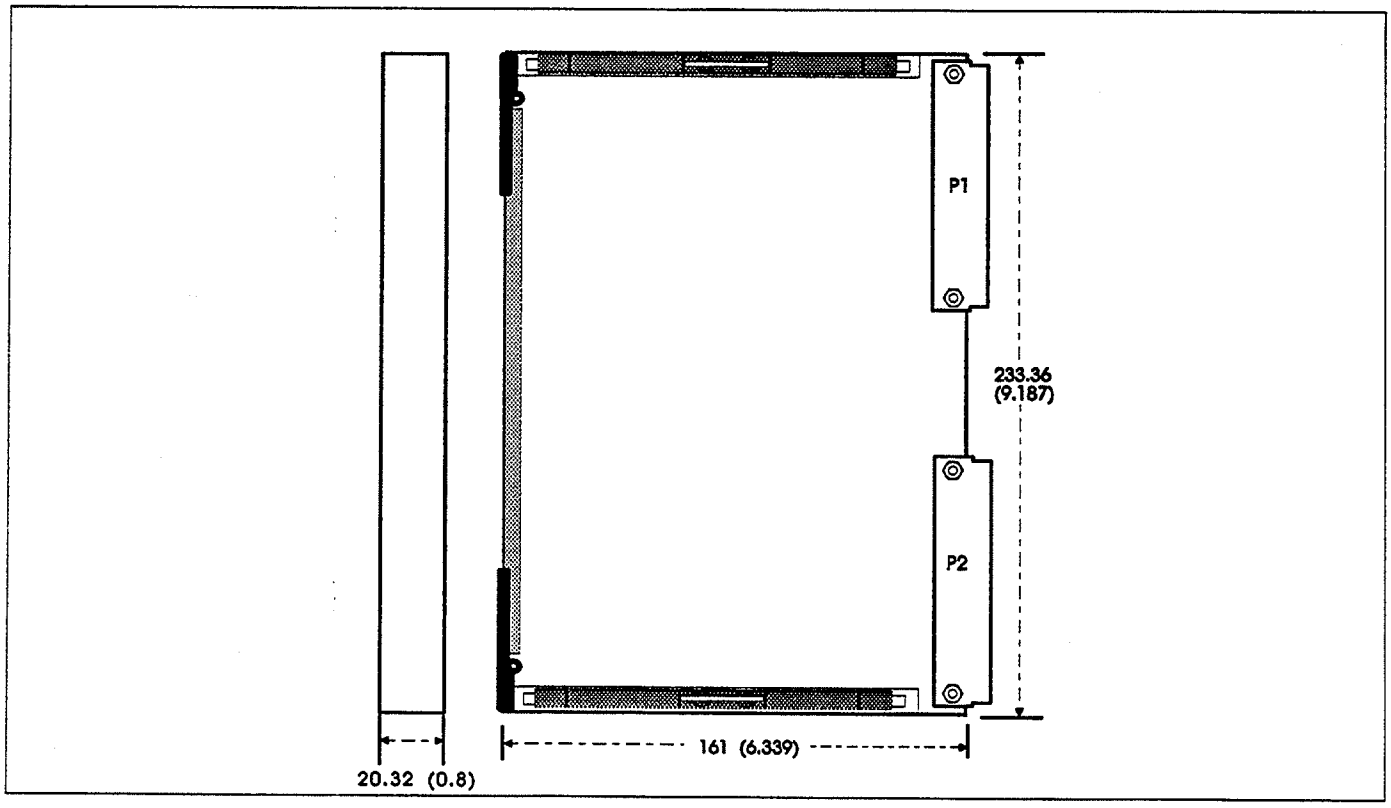


Figure 7.2 VME Dimensions of Conduction-cooled Boards



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Environmental Specifications

Convection-cooled Boards

BUILD STYLE	OPERATING TEMP (°C)	STORAGE TEMP (°C)	VIBRATION	SHOCK	HUMIDITY	COMMENTS
Standard	0 to +55 with airflow 300ft/min	-50 to +100	0.002g2/Hz from 10-2000Hz random and 2g sinusoidal from 5-500Hz	20g peak sawtooth, 11ms duration	Up to 95% RH	Commercial grade, cooled by forced air, for use in benign environments and software development applications.
Extended Temperature	-20 to +65	-50 to +100	0.002g^2/Hz from 10-2000Hz random and 2g sinusoidal from 5-500Hz	20g peak sawtooth, 11ms duration	Up to 95% RH with varying temperature, 10 cycles, 240 hours	As Standard but conformally-coated and temperature characterized.
Rugged Air-Cooled	-40 to +75 with airflow 600ft/min	-50 to +100	0.04g^2/Hz from 10-2000Hz with a flat response to 1000Hz 6db/Octave roll-off from 1000-2000Hz	20g peak sawtooth, 11ms duration	Up to 95% RH with varying temperature, 10 cycles, 240 hours	Wide temperature rugged, cooled by forced air. Conformally coated for additional protection.

Conduction-cooled Boards

BUILD STYLE	OPERATING TEMP (°C)	STORAGE TEMP (°C)	VIBRATION	SHOCK	HUMIDITY	COMMENTS
Rugged Conduction Cooled	-40 to +75 at the thermal interface	-50 to +100	Random 0.1g^2/Hz from 5-2000Hz per MIL-STD-810E	40g peak sawtooth, 11ms duration	Up to 95% RH with varying temperature, 10 cycles, 240 hours	Mechanically compliant with IEEE 1101.2-1997. Designed for severe environment applications with high levels of shock and vibration, small space envelope and restricted cooling supplies. Conformally-coated as standard. Optional Environmental Stress Screening (ESS).
Tactical	-55 to +85 at the thermal interface	-62 to +105	Random 0.1g^2/Hz from 5-2000Hz perMIL-STD-810E	40g peak sawtooth, 11ms duration	Up to 95% RH with varying temperature, 10 cycles, 240 hours	Similar to Rugged Conduction-cooled but extended operating and storage ranges through use of military components. Conformally-coated as standard. ESS testing is standard.

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Reliability

Using MIL-HBK-217F notice 1 as a data base and the parts count method, the following estimates have been made of the Mean Time Between Failures (MTBF) for the AOP-1.

Environment	Ground Benign	Ground Fixed	Ground Mobile	Naval Sheltered	Airborne Inhabited Cargo
Temperature	30°C	40°C	45°C	40°C	55°C
S/X-style					
Failure Rate (Failures/million hours)	5.71507	18.21587	—	38.32538	—
MTBF (Hours)	174,976	54,879	—	26,092	—
RA/RC-style					
Failure Rate (Failures/million hours)	2.46879	7.85285	26.91084	18.05688	28.24454
MTBF (Hours)	405,057	127,342	37,160	55,381	35,405
T-style					
Failure Rate (Failures/million hours)	—	—	13.33816	8.94976	13.39992
MTBF (Hours)	—	—	74,973	111,735	74,627

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Appendix A - Sample Programs

This chapter provides AOP-1 programming examples.

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Sample Program 1

Last Modified:30 Sept 93 11:30

Author: G S Chambers

The following program sets a ramp into the selected output channel. The ramp should be observable on an oscilloscope.

```
/*      CONSTANTS               */
# define BASE_ADDRESS    0x1C00000
# define BITE_OFF_BIT    (BASE_ADDRESS + 0x10)
# define ADC                    (BASE_ADDRESS + 0x12)
# define CONT_STAT_REG   (BASE_ADDRESS + 0x20)

typedef unsigned char   Uchar;
typedef unsigned short  Ushort;
typedef unsigned long   Ulong;

char key;

int test_channel;       /* points to DAC channel to be tested */
/*-------------------------------------*/
/*-------------------------------------*/
/* UTILITY PROGRAMS                                           */
/*-------------------------------------*/
/*-------------------------------------*/
/* VME write driver Routine  */
write_vme(address,data)
int address,data;
        {
        *((Ushort *) address) = data; /* write the 'data' to 'address'*/
        }
/*-------------------------------------*/
```

/* Routine to write data into a port */
/* The routine is entered with the port number (a number from 0 to 7), and the data to write to that port. The port number is first converted to a VME address */

```
write_port(port,data)
int port,data;
        {       int address;
        data = data & 0x3FF;            /* limit to 12 bits          */
        address = BASE_ADDRESS + (2 * port);/* set up port address   */
        write_vme(address,data);                /* send out the data */
        }
/*-------------------------------------------------------------------*/
```

/* The following routine selects the channel to be tested */

```
change_test_chan()
        {
        do {
```


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```
            printf("\n\n\n Select one of the 8 channels to be");
            printf(" tested (0 - 7) ");
            key = getchar();
            printf("%c",key);
            printf("\n");
            if (key < '0') (key = '~'); /* Test minimum boundary */
            if (key > '7') (key = '~'); /* Test maximum boundary */
            if (key != '~') test_channel = (key - '0'); /*remove ASCII*/
            if (key == '~')
            printf("  Number must be in the range 0 to 7\n");
            } while (key == '~');
      key = ' ';
      }
/*-------------------------------------------------------*/
/*      Pause to allow filter to settle        */
/*-------------------------------------------------------*/
pause()
      {
      int pause;
      char dummy;
      for (pause = 0;pause <10000;pause++) dummy = 's';
      }

/*****************************************************************/
/*                    MAIN ROUTINES                              */
/*****************************************************************/
/*-----------------------------------------*/
/*            Ramp test        */
/*-----------------------------------------*/
```

/* One channel is tested at a time. The program outputs an incrementing value such that all possible DAC values are written out.
At the channel outputs these values form a ramp.
The DAC is programmed using twos complement notation.

```
*/
main()
      {
      int   data,port,count;
      printf("\n Ramp test");

                  /* SELECT CHANNEL TO BE TESTED */

      change_test_chan();
      write_vme(BITE_OFF_BIT,0);          /* enable outputs */
      pause();                        /* Let command complete */

                  /* CARRY OUT RAMP TEST */
```


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```
printf("\n          Ramp Started\n");

                /* CREATE NEGATIVE PORTION OF RAMP */

write_port(test_channel,0x800);      /* First value will take
                                        a long time to settle */
for (count = 0;count <20;count++)
      pause();                       /* Let output settle */
for (data = 0x800;data<0x1000 ;data++)
      {
      write_port(test_channel,data);
      pause();                       /* Let output settle */
      }

                /* CREATE POSITIVE PORTION OF RAMP */

for (data = 0;data<0x800 ;data++)
      {
      write_port(test_channel,data);
      pause();                       /* Let output settle */
      }
printf("\n\n       Ramp Completed");
}
```


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Sample Program 2

Last Modified: 1 Oct 93 8:00
Author: G S Chambers

The following program provides an example of programming the ADC

Initially Port 0 is set to its maximum positive value (code 7FF hex), the ADC is set to read the DAC output of Port 0, the value is read and displayed. (Note this will be less than 5 Volts)

The top 4 bits of channel 0 DAC are then independently set to logic 1 The voltage measured by the ADC for each of the 4 bits is displayed. Note that the internal ADC feedback is used for measuring purposes rather than the external feedback, the main outputs being clamped to 0 Volts. Each bit will produce a change in voltage but since the ADC measurement is not accurate these voltages are useful only as indicators that the bits are active.

Finally, Port 0 is set to its middle point (code 0), and, as above the voltage is measured and displayed.

```
/*      CONSTANTS   */

# define BASE_ADDRESS       0x1C00000
# define BITE_OFF_BIT       (BASE_ADDRESS + 0x10)
# define ADC                (BASE_ADDRESS + 0x12)
# define CONT_STAT_REG      (BASE_ADDRESS + 0x20)

typedef unsigned char   Uchar;
typedef unsigned short  Ushort;
typedef unsigned long   Ulong;
char key;
int adc_data;                   /* used to return converted ADC data  */
int adc_decimal;            /* same as adc_data but converted to decimal */
int read_data;              /* used to return port data*/
/*-------------------------------------------------------------------*/
/*-------------------------------------------------------------------*/
/* UTILITY PROGRAMS                    */
/*-------------------------------------------------------------------*/
/*-------------------------------------------------------------------*/
```

/* VME write Routine */

/* This routine handles writing of data to the AOP card across the VME bus, it is normally used for other than DAC output port (channel) updates which are handled more easily by the next Routine */

```
write_vme(address,data)
int address,data;
      {
      *((Ushort *) address) = data; /* write the data out to 'address'*/
      }
/*-------------------------------------*/
```


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```
/* Routine to write data into a port */
/* The routine is entered with the port number (a number from 0 to 7), and the data to write to that port.
The port number is first converted to a VME address */
write_port(port,data)
int port,data;
        {
        int address;
        data = data & 0x7FF;            /* limit to 12 bits              */
        address = BASE_ADDRESS + (2 * port);/* set up port address       */
        write_vme(address,data);        /* send out the data             */
        }
/*-------------------------------------------------*/

/* VME read Routine */
read_vme(address)
int address;
        {
        read_data = (*((Ushort *) address));/* read VME data at 'address'*/
        }
/*-------------------------------------------------*/
/*      Pause to allow filter to work   */
/*-------------------------------------------------*/
wait_filter()
        {
        int pause;
        char dummy;
        for (pause = 0;pause <100000;pause++) dummy = 's';
        }
/*-------------------------------------------------*/
/*      Pause to allow ADC to sample    */
/*-------------------------------------------------*/
wait_20usec()
        {
        int pause;
        char dummy;
        for (pause = 0;pause <27;pause++) dummy = 's';
        }
/*-------------------------------------------------*/
/*      Read back one ADC input         */
/*-------------------------------------------------*/
```

/* enter with data to be rewritten to port 0, the routine updates the variable 'adc_decimal' so that it contains the value of the ADC converted to millivolts. The act of reading data back across the isolation interface involves writing data out to one of the DAC ports, port 0 is used. To preserve the state of port 0 the data previously written out to this port has been preserved and passed to this routine so that it can be rewritten when required. */

```
measure_port0(data)
int data;
        {
```


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```
        int port;
        float float_temp;
        write_vme(ADC,8);          /* set up ADC input channel   */
        wait_20usec();             /* ADC input needs to settle  */
        write_vme(ADC,8);          /* initiate ADC sample        */
        wait_20usec();             /* allow ADC conversion       */
        write_port(0,data);        /* load ADC data into shift reg*/
        wait_20usec();             /* allow command to complete  */
        write_port(0,data);        /* shift ADC data back        */
        wait_20usec();             /* allow command to complete  */
        read_vme(BASE_ADDRESS); /* read ADC data, note that BASE_ADDRESS
                                      here is just a dummy address  */
        adc_data = read_data & 0xFFF; /* limit data to 12 bits      */

        /* CONVERT TO DECIMAL (mvolts) */

        float_temp = adc_data  * 20000;/* ADC input range is 20 Volts*/
        float_temp = float_temp / 0x1000;/* ADC resolution is 12 bits*/
        adc_decimal = float_temp - 10000;/* ADC input is bipolar    */
        }
/*-------------------------------------------------------*/
/*      MAIN ROUTINE          */
/*-------------------------------------------------------*/
/*-------------------------------------------------------*/
main()      {
        int   address,data,port;
        printf("\n Weight test");
        address = BITE_OFF_BIT;
        data = 1;
        write_vme(address,data);              /* disable outputs */

         /* SET UP PORT 1 (this is necessary so that the internal ADC feedback can be used correctly) */
 data = 0;                        /* set for 0 Volts */
 port = 1;
 write_port(port,data);           /* write to DAC */

              /* SET UP AND MEASURE MAXIMUM VOLTAGE */
        write_port(port,data);           /* write to DAC */
        data = 0x7ff;                    /* set for maximum */
        port = 0;
        write_port(port,data);           /* write to DAC */
        wait_filter();                   /* Let outputs settle */
        measure_port0(data);             /* measure value of port 0 */
        printf("\nPort 0 maximum is %d mv",adc_decimal);
        printf("       DAC programmed to 5 Volts");
```


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```
        /* SET UP AND MEASURE BIT 11 VOLTAGE */
data = 0x400;                   /* set bit 11 */
port = 0;
write_port(port,data);          /* write to DAC */
wait_filter();                  /* Let outputs settle */
measure_port0(data);            /* measure value of port 0 */
printf("\nPort 0 Bit 11 set reads %d mv",adc_decimal);

        /* SET UP AND MEASURE BIT 8 VOLTAGE */
data = 0x80;                    /* set bit 8 */
port = 0;
write_port(port,data);          /* write to DAC */
wait_filter();                  /* Let outputs settle */
measure_port0(data);            /* measure value of port 0 */
printf("\nPort 0 Bit 8 set reads %d mv",adc_decimal);

        /* SET UP AND MEASURE BIT 7 VOLTAGE */
data = 0x40;                    /* set bit 7 */
port = 0;
write_port(port,data);          /* write to DAC */
wait_filter();                  /* Let outputs settle */
measure_port0(data);            /* measure value of port 0 */
printf("\nPort 0 Bit 7 set reads %d mv",adc_decimal);
        /* SET UP AND MEASURE BIT 6 VOLTAGE */
data = 0x20;                    /* set bit 6 */
port = 0;
write_port(port,data);          /* write to DAC */
wait_filter();                  /* Let outputs settle */
measure_port0(data);            /* measure value of port 0 */
printf("\nPort 0 Bit 6 set reads %d mv",adc_decimal);


        /* SET UP AND MEASURE 0 VOLTS */
data = 0;                       /* set zero */
port = 0;
write_port(port,data);          /* write to DAC */
wait_filter();                  /* Let outputs settle */
measure_port0(data);            /* measure value of port 0 */
printf("\nPort 0 zero volts set reads %d mv",adc_decimal);
printf("        DAC programmed to 0 Volts");
printf("\n\n\n    type any character to exit");
key = getchar();
}
```


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Appendix B Solid state Relay (SSR)

This appendix provides the additional information required to operate the AOP-1 variant 68114874-100, which incorporates a solid state relay.

Important:To order this style of board including the solid state relay, the order must specify part number 68114874-100 not just the sales code AOP1-100RC.

A solid state relay output is provided, which is programmed through the Control Register. The state of the relay is recorded in the Status Register. Details of the Control/Status Register Memory Map are given in Chapter 1.

Solid State Relay Specification

	minimum	typical	maximum	units
Continuous load current			1.0	Adc(see Fig B.2)
Leakage current @ V_{LOAD} = 32			50	µA
Output voltage drop @ I_{LOAD} = 1.2A, T = 85°C			0.8	Vdc
Continuous operating voltage			32	Vdc[1]
ON resistance Rds (on) @ Tj = 25°C I_{LOAD} = 100mAdc		0.52	0.65	Ohms
Reverse voltage			3	V
Turn ON time			1.5	ms(see Fig B.1)
Turn OFF time			8	ms(see Fig B.1)
$\frac{dV}{dt}$	100			V/µs
Output capacitance			1200	pF
Isolation	250			Vdc

Note: [1] This is limited by protective zener diode. The relay can withstand 60Vdc continuous.

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Figure B.1 Output Turn-on/Turn-off Timing

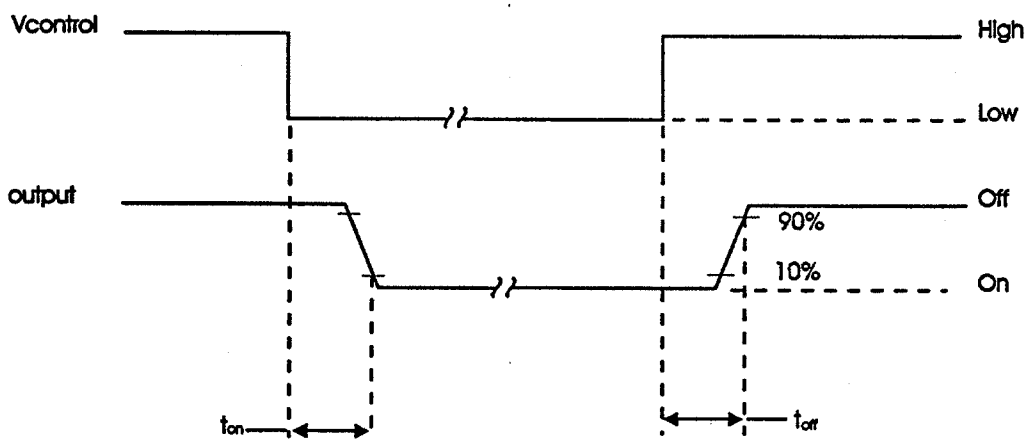
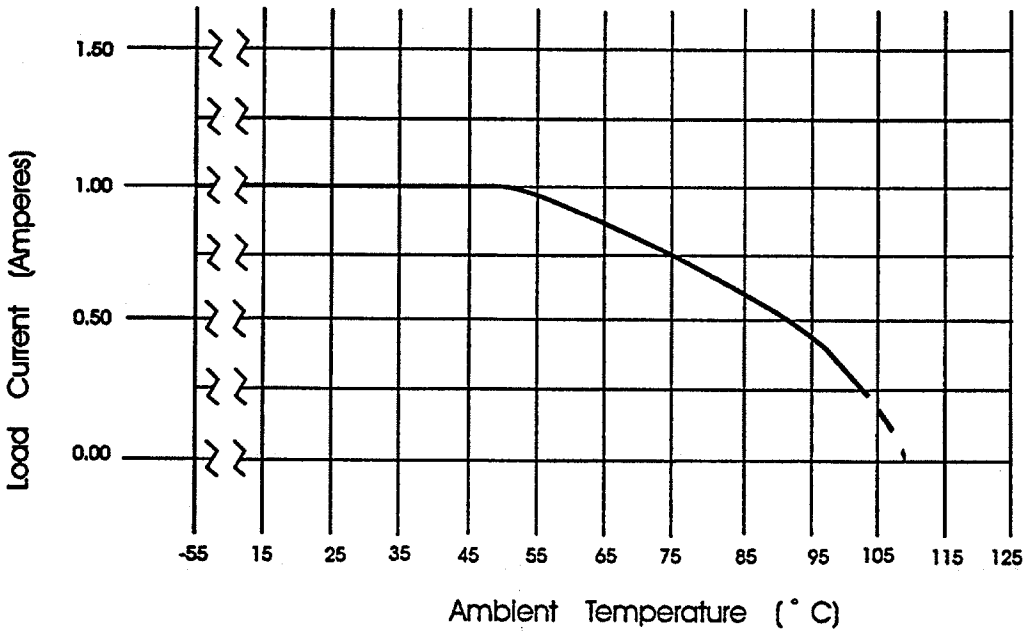


Figure B.2 Thermal Derating Curve



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Connecting The SSR

Caution! **The SSR terminals are polarity sensitive. Reversing the polarity of the terminals may cause permanent damage.**

The positive terminal (SSR POS) is connected to P2 pin A6. The negative terminal (SSR NEG) is connected to P2 pin C6.

Programming the SSR

Bit 0 of the Control/status Register is used to control and monitor the SSR. Refer to Chapter 5 Programming Control/Status Register for details of other register bit usage. Operation of bit 0 is as follows

Bit 0 = SSR Control Bit
writing 0 turns SSR OFF
writing 1 turns SSR ON

For Register Read:

Bit 0 = SSR Control Bit - 1 indicates SSR is switched ON

Note that following power-up the SSR bit is OFF.

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