

Addendum to the AOM1 Manual

The following information covers changes to the manual for the AOM1/2 and AOM1/5 modules:

ERROR IN DESCRIPTION OF STROBE OPERATION

The topics "D/A DATA" and "STROBE" on pages 6 and 7 of the AOM1 manual imply that the mechanism of updating an output channel depends on the strobe feature, which may be enabled or disabled. This information is in error. The strobe operation is always enabled. A channel will update only after the strobe line has been sent an "ISSUE DATA" command. Several channels may be loaded with data and an ISSUE DATA sent to the strobe line, or channel data may be updated individually, each followed by an ISSUE DATA.

This information is relevant only if you are writing your own low-level drivers for the AOM1 module. High-level software such as KDAC500, ASYST, or Labtech Notebook handle updating of output channels automatically.

AOM1

Analog Output Module 1

The AOM1 Analog Output Module is available in two versions. The AOM1/2 provides two channels, while the AOM1/5 provides 5 channels of high-speed analog output. Each channel has an independent D/A converter.

The D/A converters offer true 12-bit resolution with a maximum nonlinearity of $\pm 0.012\%$. Five switch-selected output ranges are available for each converter: 0 to +10V, 0 to +5V, unipolar; $\pm 10V$, $\pm 5V$, $\pm 2.5V$, bipolar.

A system strobe feature, supported by two levels of data latching in the D/A converter, allows any number of D/A channels to be updated simultaneously.

Signals are connected directly to the module via screw terminals mounted on the right-hand side of the module board.

The AOM1 module may be placed in any available slot in the system. To install the module, first turn off the power and remove the top cover of the mainframe. Insert the module in the desired slot with the component side facing the power supply. Generally, analog modules should be placed in the low-numbered slots to isolate them from power supply thermal and noise effects.

CAUTION: Always turn off the system power before installing or removing modules. To avoid possible EMI radiation, never operate the system with the top cover removed.

User-Configured Components

Each D/A converter installed on the AOM1 offers five output ranges: 0 to +5V, 0 to +10V, -5 to +5V, -10 to +10V, and -2.5 to +2.5V. Switch Sets S101-S105 on the AOM1/5 independently select the output ranges for channels 0-4, respectively. On the AOM1/2, S101 and S102 select output ranges for channels 0 and 1.

All output connections are made to screw terminals. Two terminals are provided for each channel: signal output and a common ground. All terminals accept 16-24 gauge wire stripped to 3/16 of an inch. See Table 1 and Figure 1 for a list of AOM1 user-configured components.

Table 1. Summary of User-Configured Components on the AOM1

Name	Designation	Function
Switch 101	S101	Analog Output Range Channel 0
Switch 102	S102	Analog Output Range Channel 1
Switch 103	S103*	Analog Output Range Channel 2
Switch 104	S104*	Analog Output Range Channel 3
Switch 105	S105*	Analog Output Range Channel 4
Screw Terminals	J145	Output Connection Channels 0-4

*AOM1/5 only

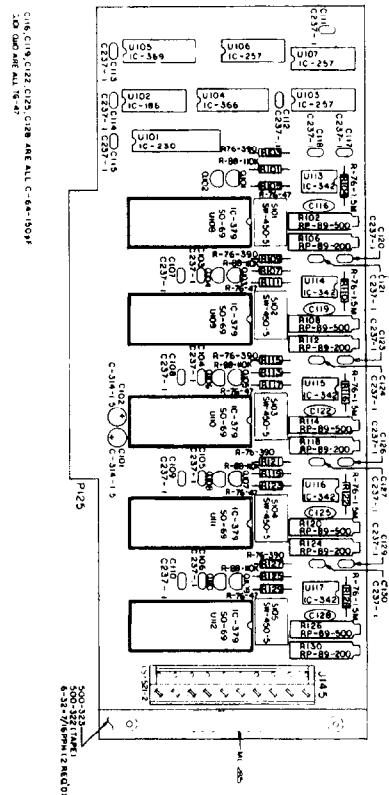


Figure 1. AOM1/5 Module (AOM1/2 is similar except, it has components only for channel 0 and 1.)

Connections

Connecting terminals on the AOM1 are shown in Figure 2, which illustrates a typical connecting scheme. The use of shielded cable is recommended to minimize the possibility of EMI radiation. Connect the shield to AOM1 ground. Leave the other end of the shield disconnected.

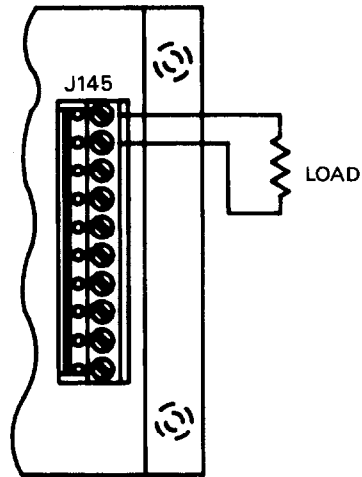


Figure 2. Typical AOM1 Output Connections (Channel 0 shown)

Range Switches

The AOM1/2 has two switch sets, S101 and S102 that control the output range of channels 0 and 1. The AOM1/5 has five switch sets, S101-S105 that control the output range of channels 0-4 respectively. Each switch set has five individual DIP switches that control the range for that channel. The settings for these five individual switches are shown in Table 2. Each channel is identical in operation. Note that changing ranges will require calibrations described in the servicing section of this manual.

Table 2. DIP Switch Settings for Switch sets S101 and S105

Output Range	DIP Switches				
	1	2	3	4	5
0 to +5V	Closed	Open	Closed	Closed	Open
0 to +10V	Closed	Open	Open	Closed	Closed
±2.5V	Open	Closed	Closed	Closed	Open
±5V	Open	Closed	Open	Closed	Closed
±10V*	Open	Closed	Open	Open	Closed

*Factory default settings

Note: DIP Switch settings are the same for all switch sets.

Output Limitations

There are certain restrictions as to the output capabilities of each channel on the AOM1 module. Generally, there is an upper limit on the amount of capacitance and a lower limit to the resistance that can be connected across the output. To avoid possible oscillation, output capacitance must be less than 1000pF. Similar restrictions apply to the output current, which is determined largely by the resistive component of the load connected across the output. If the resistance is too small, accuracy will suffer. To maintain rated accuracy, the load resistance should be no smaller than 5k Ω with a maximum of output of $\pm 10V$. Output current limit is 2-3mA.

Figure 3 shows a simplified diagram of an AOM1 output stage. Because the output is directly sensed, a certain amount of voltage drop across the internal resistance is tolerated.

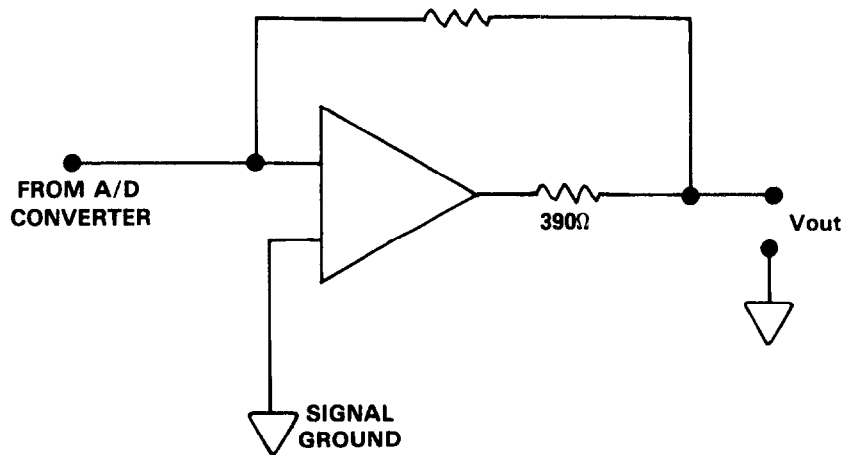


Figure 3. AOM1 Output Stage

Commands

AOM1 module commands are listed in Table 3. Table 4 summarizes the locations for slot-dependent commands.

Table 3. Command Used with the AOM1 Module

Command	Location
D/A CONTROL	Slot-dependent CMDA
D/A DATA	Slot-dependent CMDB
STROBE: CFF9D	

Table 4. Locations for Slot-Dependent Commands

Slot	CMDA	CMDB
Slot 1	CFF80	CFF81
Slot 2	CFF82	CFF83
Slot 3	CFF84	CFF85
Slot 4	CFF86	CFF87
Slot 5	CFF88	CFF89
Slot 6	CFF8A	CFF8B
Slot 7	CFF8C	CFF8D
Slot 8	CFF8E	CFF8F
Slot 9	CFF90	CFF91
Slot 10	CFF92	CFF93

D/A CONTROL

Location: Slot-dependent CMDA

D/A CONTROL always precedes D/A DATA, indicating to the AOM1 module which channel of analog output to update, and which byte of data to load. Table 5 lists values written to the D/A CONTROL locations.

The high and low bytes of data may be updated independently and in any order; there is no hardware reason that both bytes must be updated at the same time. Similarly, channels can be updated independently and in any order.

The location assigned to D/A CONTROL varies depending on which baseboard slot holds the D/A converter being addressed (see Table 4).

Table 5. Values Written to D/A CONTROL

Function	Binary	Hex	Decimal
Channel 0 Low Byte	0000	H0	0
Channel 0 High Byte	0001	H1	1
Channel 1 Low Byte	0010	H2	2
Channel 1 High Byte	0011	H3	3
Channel 2 Low Byte	0100	H4	4
Channel 2 High Byte	0101	H5	5
Channel 3 Low Byte	0110	H6	6
Channel 3 High Byte	0111	H7	7
Channel 4 Low Byte	1000	H8	8
Channel 4 High Byte	1001	H9	9

Note: AOM1/2 has only channels 0 and 1.

D/A DATA

Location: Slot-dependent CMDB

D/A DATA is used to load data values into the D/A converter. This command should

always be preceded by D/A CONTROL, which selects the channel and the byte to be loaded. The data must be separated into low and high bytes prior to loading, and each byte must be prefaced by D/A CONTROL.

When the strobe feature is not enabled, the output of the converter is updated immediately. Thus, when the strobe is not used, the low and high bytes are updated independently. When the strobe is enabled, outputs are not updated until the STROBE command is issued with the value 1 (to issued data).

The digital value loaded into the converter varies according to the output range selected via the range switch set. To determine the digital value to input for a given voltage, it is necessary to know the output range of the D/A converter. With a 12-bit digital converter, there are 4096 possible voltage levels, specified with digital values 0-4095. Therefore the actual full scale value is the nominal f.s. value minus 1 LSB. The voltage of each step equals the range divided by 4095. For an input range of 0 to +10V, for example, the voltage of each step is 10/4095 or 0.002441; hence, a formula for each voltage range can be derived (See Tables 6 and 7).

Where V is volts and D is the digital value loaded into the converter. Similarly, the following equations determine the digital value to use when a particular voltage is required.

Table 6. Digital Values to Volts

Output Range	Voltage
0 to +10V	$V = D * 0.002441$
0 to +5V	$V = D * 0.001221$
-10 to +10V	$V = -10 + (D * 0.004882)$
-5 to +5V	$V = -5 + (D * 0.002441)$
-2.5 to +2.5V	$V = -2.5 + (D * 0.001221)$

Table 7. Volts to Digital Values

Output Range	Digital Value
0 to +10V	$D = \text{INT}(V/0.002441)$
0 to +5V	$D = \text{INT}(V/0.001221)$
-10 to +10V	$D = \text{INT}(V/0.004882) + 2048$
-5 to +5V	$D = \text{INT}(V/0.002441) + 2048$
-2.5 to +2.5V	$D = \text{INT}(V/0.001221) + 2048$

STROBE

Location: CFF9D

The STROBE command is used to make possible the synchronous updating of two or more analog output channels. STROBE is issued in three modes: strobe enable, strobe disable, and issue data. The STROBE feature must either be enabled or disabled at the start of any Program, or the converters will not function (see Table 8).

When any strobe feature is disabled, all data given to a D/A converter is immediately placed in that converter's primary data latch, and the voltage output updated. The low byte and high byte are thus updated asynchronously.

When the strobe is enabled, no data is updated until the STROBE command has been issued in the issue data mode. Instead, new data is placed in a secondary data latch within the D/A converter. When the STROBE command (to issue data) is given, the new data is released to the primary data latch, updating the voltage output, and old data in other channels is reissued, leaving the voltage output of these channels unchanged. The strobe is completely flexible. Any amount of data--from a single byte to any number of channels--can be updated when the strobe is enabled.

To use the strobe, issue the strobe enable command early in the program. Use the D/A CONTROL and D/A DATA commands to load the secondary latches of the appropriate converters. This can be done as far in advance as required. To issue the new data, load STROBE with 1 (to issue data), releasing all data loaded since the last issue data command and leaving unchanged the outputs of other channels.

The STROBE feature is global, affecting all D/A modules installed in the H.TMS 1000.

Table 8. Values Written to STROBE

Function	Binary	Hex	Decimal
Strobe Enable	01000000	H40	64
Strobe Disable	10000000	H80	128
Issue Data	00000001	H01	1

AOM1 Module Calibration

The AOM modules should be calibrated whenever the range is changed. Because a considerable amount of programming is necessary, a program is presented in this manual as an aid in calibrating these modules. Program 1 is designed for the AOM1. Use the following procedure when calibrating this module.

1. Place the AOM module to be calibrated in slot 5. Set the output range as indicated in Table 9.
2. Enter the program into the computer.
3. Connect the DMM high input lead to the signal terminal of the channel being calibrated. Connect the DMM low lead to module ground. For maximum accuracy, connect the usual load resistance between the signal terminal and ground.
4. Run the program and follow its instructions. Refer to Figure 4 for adjustment locations. Make sure the output range of the module is set correctly. The program will prompt with the correct range switch settings.
5. Repeat the procedure as necessary with the remaining channels.

Table 9. AOM1 Output Range

Output Range	DIP Switches				
	1	2	3	4	5
0 to +5V	Closed	Open	Closed	Closed	Open
0 to +10V	Closed	Open	Open	Closed	Closed
±2.5V	Open	Closed	Closed	Closed	Open
±5V	Open	Closed	Open	Closed	Closed
±10V	Open	Closed	Open	Open	Closed

Program 1. AOM1 Calibration

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10 DEF SEG = &HCFF0:CLS
20 CA=&H88:CB=&H89:ST=&H9D
30 POKE ST, 64
40 PRINT "INSERT AOM1 INTO SLOT 5"
50 PRINT: INPUT "AOM1 CHANNEL (0-4)"; CH
60 IF CH<0 OR CH>4 THEN 50
70 PRINT: PRINT "CONNECT DMM TO CHANNEL"; CH
80 PRINT: PRINT "RANGE SWITCH POSITIONS"
90 PRINT" 1 2 3 4 5"
100 PRINT"1 0 TO +5V C O C C O"
110 PRINT"2 0 TO +10V C O O C C"
120 PRINT"3 +2.5V O C C C O"
130 PRINT"4 +5V O C O C C"
140 PRINT"5 +10V O C O O C"
150 PRINT: INPUT "RANGE (1-5)"; R
160 PRINT: IF R < 1 OR > 5 THEN 150
170 ON R GOSUB 300, 310, 320, 330, 340
180 POKE CA, 2*CH: POKE CB, 0
190 POKE CA, 2*CH + 1: POKE CB, 0
200 POKE ST, 1
210 PRINT: PRINT "ADJUST CHANNEL"; CH;"OFFSET FOR"; L$;"VOLT READING ON
    DMM"
220 INPUT "PRESS RETURN TO CONTINUE"; A$
230 POKE CA, 2*CH: POKE CB, 255
240 POKE CA, 2*CH + 1: POKE CB, 15
250 POKE ST, 1
260 PRINT: PRINT "ADJUST CHANNEL"; CH;"GAIN FOR"; H$;"VOLT READING ON
    DMM"
270 INPUT "PRESS RETURN TO CONTINUE"; A$
280 PRINT: INPUT"AGAIN"; A$
290 IF LEFT$(A$,1) = "Y" THEN 50
295 END
300 L$ ="0.000": H$ ="4.999": RETURN
310 L$ ="0.000": H$ ="9.996": RETURN
320 L$ ="-2.500": H$ ="2.500": RETURN
330 L$ ="-5.000": H$ ="4.996": RETURN
340 L$ ="-10.000": H$ ="9.992": RETURN

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Theory of Operation

The AOM1 schematic is located on drawing number 500-216.

The circuitry on the AOM1 module can be divided into three groups: D/A conversion circuitry for each channel, command development circuitry, and data buffering circuitry.

The primary components of the D/A conversion circuitry are complete, 12 bit D/A converters (AD567 JN) for each channel on the module. The converters contain precision voltage references, highspeed analog switches, two levels of data latching, and a precision resistor ladder. The D/A converters for channels 0-4 are designated U108-U112, respectively. Each AD567 converter is supplemented by a high-speed, high accuracy, output operational amplifier, U113-U117 for channels 0-4.

Two potentiometers calibrate the gain and offset of each D/A converter: potentiometers R106, R112, R118, R124 and R130 calibrate the gain for channels 0-4 respectively; potentiometers R102, R107, R114, R120 and R126 calibrate the offset for channels 0-4. Five five-switch DIP switches (S101-S105) set the output range for the five D/A converters.

Components U102-U107 comprise the command development circuitry. A quad transparent data latch, U104 (74LS75), stores the 4 bit command-select data (a number between 0 and 9). This latch is refreshed by a negative pulse of the D/A CONTROL command line (CMDA). CMDA is buffered and inverted by a hex inverter segment of U102 (74LS04). U105 a binary-to-decimal decoder (74LS42), generates 10 separate command lines based on the 4 bit binary word from U104. The 10 command lines are then gated by quad OR gate segments of U103, U106 and U107 (74LS32).

The 8 data lines are buffered by U101, a bus transceiver (74LS244), configured as a buffer.

AOM1 Specifications

Output channels: 5 (2 on the AOM1/2)

Output ranges: $\pm 2.5V$, $\pm 5V$, $\pm 10V$, 0 to $+5V$, 0 to $+10V$, switch selectable for each channel

Resolution: 12 bits, 1 part in 4096

Nonlinearity: $\pm 0.012\%$ of F.S. ($\pm 1/2$ lsb) max

Output impedance: 0.1Ω

Load characteristics: $5k\Omega$ min, $1000pf$ max short circuit protected

Slew rate: $15V/\mu sec$

Settling time: 5msec to 0.01% of full scale transition

Temperature coefficient:

Gain:

$0.0016\%/^{\circ}C$ of F.S., unipolar ranges

$0.0023\%/^{\circ}C$ of F.S.*, bipolar ranges

Offset:

$0.0006\%/^{\circ}C$ of F.S., unipolar ranges;

$0.0010\%/^{\circ}C$ of F.S.*, bipolar ranges

*Full scale for bipolar ranges is defined as $-V_{FS}$ to $+V_{FS}$

