INSTRUCTION MANUAL

SDM-AO4 Four Channel Analog Output Module

Revision: 7/07

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SDM-AO4 Table of Contents

PDF viewers note: These page numbers refer to the printed version of this document. Use the Adobe Acrobat® bookmarks tab for links to specific sections.

Figures

Tables

SDM-AO4 Four Channel Analog Output

1. Function

The SDM-AO4 is designed to output four continuous voltages at levels set by a Campbell Scientific datalogger.

2. Specifications

Power Requirements

Operating voltage:	12 VDC Nominal (9.6 V - 16 V)
Typical current drain:	10.5 mA

Physical Specification

Size:	6.1" X 2.7" X 1.1"
Weight:	0.9 lbs.

Analog Output

Range:	±5000 mV
Resolution	2.5 mV
Maximum Current	1 mA
Accuracy	± (0.5% of |Vout| +5 mV)
Minimum load (for above accuracy)	75, 000 ohms
Output Resistance[1]	200 Ohms

Temperature Range

-25 to +55 ^{o}C

[1] Output resistance can be viewed as a series resistance with the load the SDM-AO4 is driving. A low resistance load will cause appreciable error due to the voltage drop across the 200 ohm resistance. For example, the error (in addition to the accuracy specification above) with a 4800 ohm load = 200 / (4800 + 200) * Vout = 4 % of Vout

3. Power Supply

It is often convenient to power the SDM-AO4 from the datalogger power supply, but when doing so consideration must be given to the SDM-AO4's 10.5 mA continuous current drain. The alkaline supply available with the datalogger has 7.5 Amp-hours and will power one SDM-AO4 for less than one month. This supply is not recommended for continuous long-term operation. The rechargeable lead acid option, float charged by an AC supply or solar panel, may be used for long term operation.

The SDM-AO4 may also be powered from an external 12 Volt supply, independent from the datalogger supply. The low side of an external 12 Volt supply should be connected to datalogger ground and not directly earth grounded. Slight alterations in ground potential across the 21X terminal strip are created when the 21X 12 Volt supply is used to power peripherals. Therefore, low level voltage measurements (e.g., thermocouples, thermopiles, and radiometers) should be made differentially when powering the SDM-AO4 with the 21X 12 Volt output.

4. Physical Connections

Figure 1 shows the front panel of the SDM-AO4. The terminal block on the left is used for connection to the datalogger and the terminal block on the right provides the continuous analog output. The two ground ports on the left block are identical and at the same potential.

Table 1 describes the terminal block connections. Multiple SDM-AO4s may be utilized by connecting the datalogger side of one SDM-AO4 to the next. It is not recommended to connect more than six SDM-AO4s to one datalogger. The total cable length connecting the SDM-AO4 peripherals to the datalogger should not exceed twenty feet. Total cable lengths in excess of twenty feet may adversely influence communication performance.

With power supplied to an SDM-AO4 and before execution of the datalogger program, a random voltage between ±5 Volts will be output. To avoid outputting erroneous voltages to the receiving device, connect the SDM-AO4 to the datalogger, start the program, and then connect the receiving device.

CAUTION The order of connections is critical. ALWAYS CONNECT GROUND FIRST, followed by 12V and then the Control Ports.

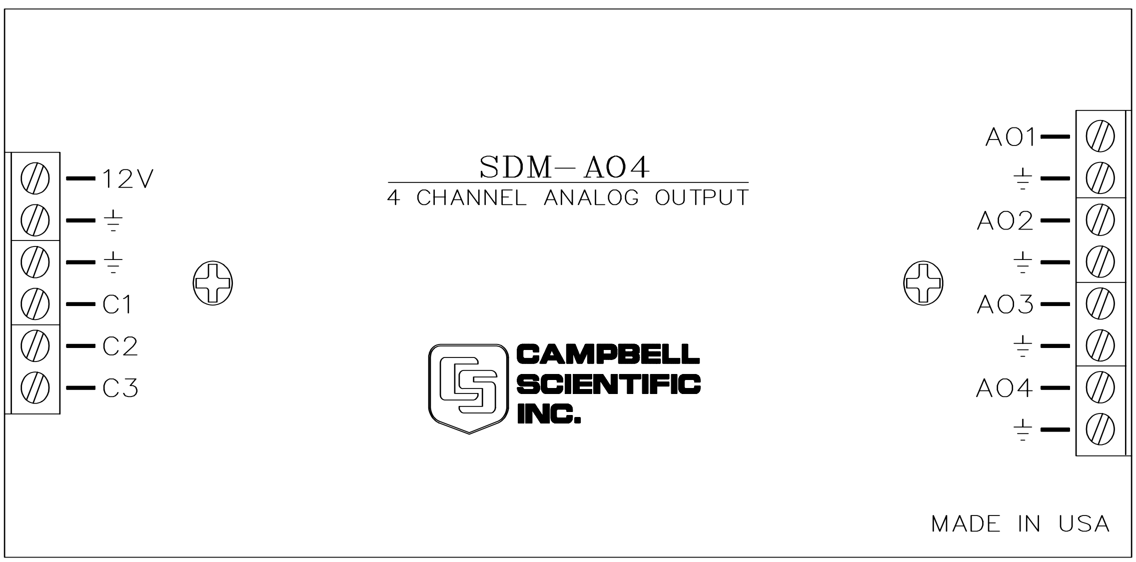

FIGURE 1. Front Panel of the SDM-AO4

TABLE 1. Description of Terminal Block Connections

Datalogger Connections	
12V	- 12 volt supply
	- ground
	- ground
SDM-C1 (CR3000, CR5000) or C1	- SDM control port #1
SDM-C2 (CR3000, CR5000) or C2	- SDM control port #2
SDM-C3 (CR3000, CR5000) or C3	- SDM control port #3
Analog Output Connections	
AO1	- analog output #1
	- ground
AO2	- analog output #2
	- ground
AO3	- analog output #3
	- ground
AO4	- analog output #4
	- ground

CAUTION The SDM-AO4 will not function correctly unless the case is fully assembled and the case screws are fully tightened.

5. Addressing

The SDM-AO4 is a synchronously addressed datalogger peripheral. Control Ports 1, 2, and 3, are used to address an SDM-AO4 and send out the digital millivolt readings for subsequent analog output. Addressing allows multiple SDM peripherals to be connected to one datalogger.

The SDM-AO4 has sixteen possible addresses, as shown in Table 2. The address for an SDM-AO4 is hardware selectable using jumpers at locations J12 and J8, as shown in Figure 2. The jumper at location J12 represents the least significant digit (LSD), and the jumper at location J8 is the most significant digit (MSD). The digit zero (0) is nearest the edge of the board, and the digit three (3) is the innermost jumper on the board. All SDM-AO4s are shipped with the address set at zero (00).

Table 2. SDM-AO4 Addressing

Base 10 [CRBasic Loggers]	Base 4 [CR10(X), CR21X, CR23X]	MSD J8	LSD J12
0	0	0	0
1	1	0	1
2	2	0	2
3	3	0	3
4	10	1	0
5	11	1	1
6	12	1	2
7	13	1	3
8	20	2	0
9	21	2	1
10	22	2	2
11	23	2	3
12	30	3	0
13	31	3	1
14	32	3	2
15	33	3	3

MSD = most significant digit   LSD = least significant digit

Multiple SDM-AO4s connected to one datalogger must have separate and sequentially increasing addresses.

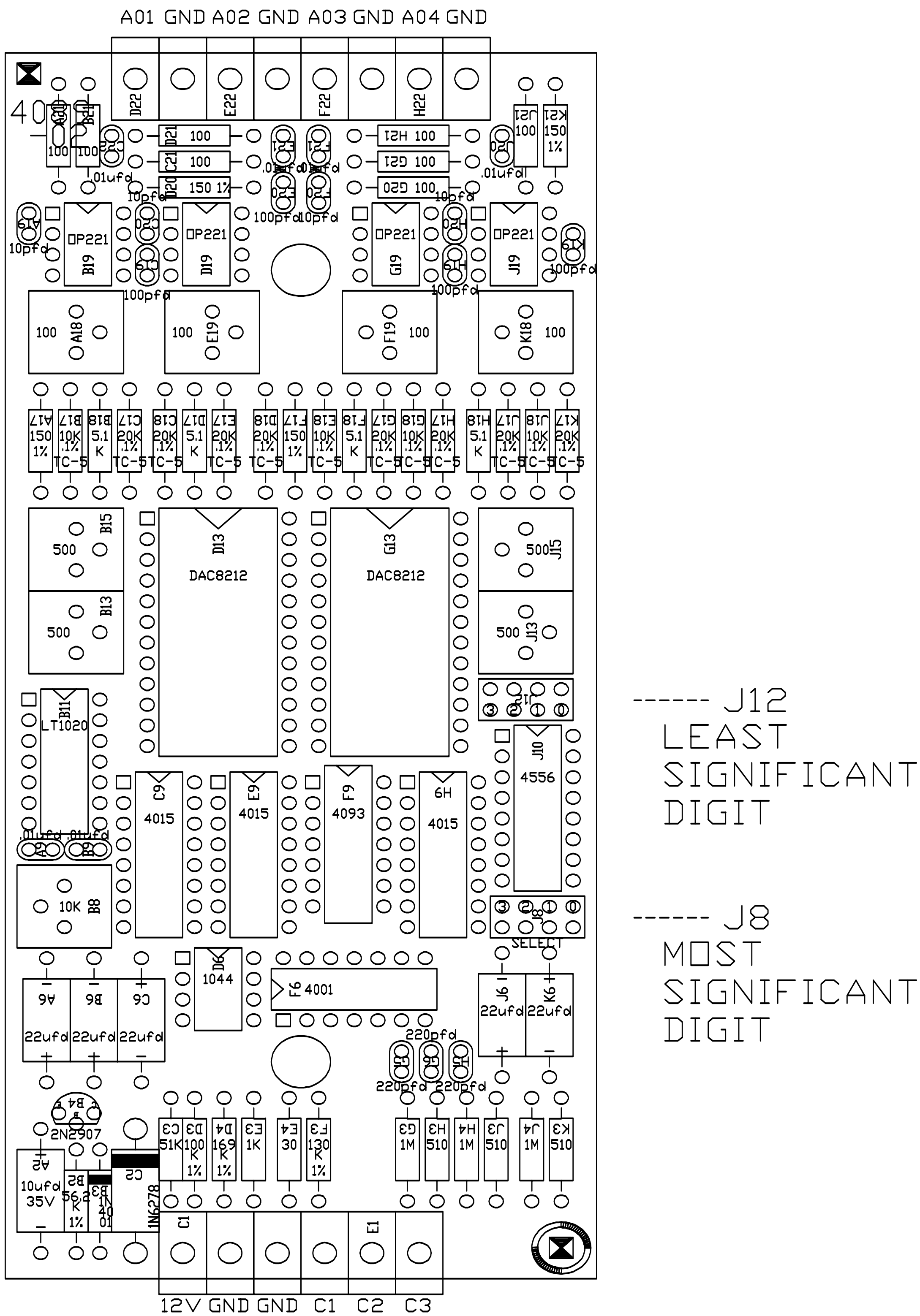

FIGURE 2. Locational Diagram for the Address Jumpers.

6. Programming

The datalogger programming instruction allows the user to set four separate voltage levels in one SDM-AO4, or move voltage levels with multiple SDM-AO4s. Voltage levels are reset each time the instruction is executed. The voltage range is ±5 Volts; voltage levels sent to the SDM-AO4 which are out of the range limits will appear as either + 5 Volts or - 5 Volts depending on whether it is overranged or underranged.

The CR10(X), CR21X, and CR23X are programmed with the SDM-AO4 Instruction 103 (See Table 3):

```
SDM-AO4 (P103)
   1:  1          Reps
   2:  00         SDM Address
   3:  0000       Loc [ _________ ]
```

The number of repetitions, Parameter 01, specifies the total number of SDM-AO4 output channels to be set. The address of the first SDM-AO4 is specified with Parameter 02, multiple SDM-AO4s must have consecutive addresses. Parameter 3 is the starting Input Location containing the first millivolt level to be output on the first channel of the first SDM-AO4. Subsequent millivolt levels must be contained in consecutive Input Locations immediately after the first Input Location specified in Parameter 3.

For example, two SDM-AO4s can be used to output eight voltage levels which are contained in Input Locations 15 through 22. There are eight repetitions, so eight (8) will be entered for Parameter 1. The SDM-AO4s must have consecutive addresses (e.g., 31 and 32), and Parameter 2 would contain 31 in this case. Fifteen (15) will be entered for Parameter 3.

TABLE 3. Description of Instruction 103

Par. No.	Data Type	Description
01:	2	Reps - Number of analog outputs.
02:	2	Address of SDM-AO4 in base 4 (00 to 33)
03:	4	Input Location containing millivolt output level
Execution Time: 1.0 ms + (0.8 ms) * R (R=Repetitions)		

CRBasic Dataloggers (CR5000, etc.) are programmed with the AO4 instruction:

AO4 (Source, Repetitions, SDM Address[Base 10])

The parameters function similarly to those in instruction 103. The source is the first element of a variable array that contains the millivolt values to output. Repetitions is the number of channels to set. The SDM address is the address of the SDM-AO4 (Base 10, see Table 2.)

Programming Examples

The following program example is given to help the user understand the general principles involved in the use of the SDM-AO4 with CSI dataloggers.

This program example is for a weather station with a CR10X Micrologger measuring wind speed, wind direction, temperature, and relative humidity. Each parameter is then scaled to 0 to 1000 mVDC, and output to a strip chart recorder through the SDM-AO4. Programming for the CR23X would be similar.

Example 1. CR10X Program Example

```
;{CR10X}
*Table 1 Program
  01: 1.0000        Execution Interval (seconds)

; Code for 03001 wind measurements, WS_ms & WindDir:

1:  Pulse (P3)
  1:  1             Reps
  2:  1             Pulse Channel 1
  3:  21            Low Level AC, Output Hz
  4:  1             Loc [ WS_ms     ]
  5:  0.75          Mult
  6:  0.2           Offset

2:  Excite-Delay (SE) (P4)
  1:  1             Reps
  2:  5             2500 mV Slow Range
  3:  1             SE Channel
  4:  1             Excite all reps w/Exchan 1
  5:  2             Delay (0.01 sec units)
  6:  2500          mV Excitation
  7:  2             Loc [ WD_0_360  ]
  8:  0.142         Mult
  9:  0             Offset

; Code for CS500 measurement, AirTC and RH:

3:  Volt (SE) (P1)
  1:  1             Reps
  2:  25            2500 mV 60 Hz Rejection Range
  3:  3             SE Channel
  4:  3             Loc [ Temp_C    ]
  5:  0.1           Mult
  6:  -40.0         Offset
```

```
4:  Volt (SE) (P1)
  1:   1            Reps
  2:   25           2500 mV 60 Hz Rejection Range
  3:   2            SE Channel
  4:   4            Loc [ RH      ]
  5:   0.1          Mult
  6:   0            Offset

; Output Data Every Minute

5:  If time is (P92)
  1:   0            Minutes (Seconds --) into a
  2:   1            Interval (same units as above)
  3:   10           Set Output Flag High (Flag 0)

6:  Set Active Storage Area (P80)            ;Set array ID to 101
  1:   1            Final Storage Area 1
  2:   101          Array ID

7:  Real Time (P77)                          ; Output Year, Day, Hour/Minute
  1:   1110         Year,Day,Hour/Minute (midnight = 0000)

8:  Wind Vector (P69)                        ; Output Average WS, WD, StdDev WD
  1:   1            Reps
  2:   0            Samples per Sub-Interval
  3:   0            S, theta(1), sigma(theta(1)) with polar sensor
  4:   1            Wind Speed/East Loc [ WS_ms     ]
  5:   2            Wind Direction/North Loc [ WD_0_360  ]

9:  Average (P71)                            ; Output Average Temperature
  1:   1            Reps
  2:   3            Loc [ Temp_C    ]

10:  Sample (P70)                            ; Sample RH
  1:   1            Reps
  2:   4            Loc [ RH      ]

; Routine to convert 0-360 deg. Direction to 0-540 deg.

11:  Do (P86)
  1:   21           Set Flag 1 Low

12:  If (X<=>F) (P89)                        ; Set Flag 1 if previous
  1:   9            X Loc [ WD_0_540  ]      ; reading was > 270
  2:   3            >=
  3:   270          F
  4:   11           Set Flag 1 High

13:  Z=X (P31)                               ; Set 0-540 value to current 0-360 reading
  1:   2            X Loc [ WD_0_360  ]
  2:   9            Z Loc [ WD_0_540  ]
```

```
14:  If (X<=>F) (P89)                                   ; If current reading is <180
  1:   9               X Loc [ WD_0_540  ]
  2:   4               <
  3:   180             F
  4:   30              Then Do

15:  If Flag/Port (P91)                                 ; And if previous reading
  1:   11              Do if Flag 1 is High             ; was > 270
  2:   30              Then Do

16:  Z=X+F (P34)                                        ; Add 360 to the current reading
  1:   9               X Loc [ WD_0_540  ]              ; otherwise, the current reading
  2:   360             F                                ; is left alone
  3:   9               Z Loc [ WD_0_540  ]

17:  End (P95)

18:  End (P95)

; Scale the measurements for the SDM-AO4 to output 0 to 1000 mV

19:  Z=X*F (P37)                                        ; Scale WS: 0-50 mps = 0-1000 mV
  1:   1               X Loc [ WS_ms     ]
  2:   20              F
  3:   5               Z Loc [ WSoutput  ]

20:  Z=X*F (P37)                                        ; Scale WD: 0-540 deg = 0-1000 mV
  1:   9               X Loc [ WD_0_540  ]
  2:   1.859           F
  3:   6               Z Loc [ WDoutput  ]

21:  Z=X+F (P34)                                        ; Scale Temperature: -40-60 deg C = 0-1000 mV
  1:   3               X Loc [ Temp_C    ]
  2:   40              F
  3:   7               Z Loc [ TempOut   ]

22:  Z=X*F (P37)
  1:   7               X Loc [ TempOut   ]
  2:   10              F
  3:   7               Z Loc [ TempOut   ]

23:  Z=X*F (P37)                                        ; Scale RH: 0-100 % RH = 0-1000 mV
  1:   4               X Loc [ RH        ]
  2:   10              F
  3:   8               Z Loc [ RHout     ]

; Send mV outputs to SDM-AO4

24:  SDM-AO4 (P103)
  1:   4               Reps
  2:   30              SDM Address
  3:   5               Loc [ WSoutput  ]

End Program
```

Example 2. CR5000 Program Example

```
'CR5000 SDM-AO4 Program Example

Public WS_ms
Public WD_0_360
Public Temp_C
Public RH
Public WD_0_540
Public Flag
Public AO4Output(4)

Alias AO4Output(1) = WSOut
Alias AO4Output(2) = WDOut
Alias AO4Output(3) = TempOut
Alias AO4Output(4) = RHOut

'Code for DataTable OneMin
DataTable(OneMin,1,-1)
    DataInterval(0,1,Min,0)
    WindVector (1, WS_ms,WD_0_360, IEEE4, 0, 0, 0, 0)
    Average(1,Temp_C,IEEE4,0)
    Sample(1,RH, IEEE4
EndTable

BeginProg
    Scan(1,Sec,1,0)
'       Code for 03001 wind measurements, WS_ms & WD_0_360:
        PulseCount(WS_ms, 1, 1, 1, 1, 0.75, 0.2)
        BrHalf(WD_0_360, 1, mV1000, 1, 1, 1, 1000, True, 1000, 250, 355, 0)
'       Code for CS500 measurement, AirTC and RH:
        VoltSE(Temp_C,1,mV5000,3,0, 0, _60Hz,0.1,-40.0)
        VoltSE(RH,1,mV5000,2,0, 0, _60Hz,0.1, 0)
'       Call Data Table
        CallTable(OneMin)

'       Convert 0-360 WD to 0-540:
        If WD_0_540 >= 270 and WD_0_360 <180 Then
            WD_0_540 = WD_0_360 + 360
        Else
            WD_0_540 = WD_0_360
        EndIf

'       Scale the measurements for the SDM-AO4 to output 0-1000 mV
        WSOut = WS_ms*20              'WS: 0-50 m/s = 0-1000 mV
        WDOut = WD_0_540 *1.859       'WD: 0-540 deg = 0-1000mV
        TempOut= 10*(Temp_C+40)       'Temp: -40-60 deg C = 0-1000 mV
        RHOut = RH *10                'RH: 0-100 % RH = 0-1000 mV
'       Send mV outputs to SDM-SIO4
        AO4 (AO4Output(),4,12)
    NextScan
EndProg
```

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