

***SDM-AO4A
Four Channel
Analogue Output Module***

User Guide

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Campbell Scientific Ltd,
Campbell Park, 80 Hathern Road,
Shepshed, Loughborough, LE12 9GX, UK
Tel: +44 (0) 1509 601141
Fax: +44 (0) 1509 601091
Email: support@campbellsci.co.uk
www.campbellsci.co.uk

PLEASE READ FIRST

About this manual

Please note that this manual was originally produced by Campbell Scientific Inc. primarily for the North American market. Some spellings, weights and measures may reflect this origin.

Some useful conversion factors:

Area:	1 in ² (square inch) = 645 mm ²	Mass:	1 oz. (ounce) = 28.35 g 1 lb (pound weight) = 0.454 kg
Length:	1 in. (inch) = 25.4 mm 1 ft (foot) = 304.8 mm 1 yard = 0.914 m 1 mile = 1.609 km	Pressure:	1 psi (lb/in ²) = 68.95 mb
		Volume:	1 UK pint = 568.3 ml 1 UK gallon = 4.546 litres 1 US gallon = 3.785 litres

In addition, while most of the information in the manual is correct for all countries, certain information is specific to the North American market and so may not be applicable to European users.

Differences include the U.S standard external power supply details where some information (for example the AC transformer input voltage) will not be applicable for British/European use. *Please note, however, that when a power supply adapter is ordered it will be suitable for use in your country.*

Reference to some radio transmitters, digital cell phones and aerials may also not be applicable according to your locality.

Some brackets, shields and enclosure options, including wiring, are not sold as standard items in the European market; in some cases alternatives are offered. Details of the alternatives will be covered in separate manuals.

Part numbers prefixed with a “#” symbol are special order parts for use with non-EU variants or for special installations. Please quote the full part number with the # when ordering.

Recycling information



At the end of this product's life it should not be put in commercial or domestic refuse but sent for recycling. Any batteries contained within the product or used during the products life should be removed from the product and also be sent to an appropriate recycling facility.

Campbell Scientific Ltd can advise on the recycling of the equipment and in some cases arrange collection and the correct disposal of it, although charges may apply for some items or territories.

For further advice or support, please contact Campbell Scientific Ltd, or your local agent.



Campbell Scientific Ltd, Campbell Park, 80 Hathern Road, Shepshed, Loughborough, LE12 9GX, UK
Tel: +44 (0) 1509 601141 Fax: +44 (0) 1509 601091
Email: support@campbellsci.co.uk
www.campbellsci.co.uk

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SDM-AO4A Four Channel Analogue Output

1. Function

The SDM-AO4A is designed to output four continuous voltages at levels set by a Campbell Scientific datalogger.

The SDM-AO4A is a replacement for the SDM-AO4. However, the SDM-AO4A offers several new features including a 0-10 V Mode, a choice of synchronous or sequential operation, and SDM signature checking. In addition, the SDM-AO4A has higher resolution, improved accuracy, and high drive current for sensor excitation.

2. Specifications

	± 5 V mode	10 V mode
V_{supply}	12 V Nominal (9.6 to 16 V)	
I_q (no load, V_{out} = 0, V_{supply} = 12 V)	11 mA typical	21 mA typical
I_q (no load, V_{out} = Fullscale, V_{supply} = 12 V)	13 mA typical	28 mA typical
I_q (w/ load, V_{supply} = 12 V)	13 mA + load typical	28 mA + 2.4*load typical
I_q (power down mode, V_{supply} = 12 V)	1.1 mA typical	
Range	± 5 V	0-10 V
Resolution	167 μV	
Accuracy @ 25°C (20 kOhm load)	± (0.05% of V _{out} (V) + 500 μV) max	
Accuracy @ -40° to 60°C (20 kOhm load)	± (0.1% of V _{out} (V) + 500 μV) max	
Additional Fullscale Error w/ 50 mA load	-1.3 mV typical	-1.5 mV typical
Max I_{out} per Channel	50 mA	
Max I_{out} Total	100 mA	
Overcurrent shutdown point	130 ± 15 mA	
Size	13.46 x 8.51 x 2.41 cm (5.3" x 3.35" x 0.95")	
Weight	175 grams (6.2 oz)	
Operating Temperature Range	-40° to +60°C	

3. Power Supply

It is often convenient to power the SDM-AO4A from the datalogger power supply, but when doing so consideration must be given to the SDM-AO4A's continuous current drain (the current drain is 11 mA in $\pm 5V$ mode and 21 mA in 10V mode). The alkaline supply available with the datalogger has 7.5 Amp-hours and will power one SDM-AO4A 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-AO4A 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 a 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-AO4A with a 21X 12 Volt output.

4. Physical Connections

Figure 1 shows the front panel of the SDM-AO4A. The terminal block on the left is used for connection to the datalogger and the terminal block on the right provides the continuous analogue output. The two ground ports on the left block are identical and connected internally.

Table 1 describes the terminal block connections. Multiple SDM-AO4As may be used by connecting the datalogger side of one SDM-AO4A to the next.

The CABLE5CBL-L or similar cable is used to connect the module to the datalogger. A 1-ft cable length should be sufficient when both datalogger and module are housed within an ENC12/14 enclosure; a 2-ft length may be required if the datalogger and SDM-AO4A are housed at opposite ends of an ENC16/18 enclosure.

CRBasic dataloggers should use the SDMSpeed instruction if the cable length is longer than 20 feet (see Section 7.1.2). The maximum recommended cable length for the CR7 is 600 ft. For other Edlog dataloggers, the maximum recommended cable length is 20 feet.

CAUTION

Cables connecting the terminals of the datalogger and SDM device should be as short as possible to minimize the risk of corruption of the signal and damage from induced surges.

When first powered up, the device is in low-power mode until the first valid SDM instruction is received. In this mode, outputs are pulled to GND.

CAUTION

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

Shielded twisted pair cabling is recommended for wiring the continuous analogue outputs.



Figure 1. Front Panel of the SDM-AO4A

Table 1. Description of Terminal Block Connections	
SDM-AO4A to Datalogger Connections	
12V	- 12 volt supply
G	- ground
G	- ground
C1	SDM-C1 (CR3000, CR5000) or C1
C2	SDM-C2 (CR3000, CR5000) or C2
C3	SDM-C3 (CR3000, CR5000) or C3
SDM-AO4A to Analogue Output Connections	
1	- analogue output #1
⏏	- ground
2	- analogue output #2
⏏	- ground
3	- analogue output #3
⏏	- ground
4	- analogue output #4
⏏	- ground

5. Addressing

The SDM-AO4A is a synchronously addressed datalogger peripheral. Control Ports 1, 2, and 3, are used to address an SDM-AO4A and send out the digital millivolt settings for subsequent analogue output. Addressing allows multiple SDM peripherals to be connected to one datalogger.

The SDM-AO4A has sixteen possible addresses, as shown in Table 2. The address is hardware selectable using the rotary switch on the SDM-AO4A. All SDM-AO4As are shipped with the address set at zero.

Table 2. SDM-AO4A Addressing		
Base 10 [CRBasic Loggers]	Base 4 [CR10(X), 21X, CR23X]	Rotary Switch
0	0	0
1	1	1
2	2	2
3	3	3
4	10	4
5	11	5
6	12	6
7	13	7
8	20	8
9	21	9
10	22	A
11	23	B
12	30	C
13	31	D
14	32	E
15	33	F

6. Operational Modes

The SDM-AO4A can be operated in ± 5 V mode or 10 V mode. In each of these modes, the SDM-AO4A can operate synchronously or sequentially.

In synchronous mode, all channels are set at the same time. This mode is slower since for large changes in voltage it may take multiple charging cycles to arrive at the final voltage. The steps occur at 5 ms intervals, thus, for a 10V step in output voltage it may take up to three charge cycles (or 15 ms) to settle to the 16-bit level. For most slowly changing signals, it will settle in a single charge cycle.

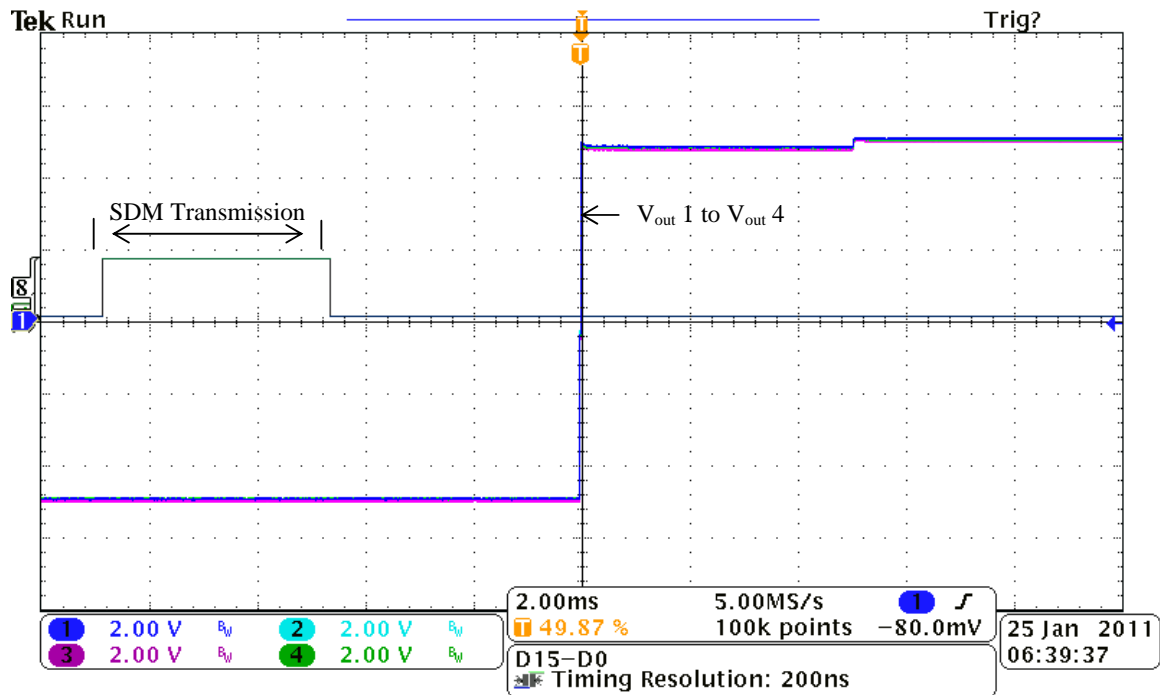


Figure 2. Synchronous Mode

In sequential mode, the channels are set sequentially. The output signal can take from 600 μ s to 1 ms (worst case) to settle to 16-bit resolution with a 10V step change. The four outputs then update 1 ms apart.

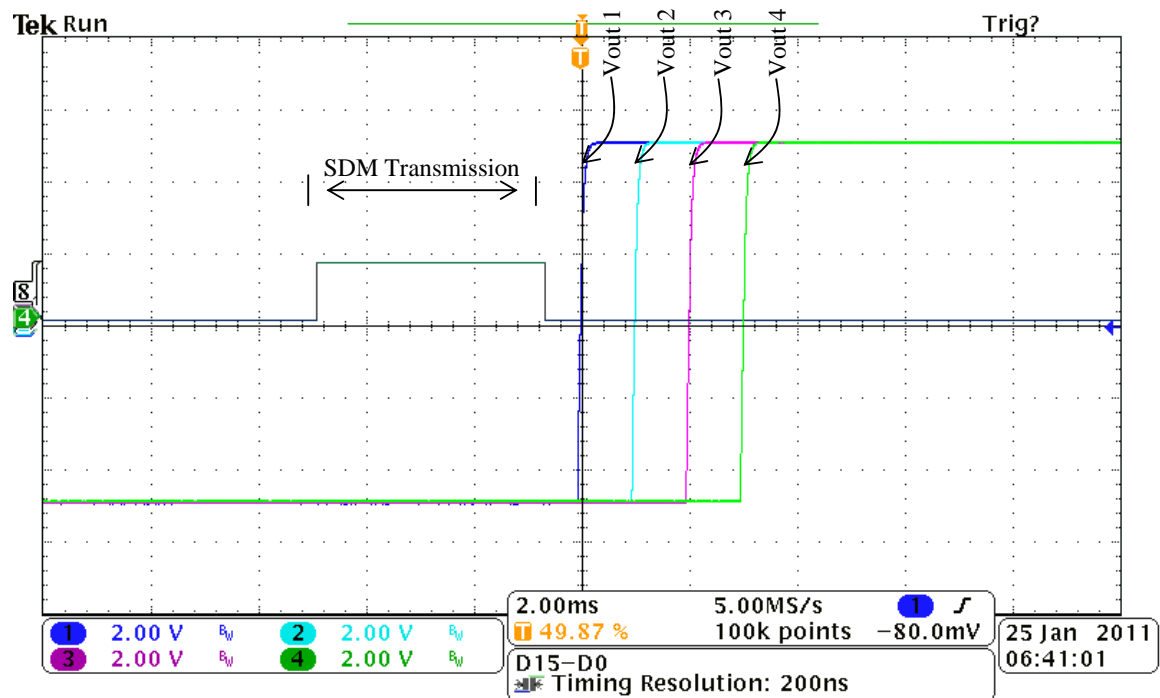


Figure 3. Sequential Mode

7. Programming

The datalogger is programmed using either CRBasic or Edlog. Dataloggers that use CRBasic include our CR800, CR850, CR1000, CR3000, and CR5000. Dataloggers that use Edlog include our CR7, CR10X, CR10, CR23X, and 21X. Both CRBasic and Edlog are included in PC400 and LoggerNet datalogger support software.

In both CRBasic and Edlog, the datalogger programming instruction allows the user to set four separate voltage levels in one SDM-AO4A, or more voltage levels with multiple SDM-AO4As. Voltage levels are reset each time the instruction is executed.

NOTE	This section describes how to write an SDM-AO4A program using CRBasic or Edlog. An SDM-AO4A program can also be generated using Campbell Scientific's Short Cut Program Generator.
-------------	--

7.1 CRBasic

7.1.1 SDMAO4A Instruction

The SDMAO4A instruction is used to set the voltage to an SDM-AO4A.

NOTE	The SDM-AO4A is backwards compatible with the SDMAO4 CRBasic instruction. Therefore, programs written using the SDMAO4 instruction will work with an SDM-AO4A but will not take advantage of any of the SDM-AO4A's additional features. If the older instruction is used, the device will use the default option code 1.
-------------	--

The SDMAO4A instruction has the following syntax:

SDMAO4A (Source, SDMAO4ADest, SDMAAddress, SDMAO4AStartChan, Reps, SDMAO4AOption)

The SDMAO4A instruction has the following parameters:

Source: The Source parameter is the variable or variable array that holds the voltage(s), in millivolts, that will be sent to the SDM-AO4A(s). If multiple SDM-AO4As are to be triggered with one instruction, this parameter must be dimensioned to the total number of channels for all the devices being set (e.g., if all four channels are being set on two SDM-AO4 devices, Source must be dimensioned to eight).

SDMAO4ADest: The SDMAO4ADest parameter is a variable that holds a status code indicating success or failure of the instruction.

Response Code	Description
240	Successful
241	Signature error
242	Current overload error
243	Current overload and signature error

A current overload error occurs when current overload protection is triggered (130 mA, +/- 15 mA). A signature error usually indicates noise on the line. Any other response code returned indicates failed communication.

SDMAAddress: The SDMAAddress parameter defines the address of the first SDM-AO4A to which a voltage should be applied. Valid SDM addresses are 0 through 14. Address 15 is reserved for the SDMTrigger instruction.

SDMAO4AStartChan: The SDMAO4AStartChan parameter is used to define the first channel on the SDMAO4A that should be set. Any reps will occur on subsequent channels.

Reps: The Reps parameter determines the number of SDM-AO4A output channels that will be set. If this parameter is greater than four (i.e., voltage is being set for more than one SDM-AO4 device), voltage is set on the next consecutively addressed SDM-AO4A device. In this case, the SDM-AO4As must have sequential SDM addresses.

SDMAO4AOption: The SDMAO4AOption parameter is used to set the operating mode for the SDMAO4A.

Option Code	Description
0	Power down
1	5V synchronous
2	5V sequential
3	10V synchronous
4	10V sequential

In the synchronous mode, all channels are set at the same time. This mode is slower since for large changes in voltage it may take multiple charging cycles to arrive at the final voltage. The steps occur at 5 ms intervals, thus, for a 10V step it may take up to three charge cycles (or 15 ms) to settle to the 16-bit level.

In sequential mode, the channels are set sequentially. The output signal can take from 600 usecs to 1 ms (worst case) to settle to 16-bit resolution with a 10V step change. The four outputs then update 1 ms apart.

7.1.2 SDMSpeed Instruction

The SDMSpeed instruction is used to change the bit period that the datalogger uses to clock the SDM data. Slowing down the clock rate may be necessary when long cable lengths are used to connect the datalogger and SDM devices.

The syntax of this instruction is as follows:

SDMSpeed ([BitPeriod](#))

The BitPeriod argument can be an integer or a variable. If the SDMSpeed instruction is not in the program, a default bit period is used. If 0 is used for the argument, the minimum allowable bit period is used. Table 3 shows the default, minimum allowable, and maximum bit period for each of our CRBasic dataloggers.

Table 3. Bit Period Values			
Datalogger	Default Bit Period	Minimum Allowable Bit Period	Maximum Bit Period
CR800, CR850	26.04 μ sec	8.68 μ sec	2.2 msec
CR1000	26.04 μ sec	8.68 μ sec	2.2 msec
CR3000	26.04 μ sec	8.68 μ sec	2.2 msec
CR5000	30 μ sec	8 μ sec	3 msec

The equation used to calculate the bit rate depends on the datalogger used. The datalogger will round down to the next faster bit rate.

Equation for CR800, CR850, and CR1000:

$$\text{bit_rate} = \text{INT}((k * 72) / 625) * \text{Resolution}$$

Where:

k= the value entered in BitPeriod

Resolution=8.68 microseconds

Equation for CR3000:

$$\text{bit_rate} = \text{INT}((k * 144) / 625) * \text{Resolution}$$

Where:

k= the value entered in BitPeriod

Resolution= 4.34 μ sec.

Equation for CR5000:

$$\text{bit_rate} = \text{INT}(k * 20) * \text{Resolution}$$

Where:

k= the value entered in BitPeriod

Resolution=50 nsec.

7.2 Edlog

The Edlog dataloggers are programmed with the SDM-AO4 Instruction 103 (See Table 4):

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-AO4A output channels to be set. The address of the first SDM-AO4A is specified with Parameter 02, multiple SDM-AO4As 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-AO4A.

Subsequent millivolt levels must be contained in consecutive Input Locations immediately after the first Input Location specified in Parameter 3.

For example, two SDM-AO4As 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-AO4As 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 4. Description of Instruction 103

Par. No.	Data Type	Description
01:	2	Reps - Number of analogue outputs.
02:	2	Address of SDM-AO4A in base 4 (00 to 33)
03:	4	Input Location containing millivolt output level
Execution Time: $1.0 \text{ ms} + (0.8 \text{ ms}) * R$ (R=Repetitions)		

NOTE

Edlog dataloggers are programmed using the SDM-AO4 instruction, and are not able to take advantage of the additional features of the SDM-AO4A.

7.3 Programming Examples

The following program examples are given to help the user understand the general principles involved in the use of the SDM-AO4A with CSI dataloggers.

Both of the example programs are for weather stations with a datalogger 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-AO4A.

7.3.1 CR5000 Program Example

Although this program is for a CR5000 datalogger, programming for other CRBasic dataloggers is similar.

```
'CR5000 SDM-AO4A Program Example

Public WS_ms
Public WD_0_360
Public Temp_C
Public RH
Public WD_0_540
Public Flag
Public AO4AOutput(4)
Public AO4AReponse

Alias AO4AOutput(1) = WSOOut
Alias AO4AOutput(2) = WDOOut
Alias AO4AOutput(3) = TempOut
Alias AO4AOutput(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-AO4A to output 0-1000 mV
    WSOOut = WS_ms*20      'WS: 0-50 m/s = 0-1000 mV
    WDOOut = 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-AO4A at SDM Address 12 (Rotary Switch at C)
    SDMAO4A (AO4AOutput(),AO4AReponse,12,1,4,1)
  NextScan
EndProg
```

7.3.2 CR10X Program Example

Although this program is for a CR10X, programming for other Edlog dataloggers is similar.

```

;{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-AO4A 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-AO4A at SDM Address 30 (Rotary Switch at C)

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

End Program
```

CAMPBELL SCIENTIFIC COMPANIES

Campbell Scientific, Inc. (CSI)

815 West 1800 North
Logan, Utah 84321
UNITED STATES

www.campbellsci.com • info@campbellsci.com

Campbell Scientific Africa Pty. Ltd. (CSAf)

PO Box 2450
Somerset West 7129
SOUTH AFRICA

www.csafrica.co.za • sales@csafrica.co.za

Campbell Scientific Australia Pty. Ltd. (CSA)

PO Box 444
Thuringowa Central
QLD 4812 AUSTRALIA

www.campbellsci.com.au • info@campbellsci.com.au

Campbell Scientific do Brazil Ltda. (CSB)

Rua Luisa Crapsi Orsi, 15 Butantã
CEP: 005543-000 São Paulo SP BRAZIL

www.campbellsci.com.br • suporte@campbellsci.com.br

Campbell Scientific Canada Corp. (CSC)

11564 - 149th Street NW
Edmonton, Alberta T5M 1W7
CANADA

www.campbellsci.ca • dataloggers@campbellsci.ca

Campbell Scientific Centro Caribe S.A. (CSCC)

300N Cementerio, Edificio Breller
Santo Domingo, Heredia 40305
COSTA RICA

www.campbellsci.cc • info@campbellsci.cc

Campbell Scientific Ltd. (CSL)

Campbell Park
80 Hathern Road
Shepshed, Loughborough LE12 9GX
UNITED KINGDOM

www.campbellsci.co.uk • sales@campbellsci.co.uk

Campbell Scientific Ltd. (France)

3 Avenue de la Division Leclerc
92160 ANTONY
FRANCE

www.campbellsci.fr • info@campbellsci.fr

Campbell Scientific Spain, S. L.

Avda. Pompeu Fabra 7-9
Local 1 - 08024 BARCELONA
SPAIN

www.campbellsci.es • info@campbellsci.es

Campbell Scientific Ltd. (Germany)

Fahrenheitstrasse13, D-28359 Bremen
GERMANY

www.campbellsci.de • info@campbellsci.de

Please visit www.campbellsci.com to obtain contact information for your local US or International representative.