Product Manual

Measurement & Control Peripheral

SDM-AO4A

Four-Channel Analog Output Module

Revision: 01/2021

RELIABLE SINCE 1974 MONITORING

CAMPBELL SCIENTIFIC

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SDM-AO4A Four-Channel Analog Output

1. Introduction

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

NOTE For Edlog and other retired data logger support, view an older version of this manual at *www.campbellsci.com/old-manuals*.

2. Specifications

	± 5 V mode	10 V mode
Vsupply	12 V Nominal (9.6 to 16 V)	
Iq (no load, Vout = 0, Vsupply = 12 V)	11 mA typical	21 mA typical
Iq (no load, Vout = Fullscale, Vsupply = 12 V)	13 mA typical	28 mA typical
Iq (w/ load, Vsupply = 12 V)	13 mA + load typical	28 mA + 2.4 × load typical
Iq (power down mode, Vsupply = 12 V)	1.1 mA typical	
Range	± 5 V	0-10 V
Resolution	167 µV	
Accuracy @ 25°C (20 kOhm load)	± (0.05% of |Vout(V)| + 500 µV) max	
Accuracy @ -40° to 60°C (20 kOhm load)	± (0.1% of |Vout(V)| + 500 µV) max	
Additional Fullscale Error w/ 50 mA load	–1.3 mV typical	–1.5 mV typical
Max Iout per Channel	50 mA	
Max Iout Total	100 mA	
Overcurrent shutdown point	130 ± 15 mA	
Size	13.46 × 8.51 × 2.41 cm (5.3 × 3.35 × 0.95 in)	
Weight	175 g (6.2 oz)	
Operating Temperature Range	–40 to 60 °C	

View EU declaration of conformity at: *www.campbellsci.com/sdm-ao4a*.

3. Power Supply

The data logger power supply is typically used to power the SDM-AO4A. Use a rechargeable lead-acid battery, float charged by AC power or a solar panel, for long-term operation. The PS150 and PS200 power supplies are ideal for this application. The BPALK alkaline battery pack is rated at 7 amp-hours and will power one SDM-AO4A for less than one month. This supply is not recommended for continuous long-term operation.

The SDM-AO4A may also be powered from an external 12 Volt supply, independent from the data logger supply. The low side of an external 12 Volt supply should be connected to data logger ground and not directly earth grounded.

4. Physical Connections

FIGURE 4-1 *(p. 3)* shows the front panel of the SDM-AO4A. The terminal block on the left is used for connection to the data logger and the terminal block on the right provides the continuous analog output. The two ground ports on the left block are identical and connected internally.

TABLE 4-1 *(p. 3)* describes the terminal block connections. Multiple SDM-AO4As may be used by connecting the data logger side of one SDM-AO4A to the next as long as each SDM-AO4A is set to a unique address.

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

CRBasic data loggers should use the **SDMSpeed()** instruction if the cable length is longer than 20 feet (see Section 7.1.2, *SDMSpeed() Instruction* *(p. 8)*).

CAUTION Cables connecting the terminals of the data logger and SDM device must 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 analog outputs.

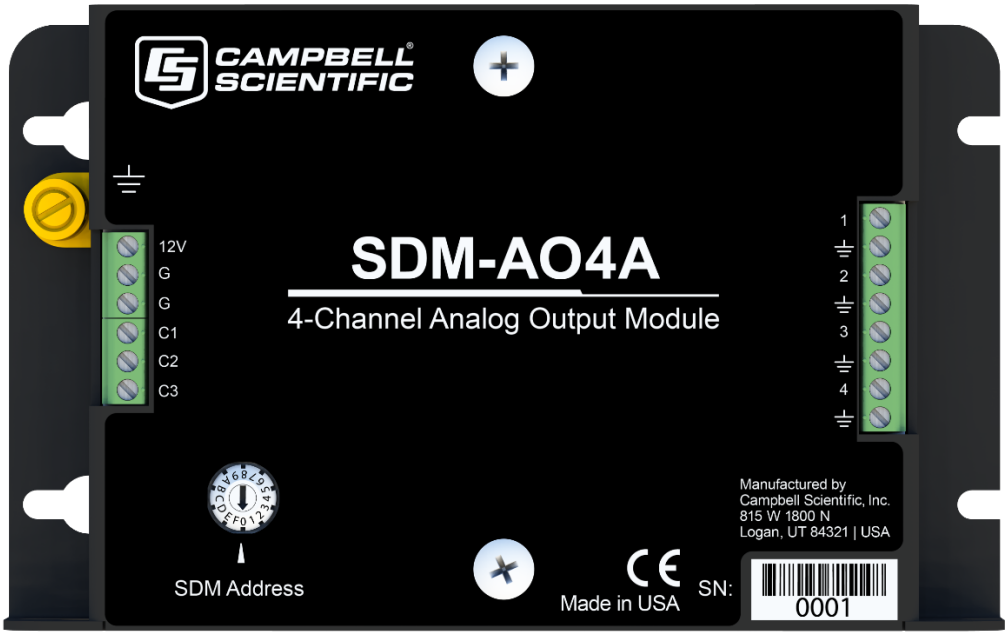

FIGURE 4-1. Front Panel of the SDM-AO4A

TABLE 4-1. Description of Terminal Block Connections	
SDM-AO4A to Data Logger Connections	
12V	- 12 volt supply
G	- ground
G	- ground
C1	C1 (SDM-C1 on CR3000)[1]
C2	C2 (SDM-C2 on CR3000)[1]
C3	C3 (SDM-C3 on CR3000)[1]
SDM-AO4A to Analog Output Connections	
1	- analog output #1
⏚	- ground
2	- analog output #2
⏚	- ground
3	- analog output #3
⏚	- ground
4	- analog output #4
⏚	- ground
[1]The CR3000 has a dedicated SDM port with three terminals.	

5. Addressing

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

The SDM-AO4A has sixteen possible addresses, as shown in TABLE 5-1. The address is hardware selectable using the rotary switch on the SDM-AO4A. All SDM-AO4As are shipped with the address set at zero. Address 15 (switch setting F) is reserved for the **SDMTrigger()** instruction.

TABLE 5-1. SDM-AO4A Addressing

Address	Rotary Switch
0	0
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9
10	A
11	B
12	C
13	D
14	E
15 (reserved)	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.

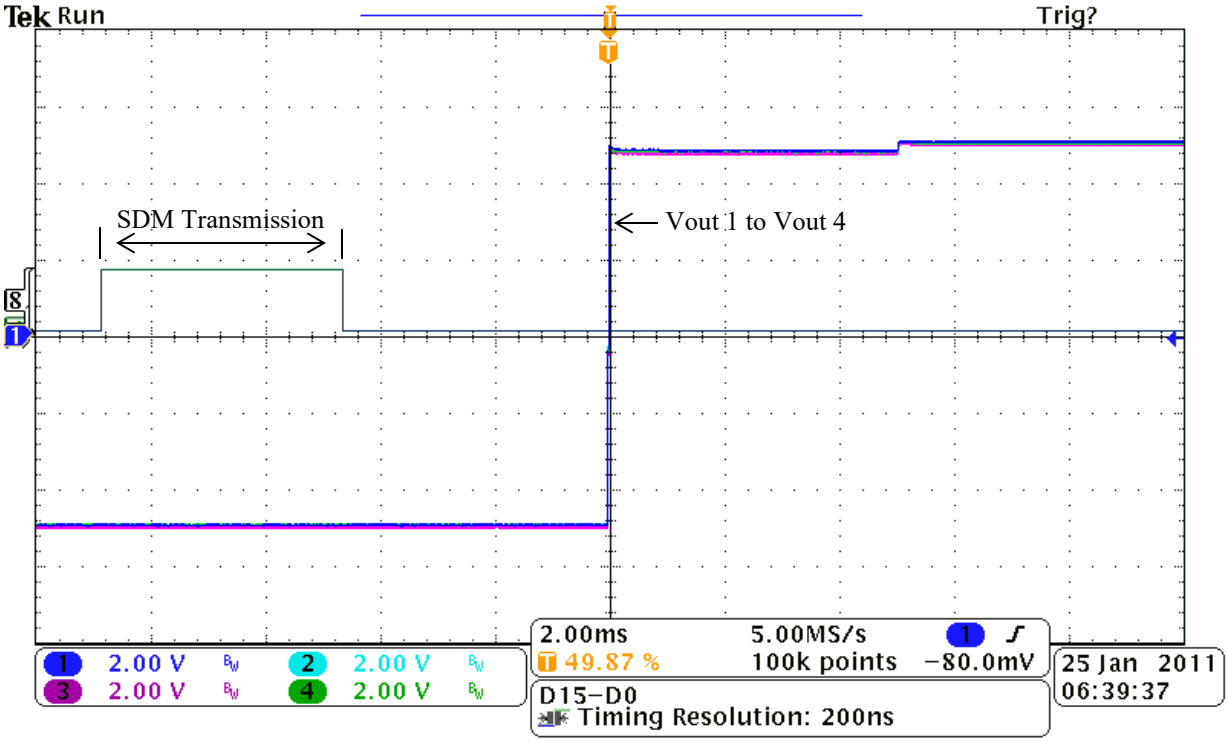

FIGURE 6-1. Synchronous Mode

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

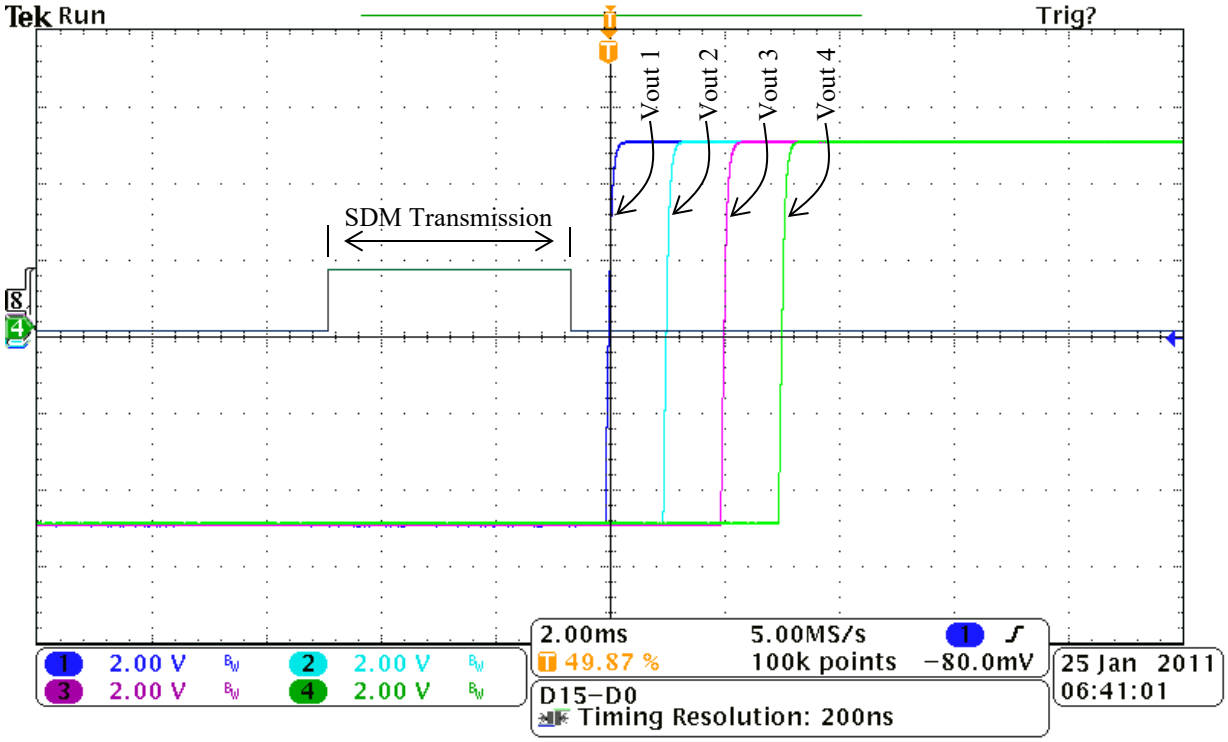

FIGURE 6-2. Sequential Mode

7. Programming

Compatible CRBasic data loggers are programmed to use the SDM-AO4A with the *CRBasic Editor* or *Short Cut*, included with *PC400* and *LoggerNet*.

In CRBasic, the **SDMAO4A()** 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. 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, SDMAddress, 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.

SDMAddress: The SDMAddress 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 SDMAO4StartChan 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 data logger uses to clock the SDM data. Slowing down the clock rate may be necessary when long cable lengths are used to connect the data logger 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 7-1 shows the default, minimum allowable, and maximum bit period for each of our CRBasic data loggers.

TABLE 7-1. Bit Period Values

Data Logger	Default Bit Period	Minimum Allowable Bit Period	Maximum Bit Period
CR6, CR1000X	28.8 µsec	10 µsec	1 msec
CR3000	26.04 µsec	8.68 µsec	2.2 msec
CR800, CR850	26.04 µsec	8.68 µsec	2.2 msec
CR1000	26.04 µsec	8.68 µsec	2.2 msec

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

Equation for CR800 series and CR1000:

$$bit\_rate = INT((k \times 72)/625) \times Resolution$$

Where:
k = the value entered in BitPeriod

Resolution = 8.68 microseconds

Equation for CR6, CR3000, CR1000X:

$$bit\_rate = INT((k \times 144)/625) \times Resolution$$

Where:
k = the value entered in BitPeriod
Resolution = 4.34 µsec

7.2 Programming Example

The following program example is given to help the user understand the general principles involved in the use of the SDM-AO4A with Campell Scientific data loggers.

This example program is for weather stations with a data logger 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.

7.2.1 CR1000X Program Example

Although this program is for a CR1000X data logger, programming for other CRBasic data loggers is similar.

CRBasic Exampe 7-1. CR1000X SDM-AO4A Program Example

```
'CR1000X SDM-AO4A Program Example
'Measure wind speed, wind direction, temperature, and humidity.
'Scale measurements to 0 to 1000 mV range and output to a strip chart recorder
'through the SDM-AO4A.

'Declare variables
'Example wind variables WS_ms and WD_0_360
Public WS_ms
Public WD_0_360
Public WD_0_540
'Example temperature and relative humidity variables
Public Temp_C
Public RH
'Example SDM-AO4A variables
Public AO4AOutput(4)
Public AO4AResponse
Alias AO4AOutput(1) = WSOut
Alias AO4AOutput(2) = WDOut
Alias AO4AOutput(3) = TempOut
Alias AO4AOutput(4) = RHOut

'Wiring
'Data logger to SDM-AO4A
'G- G
```

```
'12V- 12V
'C1- C1
'C2- C2
'C3- C3

'SDM-AO4A output
'Strip chart recorder #1- 1 and ground
'Strip chart recorder #2- 2 and ground
'Strip chart recorder #3- 3 and ground
'Strip chart recorder #4- 4 and ground

'Define OneMin DataTable
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 wind measurements, WS_ms & WD_0_360:
    PulseCount(WS_ms, 1,P1, 1, 1, 0.75, 0.2)
    BrHalf(WD_0_360, 1,mV1000, 1,Vx1, 1, 1000, True, 1000,60, 355, 0)
    ' Code for temperature/humidity measurements, Temp_C and RH:
    VoltSe(Temp_C,1,mV5000,2,0, 0, _60Hz,0.1,-40.0)
    VoltSe(RH,1,mV5000,3,0, 0, _60Hz,0.1, 0)
    'Call Data Table
    CallTable(OneMin)
    'Convert 0-360 WD to 0-540 for strip chart use:
    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
    WSOut = WS_ms*20 'WS: 0-50 m/s = 0-1000 mV
    WDOut = WD_0_540 *1.852 '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(),AO4AResponse,12,1,4,1)
  NextScan
EndProg
```

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DANGER — MANY HAZARDS ARE ASSOCIATED WITH INSTALLING, USING, MAINTAINING, AND WORKING ON OR AROUND **TRIPODS, TOWERS, AND ANY ATTACHMENTS TO TRIPODS AND TOWERS SUCH AS SENSORS, CROSSARMS, ENCLOSURES, ANTENNAS, ETC**. FAILURE TO PROPERLY AND COMPLETELY ASSEMBLE, INSTALL, OPERATE, USE, AND MAINTAIN TRIPODS, TOWERS, AND ATTACHMENTS, AND FAILURE TO HEED WARNINGS, INCREASES THE RISK OF DEATH, ACCIDENT, SERIOUS INJURY, PROPERTY DAMAGE, AND PRODUCT FAILURE. TAKE ALL REASONABLE PRECAUTIONS TO AVOID THESE HAZARDS. CHECK WITH YOUR ORGANIZATION'S SAFETY COORDINATOR (OR POLICY) FOR PROCEDURES AND REQUIRED PROTECTIVE EQUIPMENT PRIOR TO PERFORMING ANY WORK.

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General

- Protect from over-voltage.
- Protect electrical equipment from water.
- Protect from electrostatic discharge (ESD).
- Protect from lightning.
- Prior to performing site or installation work, obtain required approvals and permits. Comply with all governing structure-height regulations.
- Use only qualified personnel for installation, use, and maintenance of tripods and towers, and any attachments to tripods and towers. The use of licensed and qualified contractors is highly recommended.
- Read all applicable instructions carefully and understand procedures thoroughly before beginning work.
- Wear a **hardhat** and **eye protection**, and take **other appropriate safety precautions** while working on or around tripods and towers.
- **Do not climb** tripods or towers at any time, and prohibit climbing by other persons. Take reasonable precautions to secure tripod and tower sites from trespassers.
- Use only manufacturer recommended parts, materials, and tools.

Utility and Electrical

- **You can be killed** or sustain serious bodily injury if the tripod, tower, or attachments you are installing, constructing, using, or maintaining, or a tool, stake, or anchor, come in **contact with overhead or underground utility lines**.
- Maintain a distance of at least one-and-one-half times structure height, 6 meters (20 feet), or the distance required by applicable law, **whichever is greater**, between overhead utility lines and the structure (tripod, tower, attachments, or tools).
- Prior to performing site or installation work, inform all utility companies and have all underground utilities marked.
- Comply with all electrical codes. Electrical equipment and related grounding devices should be installed by a licensed and qualified electrician.
- Only use power sources approved for use in the country of installation to power Campbell Scientific devices.

Elevated Work and Weather

- Exercise extreme caution when performing elevated work.
- Use appropriate equipment and safety practices.
- During installation and maintenance, keep tower and tripod sites clear of un-trained or non-essential personnel. Take precautions to prevent elevated tools and objects from dropping.
- Do not perform any work in inclement weather, including wind, rain, snow, lightning, etc.

Maintenance

- Periodically (at least yearly) check for wear and damage, including corrosion, stress cracks, frayed cables, loose cable clamps, cable tightness, etc. and take necessary corrective actions.
- Periodically (at least yearly) check electrical ground connections.

Internal Battery

- Be aware of fire, explosion, and severe-burn hazards.
- Misuse or improper installation of the internal lithium battery can cause severe injury.
- Do not recharge, disassemble, heat above 100 °C (212 °F), solder directly to the cell, incinerate, or expose contents to water. Dispose of spent batteries properly.

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