PRODUCT MANUAL

Communications Device

AL200X

ALERT2 Encoder, Modulator, and Sensor Interface

07/2025

RELIABLE MONITORING SINCE 1974

Campbell SCIENTIFIC®

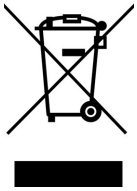
Please read first

About this manual

Please note that this manual was produced by Campbell Scientific Inc. primarily for the North American market. Some spellings, weights and measures may reflect this. 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 from Campbell Scientific it will be suitable for use in your country*.

Reference to some radio transmitters, digital cell phones and aerials (antennas) 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.

Recycling information for countries subject to WEEE regulations 2012/19/EU



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, per The Waste Electrical and Electronic Equipment (WEEE) Regulations 2012/19/EU. Campbell Scientific 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 support, please contact Campbell Scientific, or your local agent.

Table of contents

1. Introduction **1**

2. Precautions **1**

3. Initial Inspection **2**

4. QuickStart **2**

4.1 Stand-alone mode 2

4.1.1 Physical setup 2

4.1.2 Configuration 3

4.2 Data logger mode 5

4.2.1 Physical setup 5

4.2.2 Configuration 5

5. Overview **6**

6. Specifications **7**

6.1 Physical and environmental 7

6.2 System 8

6.3 DC power input 8

6.4 Communication ports 9

6.5 GPS receiver 10

6.6 ALERT2™ system timekeeping 10

6.7 Analog radio interface 11

6.8 ALERT2™ radio test button 12

6.9 Sensor interface 13

6.10 ALERT2™ operational support 15

7. Installation **15**

7.1 Configuration 16

7.1.1 Stand-alone device 17

7.1.1.1 ALERT2 17

7.1.1.2 Radio settings 20

7.1.1.3 Encryption 21

7.1.1.4 GPS settings 22

7.1.1.5 Measurement and Control 23

7.1.1.6 Sensor Data Monitoring 28
7.1.2 Data logger mode 28
7.2 Mounting in an enclosure 30
7.3 Grounding 30
7.4 Wiring 30
8. Operation 31
8.1 Terminal interface commands 31
9. Maintenance and troubleshooting 35
9.1 Maintenance 35
9.2 Troubleshooting 36
Appendix A. Glossary 39
Appendix B. Cables and connectors 41
B.1 RS-232 connector 41
B.2 USB interface 42
B.3 Power terminal 42
B.4 Analog radio interface 43
B.4.1 Connecting a Maxon SD-125 or SD-225-series radio 43
B.5 Sensor I/O interface 44
B.6 GPS input 44
Appendix C. LED indicators 45
Appendix D. AL200X settings 47
Appendix E. AL200X USB-driver installation instructions 55
Appendix F. Updating the AL200X Operating System (OS) 56
Appendix G. Recommended sensor IDs and IND multi-sensor reports 57
Appendix H. Calculating multipliers and offsets 61

1. Introduction

The AL200X is an encoder, modulator, and sensor interface designed as both a stand-alone device and as a measurement and control device with a Campbell Scientific data logger or third-party Data Collection Platform (DCP).

This device uses the Automated Local Evaluation Real Time Protocol version 2 (ALERT2) and can operate as a remote ALERT2 transmitter.

For more information on the ALERT2 protocol, refer to the National Hydrologic Warning Council ALERT2 Technical Working Group website: www.hydrologicwarning.org/content.aspx?page_id=22&club_id=61721 8&module_id=83216.

2. Precautions

- GPS input gain, antenna gain less conductor losses, should not exceed 25 dB.
- If protecting GPS input with coaxial surge protector, ensure that the protector does NOT block DC voltages.
- Ensure maximum protection against electrical transients/surges. Install coaxial surge protection on all antenna runs. Keep RS-232 connections short.
- USB is sufficient to power the AL200X for configuration. If power is only supplied over USB, the AL200X will not power up either the radio or attached 12 V sensors.
- The device driver for the AL200X must be installed on your computer before you can connect to the AL200X using USB. See AL200X USB-driver installation instructions (p. 55), for instructions on installing the device driver.
- ***Device Configuration Utility*** software 2.32 or higher is required to configure the AL200X. The latest ***Device Configuration Utility*** can be downloaded from our website, www.campbellsci.com/downloads.

3. Initial Inspection

Inspect the AL200X for any obvious signs of damage upon receipt. For each AL200X, the following items should be accounted for:

Table 3-1: Parts list

Quantity	Part
1	AL200X
1	2-pin mating screw terminal connector
1	6-pin mating screw terminal connector
1	9-pin mating screw terminal connector
2	mounting grommets
2	mounting screws
1	USB C cable

4. QuickStart

There are two basic modes of operation for the AL200X. For simplicity, these will be referred to as stand-alone and data logger modes.

4.1 Stand-alone mode

4.1.1 Physical setup

1. Attach a GPS antenna to the GPS SMA connector located on the right side of the AL200X.
2. Attach the desired sensors to the appropriate channels on the sensor input/output connector.
3. If connecting 12 V to the 2-pin connector and a radio is attached to the AL200X, connect the radio antenna connection to either an antenna or a 50-ohm dummy load.

4.1.2 Configuration

> **NOTE:**
> The device driver for the AL200X must be installed on your computer before you can connect to the AL200X using USB. See AL200X USB-driver installation instructions (p. 55), for instructions on installing the device driver.

1. Connect the supplied USB cable between a USB port on your computer and the USB port on the AL200X.
2. Open ***Device Configuration Utility***.
3. Under **Device Type**, select AL200X.
4. Click the down arrow to the right of **Communication Port** and select the port associated with the AL200X.
5. Click **OK**.
6. The **Baud Rate** must be 57600. If it is other than that, set it to 57600.
7. Click **Connect**.
8. Specify the settings on each tab to the following.

   Main

   a. Set **Operation Mode** to **Measurement and Control**.

   b. When the ***Device Configuration Utility*** is connected, the AL200X can be configured to transmit normally either with the **Test Flag** set, without the **Test Flag** set, or muting all transmissions. Setting the **Test Flag** may allow the data collection software to handle maintenance reports appropriately. Select the desired behavior from the drop-down list. The test button will continue to send test transmissions, independent of this setting.

   > **NOTE:**
   > When using the Terminal tab, the ***Device Configuration Utility*** does not maintain communications without user interaction. Accordingly, the **Test Flag** functionality only operates in the **Settings Editor** tab.

   COM1

   a. Use default values.

ALERT2

a. Configure settings to match your ALERT2 network.

Radio Settings

a. For Campbell Scientific RF320 series radios (Ritron DTX-L series), use the default settings. For other radios, check with the manufacturer for the necessary radio settings. If a power amplifier will be used at this site, additional time may be required at the start of the transmission for the amplifier to detect the transmission and switch in the amplifier.

Encryption

a. Refer to Encryption (p. 21) for details. For initial configuration, it is recommended to set the **Encrypt Outgoing Messages** to **False**. If determined to be appropriate, enable and check encrypted transmissions before deployment.

GPS Settings

a. Use default settings. For checking the configuration for use in a TDMA network, it is recommended to leave **Enable TDMA** set to **Yes**. If good GPS reception is not available, temporarily transport the AL200X, GPS antenna, and battery to a location that can receive a good GPS signal. After powering, obtaining a GPS lock to determine UTC time may require up to 13 minutes (to acquire the current value for **Leap Seconds**) and the GPS LED will go out. If the AL200X is powered, its clock will continue to run unless reset by sending a diagnostic command via the terminal, or loading an OS. When checking a transmitter's timed transmissions, use a UTC reference like www.time.gov.

Measurement and Control

The sensors are configured using either the **Load Group** or the **Multi-Sensor Report**.

a. The **Load Group** provides predefined groups of measurement and control definitions to load into the builder as a template. The values are then edited to create the required setup.

> **NOTE:**
> It may be necessary to click **Apply** then click **Connect** to display the configuration options for the **Load Group** that can be edited.

b. Click **Edit** to configure the sensor group to fit your application.

c. If **Multi-Sensor Report** is enabled, any sensor with an ID of 1 to 8 will be sent in MSR format. If MSR is not selected, all sensors (other than Rain, which is ID 0) will be sent in General Sensor Report (GSR) format.

9. Click the **Apply** at the bottom of the window. It is good practice to save the configuration file for later reference.

> CAUTION:
> The **Test** button may be pressed for up to 5 s to trigger a data transmission. If pressed for 5 to 10 s, it will transmit a 5 s tone used for radio and antenna checks and adjustments. These transmissions may interfere with reports from other stations. Do not cause radio transmissions without being connected to either an antenna or a dummy load.

4.2 Data logger mode

The AL200X can be configured for the data logger mode using **ALERT2 on RS-232**. In this mode, the AL200X receives ALERT2 IND version 2.0 layer packets and retransmits the packets as ALERT2 packets. An example of this application is the Campbell Scientific ALERT205-series transmitters. Campbell Scientific recommends reviewing Stand-alone mode (p. 2) for general operational details. Only the differences between stand-alone and data logger mode are described in this section.

4.2.1 Physical setup

The data logger must be connected to the AL200X RS-232 port using an appropriate cable. Attach a GPS antenna to the GPS port on the transmitter or the SMA connector located on the side of the AL200X.

4.2.2 Configuration

If using the AL200X in an ALERT205, it is important to set the AL200X to **Factory Defaults**. Do not change any other setting using the ***Device Configuration Utility***. Disconnect the USB from the AL200X and make all setting changes using the web browser ***User Interface*** of the data logger in the ALERT205. The CR300/310 must have the USB configured for RNDIS. The default IP address is 192.168.66.1.

If not using an ALERT205, specify the settings on each tab as the following describes:

1. **Main**—Set the **Operation Mode** to **IND**.
2. **COM1**—Ensure the settings match the data logger port that is used.

3. **ALERT2**—If the data logger does not send IND commands to configure these settings, you should configure these settings to match your ALERT2 network.

   > **NOTE:**
   > If the data logger sends the appropriate IND commands, the data logger will overwrite these values.

4. **Radio Settings**—Same as the **Radio Settings** in the Stand-alone mode (p. 2), although the data logger may overwrite these with IND commands.
5. **Encryption**—Same as the **Encryption** in the Stand-alone mode (p. 2), although the data logger may overwrite these with IND commands.
6. **GPS Settings**—Same as **GPS Settings** in the Stand-alone mode (p. 2), although the data logger may overwrite these with IND commands.
7. **Measurement and Control**—Sensor settings are grayed out in **IND Mode** since all sensors must be connected to and read by the data logger.

5. Overview

The AL200X ALERT2 Encoder, Modulator, and Sensor Interface are designed for use in radio networks using the ALERT2 protocol. The AL200X can be configured to operate as a stand-alone device or in the Intelligent Network Device (IND) with a data logger. In stand-alone mode, the AL200X will measure sensors, perform calculations, and, if appropriate, enable the attached radio to transmit the data during a designated time slot. In data logger mode, the AL200X will receive data from a data logger, such as the CR6, CR1000X/CR1000Xe, CR800-series, and CR300-series, or another device and transmit this data during a designated time slot.

The AL200X includes an RS-232 port for serial communications. A USB device port is used for configuring the AL200X, viewing real time readings and computed values of sensors, and diagnostics. An SMA female connector is provided for connecting a GPS antenna, and a removable connector with screw terminals allows for connecting an analog radio. Removable

connectors are also used for supplying power to the AL200X and connecting sensors. A copper ground lug is used for attaching an earth ground.

6. Specifications

6.1 Physical and environmental

Enclosure:	Two-piece black anodized aluminum case with 8 AWG earth ground lug.
Dimensions:	159.0 (L) x 77.5 (W) x 27.7 (H) mm 6.260 (L) x 3.05 (W) x 1.09 (H) in Additional clearance required for cables and wires.
Weight:	249 g (8.8 oz)
Mounting:	Two sets of paired mounting holes, one pair on the back of the enclosure and one pair on the side of the enclosure, mounting holes within each pair are spaced 6.00 inches apart. Mounting holes are designed for No 6 panhead hardware.
Installation environment:	This device shall be installed in a suitable enclosure in accordance with applicable electrical codes.
Operating temperature:	–40 to 60 °C
Relative humidity:	0 to 95%, non-condensing
Pollution degree:	2
Flammability rating:	UL 94 V-0
Meets compliance standards	RoHS: EN IEC 63000:2018 Emissions: FCC Part 15 (global region: United States)
View compliance documents at:	www.campbellsci.com/al200x

6.2 System

Processor (MCU): 120 MHz 32-bit Arm Cortex M4 (MCU+FPU) running at 48 MHz.

MCU internal memory: 2 MB Flash, 640 kB SRAM

Data storage: 128 MB on-board Flash (available for event logging and diagnostics)

6.3 DC power input

Supply voltage: +9 to +18 VDC, negative ground (maximum voltage may be limited by the radio used). Low voltage shutdown trip point is +8.6 ±0.3 VDC.

> **NOTE:**
> Recommended minimum supply voltage of +11 VDC for 4 to 20 mA current measurements to support a minimum of 9 VDC for the sensor plus up to 2 VDC for the current measurement.

Connector: 2-pin friction terminal connector, 0.20-inch pitch, 12 A maximum per pin.

Energy sources: Input from battery, power converter or solar panel with power conditioning.

- [1]ES1 PS2 energy sources only
- 9 to 18 VDC
- Hold current limit at 5.0 A @ +20 °C

[1] Energy Source Class 1 (ES1) and Power Source Class 2 (PS2), as defined in Clauses 5 and 7 of IEC/AS/NZS 62368-1:2022.

Current limiting: Resettable thermal fuses on both the positive and negative terminals of the connector, hold current for both fuses is 5.0 A at +20 °C.

Transient protection: TVS clamp at supply voltage >18.9 VDC

Reverse polarity: Inline Schottky diode in main power feed.

Average current drain at 12 VDC supply voltage (Ethernet port disabled)

Idle: 6.8 mA (average with GPS in standby, USB and COM1 active with cables disconnected)

USB cable installed: +1.5 mA additional when USB UFP cable connected.

RS-232 cable installed:	+2.5 mA additional when COM1 RS-232 cable connected.
GPS active:	+19 mA additional during acquisition/reacquisition based on 20 mA GPS antenna load, which occurs for ~ 1 min at power up and once every GPS update period. The GPS receive may require up to 13 minutes for initial acquisition.
Transmit:	+7 mA additional during transmission (does not include external radio consumption.

6.4 Communication ports

USB port:	Type C receptacle
Data rate:	USB 2.0 full speed at 12 Mbps
Port orientation:	Upstream Facing Port (UFP), device only configuration.
Input protection:	ESD and +5 V supply clamping diode protected.
Power configuration:	The USB host can be used to power the AL200X during configuration, however the USB connection is not sufficient to supply enough power for full AL200X operation.
RS-232 port (COM1):	9-pin female D connector configured as a DCE interface.
Signal levels:	EIA/TIA-232 and V.28/V.24
Surge/ESD protection:	±15 kV ESD protection
Configurable controls:	Programmable baud rate, stop bits and flow control.

> **NOTE:**
> The following Ethernet port functionality will be available on future versions of the AL200X.

Ethernet port:	RJ45 receptacle, magnetically isolated
Data rate:	10/100 Mbps, Base-T, full and half duplex
Connection reversal:	Auto-MDIX
Internet protocols:	Ethernet, PPP, RNDIS, ICMP/Ping, Auto-IP(APIPA), IPv4, IPv6, UDP, TCP, TLS (v1.2), DNS, DHCP, SLAAC, Telnet, HTTP(S), SFTP, FTP(S), POP3/TLS, NTP, SMTP/TLS, SNMPv3, CS I/O IP, and MQTT.
Transient protection:	Bridge connected TVS lightning and surge suppression.

6.5 GPS receiver

Antenna connector:	SMA female, 50-ohm impedance, clamping diode surge protection. Active antenna supported, 25 dB max. gain, +3.2 VDC @ 40 mA max. supplied via antenna cable.
GPS performance	
Tracking channels:	48
Receive sensitivity	
Tracking:	–163 dBm
Navigation:	–161 dBm
Aided:	–156 dBm
Cold start:	–148 dBm
Time-to-first-fix after	
Short loss of sync:	<1 s (hot start)
Power up or reboot:	35 s (cold start)
Active jammer removal:	Tracks up to 8 CW interferences and removes jammer signals up to 80 dB-Hz.
Multipath mitigation:	Yes (supports indoor tracking)

6.6 ALERT2™ system timekeeping

Time references: Based on two individual time references:

- GPS receiver with 1 µs accuracy to GPS UTC and leap second adjustment to coordinate with UCT UTC.
- Temperature controlled crystal oscillator (TCXO) with ±3.5 ppm deviance from -40° to +60 °C.

Accuracy: Internal time processing combines the two references to maintain an internal UTC accuracy of 5 ms per day or approximately 60 PPB (without GPS sync).

6.7 Analog radio interface

Connector:	6-pin friction terminal connector, 0.20-inch pitch, 12 A maximum per pin.
Transient protection:	All signals protected by 17 V TVS clamping diodes.
Power/signal ground (G):	Combined radio DC power ground and transmit and receive analog I/O analog signal ground. The ground terminal is electrically connected to the 8 AWG enclosure ground lug via the PCB ground trace connections to the enclosure.
Switched DC supply (SW12V):	Switched DC supply output to radio, maximum 1.8 A capacity, reverse polarity protected.
Voltage range:	Supply voltage –0.2 VDC @ 0.2 A, Supply voltage –0.6 VDC @ 1.8 A
Current limit:	3.00 A @ +20 °C
Push to Talk (PTT):	Open collector output to radio, active low, +40 VDC maximum open circuit voltage, +0.3 VDC maximum terminal voltage to ground at 50 mA load current when PTT is active.
Transmit modulation (Tx):	Root Raised Cosine (RRC) ALERT2 data waveform output to radio centered at +1.25 VDC (±2%).
Data rate:	4800 bps ±2% (maximum).
Amplitude:	100 to 1000 mVpp output into a 20 kohm load (radio input). Configurable in millivolts across the full output range (±3%).

> **NOTE:**
> The following Receive Demodulation and CD-RSSI input functionality will be available on future versions of the AL200X.

Receive demodulation (Rx):	RRC ALERT2 data waveform input from radio.
Data rate:	4800 bps ±2% (maximum).
Amplitude:	50 to 3400 mVpp, AC coupled, level internally adjusted via AGC control.
Input impedance:	75 kohm
Max Input voltage:	+16 VDC without damage

Receive CD/RSSI (RxCD):	Receive Carrier Detect (CD) or Receive Signal Strength Indicator (RSSI) input from radio.
Input impedance:	50 kohm
Max Input voltage:	+16 VDC without damage
Receive carrier detect (CD):	Input level: 0 to +6.8 VDC
	Input threshold: User selectable
	Input hysteresis: User selectable.
	RxCD detection time: 2 ms plus radio carrier detection time.
Receive signal strength indicator (RSSI):	Input level: 0 to +5.0 VDC based on the radio channel signal level.
	Carrier detect threshold: User selectable in dBm.
	RSSI level delay time: 2 ms plus radio signal level processing time.
	RSSI level slew rate: Up to 0.2 V/µs, limited by radio.

6.8 ALERT2™ radio test button

Location:	Located in the lower left corner of the AL200X.
Function	
Short press (0.1 to 5 s):	Press continuously for a minimum of 0.1 s to a maximum of 5 s to trigger a self-report transmission with a modulation level equal to the modulation voltage setting at a DC offset of +1.25 VDC. Transmission occurs only if the AL200X has data to send.
Long press (5 to 10 s):	Press continuously for a minimum of 5 s to a maximum of 10 s to trigger a 5 s, 1000 Hz sinewave, test tone transmission with a modulation level equal to the modulation voltage setting at a DC offset of +1.25 VDC.

6.9 Sensor interface

Connector:	9-pin friction terminal connector, 0.20-inch pitch, 12 A maximum per pin.
Transient protection:	All signals protected by 17V TVS clamping diodes, plus GDT lightning suppressors on P1, C1, C2 and C3.
Single-ended analog (SE1):	Single ended voltage and current measurement, 0 to +5000 mVDC or 4 to 20 mADC selectable, 16-bit ADC, 50 dB rejection at 60 Hz.
Voltage measurement:	Voltage range: 0 to +5.000 VDC. Voltage accuracy: ±12 mVDC maximum. Maximum input voltage: +16 VDC without damage. Input impedance: >20 Mohm when input configured for voltage measurements.
Current measurement:	**NOTE:** Recommended minimum supply voltage of +11 VDC for 4 to 20 mA current measurements to support a minimum of 9 VDC for the sensor plus up to 2 VDC for the current measurement. Current range: 4.0 to 20.0 mADC nominal. Current accuracy: ± 0.1 mA maximum. Maximum input current: 40 mADC without damage. Input impedance: Precision 100 ohm current sense resistor connected to ground when input configured for current measurements.
Signal/power grounds (G, G):	Signal and power ground for SE1 and SW12A/B, and digital ground for P1, C1, C2 and C3. These ground terminals are also electrically connected to the 8 AWG ground lug on the enclosure via the PCB ground trace and plane connections to the enclosure.
Switched DC supply (SW12A, SW12B):	Switched DC supply output to sensors, maximum 0.9 A capacity per terminal at +20 °C, individually controlled, reverse polarity protected.

Voltage range:	Supply voltage -0.2 VDC @ 100 mA Supply voltage -0.5 VDC @ 900 mA
Current limit:	900 mA at +20 °C
Pulse/switch Input: (P1):	Pulse or switch closure input for pulse or contact closure detection and counting, 100 kohm pull-up to +5 VDC, 16-bit counter.
Voltage range:	0 to +5 VDC nominal
Maximum input voltage:	+16 VDC without damage.
Event Levels:	Low: <0.4 VDC, High: >3.5 VDC
Maximum input frequency:	100 Hz
Minimum switch closed time:	5 ms
Minimum switch open time:	5 ms
Maximum bounce time:	1 ms without being detected
C port inputs/outputs (C1, C2, C3):	Control port input, output or SDI-12 communications, 0 to +5 VDC digital I/O, 200 kohm pull-down.
Maximum input voltage:	+16 VDC without damage.
Nominal voltage range:	0 to +5 VDC
	Maximum I/O frequency: 100 kHz
	Maximum bounce time: 1.5 µs without being detected.
Digital inputs:	Input logic levels: Low: <0.8 VDC, High: >2.8 VDC
	Input impedance: 200 kohm (0 to +5 VDC input)
Digital outputs:	Source drive levels: Low: <0.2 VDC, High: >4.8 VDC at no load.
	Source drive impedance: 1020 ohm
SDI-12 support:	Operational compliance: Meets SDI-12 Standard v1.4, dated January 2021
	Number of channels: Up to 3 independent channels, one per C port.
	Number of sensors/channel: Up to 10 recommended with each sensor having a cable length of 200 feet, more sensors can be accommodated per channel if shorter cable lengths are used.

6.10 ALERT2™ operational support

ALERT2 specification compliance: ALERT2™ IND API Specification, Version 2.1 (the AL200X supports all applicable feature sets for an Encoder)

ALERT2™ Airlink Protocol Specification, Version 1.2

ALERT2™ MANT Protocol Specification, Version 1.2

ALERT2™ Application Layer Protocol Specification, Version 1.3 Final-RevE, dated November 2019

Supported types:

Type 1: General Sensor Report
Type 2: Tipping Bucket Rain Gage Report
Type 3: Multi-Sensor Report – English Units
Type 4: Multi-Sensor Report – Metric Units
Type 5: Multi-Sensor Report – IND Sensor/Status

Unsupported types at the application level, but can be transmitted by the encoder if enclosed within an IND payload:

Type 7: Time Series Data Report
Type 250: SET Command
Type 251: GET Command

7. Installation

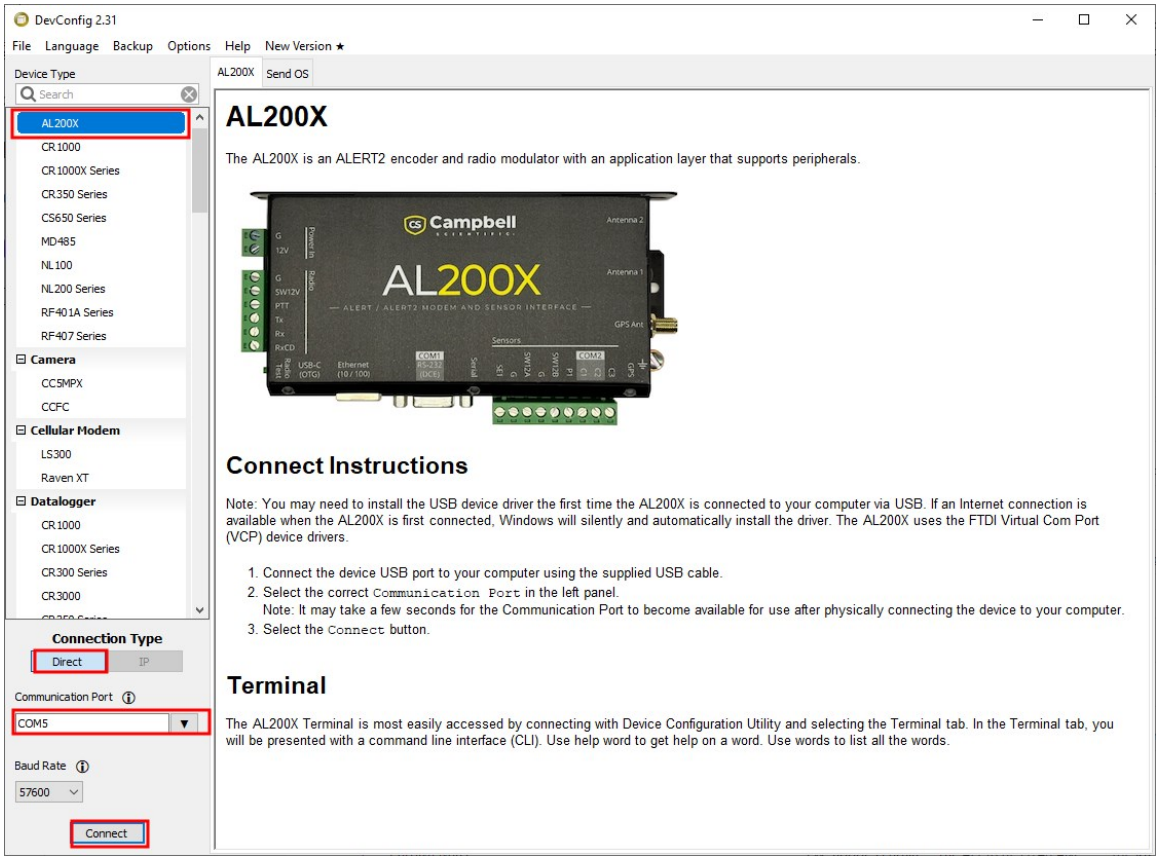
7.1 Configuration 16
7.1.1 Stand-alone device 17
7.1.2 Data logger mode 28
7.2 Mounting in an enclosure 30
7.3 Grounding 30
7.4 Wiring 30

7.1 Configuration

CAUTION:
Users need to understand the network in which the AL200X will be used. The AL200X has many settings that must be configured to determine when and how the AL200X will report data in the time division multiple access (TDMA) scheme. Incorrect settings can cause channel contention and may result in lost data.

NOTE:
The device driver for the AL200X must be installed on your computer before you can connect to the AL200X using USB. See AL200X USB-driver installation instructions (p. 55), for instructions on installing the device driver.

The AL200X is configured via the USB port using the ***Device Configuration Utility***.

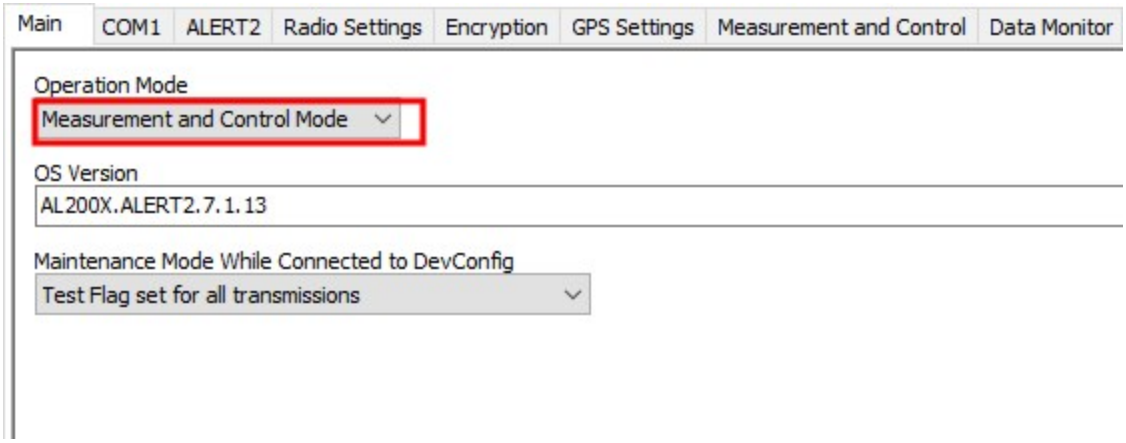


1. Connect the supplied USB cable between a USB port on your computer and the USB port on the AL200X.
2. Open ***Device Configuration Utility***.

3. Under **Device Type**, select AL200X.
4. Click the down arrow to the right of the **Communication Port** and select the port associated with the AL200X.
5. Click **OK**.
6. Ensure that the **Baud Rate** is set to 57600.
7. Click **Connect**.
8. For each tab, specify the settings for the Stand-alone device (p. 17) or Data logger mode (p. 28) mode.

7.1.1 Stand-alone device

To use the stand-alone mode, set **Main** > **Operation Mode** to **Measurement and Control**.

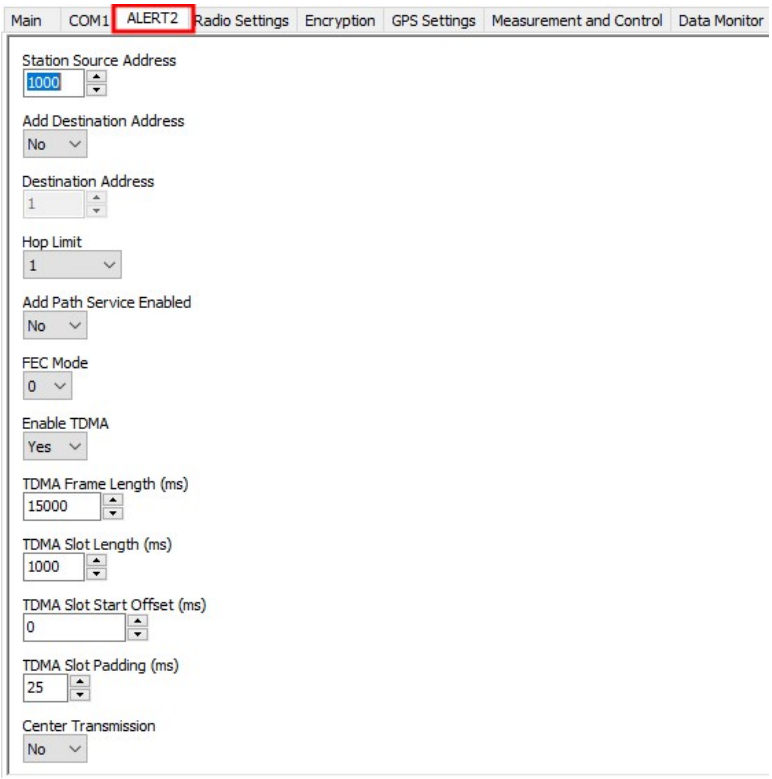


NOTE:
The settings in the **COM1** tab are not used in the stand-alone mode.

Settings for the other tabs are described in the following sections. These settings are unique to a particular station and others will be common to your network.

7.1.1.1 ALERT2

The user needs to set the following parameters since they are unique to a particular station and network. Default values are provided in parentheses.



Station Source Address (1000) – This station ID is an integer between 1 and 65,501 that must be unique within the network. Never have the same ID on more than one device in a network, including repeaters and decoders. A database of source addresses can be found at www.alert2.org.

Add Destination Address (No) – Enables or disables the **Destination Address**.

Destination Address (1) – If the **Add Destination Address** parameter is set to **Yes**, the destination parameter is included in packet header.

Hop Limit (1) – The maximum number of times a remote transmission can be retransmitted by repeaters. Each repeater decrements the value. When it reaches 0, it will not be repeated. A hop limit setting of 7 means that a hop limit will not be applied.

Add Path Service Enabled (No) – When enabled, each device that repeats a remote transmission will add its source address to the packet. This traces the path that a packet took from its beginning to its destination. The path information can be used for analysis and troubleshooting.

> **CAUTION:**
> Campbell Scientific recommends setting this value to **YES**. Enabling this option facilitates troubleshooting by allowing visibility into packet routing across the ALERT2 network. Note that enabling this setting increases the transmitted data size by 2 bytes per repeater.

FEC Mode (0) – 0 sets the highest error correction with lowest throughput. 1 provides a medium error correction and throughput. 2 sets the least error correction with the highest throughput. Increasing throughput may allow a shorter slot length to be used. The repeater or decoder that receives transmissions directly from this device must be able to decode different FECs if this is set to other than 0 (which is the original ALERT2 level of FEC).

Enable TDMA (Yes) – When enabled and the clock is accurate, the device will transmit in its time slot. If the clock drifts so that this cannot be assured, the device will transmit at random times. If this setting is not enabled, then the device will transmit in ALOHA mode and not time stamp reported readings.

TDMA Frame Length (15000) – Normally, this is the total amount of time that all of the stations in the network are able to report in (if they have reports to send). It is an integer between 5,000 and 3,600,000 ms with a resolution of 250 ms. The integer must be evenly divisible into 12 hours. In specific network designs, a site or repeater may have its TDMA Frame Length configured for an integer fraction (for example 1/3 or 1/2) of the longest system frame length. This allows that site to transmit multiple times in the system-long frame.

TDMA Slot Length (1000) – The maximum amount of time within the frame that the station can report. It is an integer value between 250 ms and 10000 ms. The AL200X allows the slot to overrun (into the next slot) to prevent reports from being disposed during major events. This can be caused by tipping bucket reports, which add bytes for the time offset of each tip. Consider this when designing the network to provide sufficient slot lengths that minimize transmission collisions.

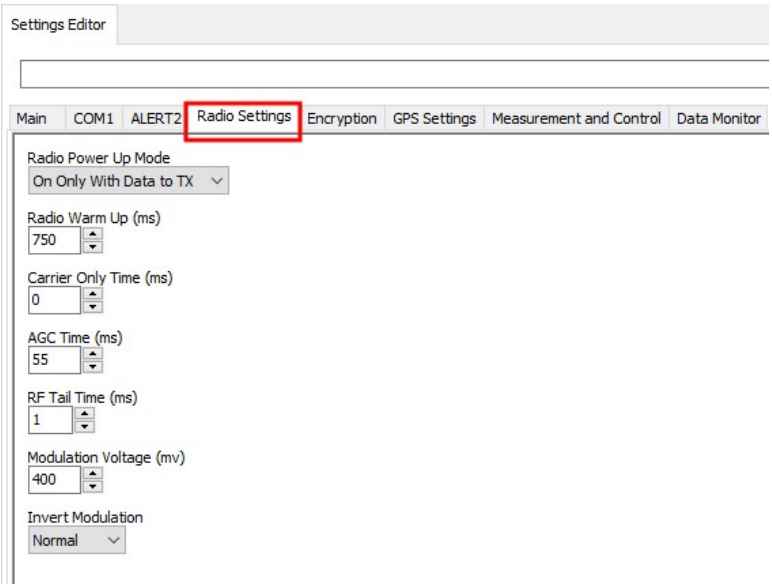
TDMA Slot Start Offset (0) – The amount of time into the frame that the slot will start. For example, if your frame is 120,000 ms (2 minutes) and your slot offset is 61,000 ms, the slot time will begin 1 second into each odd minute.

TDMA Slot Padding (25) – The number of milliseconds added before the beginning of a transmission. Higher values increase the amount of time the device can go between a GPS time sync and still be assured it's within its time slot. However, higher values reduce the amount of time available for transmitting data within the slot length. When the device cannot assure it will remain within its time slot (excepting overrun), it will switch to random transmission times and change its reported clock status.

Center Transmission (No) – When enabled, the total transmission time is calculated and the transmission is started so that the center of the transmission time will occur at the center of the slot, as long as the transmission will start no earlier than the TDMA Slot Padding value into the slot. If the transmission is too long to fit in the slot, it will overrun into the next slot. Plan your network design to minimize this possibility. If this setting is not enabled, then the transmission will start (the radio will transmit the carrier) after the TDMA Slot Padding delay.

7.1.1.2 Radio settings

The default radio settings are intended for Campbell Scientific RF320 series (Ritron DTX-L series) radios.



If using a different type of radio, consult the manufacturer to determine the settings. The following are descriptions of the radio settings.

Radio Power Up Mode (On Only With Data to TX) – Determines when the radio will be powered.

Radio Warm Up (750) – The amount of time, in milliseconds, that power will be applied to the external radio prior to enabling transmissions.

Carrier Only Time (0) – The amount of time, in milliseconds, that the radio will transmit an unmodulated carrier.

AGC Time (55) – The amount of time, in milliseconds, that the radio will transmit a tone-modulated carrier.

RF Tail Time (1) – The amount of time, in milliseconds, an unmodulated carrier will be transmitted following data transmission.

> **NOTE:**
> The default value for the **RF Tail Time** was reduced to 1 ms as proposed by the TWG in June, 2024.

Modulation Voltage (400) – The peak-to-peak voltage level of the audio modulation that will be fed to the radio. Value is expressed in millivolts.

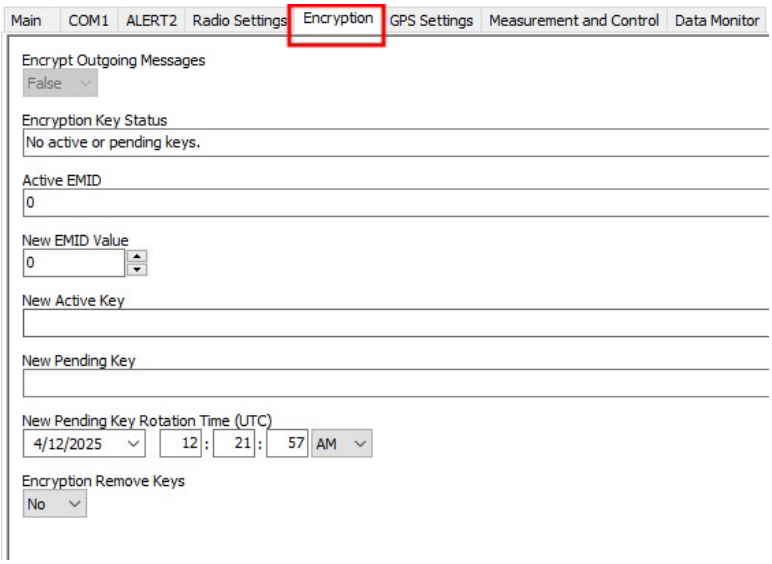
Modulation Polarity (Normal) – The polarity of the modulation fed to the radio.

NOTE:
Different brands of radios, and even different models of the same brand may need this setting changed for the transmission to be decoded by older repeaters and base station decoders.

7.1.1.3 Encryption

Encrypt Outgoing Messages – Can only be enabled if a valid key has been entered in the device.

NOTE:
Entering a key does not enable encryption but allows encryption to be enabled.



Keys, Active and Pending:

Encryption requires at least a valid **Active Key**, and the **Encrypt Outgoing Messages** drop down will not be enabled until a valid key is entered. This key is 32 hex characters, and pairs can be separated by colons. The key is used once encryption is enabled. A **Pending Key** and **Rotation Time** can also be set. Once the rotation time passes, the pending key will replace the active key. The **Encryption Key Status** shows whether keys are set. For security reasons once a key is entered, it cannot be viewed.

TIP:
When setting a **Pending Key Rotation Time**, enter the date, hour, or minutes first, and then the seconds will quit advancing.

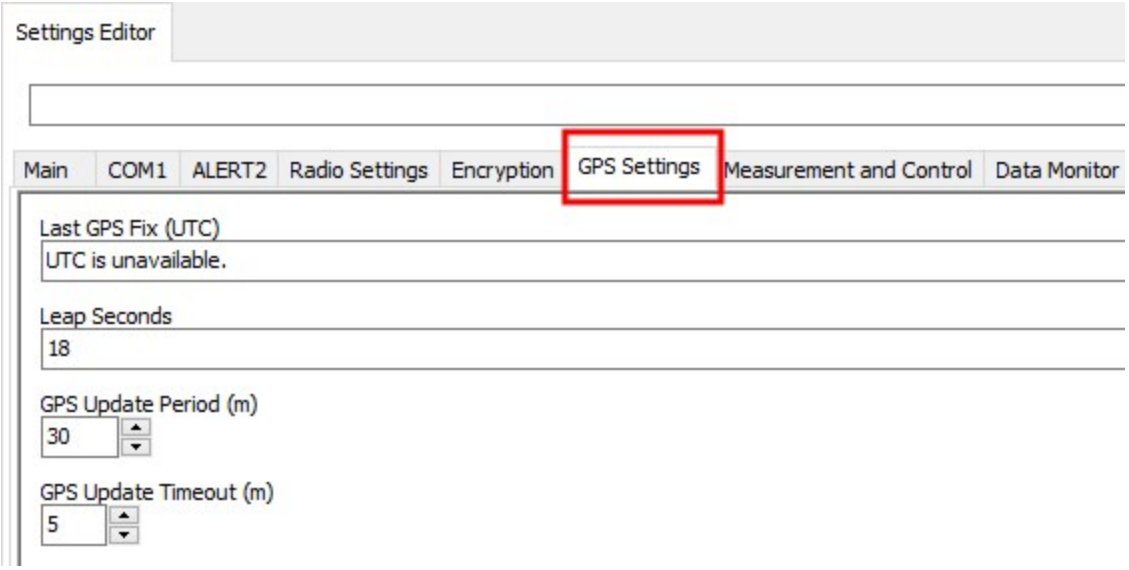
EMID, Active and New

Encrypted messages include an **Encrypted Message ID (EMID)** that increments each transmission. This prevents a "Replay Attack" where a radio transmission is recorded from Over The Air and

then resent at a later time. Each decoder keeps a table of the highest EMID received from each **Source Address** it has received encrypted messages from, so that it verifies that any new message cannot be a replay of a previous one. The impact this has on maintenance of a network is that if a transmitter is replaced in the field, the replacement transmitter must have not only the correct key set, but also the **EMID** must be set to a higher number than the previous transmitter had already used. If the EMID of the transmitter being replaced cannot be read to determine that value, the decoder may be able to be checked to see if its UI or a log file will display the highest **EMID** received for each **Source Address**. When a new key is applied, including a **Pending Key**, the **EMID** will by default be set to 0.

Encryption Remove Keys—Setting this to **Yes** then **Applying** it will remove any active and pending keys. This also sets **Encrypt Outgoing Messages** to **False**, since a valid key must be entered before enabling encryption.

7.1.1.4 GPS settings



Last GPS Fix – The data and time of the last successful GPS fix obtained by the AL200X.

Leap Seconds – This is the adjustment that the device will apply to compute UTC time from GPS time. The value is received from the GPS satellites. As of 2025, GPS is ahead of UTC by 18 seconds. It is displayed for troubleshooting and analysis, and is not settable by the user.

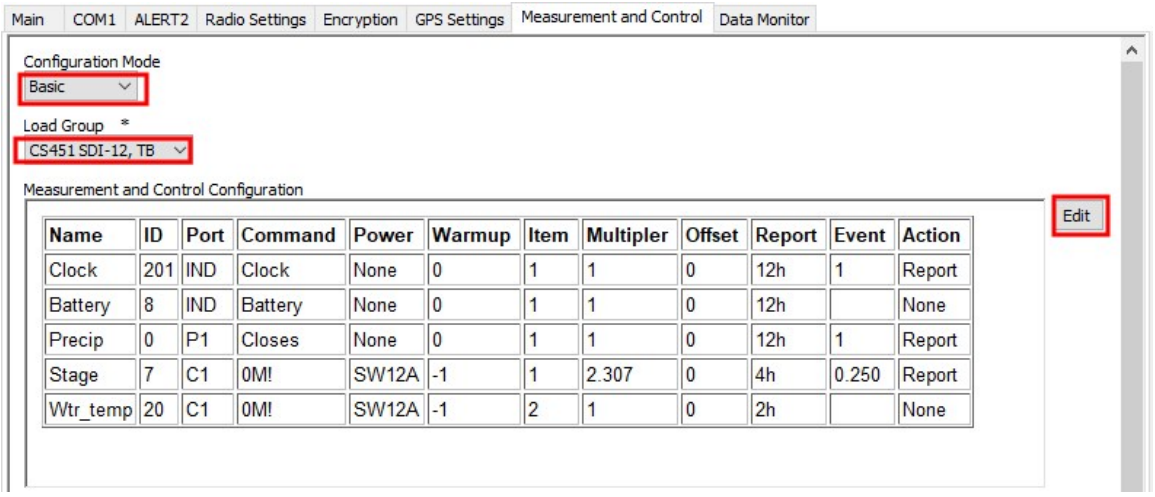
GPS Update Period (30) –Determines how often the GPS receiver will attempt to get a GPS fix. Value is expressed in minutes.

GPS Update Timeout (5) – The maximum amount of time, in minutes, that the GPS receiver will normally be enabled if a GPS fix is unable to be obtained. If the AL200X needs to update or confirm the number of **Leap Seconds**, the GPS receiver will stay on for 13 minutes regardless of the timeout setting.

7.1.1.5 Measurement and Control

Configuration Mode (Basic) – The default value is used for most applications. More parameters can be edited if set to **Advanced**.

Load Group – Provides predefined groups of measurement and control definitions to load into the builder as a template.



Name	ID	Port	Command	Power	Warmup	Item	Multipler	Offset	Report	Event	Action
Clock	201	IND	Clock	None	0	1	1	0	12h	1	Report
Battery	8	IND	Battery	None	0	1	1	0	12h		None
Precip	0	P1	Closes	None	0	1	1	0	12h	1	Report
Stage	7	C1	0M!	SW12A	-1	1	2.307	0	4h	0.250	Report
Wtr_temp	20	C1	0M!	SW12A	-1	2	1	0	2h		None

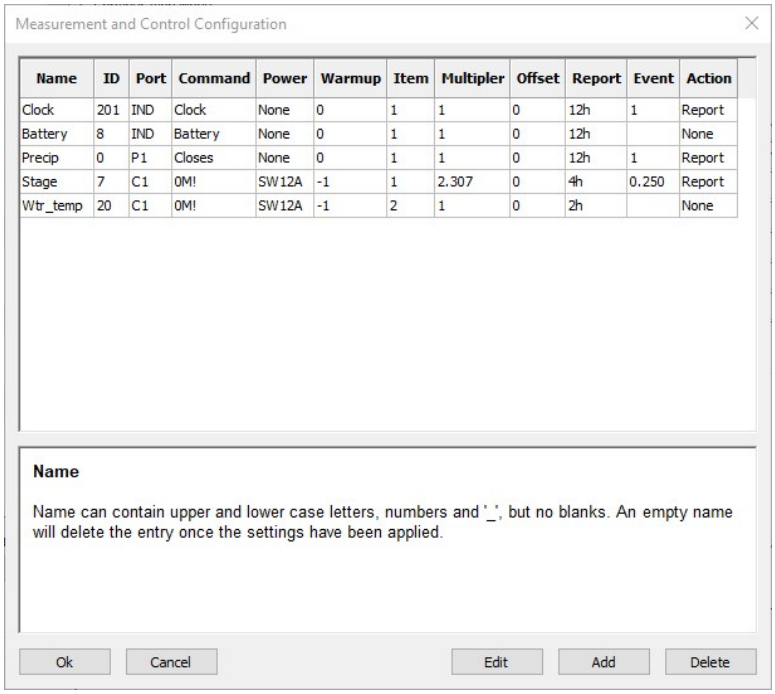
1. After selecting the **Configuration Mode** and **Load Group**, click **Apply**.

> **NOTE:**
> Selecting a **Load Group** will overwrite any settings in the builder.

> **NOTE:**
> It may be necessary to click **Apply** then click **Connect** to display the configuration options for the **Load Group** that can be edited.

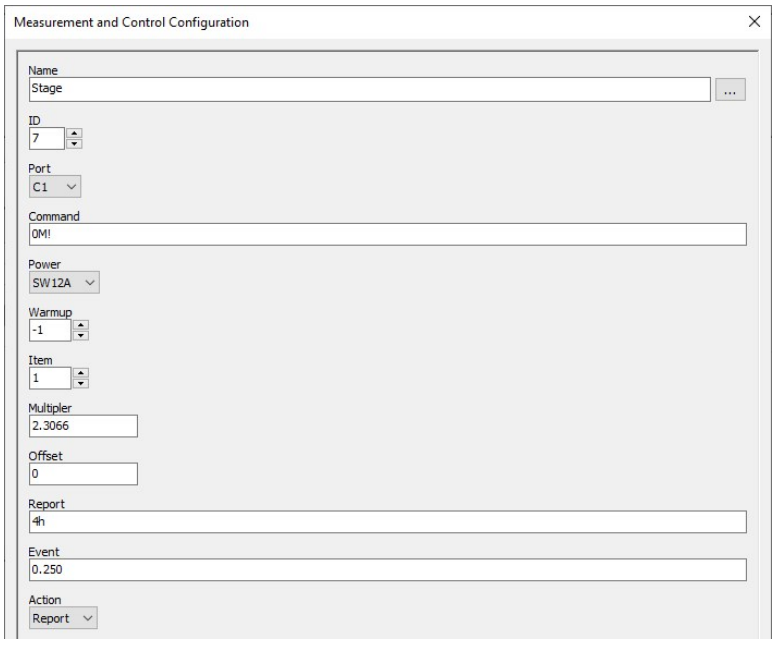
2. Click the **Edit** button that is next to the **Measurement and Control Configuration** table to revise the sensor parameters to fit your configuration.

3. A screen similar to the following will be displayed:



Name	ID	Port	Command	Power	Warmup	Item	Multipler	Offset	Report	Event	Action
Clock	201	IND	Clock	None	0	1	1	0	12h	1	Report
Battery	8	IND	Battery	None	0	1	1	0	12h		None
Precip	0	P1	Closes	None	0	1	1	0	12h	1	Report
Stage	7	C1	0M!	SW12A	-1	1	2.307	0	4h	0.250	Report
Wtr_temp	20	C1	0M!	SW12A	-1	2	1	0	2h		None

4. To change the configuration, select a row and click **Edit**, **Add**, or **Delete**. If **Edit** or **Add** is clicked, a screen similar to the following is displayed:



   a. Each row must have a unique name. The name can contain upper and lower case letters, numbers and '_', but no blanks. An empty name will delete the entry once the settings have been applied.

b. Certain IDs are predefined. See Recommended sensor IDs and IND multi-sensor reports (p. 57) for more information.

c. When the event is detected after a scan, the action is executed. Multiple rows are often used to respond to an event.

   Entering a number (without a sign) for the event will result in the action being executed if the measured value increases or decreases by that amount from the last reported value (a delta). If a sign is entered before the number (+ or –), then the action will only be performed if the measured value increases or decreases by that amount from the last reported value. Other operators and their behavior are described in the **Measurement and Control Configuration** help for the **Event** field.

   The following example sends a report if the solar sensor has a NAN (not a number) value. The help for the **Event** field details special behavior for NANs. Setting the **Action to Report** will then report only on a transition and on timed reports, so that support personnel are notified of the sensor failure not responding to the query. This may be desired separately from any control action being taken, so that the action (for example lowering a gate or turning on flashers) is not triggered by a faulty sensor or wiring.

> **NOTE:**
> Some SDI-12 sensors respond with a specific error value if they are reporting a fault condition. This is not the same as NAN, since NAN indicates that the sensor did not respond.
>
> If an SDI-12 sensor is used and the ID is mapped to an MSR, a sensor that does not report will send a value of 0 rather than NAN, because of the defined resolution of the MSR. To transmit the NAN instead, you can change the ID to be outside the range of the MSRs. If MSRs remain enabled for other sensors, it is recommended to delete the sensor that you want to change the address and apply the changes to the device. Then reconnect and add the sensor again with the new address.

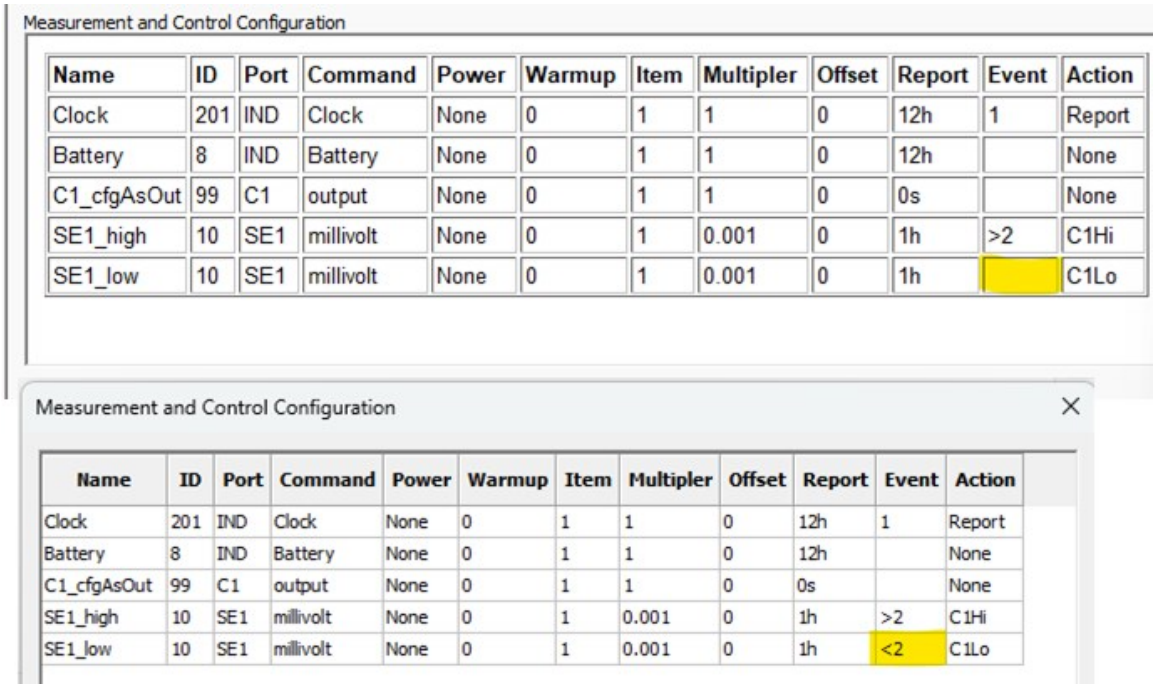
Measurement and Control Configuration *

Name	ID	Port	Command	Power	Warmup	Item	Multipler	Offset	Report	Event	Action
Clock	201	IND	Clock	None	0	1	1	0	12h	1	Report
Battery	8	IND	Battery	None	0	1	1	0	12h		None
Precip	0	P1	Closes	None	0	1	1	0	12h	1	Report
AnalogIn	7	SE1	Millivolt	None	0	1	0.001	0	4h	0.250	Report
Solar	20	C1	0M!	SW12A	-1	1	1	0	2h	0.250	Report
Solar_NAN	20	C1	0M!	SW12A	-1	2	1	0	0s	NAN	Report

The next example uses one row to open a flood gate. The second row will close the flood gate when the event is over. An additional pair of rows could be added to report the changed conditions.

> NOTE:
> C1 must be configured as an output before it can be used. The ID is not used in that configuration command.

> NOTE:
> At the time of release, the ***Device Configuration Utility*** software does not display the cell with the less than 2 (highlighted below) because of the less than symbol. It does show up correctly in the pop-up window when the table is edited. This special character formatting issue should be resolved in a future release of the ***Device Configuration Utility*** software.

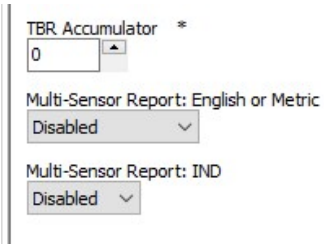


d. Details about all of the settings are provided in the ***Device Configuration*** help and AL200X settings (p. 47).

e. After the sensors are configured for your application, click **OK**.

f. Click **Apply** then click **Connect**.

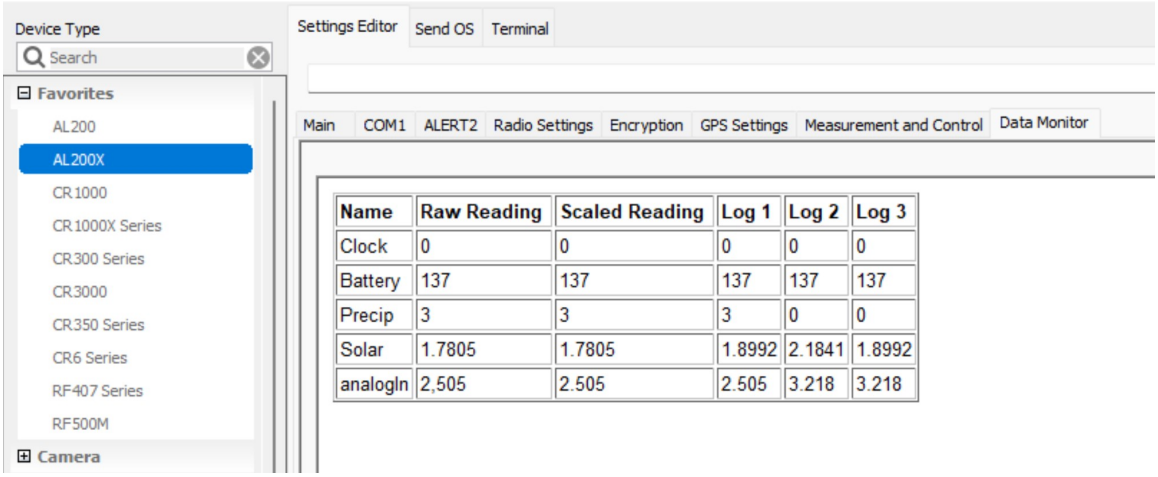
TBR Accumulator – The accumulator allows the tipping bucket accumulator to be reset.



Multi-Sensor Report: English or Metric (Disabled) – Chooses the units if the multi-sensor report is enabled. If enabled, sensors with IDs of 1 through 8 will be sent in a compact pre-defined format. See Recommended sensor IDs and IND multi-sensor reports (p. 57).

Multi-Sensor Report: IND (Disabled) – Multi-Sensor Reports (MSR-IND) are an efficient way of transmitting status reports for typical IND devices with a fixed resolution. Sensors must use IDs that are defined for that type, and then if MSD-IND reports are enabled, any sensor with an ID defined for MSR-IND will be sent as an MSR-IND Type 5 report. See Recommended sensor IDs and IND multi-sensor reports (p. 57).

7.1.1.6 Sensor Data Monitoring



Name	Raw Reading	Scaled Reading	Log 1	Log 2	Log 3
Clock	0	0	0	0	0
Battery	137	137	137	137	137
Precip	3	3	3	0	0
Solar	1.7805	1.7805	1.8992	2.1841	1.8992
analogIn	2,505	2.505	2.505	3.218	3.218

Sensors will be scanned once per frame, unless that has been changed by configuring a different Scan rate in the Advanced mode of the Measurement and Control Configuration.

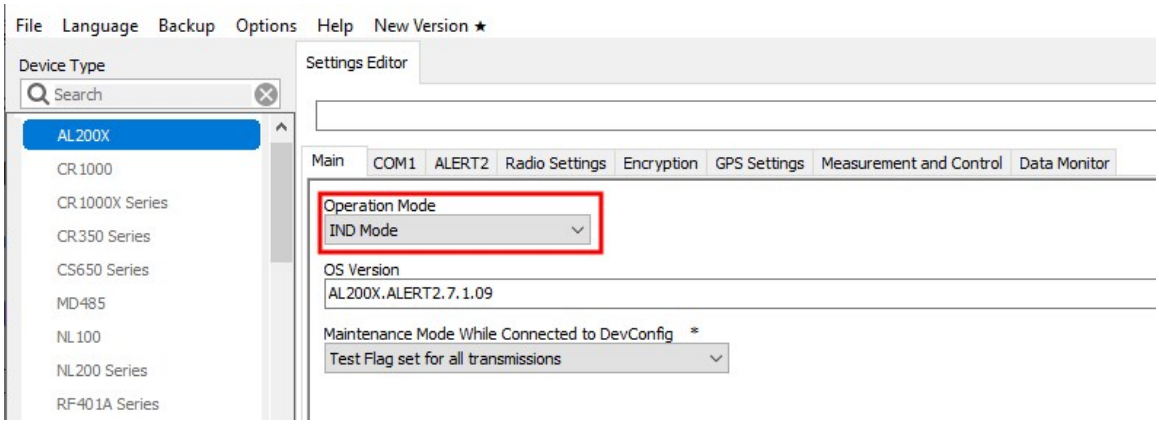
Battery – ensure that the battery voltage is in an acceptable range. It is displayed in tenths of a volt (for example, a value of 137 corresponds to 13.7 V).

> NOTE:
> After configuring the AL200X settings, click **Apply** at the bottom of the screen to send the changes to the device. Campbell Scientific recommends saving the configuration file for later reference.

7.1.2 Data logger mode

> NOTE:
> When operating in the IND mode, the AL200X's **Test** button may be used to trigger a test transmission of the datalogger. A short press of the test button will cause the AL200Xto send the string **"AL200TEST<NUL>"** out the RS-232 port. Note that AL200 was preserved for compatibility, and the string is not AL200X. If the datalogger is programmed to detect this string, it can execute test measurements and send a report.

1. To use the data logger mode, it is recommended to select Factory Defaults and then Apply. This will set **Main** > **Operation Mode** to **IND Mode**, configure other settings to known defaults, and disable sensor measurements on the AL200X (other than IND status sensors, which the data logger should query and send reports as appropriate).



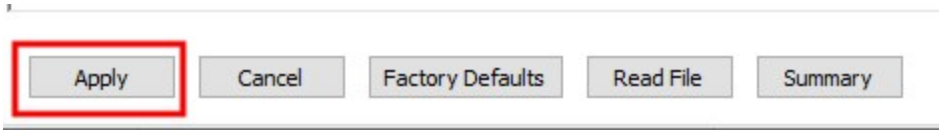
2. Click **COM1** to configure the parameters, if your data logger requires different settings.

3. Many of the **ALERT2**, **Radio**, **Encryption**, and **GPS Settings** are unique to a particular station and others will be common to your network. The settings are described in ALERT2 (p. 17), Radio settings (p. 20), Encryption (p. 21), and GPS settings (p. 22). The settings may be set by the data logger program using IND-API commands. If they are not set by the data logger, they can be set using the ***Device Configuration Utility*** software.

> **CAUTION:**
> Do not use an IND-API command and the ***Device Configuration Utility*** simultaneously because the setting will be overwritten, causing confusion.

4. The **Measurement and Control** and **Data Sensor Monitoring** tabs are not used for the data logger peripheral mode and so are disabled.

5. After configuring the AL200X settings, click **Apply** at the bottom of the screen to send the changes to the device. It is a good idea to save the configuration file for later reference.



7.2 Mounting in an enclosure

When used in outdoor applications, the AL200X should be installed in a desiccated, weatherproof enclosure. The AL200X can either be flat- or edge- mounted to a panel using the supplied plastic grommets and 6-32 screws.

7.3 Grounding

The ground lug on the AL200X should be connected to a good earth ground using 8 to 12 AWG stranded wire. This will help protect the AL200X from electrical surges. The ground reference for analog measurements should be connected to the **G** terminal on the sensor connector block.

7.4 Wiring

Connect 12 V battery wires to the AL200X **9-18Vdc** and **G** terminal. The 12 V battery should have sufficient capacity to handle the transmit current required by the radio without a significant voltage drop.

Connect the transmit audio, Push to Talk, power, and ground lines from your analog radio to the **SW12V**, **Tx (audio)**, **PTT**, and **G** terminals of the radio connector. The AL200X should be mounted as close as possible to the radio to avoid long cable runs between the two devices.

If using the AL200X in the stand-alone mode, connect the sensor wires to the appropriate sensor inputs. Depending on site conditions, additional surge protection for the sensor cables may be required.

If using the AL200X as a data logger peripheral, connect the **RS- 232** port through a null modem cable to the data logger.

8. Operation

The AL200X uses the ALERT2 protocol as developed by the ALERT2 Technical Working Group (TWG) and is designed for use as an ALERT2 transmitter. For more information on the ALERT2 protocol, visit the National Hydrologic Warning Council website: www.hydrologicwarning.org.

Under normal operation, the AL200X will obtain a GPS fix and measure sensors based on its configuration. When the sensors are measured and an event threshold has been exceeded, the AL200X will wait until its designated time slot and then power up the radio and transmit the data to a repeater or base receiver.

- Event-driven rainfall data is transmitted as a TBRG (tipping bucket rain gauge) report for **TDMA Frame Lengths** less than or equal to 240 sec with a sensor ID of zero (0). For **Frame Lengths** greater than 240 sec, only the accumulator value is sent since **TBRG Time Offsets** only have a 255 sec range.
- Other event-driven sensor data is transmitted as a GSR (general sensor report), or MSR (multi-sensor report) if MSRs are enabled and the sensor IDs are in the range of 1 to 8 (status messages can use IND-MSR reports which will use IDs in the range of 201 to 205). If events for multiple sensors are detected in the same frame, then multiple general sensor reports will be transmitted in a single MANT message.

If a GPS fix cannot be obtained and the AL200X internal clock may have drifted sufficiently that it cannot be assured that it will transmit in its time slot, the **Clock Status** will change from 0 and the device will transmit data at random times throughout the frame interval in an attempt to not continuously interfere with adjacent time slots.

8.1 Terminal interface commands

Commands are available through the **Terminal** tab of the ***Device Configuration Utility.*** Keep in mind the following:

- The **Test Flag** and behavior of the transmissions only applies to the **Settings Editor** tab. On that tab, the AL200X is being periodically queried for **Sensor Data Monitoring**. In the **Terminal** tab, these queries are not occurring, so the selected **Test Flag** and transmission behavior does not apply.
- The **Terminal** prompt should always respond with **"al200x:".** If it does not, press the [Esc] key.

- There is an extensive list of terminal commands; many are for advanced troubleshooting. You may be asked to execute some of them during troubleshooting when working with Campbell Scientific support. Only a few of the common commands are detailed here.
- A complete list of commands and basic help is returned by the command **"HELP"**. Since the list is several pages long, it may be helpful to export the terminal to a file if you want a list you can refer back to. Additionally, entering **HELP** and then another word will filter the list. For example, type **"HELP HELP"** to get a list of hints about whether arguments should precede or follow the command. **"HELP GPS"** will list only commands that include **"GPS"** in the command or the help text.

A few terminal commands follow:

- The following are examples of using terminal commands to check GPS function, restarting it to do a full acquire, and then remain on to determine the number of leap seconds:

  The following will clear current calibrations including **Leap Seconds**. The **RESTART** will reboot the device for a fresh acquisition. After the **RESTART**, it will be necessary to **Disconnect** and **Reconnect** *Device Configuration Utility*.

  ```
  al200x: RECALIBRATEGPS RESTART
  ```

  Enable debug output for the GPS.

  > **NOTE:**
  > The help for the **GPSDEBUG** command shows the argument within parentheses, as explained in **HELP HELP**, so the debug level precedes the command:

  ```
  al200x: 2 GPSDEBUG
  ```

  Depending on the state of the GPS and the reception of satellites, the output may show or go back to no time or position as shown by all commas:

  ```
  nmea> $GPRMC,,V,,,,,,,,,N*53
  ```

  This will start to fill in with the GPS time seconds, and initially the wrong date:

  ```
  nmea> $GPRMC,191028.600,V,,,,,,151111,,,N*4C
  ```

  As satellite signals are received, the time, location, and date will start to update. In the following example, **4123.9768,N,10567.3121,W** is the latitude and longitude, and **160625** shows the date as 16 Jun, 2025:

  ```
  nmea> $GPRMC,040133.666,A,4123.9768,N,10567.3121,W,0.55,318.95,160625,,,A*7C
  ```

  Once the GPS has acquired and is stable, the fractional part of the seconds will drop to 0, and the **PulsePerSecond** will be reported.

  ```
  nmea> $GPRMC,040138.000,A,4123.1522,N,10567.2260,W,0.08,307.16,160625,,,A*78
  PPS
  ```

The GPS will still need to be received for up to 13 min (typically half of that or less) to receive the number of Leap Seconds, so that the AL200X can correct GPS time to UTC time, which is used for ALERT2 networks. The log entry below shows that the clock calibrated, it required only 196 sec, UTC time is:1750046617, and the clock status is: 0.

```
nmea> $GPRMC,040336.000,A,4123.1522,N,10567.2259,W,0.00,307.16,160625,,,A*76
PPS
RMC Gap: 3
Calibrated (offset,ppss,uptime): -3 117 195
GPS off TIMEFULL baud:4800 gps_empty
UTC:1750046617 elapsed:196 Drift by 23ms: 191m TLL Locked TCXO PPM: -1.273
...
TLL Locked clock status: 0 (Clock drift < TDMA slot padding)
```

GPSDEBUG will continue to log to the terminal until the AL200X is issued a RESTART, the power is cycled (both 12 V and USB must be removed), or the following command is issued:

```
al200x: 0 GPSDEBUG
```

- SYNC will cause a GPS synchronization without restarting the device.
- WHOAMI shows many aspects of the state of the AL200X.
- The AL200X allows configuration of both Measurement and Control. Accordingly, these are considered peripherals. PERI shows the configuration, current values, and history of the ports used for measurement and control. HELP PERI will provide a list of commands that can be used with these ports. It is not recommended to use the terminal to configure measurement and control, only to check the state.
- SDI12 shows the SDI-12 states and settings. This will also show the most recent command and response for each port. This will also show the most recent command and response for each port.

```
al200x: sdi12

SW12A is Off
SW12B is Off
SW5 is On
comc1 SDI12 state = IDLE Command: Reply:
comc2 SDI12 state = IDLE Command: Reply:
comc3 SDI12 state = IDLE Command: Reply:
```

- SDI12: <command> sends the command to the C1 port by default. To see live output, see the SDI12DEBUG command below. To send a command to a different port, see the SPORT command below.

```
al200x: sdi12: ?!
al200x: sdi12

SW12A is On
SW12B is Off
SW5 is On
comc1 SDI12 state = IDLE Command: ?! Reply: 0<CR><LF>
comc2 SDI12 state = IDLE Command: Reply:
comc3 SDI12 state = IDLE Command: Reply:
```

- SDI12DEBUG is used to set the debug output level for all SDI-12 communications. To see output from the SDI12: command above, set to 3 or 4, with 4 giving the most detail.

```
al200x: 3 sdi12debug
al200x: sdi12: ?!

1749457342.318 Tx push
al200x:
1749457342.335 Tx complete
1749457342.354 Rx:0
1749457342.363 Rx:<CR>
1749457342.371 Rx:<LF>
1749457342.391 RTOI
```

- SPORT is used to change the destination port for the sdi12: command above. Use 0 for port C1, 1 for port C2, and 2 for port C3. This command must be terminated with a ! symbol. Use an @ symbol followed by a period to retrieve the set value.

```
al200x: 1 sport !
al200x: sport @ .
1
```

- **TURNON/TURNOFF** is used in conjunction with the SW12A/SW12B commands to toggle power to each switched 12 V port.

```
al200x: sw12b turnon
al200x: sdi12
SW12A is On
SW12B is On
SW5 is On
comc1 SDI12 state = IDLE Command: ?! Reply: 0<CR><LF>
comc2 SDI12 state = IDLE Command: Reply:
comc3 SDI12 state = IDLE Command: Reply:
al200x: sw12b turnoff
al200x: sdi12
SW12A is On
SW12B is Off
SW5 is On
comc1 SDI12 state = IDLE Command: ?! Reply: 0<CR><LF>
comc2 SDI12 state = IDLE Command: Reply:
comc3 SDI12 state = IDLE Command: Reply:
```

- **RESTART** is used to reset the system.
- **TDMA** is used to show all TDMA parameters including clock status.

9. Maintenance and troubleshooting

> **NOTE:**
> The AL200X is designed to provide years of trouble-free service with reasonable care. However, if factory repair is needed, first contact a Campbell Scientific application engineer to obtain an RMA (Return Materials Authorization) number. An RMA number and product-safety documents are required prior to any repair shipments being accepted at Campbell Scientific. See Assistance for more information.

9.1 Maintenance

Periodically check the sensor inputs against known values to ensure that the device is still within the specified accuracy ranges. The AL200X will normally scan each sensor every frame. This can be changed in the **Measurement Configuration Advanced** settings. Campbell Scientific recommends not changing the default setting of **Slot** without consulting Campbell Scientific,

since there can be important side effects. The current **Raw** and **Scaled** readings can be observed in the **Data Monitor**, along with a log of the last three transmissions for each sensor.

Pressing the **Test Button** for one to five seconds will trigger a test transmission containing the latest data available to the AL200X. Pressing the button for five to ten seconds will cause the AL200X to generate a test tone and sustain it for five seconds. This test tone can be used to check the forward and reflected power of the radio as well as channel frequency error and proper deviation level. Always confirm that a dummy load or properly tuned antenna is connected to the radio when transmissions may occur.

Consult your sensor and radio manufacturer manuals for recommended maintenance of these devices.

9.2 Troubleshooting

Table 9-1: Problems and possible causes

Problems	Possible causes
The AL200Xtransmissions are decoded by a Field Decoder, but not displaying in the **Data Collection Program** or in the logs for the repeater or decoder for the ALERT2 network.	• The **Hop Limit** may be configured too low for the number of repeaters in the path. The default setting is 1, and so it can only be repeated one time (since each repeater decrements it. If it will route through 2 or more repeaters, it is necessary to increase the **Hop Limit**. • Older decoders and repeaters required the polarity of the transmitted modulation to conform to the ALERT2 Airlink Spec to minimize false detections of the Bit & Frame sync patterns (this would still not result in erroneous reports, it just could consume decoding resources. This is why all encoders allow setting the modulation polarity. It is no longer simply that one manufacturer's radios use one setting, and another brand of radio uses an inverted setting. One manufacturer now sells radios where their two models require different settings. Field Decoders, will typically decode either polarity, but may warn if the polarity is inverted from the spec. Modern repeaters and Base Decoders will decode reports of either polarity. • Older decoders and repeaters typically did not implement different levels of Forward Error Correction (FEC). They will not decode FEC modes 1 or 2. Set the AL200X to FEC Mode 0.
The AL200X is not	• The AL200X is currently connected to the ***Device Configuration***

Table 9-1: Problems and possible causes	
Problems	**Possible causes**
transmitting event-triggered data.	*Utility* and is set to **Mute** all transmissions. • The event threshold is not properly set. If it has an operator before the value, it may only transmit once if the value is greater, or less than the threshold, not a delta change. Note that the less than symbol and the value associated with it is not displayed by DCU at the time of release, but if the table is edited, the symbol and value appear. This formatting problem should be fixed in a future release of DCU. • The current measurement does not exceed the event threshold. • The **Action** field must be configured to **Report**. • The **Test Flag** may be set by *Device Configuration Utility* being connected, and the **Data Collection Program** may not be displaying Test transmissions. Make sure that your login and settings for your **Data Collection Program** allow you to view test reports. Checking with a Field Decoder will normally allow you to see the transmission and if the **Test Flag** is set.
The **Test** button is not initiating a data transmission.	The AL200X is configured as a data logger peripheral and the test button functionality has been disabled (except that it will send a command to the data logger that may cause it to generate a report if that has been implemented).
The AL200X is reporting incorrect values.	• The applied multipliers and offsets are not correct. • The attached sensor isn't working properly. Ensure the sensor is wired correctly and that the sensor cable is in good shape. • The sensor may require a warm-up time, and the configured **SW12A** or **SW12B ON time** may not be sufficient. Setting the warm-up time to **-1** will turn the SW12A or SW12B on continuously, and may be useful for troubleshooting.

Table 9-1: Problems and possible causes	
Problems	Possible causes
The radio LED is always green.	The AL200X has been configured to keep the radio always on.
The GPS LED has not changed to green for an extended period longer than the normal lock time.	The GPS module is attempting to obtain leap second information and may take up to 13 minutes to complete. An example of monitoring the GPS behavior where this process can be observed is included in the section on Terminal interface commands.

Appendix A. Glossary

A

ALERT

Automated Local Evaluation in Real Time. A communication protocol developed in the early 1970's for the efficient reporting of real-time rainfall data over radio telemetry networks.

ALERT2

Successor of the ALERT communication protocol. A layered protocol suite designed for the primary purpose of real-time and coordinated communication of data over a radio telemetry network.

E

EMID

An encrypted message ID that increments. This allows decoders to detect a possible "replay attack" where a message is captured and then replayed at a later time.

I

IND

Intelligent Network Device. A device that implements the AirLink and MANT protocols for the transmission, repeating, or receipt of ALERT2 data.

P

PDU

Protocol Data Unit. Data payload with control header used for exchange between protocol layers. Sometimes generalized as "packet".

S

SDI-12

Serial Data Interface at 1200 baud. Communication protocol for transferring data between the data logger and SDI-12 compatible smart sensors.

Appendix B. Cables and connectors

B.1 RS-232 connector 41
B.2 USB interface 42
B.3 Power terminal 42
B.4 Analog radio interface 43
B.4.1 Connecting a Maxon SD-125 or SD-225-series radio 43
B.5 Sensor I/O interface 44
B.6 GPS input 44

B.1 RS-232 connector

RS-232 is used for asynchronous serial communication. It is a standard EIA/TIA-232 DB9 female connector supporting a DCE interface. A DB9 male to male null terminal cable is used to connect the AL200X to a Campbell Scientific data logger RS-232 port.

Table B-1: RS-232 pin description

Pin	AL200X function, DCE, DB9 female
1	DCD[1]
2	RXD
3	TXD
4	N/C
5	Signal ground
6	DSR[1]
7	N/C
8	CTS[1]
9	N/C

[1]DCD, DSR, and CTS are individually pulled up to +5 VDC through 3.3 kohm resistors.

B.2 USB interface

The USB interface is a Type C configuration. On-the-Go (OTG) and Downstream Facing Port (DFP) features are currently not supported. The CC1 and CC2 pins are electronically terminated with 5.1 kohm resistors to indicate to a USB host that this port is configured as a conventional USB device only port (Upstream Facing Port [UFP]) with a VBUS voltage of 5 VDC. A USB-A to USB-C cable is supplied. Connection to a computer requires installation of the FTDI Virtual COM Port (VCP) device driver.

Table B-2: USB pin description

Pin	Function
A1, A12, B1, B12	Ground
A4, A9, B4, B9	VBUS
A5, B5	CC1, CC2
A6, B6	DP1, DP2
A7, B7	DN1, DN2
A8, B8	Not used

B.3 Power terminal

Input power is supplied using a 2-pin screw terminal. A mating connector is supplied.

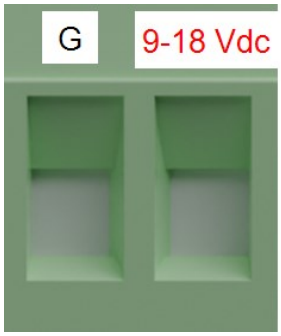


Table B-3: Power input pin description

Pin	Function
G	Supply ground
9-18Vdc	Supply voltage

B.4 Analog radio interface

The analog radio interface is a 6-pin screw terminal. A mating connector is supplied.

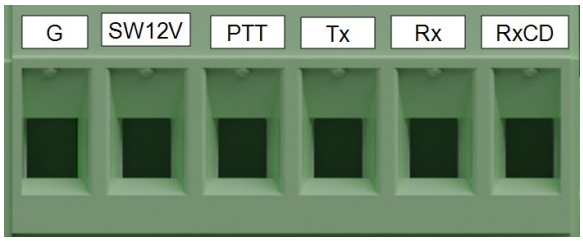


Table B-4: Radio interface pin description

Pin	Function
G	Power and signal ground
SW12V	Switchable radio power supply output
PTT	Push-to-talk output, grounded during transmission
Tx	Transmit modulation output to radio
Rx	Receive demodulation input from radio (for future use)
RxCD	Receive carrier detect/RSSI input from radio (for future use)

B.4.1 Connecting a Maxon SD-125 or SD-225-series radio

A Maxon SD-125 or SD-225 Series Radio can be connected to the AL200X using a radio data cable (Campbell Scientific pn 31924).

Table B-5: Maxon SD-125/225 radio connections

Wire color	AL200X terminal	DB9 pin number
Black	G	4
Red	SW12V	5
White	PTT	3
Green	Tx	1

B.5 Sensor I/O interface

The sensor I/O interface is a 9-pin screw terminal. A mating connector is supplied.

Table B-6: Sensor I/O pin description

Pin	Function
SE1	Analog voltage / current input
SW12A, SW12B	Switchable sensor power supply
P1	Pulse or switch closure input, internally pulled high to 5 V through a 100 kΩ resistor.
G	Ground
C1, C2, C3	Digital I/O, control port input, output, or SDI-12 communications, each port internally pulled low to ground through a 200 kΩ resistor. For voltage levels, see the Specifications section. An input will report 1/0 for high/low.

B.6 GPS input

The GPS input is a SMA female connector.

Table B-7: GPS Input Pin Description

Pin	Function
Center conductor	RF Input, biased by 3.2 VDC for use with active antennas
Connector shell	RF ground

Appendix C. LED indicators

The **GPS** LED is located next to the GPS antenna connector. It is used for monitoring the GPS receiver power up acquisition of and lock to the GPS satellite network.

Table C-1: GPS LED state descriptions

State	Description
Red	Double blink red once per second when the GPS receiver is on and attempting to acquire lock. It can stay in this state longer than the GPS Timeout if calibrating for leap seconds.
White	Double blink white once per second when the GPS receiver is calibrating.
Purple	Double blink purple once per second when the GPS receiver is locked but timing is not stable for sensors nor TDMA transmissions.
Blue	Double blink blue once per second when the GPS receiver is locked and timing is stable for sensors and random TDMA transmissions, but not for slotted TDMA transmissions.
Green	Double blink green once per second when the GPS receiver is locked and timing is stable for sensors and slotted TDMA transmissions.

The **Serial** LED is located between the **COM1 RS-232** and sensor connectors. It can be used to monitor the data activity on the transmit and receive data pins on the RS-232 port.

Table C-2: Serial LED state descriptions

State	Description
Blue	Flashes blue when there is data activity on the RXD receive data pin.
Red	Flashes red when there is data activity on the TXD transmit data pin.
Purple	Flashes purple when there is simultaneous data activity on both the RXD receive data pin and TXD transmit data pin.

The **Radio** LED is located above the **USB** connector. It can be used to monitor the power and communication state of the analog radio.

Table C-3: Radio LED state descriptions	
State	Description
Red	Solid red when transmitting an AirLink frame or test tone.
Green	Solid green when power is applied to the radio, SW12V is on.
Purple	Double blinks purple once per second if the hardware is not certified. In this mode the transmitter is inhibited from transmitting.

Under normal operation, the LED sequence should be as follows from powering up the device through a data transmission:

1. **GPS** LED blinks red immediately after power is applied, then flashes green after the AL200X has a GPS fix.
2. **GPS** LED blinks red for up to 13 minutes if the AL200X is actively downloading leap second information from the GPS network.
3. **Serial** LED remains off unless there is data being transferred over the **COM1 RS-232** port.
4. **Radio** LED is green while the radio is powered up. If the radio is set to always on, this LED will constantly be green unless a transmission is occurring.
5. **Radio** LED is red when the AL200X is transmitting data or a test tone.

Appendix D. AL200X settings

Table D-1: Main tab setting descriptions

Setting	Description
Operation Mode	The AL200X supports ALERT2 sensor measurements and IND-API version 2.0 encoding. Each process can service one physical connection on the AL200X at a time. Those connections are the RS-232 and direct-sensor inputs. • **IND Mode** (default): Enables the Intelligent Network Device (IND) interface for connecting a data logger to the COM1 RS-232 port. • **Measurement and Control**: Enable the measurement and control tab to configure the system with sensors, digital I/O, and power interfaces.
OS Version	The operating system (OS) version currently running on this device. OS updates are available at: www.campbellsci.com/downloads.
Maintenance Mode While Connected to DevConfig	When connected to the ***Device Configuration Utility*** using a USB cable and clicking **Connect**, the AL200X can be configured to transmit normally either with the **Test Flag** set, without the **Test Flag** set, or muting all transmissions. Setting the **Test Flag** may allow the ***Data Collection Software*** to handle maintenance reports appropriately. Select the desired behavior from the drop-down list. The test button will continue to send test transmissions, independent of this setting. **NOTE:** When using the **Terminal** tab, the **Device Configuration Utility** does not maintain communications without user interaction. Accordingly, the **Test Flag** functionality will only operate as selected when in the **Settings Editor** tab.

Table D-2: COM1 tab setting descriptions	
Setting	Description
RS-232 Baud Rate	The baud rate used for communication over RS-232.
RS-232 Stop Bits	The number of stop bits sent after each character during communication over RS- 232.
RS-232 HW Flow Control	Use RTS/CTS hardware flow control over RS-232.

Table D-3: ALERT2 tab setting descriptions	
Setting	Description
Station Source Address	ALERT2 station source address. Each station in an ALERT2 network must have a unique source address (range is 1 to 65534).
Add Destination Address	Determines whether the **Destination Address** is added to the packet header. A setting of **No** disables the **Destination Address** settings control.
Destination Address	If enabled, the source address of the device to which packets are directed.
Hop Limit	The maximum number of times a packet, originating from this device, will be repeated (hop) before being discarded. None (7) disables the limiting of hops. Example: if this station requires 1 repeater hop to reach the base station receiver, the hop limit should be set to a minimum of 1.
Add Path Service Enabled	Request that each device that forwards data originating from this station adds its source address to the packet header. Enabling this option allows a receiver to know the path that the packet took through the network, which is important for determining network performance and troubleshooting. This is disabled by default to comply with IND-API 2.0 Spec defaults. If a repeater implements the **Add Path Override**, it is possible leave to it disabled at gauge sites for normal operation and enable the override at the repeaters when required.

Table D-3: ALERT2 tab setting descriptions	
Setting	Description
FEC Mode	**Forward Error Correction** modes trade throughput for redundancy: 0 = Highest error correction with lowest throughput. This is the original ALERT2 level of correction and must be used with older repeaters or decoders. Levels 1 and 2 can only be used if the device that directly receives transmissions from this site is capable of decoding different FEC levels. 1 = Medium error correction and throughput. 2 = Least error correction with highest throughput.
Enable TDMA	When enabled and the clock is accurate, the device transmits in its time slot. If the clock drifts, the device transmits at random times. If this setting is not enabled, the device transmits in ALOHA mode and does not report the time stamp with the readings.
TDMA Frame Length	The total amount of time (in milliseconds) that all of the stations in the network will report. It is an integer between 500 and 43,200,000 (12 hours). The value must be evenly divisible into 12 hours, for example (43200000 / **Frame Length** = Whole Number) or (43200000 MOD **Frame Length** = 0). ALOHA mode would be a network design decision and is not assured to be random. Collisions would be expected to occur.
TDMA Slot Length	The maximum amount of time (in milliseconds) that this device can transmit within a single frame. The value has a resolution of 250 ms. It is an integer value in the range of 250 to 10000 ms.
TDMA Slot Start Offset	The offset, from the beginning of the frame, for the transmission slot. The value is expressed in milliseconds with a resolution of 250 ms. The value cannot exceed (**Frame Length** - 250 ms).
TDMA Slot Padding	This is the number of ms that will be added before the beginning of a transmission. The higher this value, the longer the device can go between GPS time sync and still be assured of being within its time slot.
Center Transmission	When enabled, the total transmission time is calculated and the transmission is started so that the center of the transmission time will occur at the center of the slot, as long as the transmission will start no earlier than the Slot Padding value into the slot.

Table D-4: Radio setting descriptions	
Setting	Description
Radio Power Up Mode	This setting controls when the attached radio is powered up. The radio can be powered up every frame, or continuously. For maximum power savings, set to **On Only With Data to Tx**. The radio will only power up if the AL200X has data to be transmitted. For maximum responsiveness, set to **On Continuously**.
Radio Warm Up	The amount of time power should be applied to the radio prior to the start of the transmission slot. Power will be applied according to the Radio Power Up Mode. The value is expressed in milliseconds with a resolution of 10 ms
Carrier Only Time	Amount of unmodulated carrier used in Airlink preamble. The value is expressed in milliseconds. ALERT2 Intelligent Network Device Application Program Interface Specification June 2020 Version 2.0 recommends that APDs set carrier only time to 0, and instead use AGC time.
AGC Time	Amount of tone-modulated carrier used in Airlink preamble. The value is expressed in milliseconds
RF Tail Time	Amount of unmodulated carrier to follow transmitted frame. The value is expressed in milliseconds.
Modulation Voltage	This setting controls the modulation voltage. The value is expressed in millivolts, peak-to-peak. Settings do not take effect until applied.
Invert Modulation	Depending on the radio used the audio, the Airlink modulation signal may need to be inverted. For Ritron radios, this is typically set to **Normal**. Different radio models from the same manufacturer may need to be set differently, especially if using older decoders and repeaters in the network. Newer decoders such as the AL205R/B will work with transmitters using either polarity.

Table D-5: Encryption setting descriptions	
Setting	Description
Encrypt Outgoing Messages	This can only be enabled if a valid key has been entered in the device. **NOTE:** Entering a key does not enable encryption but allows encryption to be enabled.
Encryption Key Status	Shows whether the active and pending keys are set.
Active EMID	Lists the current EMID being used by the encryption. If a transmitter is replaced in the field, the replacement transmitter must have not only the correct key set, but also the EMID must be set to a higher number than the previous transmitter had already used.
New EMID Value	Used for replacing a transmitter in the field without changing the key on this transmitter and at the decoders. If a new key is set, the EMID will automatically be set to 0
New Active and Pending Keys	Encryption requires at least a valid **Active Key**. This key must be 32 hex characters. Pairs can be separated by colons. The **Active Key** is used after encryption is enabled. A **Pending Key** and **Rotation Time** must also be set. For security reasons, once a key is entered, it cannot be viewed.
New Pending Key Rotation Time	Once the **Pending Key Rotation Time** lapses, the Pending Key will become the active key. The EMID will also be set to 0.
Encryption Remove Keys	Remove active and pending keys and sets the Encrypt Outgoing Messages to False, since it is necessary to enter a valid key before enabling encryption.

Table D-6: GPS settings descriptions	
Setting	Description
Last GPS Fix	The last time that the device successfully acquired a GPS fix. The time is shown in UTC. Remember that the time needs to be corrected for your time zone offset when trying to understand this value in context of the local time.
Leap Seconds	This read only value is required to compute UTC time from GPS time. It may require up to 13 minutes to be received.
GPS Update Period (m)	Time between GPS fix attempts. The value is expressed in minutes.
GPS Update Timeout (m)	The maximum time the GPS will normally remain on while trying to obtain a fix. The value is expressed in minutes. If the device is checking or updating its **Leap Second** value, the GPS may remain on for up to 13 minutes.

Table D-7: Measurement and Control settings descriptions	
Setting	Description
Configuration Mode	Used with the load group to determine the parameters that are configured in the measurement and control builder.
Load Group	Provides predefined groups of measurement and control definitions to load into the builder as a template. The values loaded in the builder are edited to create the required setup. Options are Clock and Battery and CS451 SDI12, TB.
Measurement and Control Configuration	Click **Edit** to configure and edit the load group sensors.
Name	Name can contain upper and lower case letters, numbers and the underline character (_), but no blanks. An empty name will delete the entry.
ID	A number from 0 to 255. Certain IDs are predefined. The predefined IDs are listed in Recommended sensor IDs and IND multi-sensor reports (p. 57).
Port	Select the port in which the sensor is connected. Select IND when the sensor is internal to the AL200X and defined in the MSR-IND list of sensors (even if MSR-IND reports are not enabled), such as the clock status or battery.

Table D-7: Measurement and Control settings descriptions	
Setting	Description
Command	The appropriate command depends on the **Port** setting: • SE: Milliamp, Millivolt • P1: Closes • IND: Temperature, Clock, Status, Battery • C1, C2, C3: Output, Level, or 0M! (SDI-12 command) • Off
Power	Determines whether using one or both SW12V terminals, using continuous power, or not using power.
Warmup	The number of seconds needed for the sensor to warmup. Maximum value is 127. 0 is off and –1 is always on.
Item	Selects the SDI-12 result to return from the SDI-12 command. Use the default value of 1 if not configuring an SDI-12 sensor.
Multiplier, Offset	Factors by which to scale the raw results of the measurement.
Scan (Advanced Configuration Mode only)	Set the scan interval. **Slot** means just before the TDMA slot. A number means every period of seconds. If it has a suffix of **h** then hours, or **m** then minutes or **s** then seconds. It must be an integer multiple of the **Frame length**. Assuming that is met, valid entries could include: Slot, 1h, 30m, 30s, 120. None will mean no scan will be done.
Report	Controls the frequency at which sensor data should be reported, without being triggered by an event. Value is expressed in seconds.
Format (Advanced Configuration Mode only)	The report format for the measurement. GSR (Type 1) is default. P1 is reported in the TBR report. ID's 1-8 are reported in the Multi Sensor Report English units (Type 3) and Multi Sensor Report Metric units (Type 4) formats if set. MRI (Type 5) is for Multi Sensor Report IND Layer which provides status about internal operations of the IND. ID's are 201-205 and 8. The report format is determined from **Multi Sensor Report** settings, the selected **Port**, and sensor IDs. If MSRs are enabled, then all sensors with IDs that are defined for that type of MSR will be sent in that format. This value is read only.

Table D-7: Measurement and Control settings descriptions	
Setting	Description
Event	Describe a transitional event with a single operator: + - > < or = and a value. No spaces are allowed and the value may be floating point or integer. No operator is a change by that amount up or down, whereas a prefix of + or - indicate a change only up or down. Event examples: 1, +1, -12, >10, <11.5, =13.2 When the event is detected after a scan, the action is run. If NAN is entered as an event then transitions to and from a NAN are considered events. This can point to measurement problems with the sensor, wiring or other related items. If the last value reported was a good value and the scan returns a NAN, the action will be executed. It is recommended to have Report as the action in this case. If the last reported value is an NAN and the scan returns a good value, this is also considered a NAN transition and the action will be executed.
Action	The action occurs when the event is true. The actions can be to report, set a control terminal high, or set a control terminal low. Setting the control terminal high or low is used to control a device such as open a flood gate or turn on flashers.
Log (Advanced Configuration Mode only)	Set the data logging interval. 'Report' means log right after a report. 'Scan' means log after every scan. 'None' means no logging.
TBR Accumulator	The rainfall tip Accumulator value is sent in the Tipping Bucket Report. The Accumulator is stored during power cycles, but is not saved after OS download.
Multi-Sensor Report: English or Metric	If enabled, sensors with IDs 1 through 8 will be sent in a compact pre-defined format. See Recommended sensor IDs and IND multi-sensor reports (p. 57).
Multi-Sensor Report: IND	Multi-Sensor Reports (MSR-IND) are an efficient way of transmitting status reports for typical IND devices with a fixed resolution. Sensors must use IDs that are defined for that type, and then if MSD-IND reports are enabled, any sensor with an ID defined for MSR-IND will be sent as an MSR-IND Type 5 report. See Recommended sensor IDs and IND multi-sensor reports (p. 57).

Appendix E. AL200X USB-driver installation instructions

When plugging the AL200X into your Windows XP or Vista PC for the first time, it may be necessary to install the FTDI Virtual COM Port (VCP) driver. This is not required when using Windows 7 or 8.

Visit www.ftdichip.com/Drivers/VCP and select the appropriate file based on your computer operating system. Download the zip file to your computer and extract the files to a directory of your choosing. Select and open the executable file and proceed through the install wizard. After the drivers finish installing, you should see a confirmation screen indicating that the drivers were installed or updated successfully. You will then need to restart your computer to apply the changes.

Appendix F. Updating the AL200X Operating System (OS)

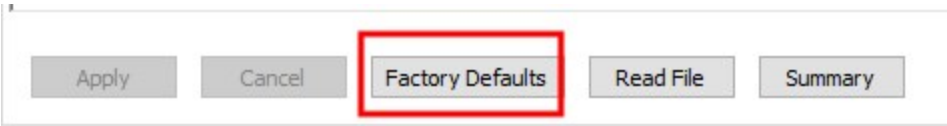
Whenever a new operating system (OS) is released for the AL200X, it will be available from our website, www.campbellsci.com/downloads.

Follow these steps to send the new OS to the AL200X:

1. Connect a USB cable between one of your computer USB ports and the USB port on the AL200X.
2. Open the ***Device Configuration Utility***.
3. Select the **AL200X** under **Device Type**.
4. Select the appropriate **Communication Port**.
5. Click the **Send OS** tab.
6. Press **Start**.
7. In the resulting dialog box, select the file that should be sent to the device as an operating system (this file should have a .hex extension) then press **OK**. The operating system will be sent to the AL200X.

   > **CAUTION:**
   > Do not remove power while an OS download is in process.

8. After the OS has been successfully updated, **Apply Factory Defaults** first then make appropriate changes to configure the station.



Appendix G. Recommended sensor IDs and IND multi-sensor reports

The following are the recommendations provided in the ALERT2 Application Layer Protocol Specification document, Version 1.3.

Table G-1: Recommended sensor IDs

ID	Sensor type
0	Rain
1	Air temperature
2	Relative humidity
3	Barometric pressure
4	Wind speed
5	Wind direction
6	Peak wind speed
7	Stage
8	Battery voltage

ID 0 is assigned to Rain as measured with a tipping bucket. P1 input counts the number of pulses, and the accumulator value is sent as an integer. For TDMA Frame Lengths ≤240 sec, this is sent as a TBRG (Type 2) report with Time Offsets for each tip. For Frame Lengths > 240 sec, only the accumulator value is sent since TBRG Time Offsets only have a 255 sec range (effectively 240 since the Frame Length must be evenly divisible into 12 hours).

Multi-Sensor Reports are an efficient way of transmitting reports for typical weather station sensors in both English (type 3) and Metric (type 4) units with a fixed resolution. Sensors must use IDs 1 to 8, and then any sensor with an ID in that range will be sent in the MSR. Sensors that are not enabled are not transmitted.

Table G-2: Type 3 (English units) sensor, bytes, format, resolution, and units					
ID	Sensor	Bytes	Format	Resolution	Units
1	Air temperature	2	Signed integer	0.1	°F
2	Relative humidity	1	Unsigned integer	1	%
3	Barometric pressure	2	Unsigned integer	0.1	hPa
4	Wind speed	1	Unsigned integer	1	mph
5	Wind direction	2	Unsigned integer	1	deg
6	Peak wind speed	1	Unsigned integer	1	mph
7	Stage	2	Signed integer	0.01	ft
8	Battery voltage	1	Unsigned integer	0.1	V

Table G-3: Type 4 (Metric units) sensor, bytes, format, resolution, and units					
ID	Sensor	Bytes	Format	Resolution	Units
1	Air temperature	2	Signed integer	0.1	°C
2	Relative humidity	1	Unsigned integer	1	%
3	Barometric pressure	2	Unsigned integer	0.1	hPa
4	Wind speed	2	Unsigned integer	1	km/hr
5	Wind direction	2	Unsigned integer	1	deg
6	Peak wind speed	2	Unsigned integer	1	km/hr
7	Stage	3	Signed integer	0.001	m
8	Battery voltage	1	Unsigned integer	0.1	V

Multi-Sensor Reports (MSR-IND) are an efficient way of transmitting status reports for typical IND devices with a fixed resolution. Sensors must use IDs that are defined for that type, and then if MSD-IND reports are enabled, any sensor with a ID defined in Table G-4 (p. 59) will be sent as an MSR-IND Type 5 report. Some sensor values only apply to a repeater (for example, Messages Received).

Table G-4: Measurement suite

ID	Sensor	Bytes	Format	Resolution	Units
201	Clock status	1	Unsigned integer		See Table G-5 (p. 59)
8	Battery voltage	1	Unsigned integer	0.1	V
202	IND temperature	2	Unsigned integer	0.1	°C
203	Message received	2	Unsigned integer	1	Accumulator value
204	Message sent	2	Unsigned integer	1	Accumulator value
205	Status bits	1	Unsigned integer		See Table G-6 (p. 60).
	Reserved				
	Reserved				

The clock status sensor reports the following.

Table G-5: Clock synchronization values

Value	Description
0	Clock uncertainty is sufficiently small to allow TDMA (e.g., synchronized to GPS)
2	Clock drifted (e.g., clock was synchronized to GPS in the past)
3	Clock was never synchronized (no GPS, no NTP)
4	Clock uncertainty is less than ~1 second, but is too large for TDMA (e.g., synchronized to NTP poll).

The status bits sensor is a bit field with each bit having the following meaning:

Table G-6: Status bit values[1]

Bit position	Description
0 (0x01)	Decoder substystem warning or error
1 (0x02)	Encoder substystem warning or error
2 (0x04)	GPS clock subsystem warning or error
3 (0x08)	API subsystem warning or error
4 (0x10)	IO subsystem warning or error
5 (0x20)	User initiated warning or error (misconfiguration, etc)
6 (0x40)	Device was reboot (set on device power up)
7 (0x80)	Slot overrun. TDMA slot overrun occurred, or slot overrun protection was triggered.

[1]The bits are reset after each read/transmit to indicate whether the problem is transient or recurring.

Sensors that are not enabled are not transmitted.

Appendix H. Calculating multipliers and offsets

Unlike ALERT which could only represent measurement values between 0 and 2047, ALERT2 has the ability to represent a much larger range of floating point numbers. The reading does not need to be scaled to a unitless number that is less than 2047. Instead, with ALERT2, you can transmit values in engineering units with a high degree of resolution. The simplified example below demonstrates how to calculate the multiplier and offset that are needed to convert a pressure transducer output, 0 to 5 volts, to feet of water.

For this example, we will use a pressure transducer that has a 0 to 30 psi range and a 0 to 5 volts output. From the manufacturer supplied calibration report it is known that the sensor outputs 0.0123 volts at 0 psi and 4.987 volts at 30 psi (12.3 and 4987 millivolts respectively).

The relationship between the sensor's output in millivolts and pressure is defined by the equation of a line (assuming linearity), Y = mX + b, where Y is pressure, m is the calculated multiplier, X is the sensor's output in millivolts, and b is the calculated offset.

Y = mX + b

OR

Pressure = Multiplier x Sensor Output + Offset

The multiplier is determined by dividing the sensor's measurement ranges by the sensor's range of output. For this example the multiplier will be:

Multiplier

$$Multiplier = \frac{Y2 - Y1}{X2 - X1}$$

OR

$$Multiplier \frac{30-0}{(4987-12.3)} = \frac{30}{(4974.7)} = 0.0060\ psi\ per\ mV$$

The offset is determined by entering the multiplier into the pressure equation and solving for the offset using a known pressure and sensor output.

Offset = Pressure – (Multiplier • Sensor Output)

OR

Offset = 0 – (0.0060 x 12.3) = –0.074 psi per mV

Now, we can calculate pressure based on the reading we get from the sensor. For example, you measure the sensor's output as 2543.210 mV. Pressure would be determined by:

Pressure = (0.0060 • 2543.210) + (–0.074) = 15.263 psi

To determine water depth, simply multiply the pressure value by the appropriate conversion factor.

For fresh water this is:

1 psi = 2.308 ft.

For salt water this is:

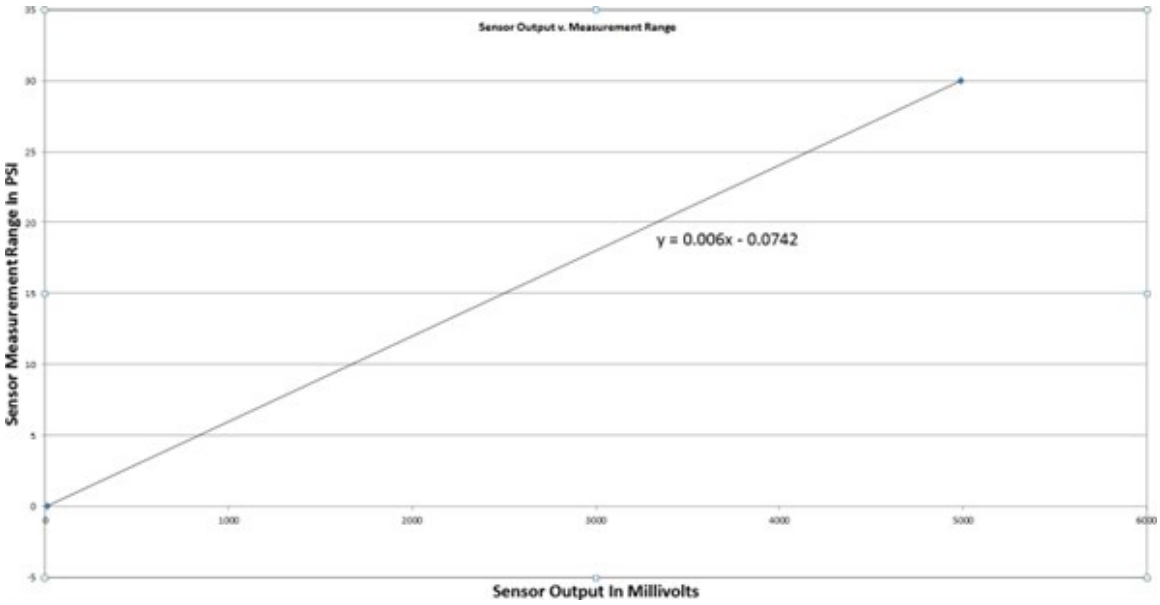
1 psi = 2.250 ft.

For the above example (assuming fresh water):

Depth of Water = Pressure x 2.308

Depth of Water = 15.263 x 2.308 = 35.226 ft.

These calculations can easily be performed using many spreadsheet programs by plotting the sensor's measurement range versus the sensor's output range. The equation of the trendline contains the multiplier and offset.



Limited warranty

Covered equipment is warranted/guaranteed against defects in materials and workmanship under normal use and service for the period listed on your sales invoice or the product order information web page. The covered period begins on the date of shipment unless otherwise specified. For a repair to be covered under warranty, the following criteria must be met:

1. There must be a defect in materials or workmanship that affects form, fit, or function of the device.

2. The defect cannot be the result of misuse.

3. The defect must have occurred within a specified period of time; and

4. The determination must be made by a qualified technician at a Campbell Scientific Service Center/ repair facility.

The following is not covered:

1. Equipment which has been modified or altered in any way without the written permission of Campbell Scientific.

2. Batteries; and

3. Any equipment which has been subjected to misuse, neglect, acts of God or damage in transit.

Campbell Scientific regional offices handle repairs for customers within their territories. Please see the back page of the manual for a list of regional offices or visit www.campbellsci.com/contact to determine which Campbell Scientific office serves your country. For directions on how to return equipment, see Assistance.

Other manufacturer's products, that are resold by Campbell Scientific, are warranted only to the limits extended by the original manufacturer.

CAMPBELL SCIENTIFIC EXPRESSLY DISCLAIMS AND EXCLUDES ANY IMPLIED WARRANTIES OF

MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. Campbell Scientific hereby disclaims, to the fullest extent allowed by applicable law, any and all warranties and conditions with respect to the products, whether express, implied, or statutory, other than those expressly provided herein.

Campbell Scientific will, as a default, return warranted equipment by surface carrier prepaid. However, the method of return shipment is at Campbell Scientific's sole discretion. Campbell Scientific will not reimburse the claimant for costs incurred in removing and/or reinstalling equipment. This warranty and the Company's obligation thereunder is in lieu of all other

warranties, expressed or implied, including those of suitability and fitness for a particular purpose. Campbell Scientific is not liable for consequential damage.

In the event of any conflict or inconsistency between the provisions of this Warranty and the provisions of Campbell Scientific's Terms, the provisions of Campbell Scientific's Terms shall prevail. Furthermore, Campbell Scientific's Terms are hereby incorporated by reference into this Warranty. To view Terms and conditions that apply to Campbell Scientific, Logan, UT, USA, see Terms and Conditions. To view terms and conditions that apply to Campbell Scientific offices outside of the United States, contact the regional office that serves your country.

Assistance

Products may not be returned without prior authorization. Please inform us before returning equipment and obtain a **return material authorization (RMA) number** whether the repair is under warranty/guarantee or not. See Limited warranty for information on covered equipment.

Campbell Scientific regional offices handle repairs for customers within their territories. Please see the back page of the manual for a list of regional offices or visit www.campbellsci.com/contact to determine which Campbell Scientific office serves your country.

When returning equipment, a RMA number must be clearly marked on the outside of the package. Please state the faults as clearly as possible. Quotations for repairs can be given on request.

It is the policy of Campbell Scientific to protect the health of its employees and provide a safe working environment. In support of this policy, when equipment is returned to Campbell Scientific, Logan, UT, USA, it is mandatory that a "Declaration of Hazardous Material and Decontamination" form be received before the return can be processed. If the form is not received within 5 working days of product receipt or is incomplete, the product will be returned to the customer at the customer's expense. For details on decontamination standards specific to your country, please reach out to your regional Campbell Scientific office.

> NOTE:
> All goods that cross trade boundaries may be subject to some form of fee (customs clearance, duties or import tax). Also, some regional offices require a purchase order upfront if a product is out of the warranty period. Please contact your regional Campbell Scientific office for details.

Safety

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.

Use tripods, towers, and attachments to tripods and towers only for purposes for which they are designed. Do not exceed design limits. Be familiar and comply with all instructions provided in product manuals. Manuals are available at www.campbellsci.com You are responsible for conformance with governing codes and regulations, including safety regulations, and the integrity and location of structures or land to which towers, tripods, and any attachments are attached. Installation sites should be evaluated and approved by a qualified engineer. If questions or concerns arise regarding installation, use, or maintenance of tripods, towers, attachments, or electrical connections, consult with a licensed and qualified engineer or electrician.

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, such as those of the FAA in the USA.
- 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.

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.

Use and disposal of batteries

- Where batteries need to be transported to the installation site, ensure they are packed to prevent the battery terminals shorting which could cause a fire or explosion. Especially in the case of lithium batteries, ensure they are packed and transported in a way that complies with local shipping regulations and the safety requirements of the carriers involved.
- When installing the batteries follow the installation instructions very carefully. This is to avoid risk of damage to the equipment caused by installing the wrong type of battery or reverse connections.
- When disposing of used batteries, it is still important to avoid the risk of shorting. Do not dispose of the batteries in a fire as there is risk of explosion and leakage of harmful chemicals into the environment. Batteries should be disposed of at registered recycling facilities.

Avoiding unnecessary exposure to radio transmitter radiation

- Where the equipment includes a radio transmitter, precautions should be taken to avoid unnecessary exposure to radiation from the antenna. The degree of caution required varies with the power of the transmitter, but as a rule it is best to avoid getting closer to the antenna than 20 cm (8 inches) when the antenna is active. In particular keep your head away from the antenna. For higher power radios (in excess of 1 W ERP) turn the radio off when servicing the system, unless the antenna is installed away from the station, e.g. it is mounted above the system on an arm or pole.

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.

WHILE EVERY ATTEMPT IS MADE TO EMBODY THE HIGHEST DEGREE OF SAFETY IN ALL CAMPBELL SCIENTIFIC PRODUCTS, THE CUSTOMER ASSUMES ALL RISK FROM ANY INJURY RESULTING FROM IMPROPER INSTALLATION, USE, OR MAINTENANCE OF TRIPODS, TOWERS, OR ATTACHMENTS TO TRIPODS AND TOWERS SUCH AS SENSORS, CROSSARMS, ENCLOSURES, ANTENNAS, ETC.

Global Sales and Support Network

A worldwide network to help meet your needs

Campbell Scientific Regional Offices

Australia

Location:	Garbutt, QLD Australia
Phone:	61.7.4401.7700
Email:	info@campbellsci.com.au
Website:	www.campbellsci.com.au

Brazil

Location:	São Paulo, SP Brazil
Phone:	11.3732.3399
Email:	vendas@campbellsci.com.br
Website:	www.campbellsci.com.br

Canada

Location:	Edmonton, AB Canada
Phone:	780.454.2505
Email:	dataloggers@campbellsci.ca
Website:	www.campbellsci.ca

China

Location:	Beijing, P. R. China
Phone:	86.10.6561.0080
Email:	info@campbellsci.com.cn
Website:	www.campbellsci.com.cn

Costa Rica

Location:	San Pedro, Costa Rica
Phone:	506.2280.1564
Email:	info@campbellsci.cc
Website:	www.campbellsci.cc

France

Location:	Montrouge, France
Phone:	0033.0.1.56.45.15.20
Email:	info@campbellsci.fr
Website:	www.campbellsci.fr

Germany

Location:	Bremen, Germany
Phone:	49.0.421.460974.0
Email:	info@campbellsci.de
Website:	www.campbellsci.de

India

Location:	New Delhi, DL India
Phone:	91.11.46500481.482
Email:	info@campbellsci.in
Website:	www.campbellsci.in

Japan

Location:	Kawagishi, Toda City, Japan
Phone:	048.400.5001
Email:	jp-info@campbellsci.com
Website:	www.campbellsci.co.jp

South Africa

Location:	Stellenbosch, South Africa
Phone:	27.21.8809960
Email:	sales@campbellsci.co.za
Website:	www.campbellsci.co.za

Spain

Location:	Barcelona, Spain
Phone:	34.93.2323938
Email:	info@campbellsci.es
Website:	www.campbellsci.es

Thailand

Location:	Bangkok, Thailand
Phone:	66.2.719.3399
Email:	info@campbellsci.asia
Website:	www.campbellsci.asia

UK

Location:	Shepshed, Loughborough, UK
Phone:	44.0.1509.601141
Email:	sales@campbellsci.co.uk
Website:	www.campbellsci.co.uk

USA

Location:	Logan, UT USA
Phone:	435.227.9120
Email:	info@campbellsci.com
Website:	www.campbellsci.com