EMERSON
Process Management

IntelliSAW CAM™-4

USER MANUAL

Document: 910.00262.0001

Revision: 2.0

Date: 04 October 2016

Copyright © 2016, IntelliSAW

IntelliSAW
Rosemount Measurement
Emerson Process Management
100 Burtt Rd.
Andover, MA 01810
+1-978-409-1534

WARRANTY

These products are warranted to be free from functional defects in material and workmanship at time of manufacture and to conform at that time to the specifications set forth in the relevant instruction manuals or data sheets, for such products for a period of one year.

Reference IntelliSAW terms and conditions provided at time of purchase for complete warranty details.

IMPORTANT INFORMATION

⚠ This symbol identifies messages in this document related to safety.

⚠ **DANGER**

DANGER indicates an imminently hazardous situation, which, if not avoided, will result in death or serious injury.

Failure to follow the instructions given will result in death or serious injury.

⚠ **WARNING**

WARNING indicates a potentially hazardous situation, which, if not avoided, could result in death or serious injury.

Failure to follow the instructions given can result in death or serious injury

---

⚠ **CAUTION**

CAUTION indicates a potentially hazardous situation, which, if not avoided, may result in minor or moderate injury.

Failure to follow these instructions can result in personal injury.

NOTICE

NOTICE alerts you to practices unrelated to personal injury, such as those that can cause property damage.

Failure to follow these instructions can result in property damage.

IMPORTANT

IMPORTANT indicates additional information about making effective use of this product.

TABLE OF CONTENTS

1 INTRODUCING THE CAM™-4

The IntelliSAW CAM™-4 provides a local human machine interface (HMI), remote monitoring capabilities (temperature, partial discharge (PD), and humidity), data trending and alarming, data aggregation, and multiple communication interfaces such as Modbus TCP or DNP to integrate into existing SCADA / DCS systems.

The CAM-4 can be a stand-alone system ideal for predictive condition-based monitoring of electrical power critical assets such as switchgear, generator circuit breakers, and bus ducts.

This manual covers CAM-4 functionality, configuration, integration, and installation.

1.1 MODELS
The following table outlines available CAM-4 models.

Model	OPTIONS							
	Universal Input	Temp	PD	Humidity	Alarms	Multi-Unit	RS485 SCADA	Modbus TCP
CAM4U-000-AM00	✓				✓	✓		✓
CAM4U-T00-0M00	✓	✓				✓		✓
CAM4U-T00-AMS0	✓	✓			✓	✓	✓	✓
CAM4U-T0H-AMS0	✓	✓		✓	✓	✓	✓	✓
CAM4U-TP0-AMS0	✓	✓	✓		✓	✓	✓	✓
CAM4U-TPH-0M00	✓	✓	✓	✓		✓		✓
CAM4U-TPH-AMS0	✓	✓	✓	✓	✓	✓	✓	✓

1.2 INSTRUCTIONS FOR USE
The CAM-4 is intended to be installed in the Low Voltage compartment of switchgear or in similar types of assets. The CAM-4 is intended for use at a maximum altitude of 5km, between 0°C to +50°C and between 10 - 90% non-condensing relative humidity.

⚠ **WARNING**

The CAM-4 is intended only for installation in Low Voltage Control Compartments. Only sensors and air interfaces are intended for installation in medium / high voltage compartments.

Failure to follow the instructions given can result in death or serious injury

1.3 SYSTEM INPUTS AND OUTPUTS

The maximum system inputs and outputs are as follows:

Inputs	Outputs
12 SAW wireless temp sensors	Communications: Modbus RTU (SCADA)
4 air interfaces (TMP or TPD)	Modbus TCP
8 humidity sensors (series connected)	DNP3
Modbus RTU (Devices)	Email alarms
Power: 100 to 250V AC 50/60 Hz (12W) 120 to 250V DC	Alarms: 4 NO Alarms with a shared COM

1.4 LABELING

The CAM-4 has two identification labels; a Model/Serial ID label on the top of the unit and a compliance label on the side.

1.4.1 Serial ID Label

The CAM-4 Serial ID label provides a model number, serial number and MAC address for the CAM-4.
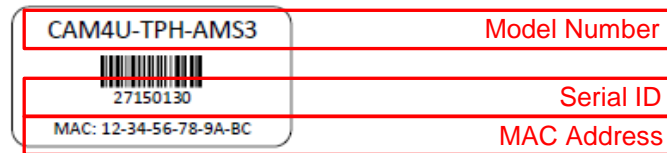
Figure 1: CAM-4 Model Number, Serial ID, and MAC Address

1.4.2 Safety and Compliance Label

The compliance label provides product certification information, input supply ratings, installation ratings, and alarm relay ratings.
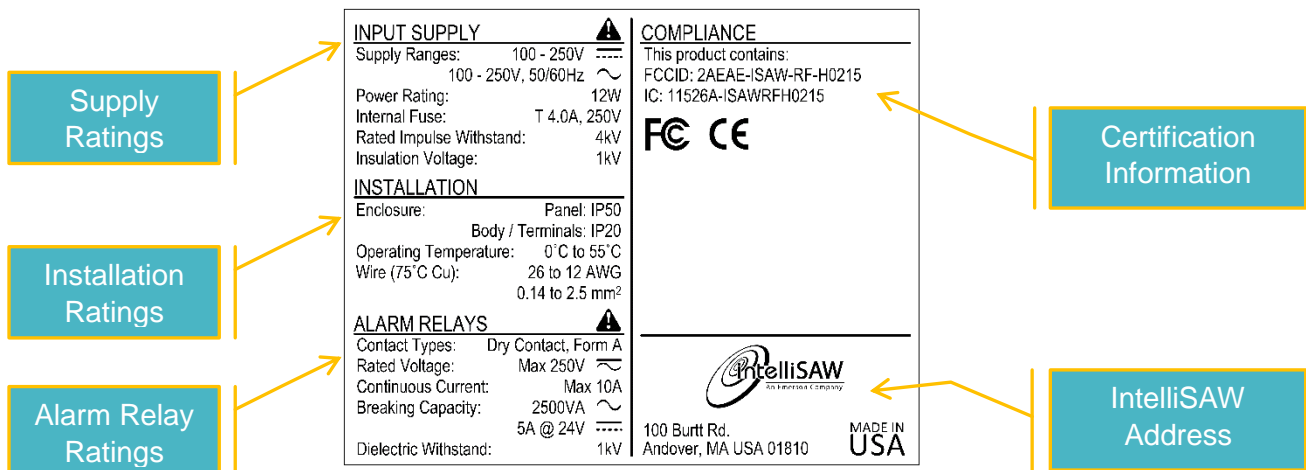
Figure 2: CAM-4 Compliance Label

2 HMI OVERVIEW

The CAM-4 provides a Human Machine Interface (HMI) allowing operators to visualize data, trending, and alarms. The CAM-4 accepts up to 8 IntelliSAW Readers through the multi-unit hardware option (Modbus RTU); the CAM-4 internal monitoring would be considered one of the eight channels.

The following section provided details on the HMI views and operations.

2.1 HOME SCREEN

The CAM-4 home screen provides system measurement summary, alarming information, system health, and a method to step into the details of each connected external data device. The active devices will have available data based on their individual measurement configurations.
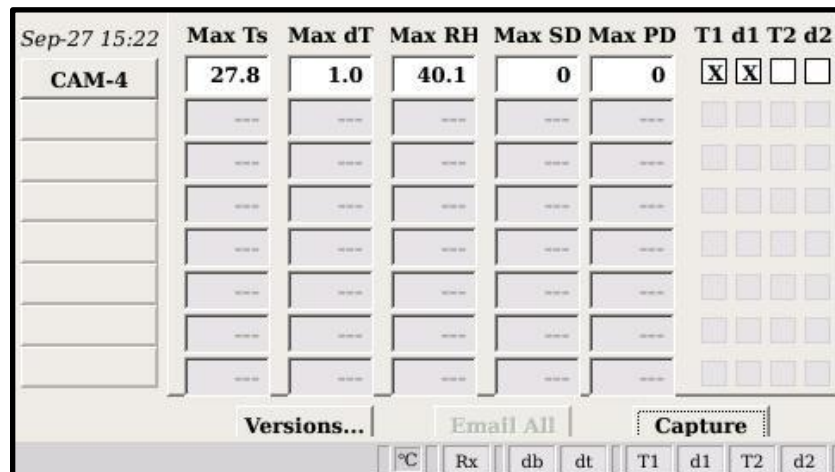
Figure 3: Example CAM-4 Home Screen

2.1.1 Home Screen Segments

The Home screen is broken into the following segments (shown in figure below):

Segment	Description
1	**Date/Time.** The date/time stamp is factory set as UTC+0.
2	**Device Select Buttons.** The CAM-4 unit and extended data device measurements can be cycled through by selecting the appropriate button. The detail screens will loop 5 times and then return to the home screen.

3	**System status.** The CAM-4 system status bar includes: - *Status:* system activity details will show in a text bar - *System display units* - *System Indicators:* Received data (Rx), dead-band trigger (db), timer trigger (dt), and Alarm status - *Capture button:* taking screen captures (saves to extended memory) - *Version Button:* shows device versions
4	**Max Temperature (Max Ts).** Shows the maximum temperature of all sensors being interrogated by the measurement device.
5	**Max Differential Temperature (Max dT).** Shows the maximum temperature differential between groups of 3 sensors being interrogated by the measurement device. Groups are defined based on unit configuration.
6	**Max Relative Humidity (Max RH).** Shows the maximum relative humidity of all sensors being monitored by the measurement device.
7	**Max Surface Discharge (Max SD).** Shows the maximum Surface Discharge of all Air Interfaces configured for PD monitoring by the measurement device
8	**Max Partial Discharge (Max PD).** Shows the maximum Partial Discharge of all Air Interfaces configured for PD monitoring by the measurement device
9	**Alarms.** There are 4 Alarm outputs associated with readings. Each connected unit can trigger the alarm. The check box indicates if an alarm is active for that unit. The alarms are configurable allowing multiple type of output settings.

Figure 4: CAM-4 Home Screen Segments

2.1.2 HMI Warning & Alarm Indications

Warnings and alarms can be triggered from absolute temperatures, the difference within a group of three temperature sensors, relative humidity, and surface or internal partial discharge events. **Warning and alarm limits are configurable (Section: 3.1.3.4 Alarm Mode)**

When a warning occurs, the measurement which created the warning will turn yellow along with the alarm indictor and associated status bar indicator. When the measurement results in an alarm all indicators previously mentioned will turn Red and the alarm relay will close (if option is available). The example below shows a warning on Max Ts and an alarm on Max dT.

Alarm States:

- Yellow (warning) will show immediately
- Alarm (red) requires three consecutive readings over or under the configured limit to set / reset the alarm status
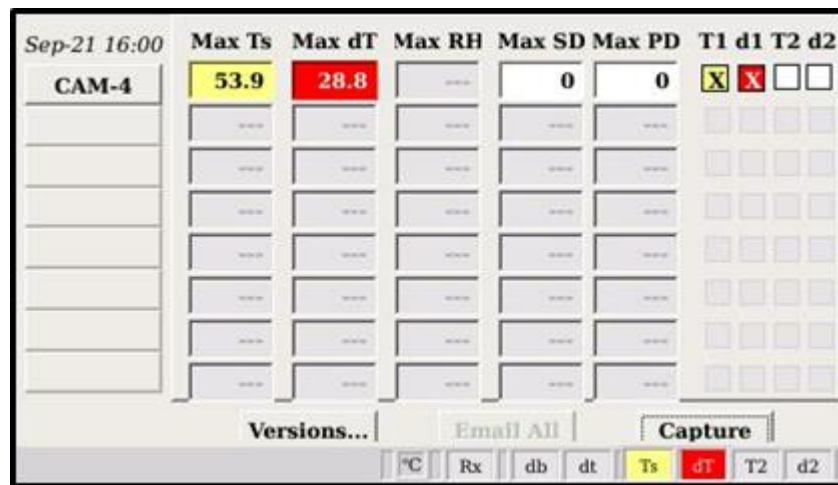
Figure 5: Example of Warning and Alarm Status

2.1.3 Unit Details & Measurement Selection

Selecting the unit button (example in Figure above: CAM-4) will step into the unit's details and cycle through the individual measurement pages.

Selecting the specific unit measurement will go directly to the unit's detailed measurement page. For example, on the home screen in the figure above, when selecting the Max Ts for the CAM-4 (53.7°C), the HMI will immediately go to that device's detail page as shown in the Detailed Data Screen (Figure 6) below.

2.1.4 Capture & Log Files

A USB device can be placed in the extended memory USB port on the side of the CAM-4 for logging data and capturing screen shots. The memory stick must have a folder called **logfiles** in order for data files and capture files to be saved.

2.1.4.1 Capture Button

The capture button will take a screenshot of the current screen and save to disk with a file name that includes the location (summary or DEV# where # is 1 to 8) and a date/time stamp. This button is only enabled when an inserted USB drive has a valid logfiles folder.

2.1.4.2 Log Files

One log file is saved per connected device per day, they are saved as CSV files with headings. The system data is analyzed for value changes against process deadbands and elapsed time before writing to file; both of these limits are configurable based on measurement type.

2.1.5 Versions

The versions button can be selected to evaluate the CAM-4 Application list and currently installed versions. **Select OK to exit screen.**
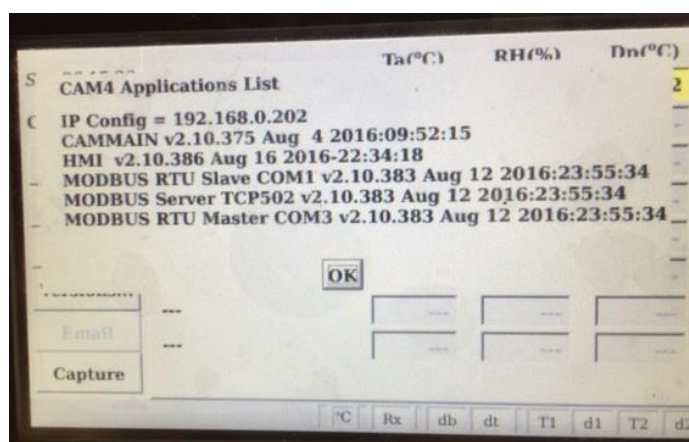
Figure 6: CAM-4 Versions

2.2 DEVICE SPECIFIC DETAIL SCREENS

Each connected device has their own specific detail screens which are configurable. The CAM-4 application allows each screen to be enabled/disabled and for the text on each screen to be customized. The CAM-4 cycles through each enabled screen once every 5 seconds. The following display screens are available and the Data and Graph views are configurable to be enabled (visible) or disabled:

Measurement Type	Display Screens	Data
Temperature	Data & Graph	Up to 12 sensors
Humidity / Ambient Temp	Data & Graph	Up to 8 sensors
Partial Discharge Summary	Data	All Summary PD & SD
	Graphs	Air Interface – port 1 Air Interface – port 2 Air Interface – port 3 Air Interface – port 4

2.2.1 Device Detail Screen Overview

Each device detail screen is slightly different depending on the data it's displaying, but there are a few main sections:
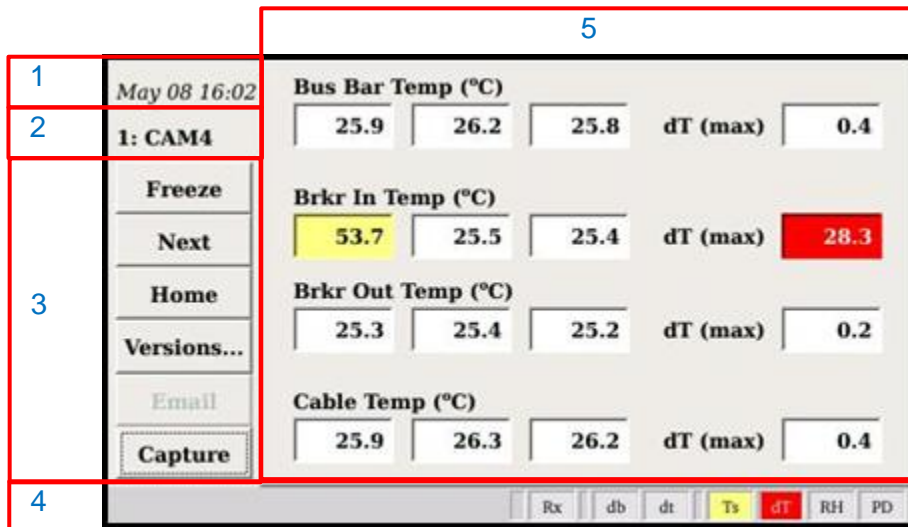
Figure 7: Example Device Detail Screen

Section	Description
1	**Date/Time.** The date/time stamp
2	**Data Device Name. T**he name of specific device the data is being displayed for.
3	**Function Buttons.** **Freeze:** Stays on the current detail screen for 5 minutes. **Next:** Moves to the next detail screen. **Home:** Goes to the home screen. **Versions:** Shows unit versions. **Capture:** Generates a screen capture.
4	**System status.** The CAM system status bar includes: - Text bar for details on an action that occurred. - Indicators for received data (Rx), dead-band trigger (db), timer trigger (dt), and Alarm status
5	**Data Field.** Depending on the data type and whether it is numerical or graphical, this section will change. *Numerical data fields:* white background indicates normal status. Yellow background indicates warning level, and red background alarm level. *Graphical data:* the graph timespan can be configured. The vertical axis auto-scales with the measurements.

2.2.2 Temperature Measurements

2.2.2.1 Numerical Data Screen

The data points are grouped in sets of three and dT is based on these groups. The data fields are fixed groups based on the data device's (Reader or CAM-4 internal) physical Modbus registers as shown in the table below. The registers are configured using the ***IntelliSAW Configuration Tool.*** Only configured registers which read with values other than error codes will show on the HMI. The HMI group text headings are configurable.

Data Group	Device Physical Modbus Register
1	418 – 420
2	421 – 423
3	424 – 426
4	427 – 429

Table 1: Modbus Registers for Temperature Measurements
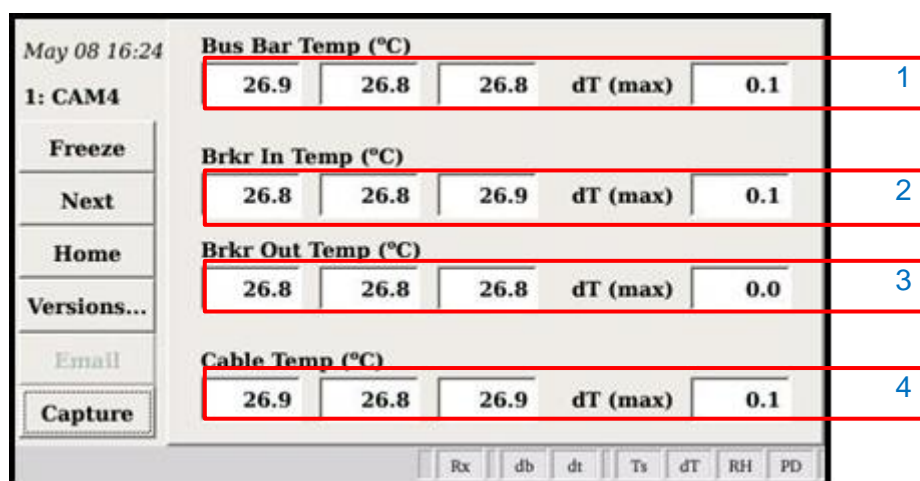
Figure 8: Temperature Numerical Data Screen Example

2.2.2.1.1 Delta-T (dT)

The delta-T max value is based only on the temperature sensors in the associated groups. Although dT is displayed and alarms can be triggered from this calculation, the value is NOT stored in Modbus registers.

2.2.2.2 Graphical Data Screen

The temperature sensor data can also be displayed in a graphical form. The legend shows all available sensors (up to 12) and 1 ambient temperature sensor. The graph only displays data for enabled registers.
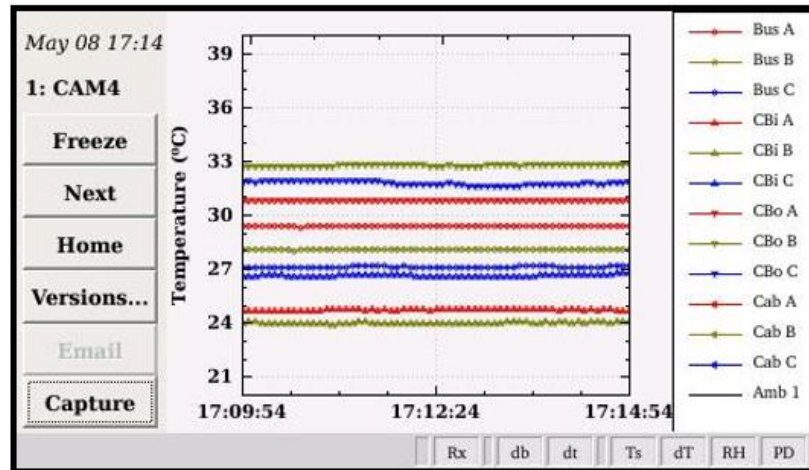
Figure 9: Example Temperature Graphical Display

Notes:

- Ambient Temperature is pulled from the first connected Humidity Sensor to a device
- Legend labels cannot be modified through the configuration tool.

2.2.3 Humidity and Ambient Temperature

2.2.3.1 Numerical Data Screen

IntelliSAW monitoring units support up to 8 humidity sensors – e.g. for bus duct monitoring between generators and transformers. The ambient temperature, relative humidity, and dew point are displayed. The ambient sensors are displayed sequentially based on their address (starting with address 0) when configured with the ***IntelliSAW Configuration Tool.*** The text location names can be edited based on system installations.
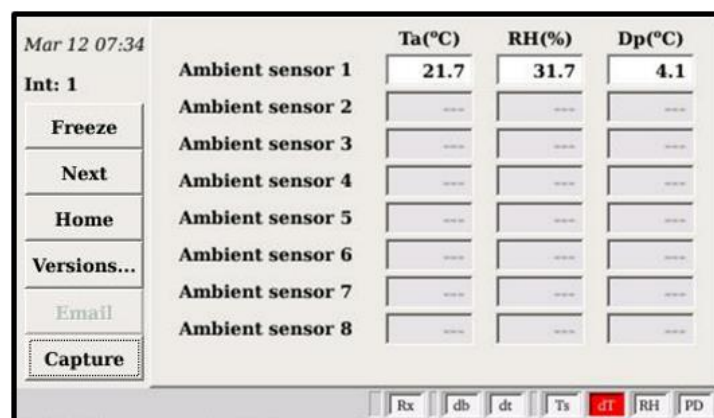
Figure 10: Example Ambient Temperature and Humidity Screen

2.2.3.2 Graphical Data

The ambient temperature / humidity sensor data can also be displayed in a graphical form. The legend shows all available sensor data (up to 8).
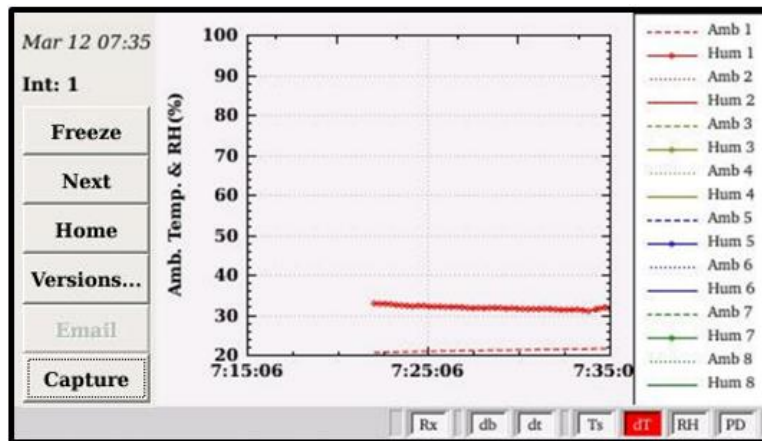
Figure 11: Example Ambient Temp and Humidity Graph

Notes:

- Legend labels cannot be modified through the configuration tool.

2.2.4 Partial Discharge (PD)

IntelliSAW monitoring units include specific hardware and an algorithm for analyzing ultra-high frequency (UHF) radio emissions to detect and quantify the signatures of symmetric and asymmetric discharges that are synchronous with the power line frequency, while distinguishing them from other modulated UHF emissions that come from non-discharge related noise sources. Monitoring units support up to 4 PD Air interfaces (model: TPD). The IntelliSAW partial discharge detection solution specifically monitors three distinct bands (300MHz, 600MHz, and 1200MHz) affording multiple opportunities to detect partial discharge events and to distinguish these events from noise sources.

All raw frequency data is provided through Modbus registers and stored to local data storage – this data does not get displayed on the HMI. The HMI can report the total surface discharge (SD) and partial discharge (PD) for each port connected to a suitable air interface.

2.2.4.1 PD Monitoring Signals

The IntelliSAW system classifies the processed modulation signals into three categories:

2.2.4.1.1 Noise

Noise denotes UHF energy in the selected frequency band(s) that does not correlate well with the power line frequency. External radio interference is reliably classified as noise; however weak and erratic partial discharge – which occurs early in the evolution of a defect – can sometimes also be classified as noise.

2.2.4.1.2 Partial Discharge

Partial discharges that occur in insulation surrounding conductors have a more symmetric pattern with respect to the power line frequency. The portion of incoming energy matching this pattern is classified as PD. The value represents the magnitude of the symmetric signal in excess of the combination of detected noise and the asymmetric value.

2.2.4.1.3 Summary PD

Summary PD is the maximum PD for one antenna port accumulated in one register over the enabled bands. The enabling / disabling of frequency bands will affect the summary value if the enabled or disabled band is the highest. This data point in the Modbus registers should be used for trending.

2.2.4.1.4 Surface Discharge (Corona)

Surface discharges are events that depend on the polarity of an object because of a metal/air boundary. These events occur on the negative polarity wave cycle when emitted electrons ionize the air, causing corona discharges. The value represents the magnitude of the asymmetric signal in excess of detected noise.

2.2.4.1.5 Summary SD

Summary SD is the maximum SD for one antenna port accumulated in one register over the enabled bands. The enabling / disabling of frequency bands will affect the summary if the enabled or disabled band is the highest. This data point in the Modbus registers should be used for trending.

2.2.4.2 PD Monitoring Units

The IntelliSAW system measures the integrated (cumulative) discharge over a power cycle with a relative scale approximately related to pico-coulombs (pC) cumulative/ power cycle. The MODBUS registers are scaled by 10 with counts of 1 – 65534 representing approximately 10 – 655,340 pC cumulative (but non-linear and un-calibrated by default). The measured values depend on the distance of the air interface from the discharge and may other factors. While the result can be calibrated to a reference location using a discharge synthesizer, variability in the source of real discharges and the exact nature of the discharge will have significant influences on the measurement, as does non-linearity in the detector. *Therefore, the resultant data from the unit should only be used for trending and differential analysis over time as an early warning system for detecting corona and partial discharge and not as an absolute measurement.*

2.2.4.3 PD / SD Summary: Numerical Data Screen

The Numerical Data Screen shows the last measured PD and SD data for each Air Interface. Data will only be shown for ports that have been configured to monitor PD through the **_IntelliSAW Configuration Tool._**
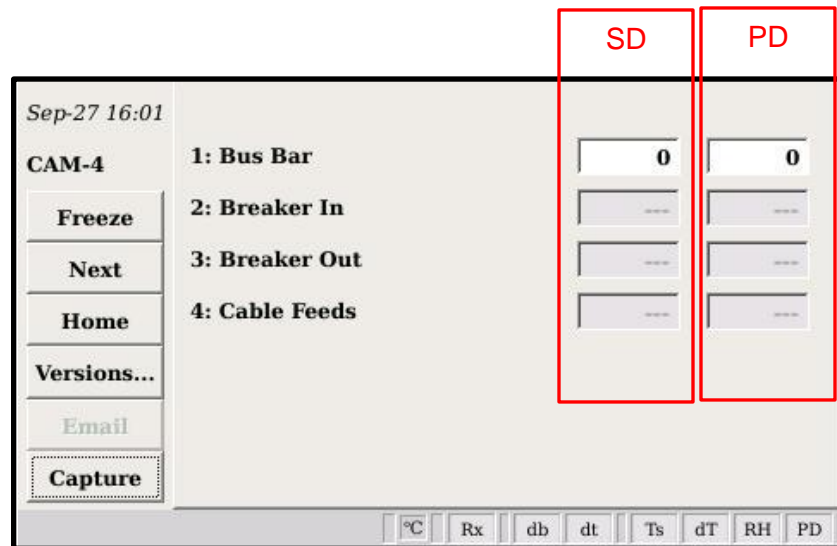
Figure 12: Example SD / PD Summary: Numerical Data Screen

2.2.4.4 PD / SD Summary: Graphical Data

The PD / SD Summary data can also be displayed in a graphical form. There is a unique page for each port that has been configured for PD monitoring. The data shows instantaneous values along with short and long term exponential weighted averages (α and β) for trending.
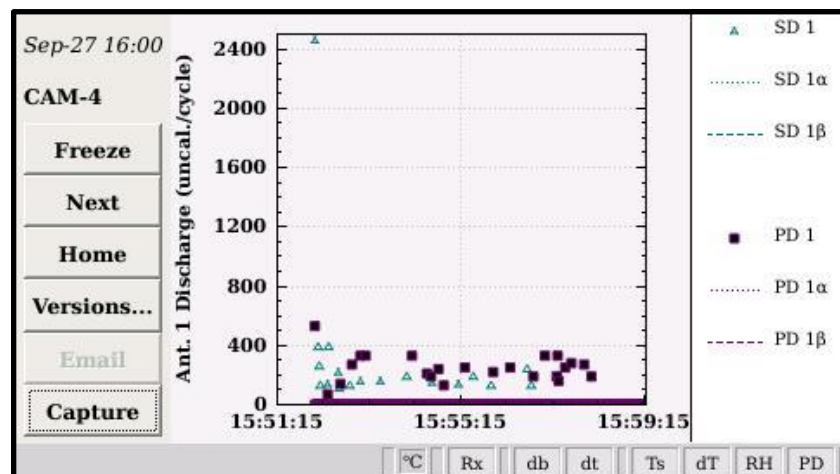
Figure 13: Example PD / SD Summary: Graphical Data Screen

3 HMI CONFIGURATION

The CAM-4 HMI configuration settings are stored in an XML file format and will need to be loaded onto the unit. The following section outlines the tools and process for loading a config.xml file onto a CAM-4.

3.1 CAM-4 HMI CONFIGURATION TOOL

The CAM-4 Configuration tool is an easy to use wizard stepping through all available HMI features to create the necessary configuration file. The CAM-4 Configuration Tool can create a new _config.xml_ file or load a previous file for editing. **Note that the config tool allows the file to be saved with an arbitrary name and that this is convenient for keeping track of multiple files; however, the file loaded onto the CAM4 MUST be named config.xml.**

This section has been updated for **Configuration Tool 1.0 (Revision 1220 or greater) and supports CAM-4 firmware Version 2.10 and above.** Previous revisions may operate differently.

3.1.1 CAM-4 Configuration Tool Launch Screen

The launch screen gives the option of creating a new Config File or Opening and editing an existing Config File. This manual assumes the creation of a new Config File. The screens and available features for editing an existing file are the same as those of creating a new file.
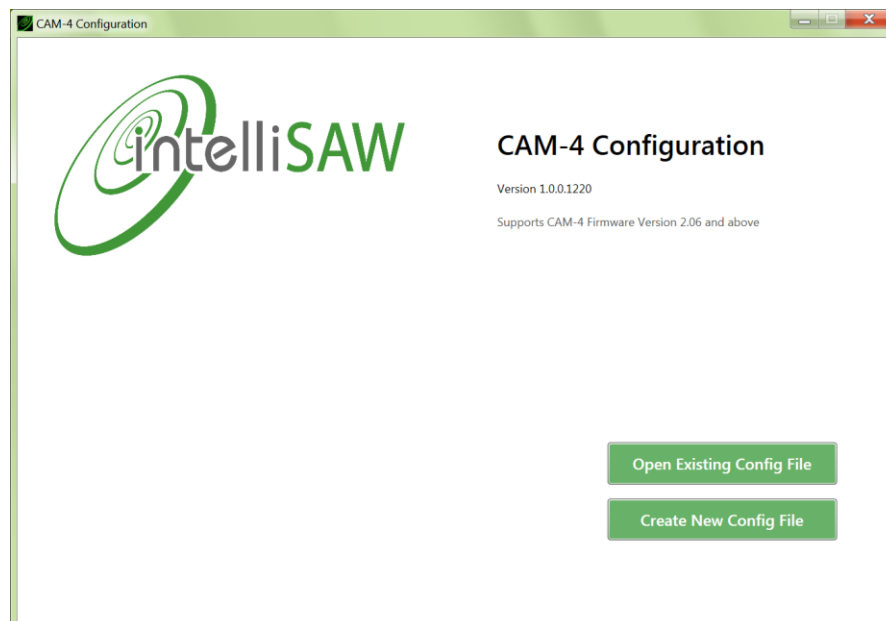
Figure 14: CAM-4 Configuration Tool Launch Screen

> ➢ Select **Create New Config File** to create new file

3.1.2 CAM-4 Features Screen

The CAM-4 features screen provides a way to select the CAM-4 unit model and features to be configured.

➢ **Model:** Select the drop down menu, and choose the model that applies.
➢ **Features:** Select optional features in the selection panel; these will change when new models are selected.

Note: NOT all features may be available for every model.

For example, when selecting model CAM4U-T00-0M00, Humidity will default to 'not selected' due to not being a capability of that model. The CAM-4 configuration tool **WILL** allow Humidity to be manually selected, however without the necessary hardware the data will not be collected and a blank Humidity screen will show on the HMI.
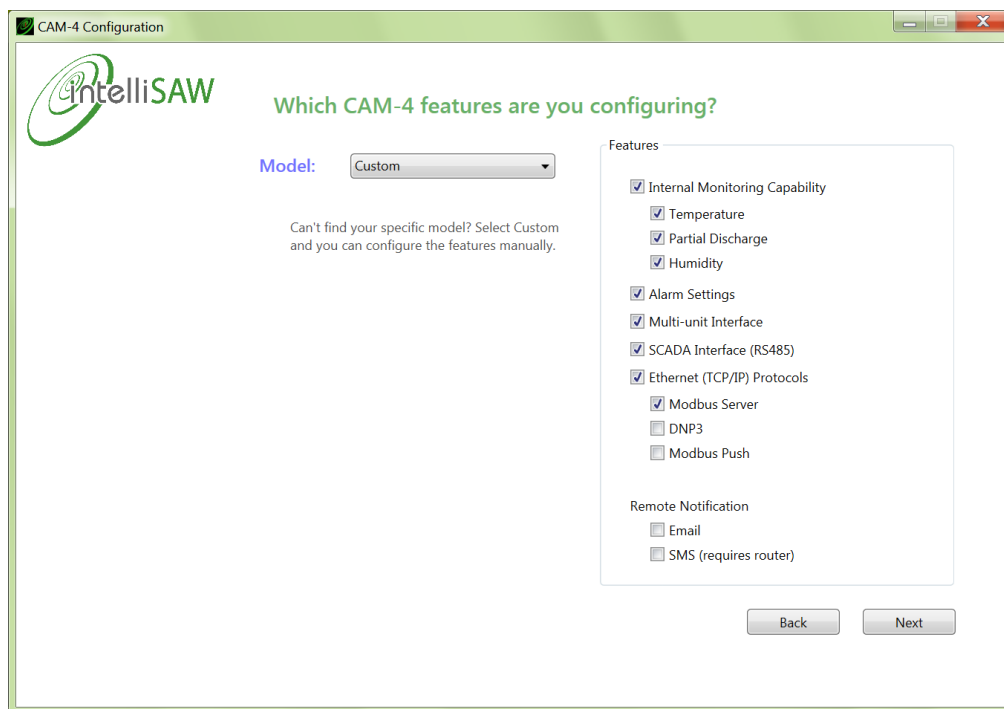
Figure 15: CAM-4 Configuration Tool Feature Screen

3.1.2.1 Model Change

When a CAM-4 Model is selected, the default features for Internal Monitoring, Alarm Settings, Multi-Unit Interface and SCADA Interface are selected; Modbus TCP is standard and will always be selected in the Ethernet (TCP/IP) Protocols. Additional features, such as DNP3, Modbus Push, Email and SMS can be selected as needed.

➢ Once the model and additional features are selected, continue by selecting **Next**

3.1.2.2 Tool Navigation Buttons

The CAM-4 Configuration Tool allows navigation through the configuration screens using the Back and Next buttons. However, selecting **Back** in the CAM-4 Features Screen will discard all settings**.**
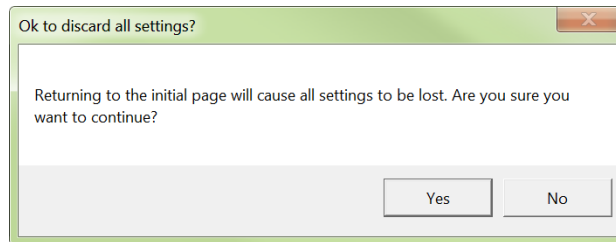
Figure 16: Selecting Back in the CAM-4 Features Screen

3.1.3 HMI Settings: General

This screen configures the Temperature Units, Default HMI Language, Date Format and Alarm Mode that will be shown in the HMI.
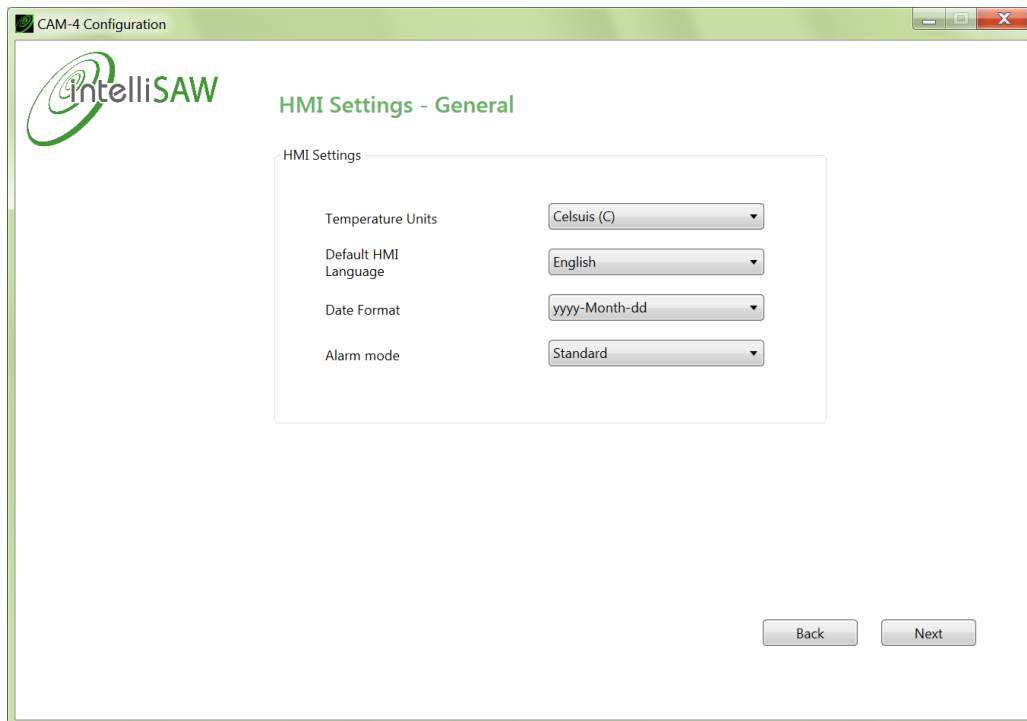
Figure 17: CAM-4 Config Tool HMI Settings

3.1.3.1 Temperature Units

The Temperature Units changes the HMI display units to either Celsius or Fahrenheit.

Note, Modbus and DNP-3 registers are always in Celsius.

3.1.3.2 Language

The Default HMI Language menu provides English, Portuguese, Spanish, and Chinese as standard available display languages. A choice of Programmable (Unicode) will allow custom XML file configuration of any supported UTF-8 character, but is not discussed further.

The Language setting changes major HMI default components, it does not translate data that has been inputted through system configuration.

3.1.3.3 Date Format

The Data format will show the date as yyyy-*Month-dd* or *dd-Month-yyyy* on the display and when written to the log files. This setting facilitates proper insertion to csv files in various locales.

3.1.3.4 Alarm Mode

The Alarm Mode provides three variations for the measurement type that will trigger Relay outputs (A-out 1 to A-out 4). The alarm mode applies to all connected devices

Alarm Mode	A-out 1	A-out 2	A-out 3	A-out 4
Standard	Max Temp	Max dT	Max Humidity	Max PD / SD
All Temperature	Temp Warning	dT Warning	Temp Alarm	dT Alarm
All SD/PD	SD Warning	PD Warning	SD Alarm	PD Alarm

3.1.4 HMI Settings: Graphs and Triggers

The HMI Settings: Graphs and Triggers menu allows configuration of how to view and store data collected from devices and sensors. Configuration applies to all connected devices.
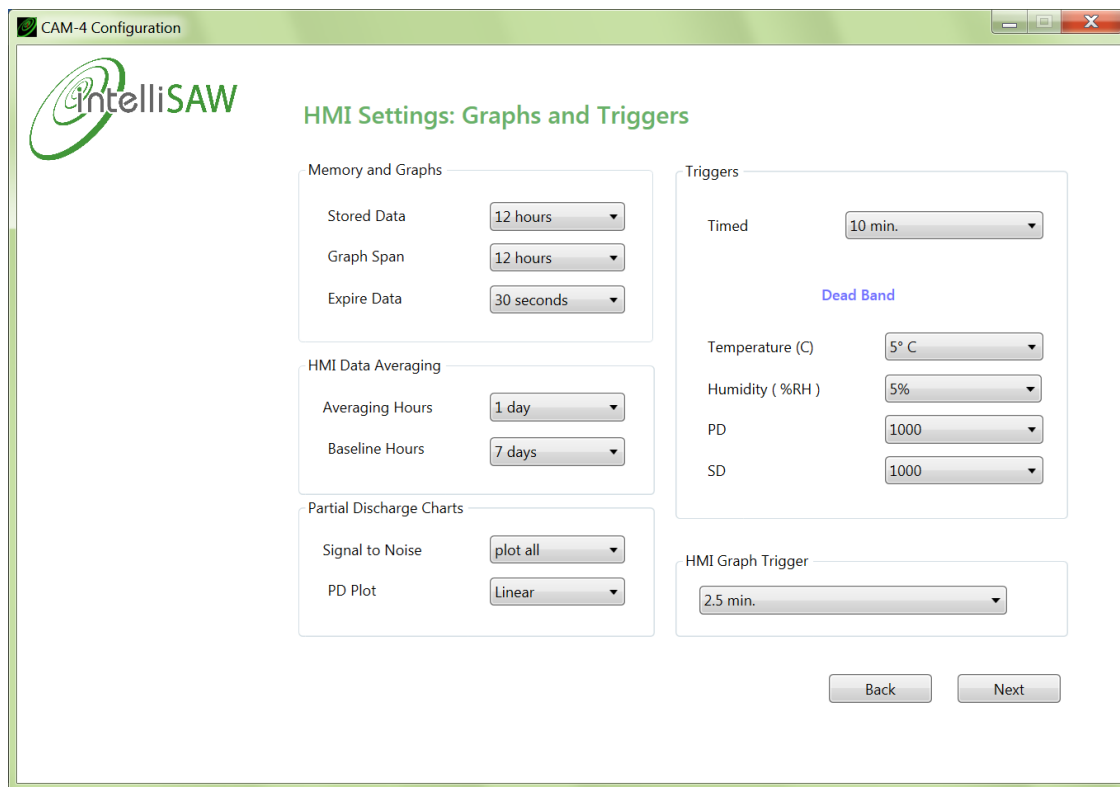
Figure 18: HMI Settings: Graphs and Triggers Menu

3.1.4.1 Memory and Graphs:

The Memory and Graphs defines how long to store data (Stored Data), how long to show the stored data on the graph (Graph Span), and the data refresh rate on screen (Expired Data).

- **Stored Data**: Identifies how long to store measured data in CAM-4 memory, options are from 1 to 12 hours. This does not affect the stored data in the external USB storage device.

- **Graph Span**: Identifies how much data to display on the graphs, options are from 1 to 12 hours. Normally stored data is as long or longer then the Graph Span, allowing enough data to fill the graph span. If the HMI does not have enough data to fill the Graph Span, it will shorten the graph to only show Stored Data.

- **Expire Data**: Determines a maximum interval between reading fresh data before the data will be considered invalid. After this time, HMI numerical display will be cleared and MODBUS registers, and DNP-3 values will revert to error codes. Default is 30 seconds, but with multiple readers being connected, it may take up to a full minute to get all data from all readers and longer settings may be desirable.

3.1.4.2 HMI Data Averaging

Defines the length of time of the Exponential Weighted averages of **Averaging Hours** and **Baseline Hours**.

- **Averaging Hours:** defines the length of time for a short term exponential weighted averaging. It is graphed on the HMI as the "α" line.
- **Baseline Hours:** defines the length of time for a long term exponential weighted averaging. It is graphed on the HMI as the "β" line. The intended use is a long baseline above which the average and instantaneous values are deemed relevant.

3.1.4.3 Partial Discharge Charts

The Partial Discharge Charts provide customization on viewing PD data.

- **Signal to Noise:** Determines a level of viewing PD data based on the signal to noise ratio; if PD data is greater than noise by a multiplicative factor of 'x' where 'x' is a signal to noise ratio it will be shown on the graph.
- **PD Plot:** Identifies whether to view the data linearly or logarithmically

3.1.4.4 HMI Graph Trigger

The HMI Graph Trigger identifies the time interval that is the longest time between data points on a graph (assuming there is valid data) if the data does not change outside a deadband from the last plot point.

Because of finite memory the time interval has a minimum value determined by the Max data length and number of devices.

- 0 – 4 hours, use the HMI graph trigger setting
- 4 – 6 hours, use the greater of the setting and 38 seconds * number of connected devices (e.g. 2.5 minutes at 4 devices and 5 minutes at 8 devices)
- 6 – 9 hours, use the greater of the setting and 112 seconds * number of connected devices (e.g. 7.5 minutes at 4 devices and 15 minutes at 8 devices)
- 9 - 12 hours, use the greater of the setting and 225 seconds * number of connected devices (e.g. 15 minutes at 4 devices and 30 minutes at 8 devices)

3.1.4.5 Triggers

The CAM-4 has several triggers which force data to be written to the HMI, stored to local file, or pushed through Modbus TCP/IP to a server. DNP-3 has an independent set of triggers.

- **Timed**: During Normal Operation, the "Timed" trigger will determine how often to trigger on data. Timed triggers can be set to a time interval or trigger on **deadband** only.
- **Deadband triggers:** A value change over the previous reference measurement will generate a trigger. For example, temperature would have to change by 5˚C to register a graph point or log to file. Deadband triggers also force graph updates.

3.1.5 TCP/IP Setup and Protocol Configuration

This screen has up to 4 tabs available: IP Settings, Modbus TCP, Modbus Push, and DNP3

Note: Not all tabs may be available in every model. If the feature is not selected at the CAM-4 Features Screen it will not be available for configuration
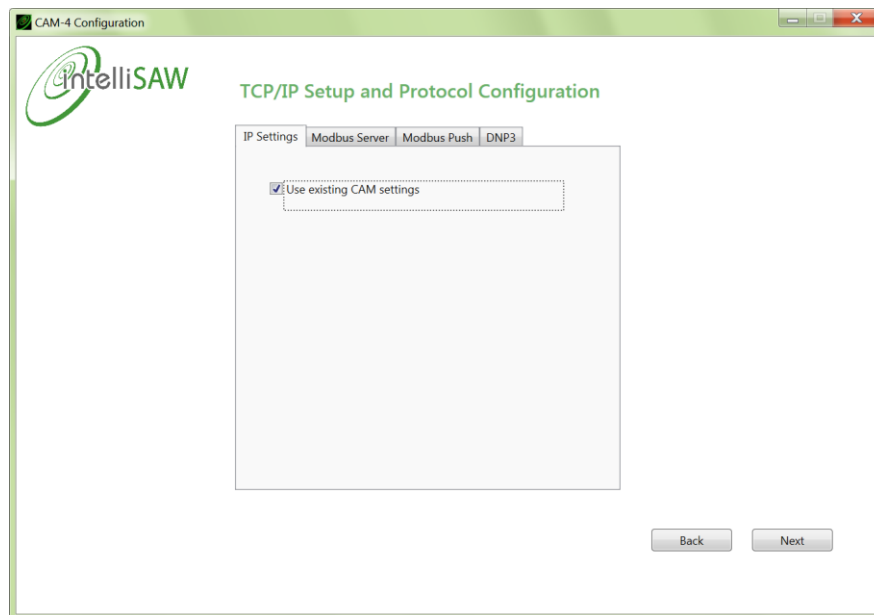
Figure 19: TCP/IP Setup and Protocol Configuration, Use existing CAM Settings

3.1.5.1 IP Settings

IP Setting will use the pre-existing IP settings of the HMI unless otherwise specified.

Unchecking the "Use existing CAM Settings" box will display the IP Settings options.

All CAM-4 units are shipped with a default IP address of 192.168.1.201

The IP Setting Tab defines the IP Address, Net Mask, Gateway and DNS of the CAM-4.

If multiple CAM-4 units are being configured for a single network, they should **NOT** have the same IP Address.

3.1.5.2 Modbus Server Tab

Settings are for Modbus Server interface to a DCS, configurable fields include:

- **Port:** The default Ethernet port for MODBUS is 502. Change this only if the remote master/client expects a nonstandard port.

- **Idle:** If there has been no communication with the remote client, then the connection is dropped to allow the server to forget devices that lose connection then reconnect on a new socket.
- **Max Connections:** This sets the maximum number of connections (clients) that the server will support.
- **Base Register:** The data is located in registers BaseReg to BaseReg+80. By default BaseReg is 418 for compatibility with IRM-48 Reader firmware. Attempts to read registers less than BaseReg or greater than BaseReg+80 will result in an illegal address exception.

3.1.5.3 Modbus Push

Settings are for Modbus TCP push to a Server which is configured specifically to accept CAM-4 packets, configurable fields include:

- **Port:** The default Ethernet port for MODBUS Push is 503.
- **Request Timeout:** timeout between request for connections to server
- **Request Retries:** how many times to try to connect to server
- **TCP Send to IP Address:** IP address of server
- **Station ID:** identification of location where CAM-4 is; this is unique per device

Data packets are not configurable. Data is transmitted on timed or dead-band triggers events. In either case, all data for the device is sent and all data references are updated.

3.1.5.4 DNP3

Settings are for DNP configurable fields include:

- **Port:** The default Ethernet port for DNP3 is 20000
- **Station ID:** Identification ID for CAM-4 on the DNP3 network, which must be unique on the network.
- **Master ID:** Identification ID for master device on DNP3 network, which is typically 1.
- **Analog Variation:** Refer to the DNP-3 specifications for details. Analog values may be sent as 16 bit integer, 32 bit integer, 32 bit float, or 64 bit float. Any format may be accompanied by a flag and/or a timestamp.

3.1.6 DNP3 Deadband Settings

When the DNP3 option is selected, the DNP3 Deadband settings screen provides the ability to further configure the unit. DNP-3 deadbands trigger individual data point transmissions to the master.
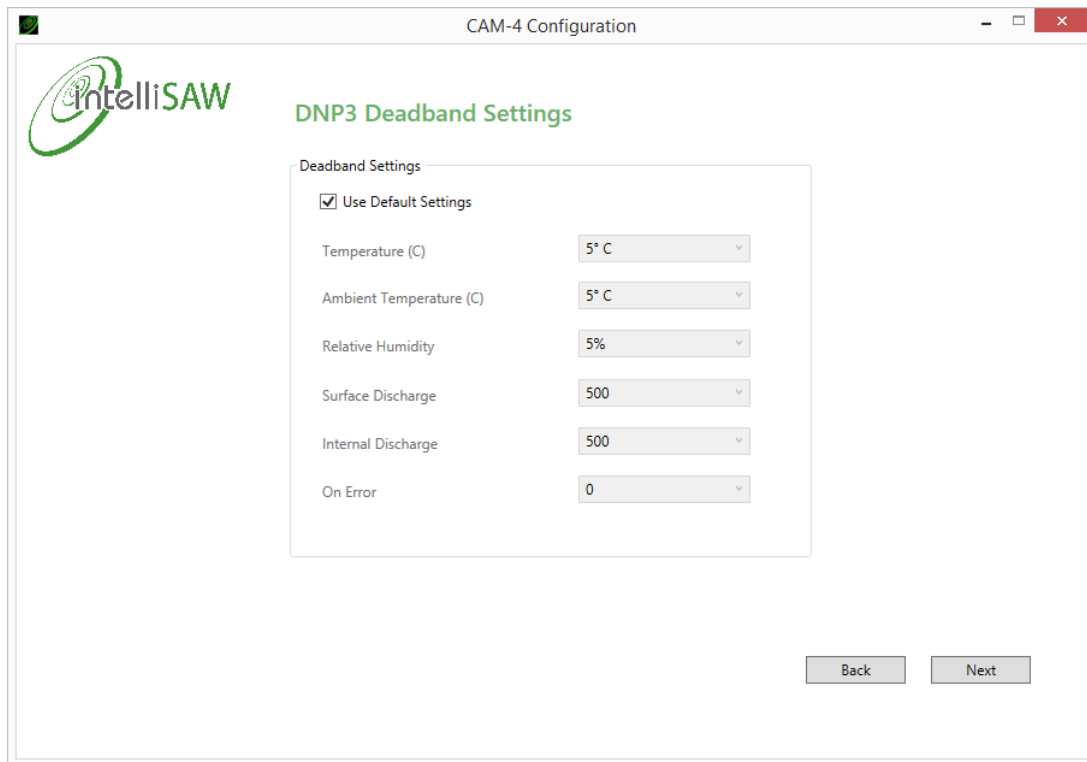
Figure 20: DNP3 Deadband Settings

The following settings are available:

- **Temperature**: A SAW temperature sensor change from previous value: 2.5°C, 5°C, 7.5°C, and 10°C.
- **Ambient Temperature**: An ambient temperature (from humidity/ambient sensor) change from previous value: 2.5°C, 5°C, 7.5°C, and 10°C.
- **Relative Humidity**: A humidity change from previous value: 2.5 %RH, 5%, 7.5%, and 10%
- **Surface Discharge**: A Surface discharge change from previous value: 200, 500, 1000, 1500, 2500, and 5000.
- **Internal Discharge**: An Internal discharge (Partial Discharge) change from previous value: 200, 500, 1000, 1500, 2500, and 5000.
- **On Error:** options of 0 or 1 disable or enable sending an update when a value reverts to an error code.

3.1.7 Modbus RTU SCADA Settings

Settings are for the CAM-4 Modbus SCADA (RS485) port to communicate with a SCADA/DCS.

Figure 21: Modbus RTU SCADA Settings

System configurable fields include:

- **Baud rate:** The default (and recommended) rate is 9600.   Other options are available (4800, 9600, 19200, 38400, 57600 or 115200)
- **Parity:** Standard serial parity settings – Odd / Even / None
- **Serial Idle:** The MODBUS standard specifies that 3.5 character times (35 bit times without parity) is a break between messages. On slower systems a minimum time in ms is also specified. The larger of the two times is used. At 9600 baud the actual value is 3.65ms. The default value is recommended unless the system uses packet radios or other repeaters that might fracture a packet. In this case the idle time must be longer than the longest fracture period.

3.1.8 Multi-Unit Setup: Communications

Defines the communication setting for how to communicate with the connected Readers (Modbus devices).

Figure 22: Multi-Unit Setup

Configurable fields include:

- **Baud Rate:** The default (and recommended) rate is 9600.   Other options are available (4800, 9600, 19200, 38400, 57600 or 115200)
- **Parity:** Standard serial parity settings – Odd / Even / None
- **Serial Idle:** The MODBUS standard specified that 3.5 character times (35 bit times without parity) is a break between messages. On slower systems a minimum time in ms is also specified. The larger of the two times is used. At 9600 baud the actual value is 3.65ms. This value, although it can be modified, is not recommended
- **Min Loop Interval:** Sets the minimum interval between measurement loops (all devices). At a minimum, the loop time will be the greater of *Min Loop Interval* or (*Min Request Interval* * # of devices in the loop).
- **Min Request Interval:** Sets the minimum request time per connected device.
- **Request Timeout:** Sets the timeout on each Modbus query.
- **Request Retries:** Sets the number of tries to communicate to a connected device.

3.1.9 Device Detail Setup

The Device Detail Setup is used to identify all monitoring units connected to the CAM-4 multi-unit device hardware interface along with their specific measurement capabilities. Note, the CAM-4 internal measurement capability is considered a connected device.

Figure 23: Device Detail Setup

3.1.9.1 Number of External Readers

The HMI displays data for up to 8 measurement units. There a two options for setting up the HMI based on external devices:

CAM-4 with On-board Monitoring: if the CAM-4 has on board monitoring capabilities, then it is allowed to have up to 7 additional Readers connected. The configuration tool will have a note: "CAM-4 internal monitoring and multi-unit monitoring are enabled". The option for number of external readers is capped at 7.

CAM-4 without Monitoring: if the CAM-4 is only being used as a display (model CAM4U-000-xxxx) then it is allowed to have up to 8 additional devices connected. The configuration tool will have a note: "CAM-4 internal monitoring disabled".

3.1.9.2 Name

The Name of the location or device for a connected reader. Note, the names will appear in order on the HMI. Modbus addresses do not have to be consecutive.

The Names will be shown on the HMI.

3.1.9.3 Modbus Addresses

- **Physical:** The physical Modbus address of the connected Reader. Setup through the **_IntelliSAW Configuration Tool._**
- **Mapped:** The mapped Modbus address is internal to the CAM-4. This option would be used if a pre-configured system is being installed with an already existing system, where the physical address of a monitoring device might already be in use on the Communication bus.
  The "Use Modbus Physical Address for Mapped Address" option is checked by default, keeping the mapped address and physical address are the same. To change the mapped address, de-select this option and apply a mapped address accordingly.

3.1.9.4 Unit Measurements

The Temperature, PD and Humidity checkboxes indicate the measurement capabilities of the connected Readers and determine which measurement screens to display.

3.1.10   Measurement Details: Labels and Views

Once the connected Readers are defined, the individual measurement screens need to be configured through the Measurement Details: Labels and Views. The tool will step through each connected device for setup based on the device detail's selected measurements.

Figure 24: Measurement Details: Labels and Views – Temperature

If Temperature, PD, or Humidity data is being monitored by a device, but their associated screens are not enabled, the device will log and transmit the data to a SCADA system, but the data will not be viewable in the HMI.

Labels are not required for all locations. An error message will show at the bottom of each Device Settings Menu until all selected measurement types are configured.

3.1.10.1   Temperature

The Temperature Menu allows naming the location of the Temperature sensors. These labels are shown in the HMI Device Detail screen. The data is broken up into 4 groups of 3 registers as identified by the ***InteliSAW Configuration Tool.*** Selections are available to show the Data View and Charts.

Labeling Consistency

When Configuring the Temperature Settings, the temperature registers labels being shown should match the registers that were configured in the ***IntelliSAW Configuration Tool.***

IntelliSAW standard configurations are:

- Registers 418-420: Incoming Bus
- Registers 421-423: Circuit Breaker Input
- Registers 424-426: Circuit Breaker Output
- Registers 427-429: Outgoing Line

If a different configuration sequence is used, ensure it remains consistent across Readers.

3.1.10.2   PD

The PD Menu allows naming the location of the PD air interface and are based on the specific Reader port they are connected to.   The specific port is configured in ***the IntelliSAW Configuration Tool***. Selections are available to show the Data View and Charts.

Only the PD Air Interfaces should be named in this section. If a Temperature Only Air Interface is connected, it should not be labeled.

3.1.10.3   Humidity

The Humidity Menu allows naming the location of the humidity sensors. Up to 8 sensors can be attached to a CAM-4 or Reader, each of which provides an ambient temperature and a humidity value. The sensors are configured in the ***IntelliSAW Configuration Tool***. Selections are available to show the Data View and Charts.

3.1.10.4   Copy Settings to Remaining Devices

If there are multiple Readers connected to the CAM-4 and they have similar labeling schemes, use the "Copy Settings to Remaining Devices" to speed up the configuration process.

3.1.11   Warning & Alarms Configuration

The Warnings and Alarms screen is used to set the Warning and Alarm levels for all monitoring devices connected to the CAM-4. Warning and Alarm Levels can be set for the following:

- **Max Temperature:** max value out of all potential 12 sensor for the connected device
- **Max Temperature Differential:** max dT between groups of 3 sensors for connected device.
- **Max % Relative Humidity:** max %RH for all connected sensors for the device
- **Max Partial Discharge:** max PD value. No analytics are performed, this is only based on a maximum value being reached.
- **Max Surface Discharge:** max SD value. No analytics are performed, this is only based on a maximum value being reached.

Depending on selected alarm mode, specific warning and alarm channels could be disabled.

Figure 25: Standard Alarm Configuration

3.1.11.1 Enabling Channels

Enable All: identifies if the alarm contact will close when an alarm is reached on any Reader

Individual Enables: option to enable / disable alarms for a specific Reader

3.1.11.2 Warning and Alarm Settings

Global: An easy way to apply new settings to enabled channels

Individual: Warning and Alarm settings can be set for individual devices

3.1.12 Email Configuration

If a CAM-4 is connected to an email server, the unit can be configured to send emails when a warning or alarm was reached.

Knowledge of the Email server, firewall, connection types and login details are needed for a successful setup.

The system name should be updated, as it is used in the title of the email. Most secure email servers use TLS and AuthLogin. Consult your IT department.

The user name and password are those values required by your SMTP server. The display name is arbitrary and the sender's email address is placed in the SMTP from: and replyto: fields.

HTML formatted emails are strongly suggested, as the CAM-4 may then insert screen shots of the device data associated with the alarm or warning.

Figure 26: Email Configuration

3.1.12.1 Email Recipients

The email Recipients window allows up to 16 email address to receive status updates. Recipients can be configured to be Carbon Copied (CC) or Blind Carbon Copied (BCC).

At least one valid email address is required.

3.1.13 SMS Configuration

The CAM-4 can communicate with a modem and send SMS messages for warnings and alarms. This requires cellular connectivity through an F3427-ISAW 3G cellular router.

Figure 27: SMS Configuration

Configuration includes:

- **Modem Model:** The SMS configuration requires a configured **Four Faith F3427** modem and valid SIM Card.
- **SMS Port:** This is the Telnet port on which the router listens for commands to send SMS.
- **TCP Send To IP Address:** This is the IP address of the router.
- **SMS Doman:** Older networks are circuit switched and some have difficulty sending SMS over the newer packet switched (data domain) network. For example T-Mobile SIM cards have only succeeded with circuit switched. "Preferred" simply means to try the preferred method first.

3.1.13.1 SMS Recipients

The SMS recipients Menu allows up to 10 phone numbers for SMS communication of Warnings and system status.

At least one valid SMS Recipient is required.

3.1.14 CAM-4 Configuration Complete

Once all configuration settings have been completed the CAM-4 *config.xml* file must be saved so it can be sent to the unit. Select **SAVE** to save the file or **BACK** to make changes. While it is possible, and even beneficial, to use a descriptive name, the file must be uploaded as config.xml.

3.1.14.1 Saving CAM-4 Config File

Once the configuration has been completed, select **SAVE**.

In order for the CAM-4 unit to properly read the file, it **MUST BE UPLOADED UNDER THE NAME "config.xml".**
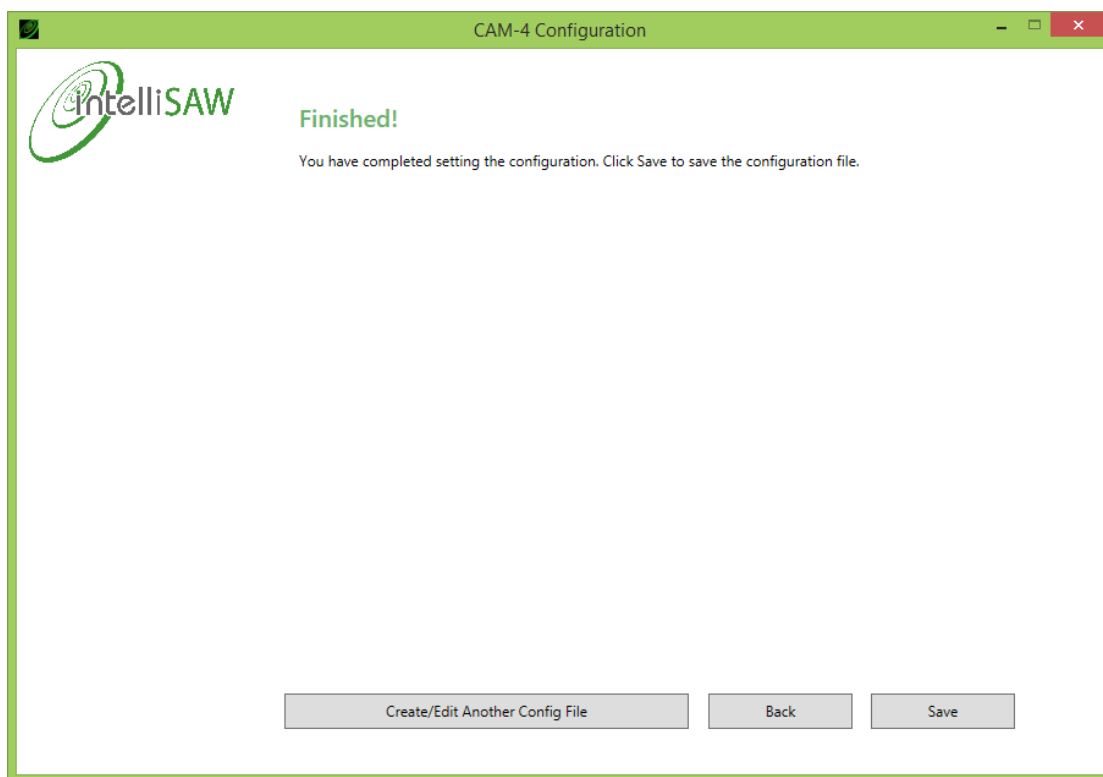
Figure 28: CAM-4 Configuration Complete

Once saved, the tool will provide the option to **CREATE/EDIT ANOTHER CONFIG FILE.** If no other configuration file is needed, the application can be closed.

4 LOADING A CAM-4 HMI CONFIGURATION FILE

4.1 NEEDED APPLICATIONS:

All applications listed are free, open source and contain their own licensing and restrictions that should be read and accepted before downloading. IntelliSAW shall not be held responsible for customers downloading these applications.

4.1.1 Secure FTP Application
Function: Loading a configuration file

The IntelliSAW CAM-4 HMI uses a Secure File Transfer Protocol (SFTP) for transferring HMI configuration files. There are many open source FTP/SFTP applications available for use, the examples within this document will use FileZilla FTP Client (download link).

4.1.2 XML Editing Application
Function: Manually editing a configuration file. (For advanced users only)

The IntelliSAW CAM-4 HMI configuration files are XML based and require an editing application to modify and update for advanced applications and settings. There are many open source XML editing applications available for use, the examples within this document will use Notepad++ (download link).

4.1.3 SSH Application
Function: Editing Date/Time. (For advanced users only)

The IntelliSAW CAM-4 HMI runs an instance of the Linux 2.6 operating system and requires a secure shell connection to provide remote session for issuing commands. There are many open source SSH applications available for use, the examples within this document will use PuTTY (download link).

4.2 CONNECTING TO A CAM-4 UNIT

There are a few methods to connect to a CAM-4, the examples below assume a one-to-one connection between the PC and the CAM-4 Unit through TCP/IP Ethernet interface.

The following process may be unique depending on operating system.

4.2.1 Change PC IP address
On the PC systems Network connections, select the Ethernet port used and edit the properties as shown in the figure below.
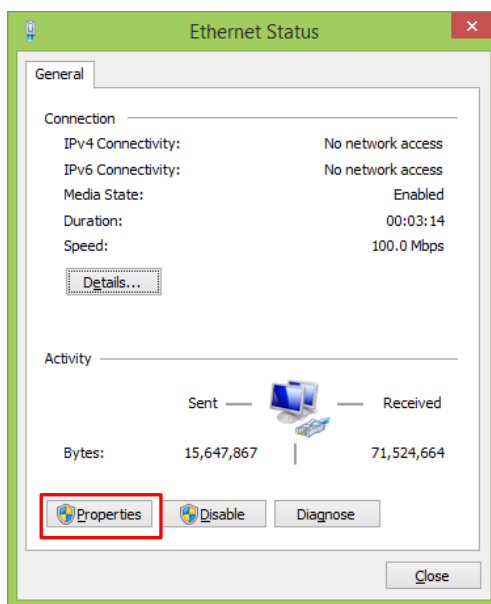
Figure 29: Ethernet Status Dialog.

Once the properties are open, select the Internet Protocol Version 4 and then select Properties.
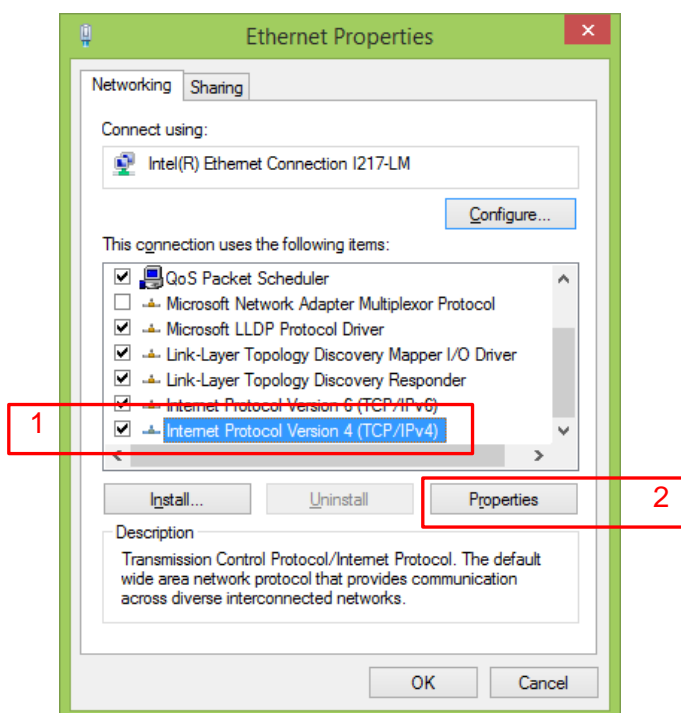
Figure 30: Select TCP/IPv4 properties

Set the IP address to the specific network the CAM-4 is on, with a unique host component as shown in the following figure.

It is assumed for this document that the CAM-4 IP address is: 192.168.0.201.

- The PC should use 192.168.0.*aaa* where *aaa* DOES NOT equal 201 or any other connected device.
- The subnet mask should be set to 255.255.255.0.
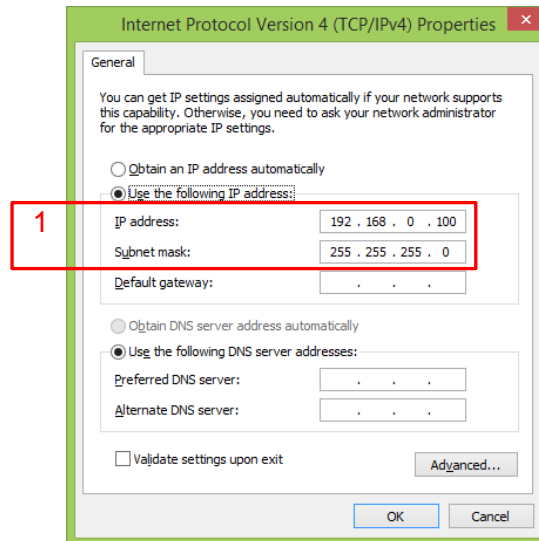
Figure 31: Example PC IP address with identical network and unique host components

4.3 OPENING FTP APPLICATION (FILEZILLA)

Once the PC and CAM-4 are on the same network, the next step is to SFTP into the CAM-4 unit to retrieve or replace the config.xml file. Open FileZilla. The following document is not a FileZilla User manual, but will describe the interface sections as they pertain to loading CAM-4 configuration file:
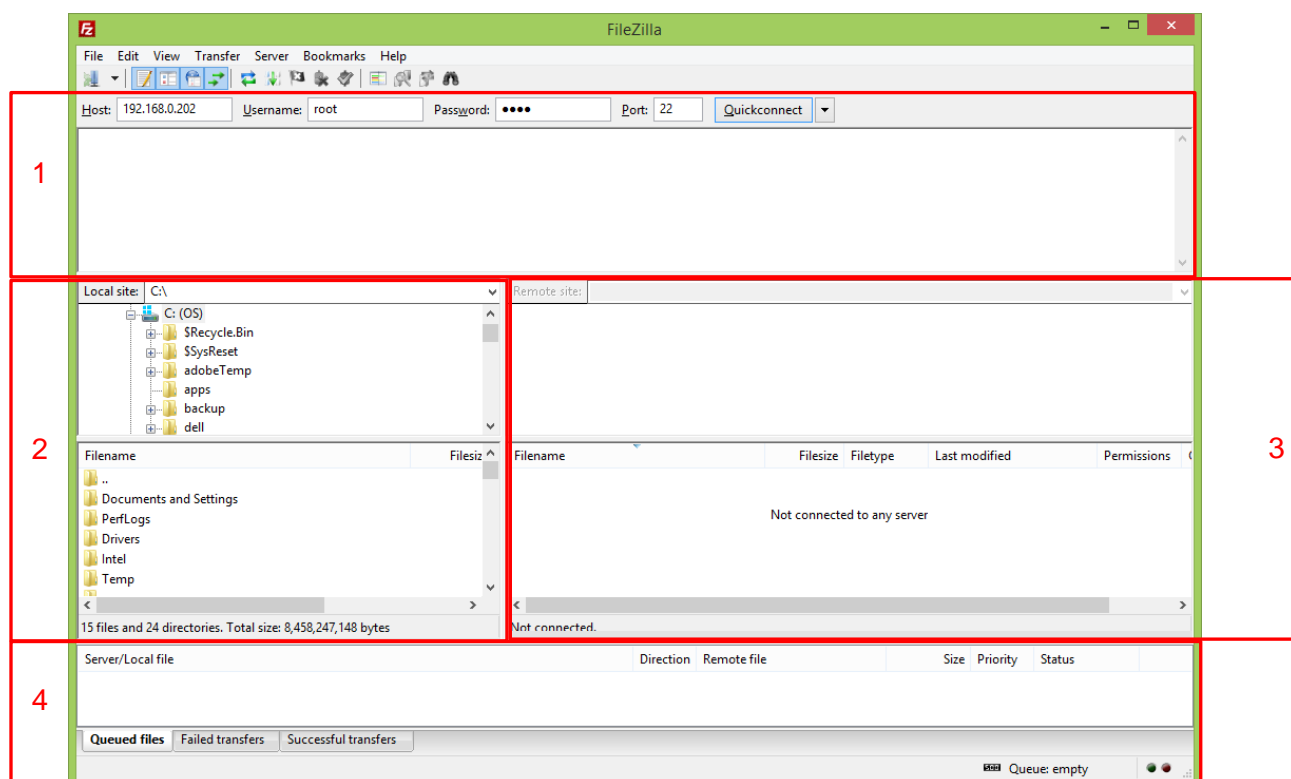
Figure 32: FileZilla User Interface

Section	Description
1	**Connection.** This section is where the CAM-4 unit connection details (host, user name, password and port) are entered. The white space below shows connection details as to whether it was successful or connection errors are occurring. *NOTE: If there are connection errors, it is most often (1) the PC IP address was not setup, or (2) the wrong CAM-4 (host) IP address was used.*
2	**Local Site.** This section is a directory of the connected PC. Navigating *Local Site* to a folder where the CAM-4 configuration file is (or will be) located.
3	**Remote Site.** This section is a directory of the CAM-4.
4	**File Status.** This section highlights files that are being transmitted between the CAM-4 and the PC.

4.3.1 CAM-4 IP SFTP Connection Details

In the Connection Section, set the following:

- Host: CAM-4 IP Address   (ex: 192.168.0.201)
- User Name: root
- Password: 1234
- Port: 22

Select **Quickconnect** to start the connection process.

If successful, the status section will show 'Successful' and the remote site directly will be retrieved and populated as shown in the following image.
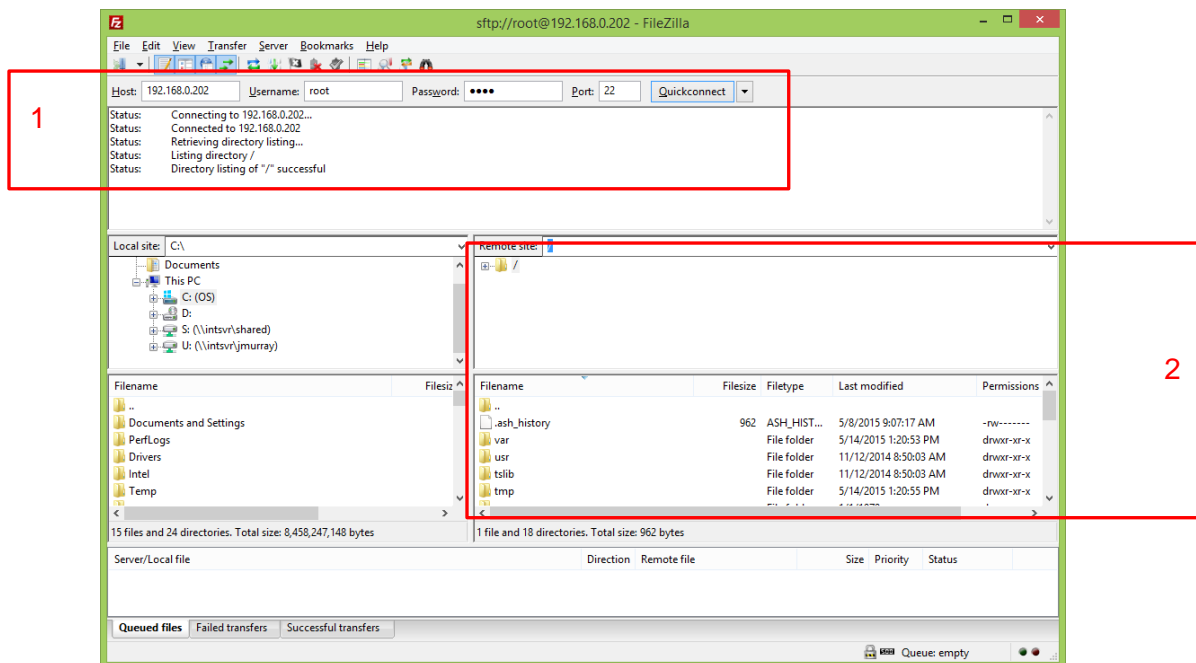
Figure 33: Example of a successful connection

If it's the first time the PC is connecting to the CAM-4, the following message may appear:

Figure 34: Unknown host key - Appears first time connecting to CAM-4

Select: _Always Trust host, and this key to the cache_, then select **OK**.

4.3.2 Identifying Files and Locations

1. Navigate to the Local directory to the new **config.xml** file was just created.
2. Navigate to the following CAM-4 directory location: **/home/isaw**
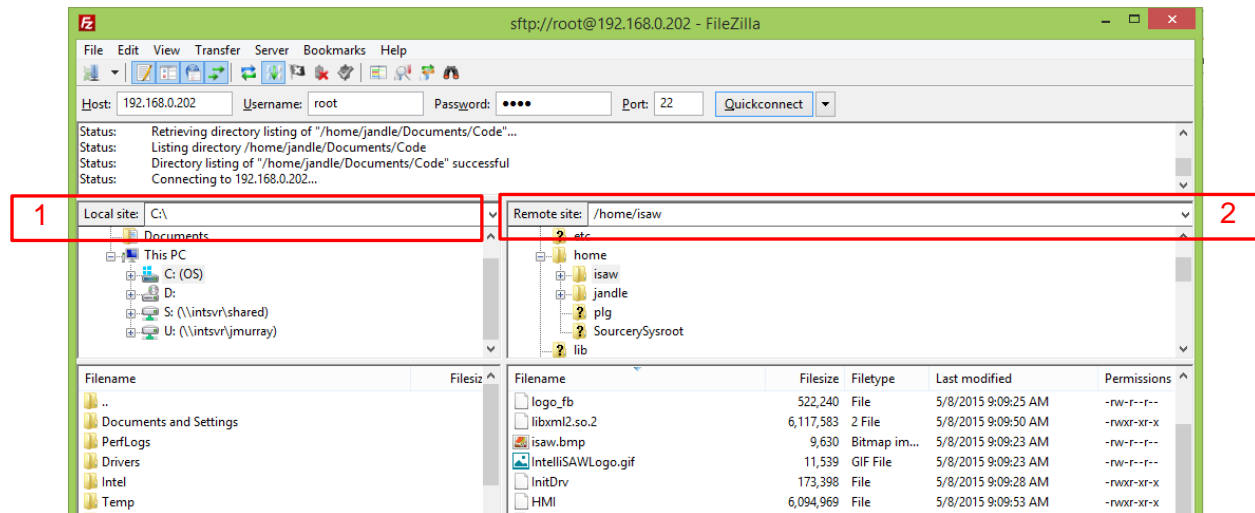
Figure 35: Connected to a CAM-4 and Navigate to folder location

4.3.3 Transferring Config File

Locate the config.xml file on the local site (laptop) and drag / drop into the Remote Site (CAM-4)
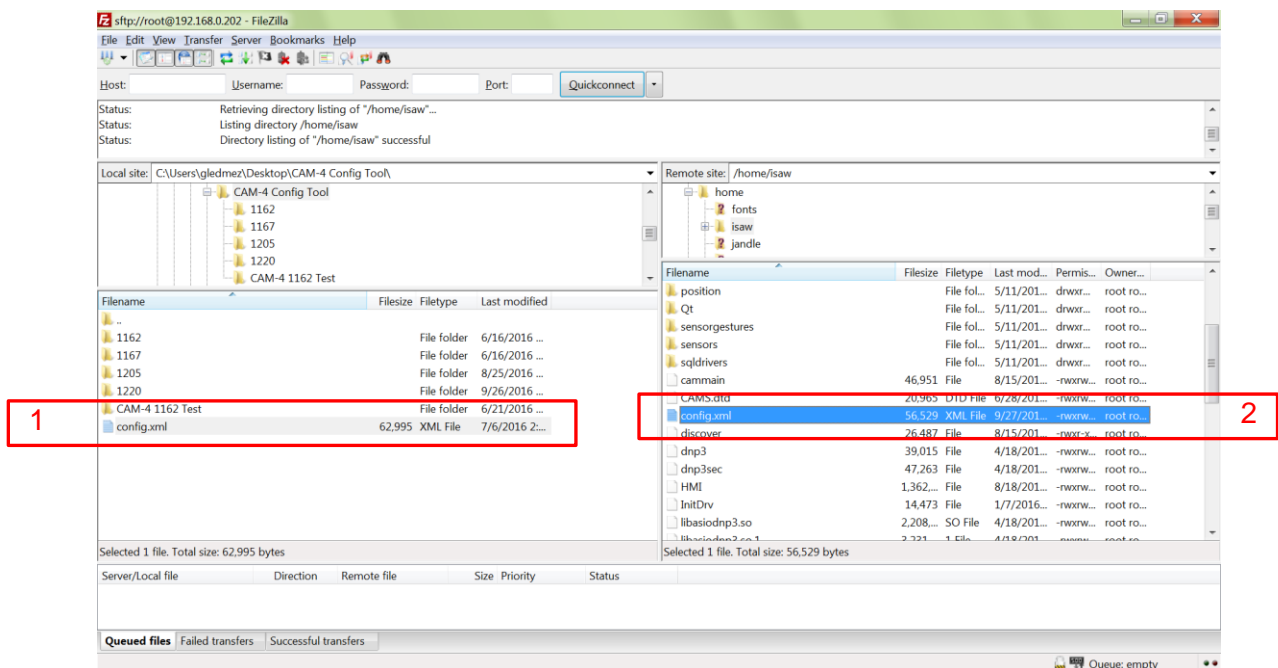
Figure 36: Replacing config.xml file

> **NOTICE**
>
> **ONLY Replace config.xml file.**
>
> **Deleting or Modifying other files could result in a corrupt CAM-4 file structure.**

4.3.3.1 File Replacement

Because the unit already has a default config file, the system will ask to replace. Select Overwrite, then OK.
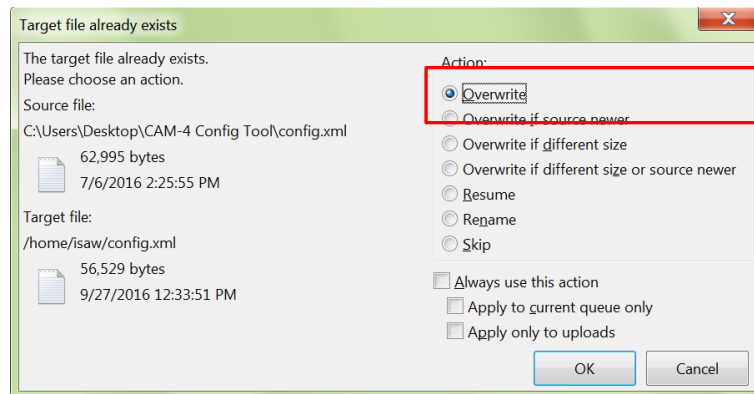
Figure 37: Overwrite existing file

4.4 REBOOT CAM-4

The CAM-4 configuration file is only loaded at unit start-up, therefore, once the configuration file has been successfully loaded, remove power and then reconnect power to reboot the unit.

Note: If the IP was changed, follow Connecting to a CAM-4 Unit to reconnect to the CAM-4.

5 MEASUREMENT CONFIGURATION & SENSOR INSTALLATION

5.1 MEASUREMENT CONFIGURATION

If the CAM-4 has internal measurements, it will require measurement configuration for the associated installed temperature sensors, air interfaces, and humidity sensors. Configuration is performed through the USB mini port and uses the IntelliSAW Configuration Tool. Details are not discussed here, please refer to the *(910.00160.0001) IntelliSAW Configuration Tool User Manual* for detailed instructions.
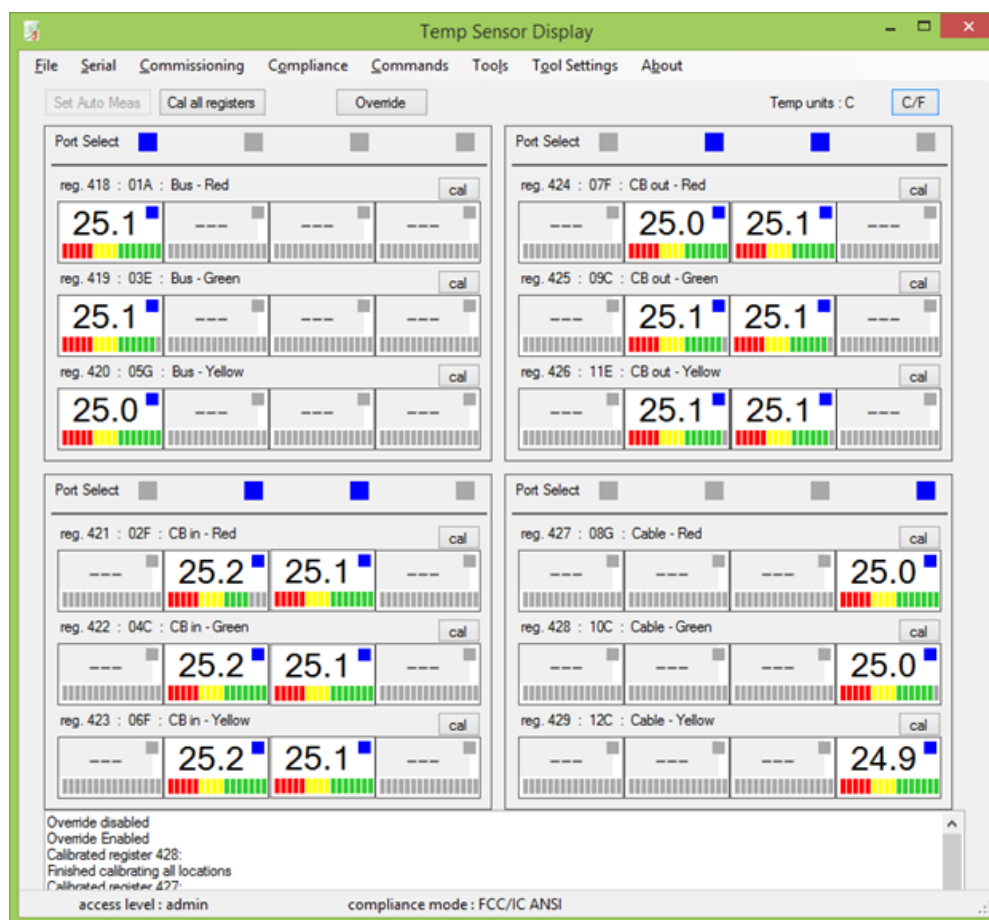
Figure 38: IntelliSAW Configuration Tool

5.2 SENSOR INSTALLATION

This manual does not cover specific sensor installation. Please reference the *(910.00379.001) IntelliSAW Sensor Installation Manual* for more details.

6 CAM-4 INSTALLATION

⚠ **WARNING**

INSTALLATION AND CONFIGURATION SHOULD BE PERFORMED ONLY BY
PERSONNEL WHO ARE TECHNICALLY COMPETENT AND AUTHORIZED TO DO SO.
LOCAL REGULATIONS REGARDING ELECTRICAL INSTALLATION AND SAFETY MUST
BE OBSERVED.

Failure to follow the instructions given can result in death or serious injury

---

⚠ **WARNING**

THE USE OF THIS EQUIPMENT IN A MANNER NOT SPECIFIED IN THIS MANUAL OR BY
THE MANUFACTURER MAY IMPAIR PROTECTION OF THE USER AND EQUIPMENT.

Failure to follow the instructions given can result in death or serious injury

---

⚠ **CAUTION**

THIS EQUIPMENT IS DESIGNED FOR INSTALLATION IN AN ENCLOSURE THAT
PROVIDES ADEQUATE PROTECTION AGAINST ELECTRIC SHOCK.

Failure to follow these instructions can result in personal injury.

6.1 UNPACKING

1. Remove the product from its packing. Retain the packing for future use, to transport the instrument to a different site or to return it to the supplier for repair/testing.
2. Examine the delivered items for damage or defects. If any are found, contact the courier immediately.
3. In the Box:
   a. CAM-4 Unit
   b. Power terminal block (3 position 7.62mm Plug)
   c. Devices terminal block (3 position 3.5mm Plug) if option exists
   d. SCADA terminal block (3 position 3.5mm Plug) if option exists
   e. Alarm terminal block (5 position plug) if option exists
   f. 16GB Flash Drive
   g. Mounting Kit:
       i. (2) Mounting Clips
       ii. (4) M3 Size 10 mm screws
       iii. (2) M4 Size 20 mm screws

6.2 DIMENSIONS

The CAM-4 HMI instrument has front screen dimensions of 105 H X 138.1 mm W with a screen depth of 6.5 mm. The Body dimensions of the CAM-4 are 93.1 H × 129.2 W x 135.5 mm D.
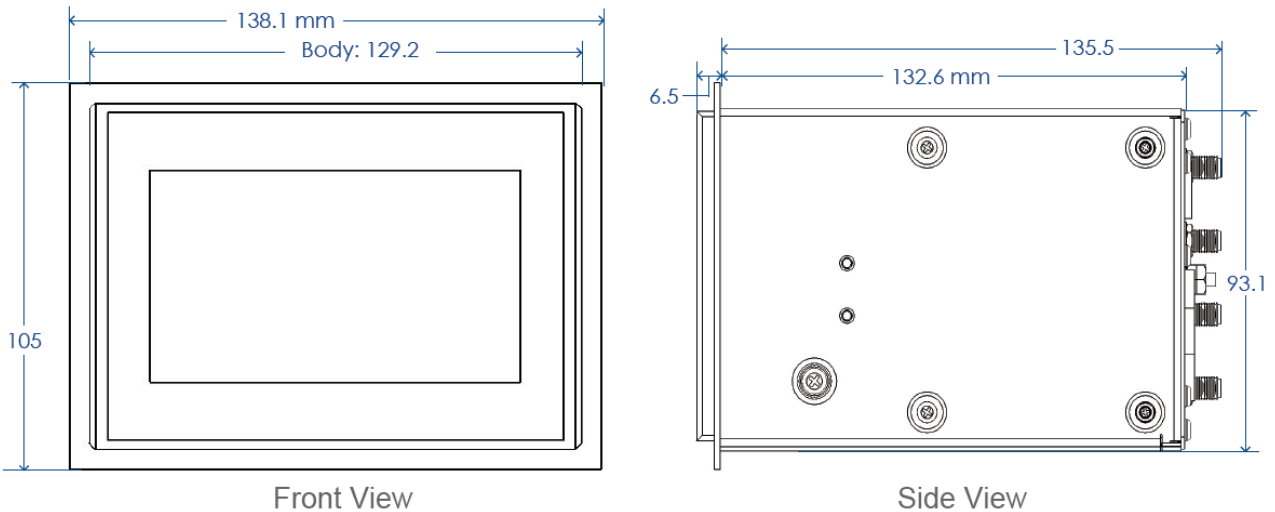
Figure 39: CAM-4 Dimensions (in mm)

6.3 CONNECTORS

The product has up to thirteen connectors (depending on model):

Constant Connectors:

- (1) Input Power Connector
- (1) USB connector (Mini-B) – used for measurement configuration
- (1) USB connector (Standard-A) – used for data logging
- (1) Ethernet Connector
- (1) Ground lug – chassis ground

Option Dependent Connectors:

- (4) SMA (RF) connectors – used for air interface connections
- (1) Alarms Connector
- (1) SCADA (RS485) Connector – SCADA integration through Modbus RTU
- (1) Devices (RS485) Connector –Reader Input through Modbus RTU
- (1) Humidity connector

Figure 40: CAM-4 Back View

Figure 41: CAM-4 Bottom and Left Side Views
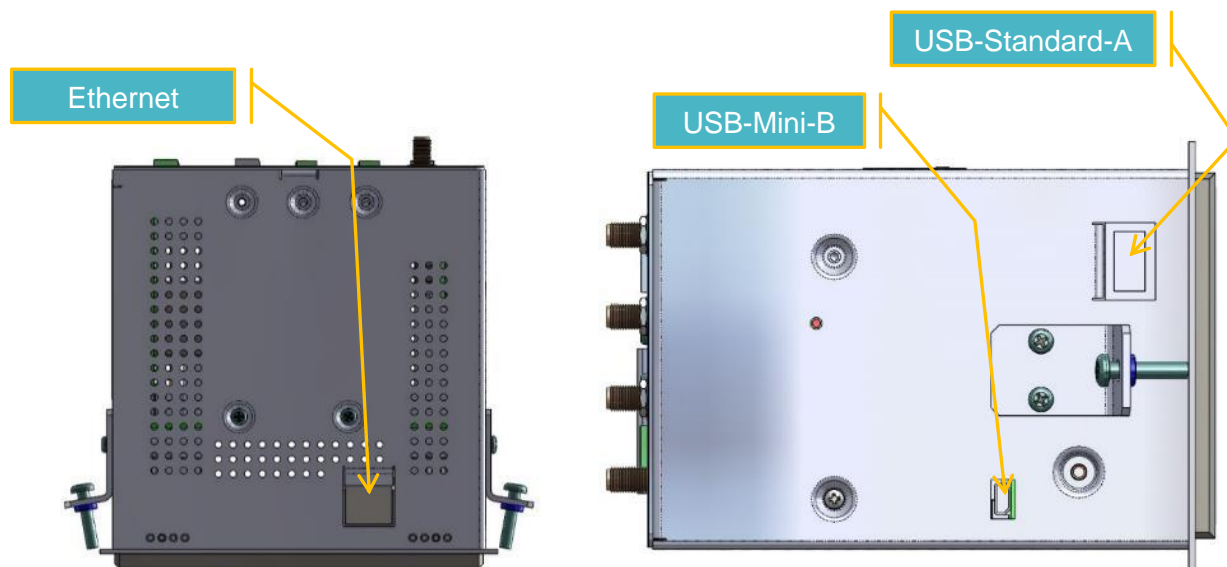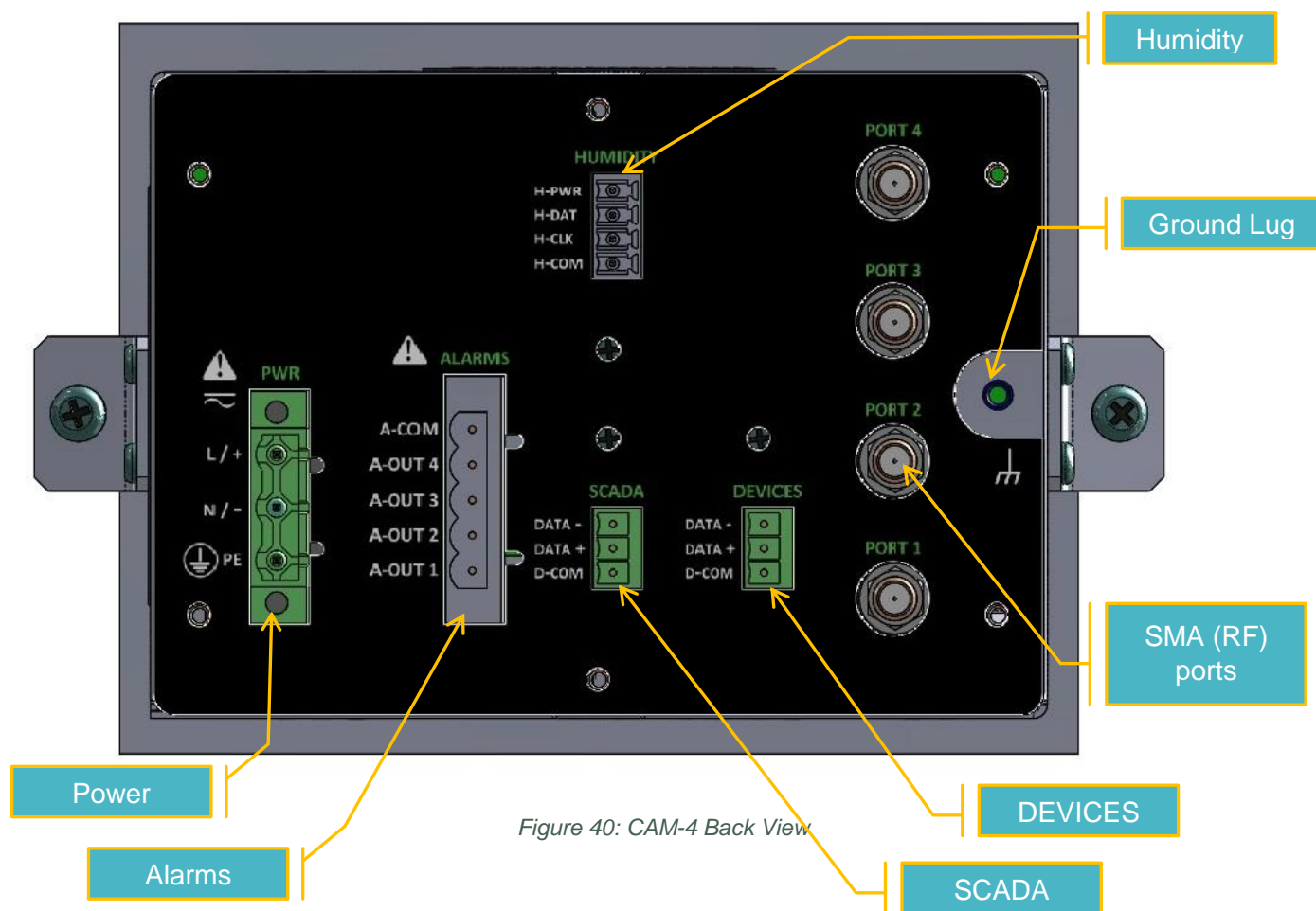
6.3.1 Power Connector

Pin	Name	Description
V+	Power In +	Input power range from 24 to 60V DC.
V-	Power In -	Input power range from 24 to 60V DC.
PE	Protective Earth	This pin is used for ground and shield connectivity. Should use separate wire from Case Ground.

6.3.2 Ethernet Connector

Interface	Name	Description
RJ45	Ethernet	Used for configuration and Ethernet communication

6.3.3 USB Mini-B Cable Connector

Interface	Name	Description
Mini-B	USB-Mini-B	USB Mini-B used for unit configuration

6.3.4 USB Standard-A Connector

Interface	Name	Description
Standard-A	USB-Standard-A	USB Standard-A used for image capture and data storage

6.3.5 Chassis Ground Connector

Lug	Name	Description
Ground	Chassis Ground	Chassis ground lug connection, required for safety when air interfaces are near energized conductors.

6.3.6 SCADA Connector

Pin	Name	Description
D-COM	DATA Common	Common Output for Modbus RTU (RS485)
DATA-	DATA Negative	Negative Output for Modbus RTU (RS485)
DATA+	DATA Positive	Positive Output for Modbus RTU (RS485)

6.3.7 Devices Connector

Pin	Name	Description
D-COM	DATA Common	Common input for Modbus RTU (RS485)
DATA-	DATA Negative	Negative Input for Modbus RTU (RS485)
DATA+	DATA Positive	Positive Input for Modbus RTU (RS485)

6.3.8 SMA (RF) Connectors

Pin	Name	Description
P1	RF Port 1	Air Interface Radio Frequency Port 1
P2	RF Port 2	Air Interface Radio Frequency Port 2
P3	RF Port 3	Air Interface Radio Frequency Port 3
P4	RF Port 4	Air Interface Radio Frequency Port 4

6.3.9 Humidity Sensor Connector

Pin	Name	Description
H-PWR	Humidity Power	Humidity Cable Power Input from Humidity Sensor
H-DAT	Humidity Data	Humidity Cable DATA Input from Humidity Sensor
H-CLK	Humidity Clock	Humidity Cable Clock Input from Humidity Sensor
H-COM	Humidity Common	Humidity Cable Common Input from Humidity Sensor

6.3.10 Alarms Connector

Pin	Name	Description
A-OUT 1	Alarm Output 1	Normally Open Alarm Output 1
A-OUT 2	Alarm Output 2	Normally Open Alarm Output 2
A-OUT 3	Alarm Output 3	Normally Open Alarm Output 3
A-OUT 4	Alarm Output 4	Normally Open Alarm Output 4
A-COM	Alarm Common	Common output for Alarms Connector

6.4 MEASUREMENT FEEDBACK LED

The CAM-4 has one feedback LED for units with measurement capabilities to identify if measurements are being automatically acquired.

LED States:

- No Illumination: No Power
- Solid Green: Power, no measurements
- Green / Amber toggle: Automated measurements
- Fast flashing Amber: Rebooting
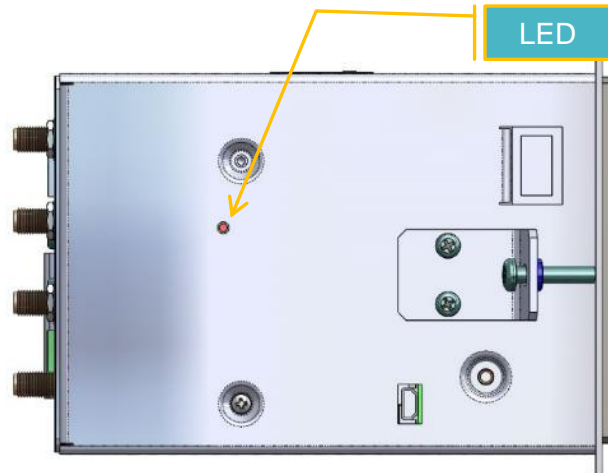
Figure 42: CAM-4 Left Side View

6.5 PANEL MOUNTING

The CAM-4 can only be mounted horizontally.

A panel cutout of 94.5 H x 130.5 mm W should be used.

⚠️ **CAUTION**

ENSURE THE INSIDE OF THE PANEL IS WITHIN THE CAM-4 OPERATING
TEMPERATURE AND THERE IS ADEQUATE AIR FLOW TO PREVENT OVERHEATING.

6.5.1 Installation Location

The CAM-4 is intended for indoor use and installation in weather protected enclosures such as switchgear low voltage compartments. If the CAM-4 is being used as a measurement device, it must not exceed the maximum air interface cable length (assuming cable routing). Reference the **(910.00379.001) IntelliSAW Sensor Installation Manual** for more details.

6.5.2 Recommended Spacing

It is recommended to allow up to 5 cm (2 in.) the rear of the CAM-4 HMI for connectors. If other devices are installed on the panel, it is advised that the CAM-4 be installed in a location where both USB ports and Ethernet port are easily accessible.

6.5.3 Mounting Bracket Installation

Do not affix the mounting screws and brackets until the CAM-4 is inserted into the panel cut-out.

Mounting Bracket

M3 10 mm screws
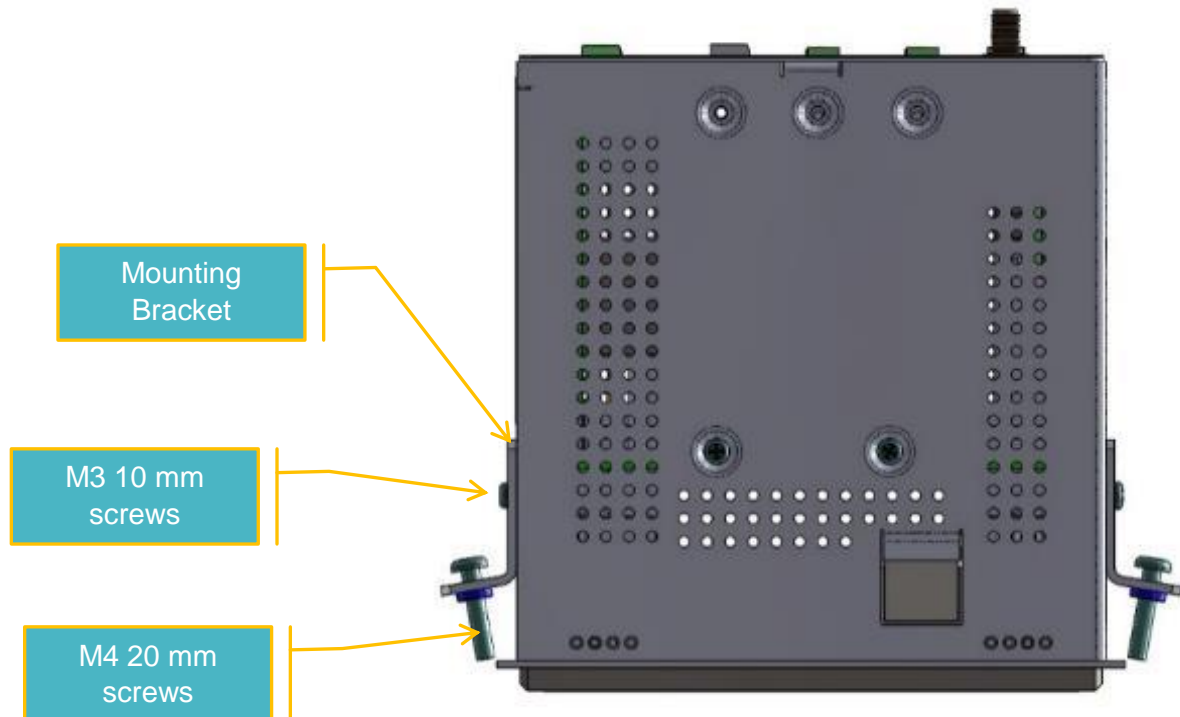
M4 20 mm screws

Figure 43: CAM-4 Bottom View

- Insert the CAM-4 into the panel cut-out

- Connect the mounting brackets with the two M3 10 mm screws

- Use the M4 20 mm screws to slowly exert pressure on the back of the mounting panel making a secure fit without damaging the CAM-4 or installation panel.

7 WIRING

⚠ **WARNING**

SYSTEM WIRING SHOULD BE PERFORMED ONLY BY PERSONNEL WHO ARE
TECHNICALLY COMPETENT AND AUTHORIZED TO DO SO. LOCAL REGULATIONS
REGARDING ELECTRICAL INSTALLATION AND SAFETY MUST BE OBSERVED.
Failure to follow the instructions given can result in death or serious injury

---

⚠ **WARNING**

TO AVOID ELECTRICAL SHOCK. AC POWER WIRING MUST NOT BE CONNECTED TO
THE SOURCE UNTIL ALL WIRING CONNECTIONS PROCEDURES ARE COMPLETED.

Failure to follow the instructions given can result in death or serious injury

---

⚠ **WARNING**

CHECK THE INFORMATION LABEL ON THE CASE TO DETERMINE THE CORRECT
VOLTAGE BEFORE CONNECTING TO A LIVE SUPPLY.

Failure to follow the instructions given can result in death or serious injury

---

IMPORTANT

All wiring connections should be made to the CAM-4 after it is panel mounted.

It is recommended that Ferrules be used for all terminating wires.
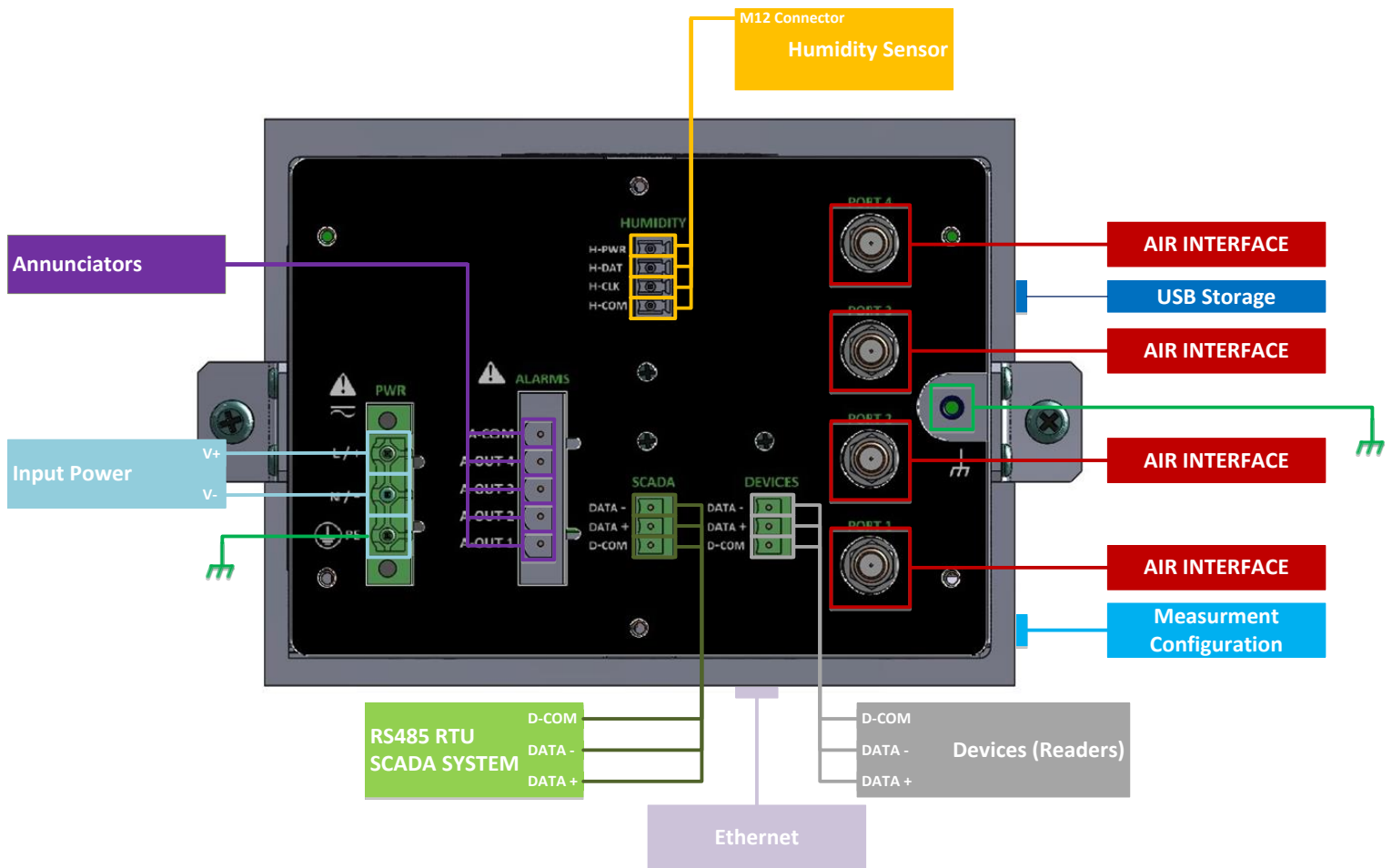
Figure 44: CAM-4 Connections and Common Wiring

7.1 POWER CONNECTION
Connector included with purchase of unit

The CAM-4 HMI uses a single connector for AC/DC power. The connector is a 3-position male type that accepts 16-26 AWG wire. Power connections shall be a minimum 18 AWG, tin-coated, soft drawn copper per ASTM B8, Class B stranding, 300V rated. Insulation shall be EP (ethylene propylene) or EPCP (ethylene propylene chlorosulfonated polyethylene compound).

7.1.1 Input Power Details
The CAM-4 has a universal input power rating of:

- 100 to 250VAC   50/60 Hz   12W
- 125 to 250DC   12W

The following block diagram outlines the recommended power wiring for the CAM-4 with a 2-pole circuit breaker. Surge suppression devices can also be installed if higher safety ratings are required.
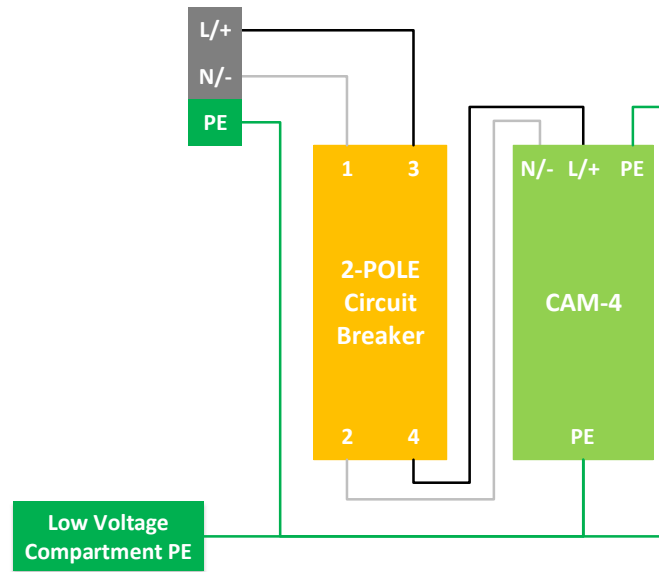
Figure 45: IntelliSAW CAM-4 Power Wiring

7.1.2 Protective Earth (PE) wiring

Protective earth (PE) connection should always be installed between the CAM-4's PE terminal, PE post, and the PE connection in the low-voltage compartment. Note, there are two INDEPENDENT PE connections that must be wired separately, ensuring the shortest distance. PE at the cable connection shunts transients at the cables without connecting them to the case, while case ground provides both RF shielding and safety against induced voltages on air interface cables.

7.2 RS485 COMMUNICATION (DEVICE AND SCADA)

The CAM-4 has two RS485 ports:

- **Device port:** Modbus Master to communicate with Readers
- **SCADA port:** Modbus Device to communicate with external SCADA.

Connectors are included with purchase of system options

7.2.1 CAM-4 Connection to Readers

The IntelliSAW readers are connected to the CAM-4 through a standard, half-duplex RS485 serial Modbus RTU configuration. This is a 3-wire bus, differential signals for data +/- and a common signal return. The common signal is clamped to PE for safety and connects to the line driver through a high resistance to prevent ground loops. The figure below shows the various elements of a network in a switchgear substation.
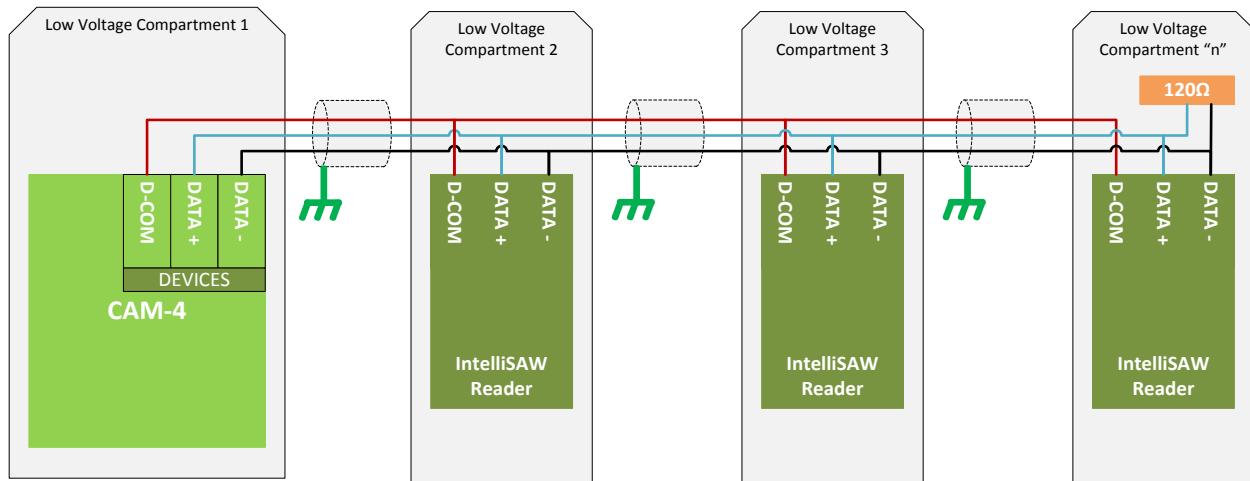
Figure 46: RS485 Data Communication Bus Topology

7.2.2 CAM-4 Connections to External SCADA

The CAM-4 SCADA interface is a standard, half-duplex RS485 serial Modbus RTU configuration. This is a 3-wire bus, differential signals for data +/- and a common signal return.

 All connected readers can be queried through the SCADA interface.
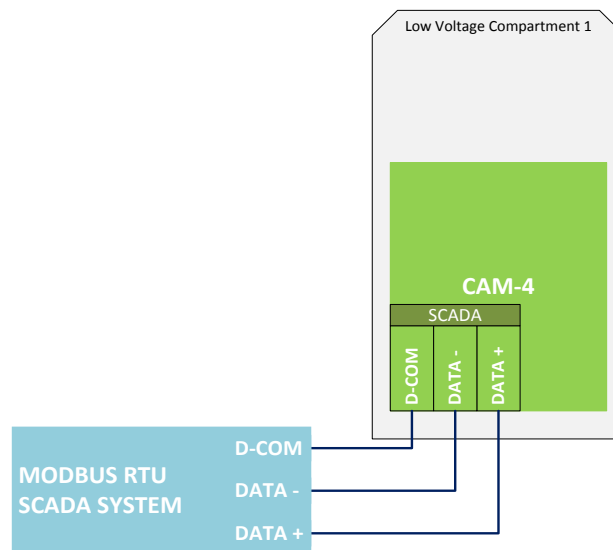
Figure 47: RS485 SCADA Communication

7.2.3 RS485 Cabling

7.2.3.1 Recommended Cabling

IntelliSAW recommends the use of shielded cable for the RS485 wiring, providing at least one twisted pair, one single line, and a drain wire, although typical cable has two twisted pair. The

twisted pair provides DATA+/- signals to each reader while the single line would be for D-COM, providing a low-impedance return for each reader.

7.2.3.2 Bus cable shielding

The drain wire associated with the RS485 bus shielding foil should be connected to the protective earth at the source end (the end of the line segment closest to the bus master, usually the CAM-4) with the destination end left unconnected. This prevents ground loops and induced noise. Each segment of the bus should be shield-terminated to the protective earth in the cabinet from which it originates.

7.2.4 Bus Termination

The RS485 bus needs to be terminated at each end with 120 Ω resistors when long stretches of cable are used. This ensures that the bus has the correct impedance. In general, RS485 adapters and bus masters provide the source impedance internally and should be located at one end of the bus.

If the bus length is less than 2% of the maximum (20 meters at 9600 baud), the termination resistor may be omitted, as long as the bus master has termination and failsafe resistors.

7.2.5 Bus data rate (baud rate) considerations

The RS485 bus data rate is dependent on the bus cable length. In industrial environments, slower data communication rates are generally more reliable; **IntelliSAW recommends 9600 baud for the data rate.**

Bus length

Bus cable length has an impact on the overall data rates that can be achieved. A conservative rule for RS485 uses the equation: (baud rate * cable length (m)) < 10×10^6. A 9600 baud network would require a bus less of ($10 \times 10^6 \div 9600$), or 1042 meters (about 3400 feet). This is perfectly adequate for most substation installations.

7.3 ETHERNET COMMUNICATION CONNECTION

Ethernet connection is done through an RJ45 Connector at the Bottom of the unit.

No cable is provided.

7.4 HUMIDITY SENSOR CONNECTIONS

The IntelliSAW Humidity sensors are shipped with a cable assembly.

The Humidity Sensor Connector is a 4 position male connector accepting 16-26 AWG wire. For more details, reference the **_(910.00379.001) IntelliSAW Sensor Installation Manual._**

7.5 AIR INTERFACE CONNECTIONS

The IntelliSAW Air Interfaces are shipped with a cable assembly.

The CAM-4 supports up to 4 Air Interface connections (Port 1 to Port 4) through female SMA connections. Only IntelliSAW provided Air Interfaces are suitable for the desired performance and for compliance with transmitter authorizations. For more details, reference the **(_910.00379.001) IntelliSAW Sensor Installation Manual._**

7.6 ALARM WIRING

Connector is shipped with system option

> ⚠ **WARNING**
>
> ALARM CHANNELS ARE NOT TO BE USED AS SWITCHGEAR OR OTHER ASSET CONTROL SIGNALS.
>
> **Failure to follow the instructions given can result in death or serious injury**

Four (4) Normally Open Dry Contact Relays are provided with the Alarm option. A common signal is applied to A-COM, and when the relay closes (on a positive alarm trigger) the common signal will propagate through the closed relay. Reference section: 3.1.3.4 Alarm Modes for the definition alarm output configurations.
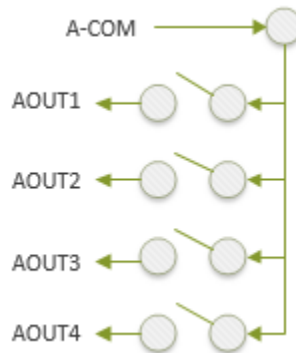

Figure 48: Relay topology

7.7 EXAMPLE WIRING DIAGRAM

The example wiring diagram shows how a typical CAM-4 unit would be wired using Modbus RTU to communicate to the SCADA system (instead of Modbus TCP).
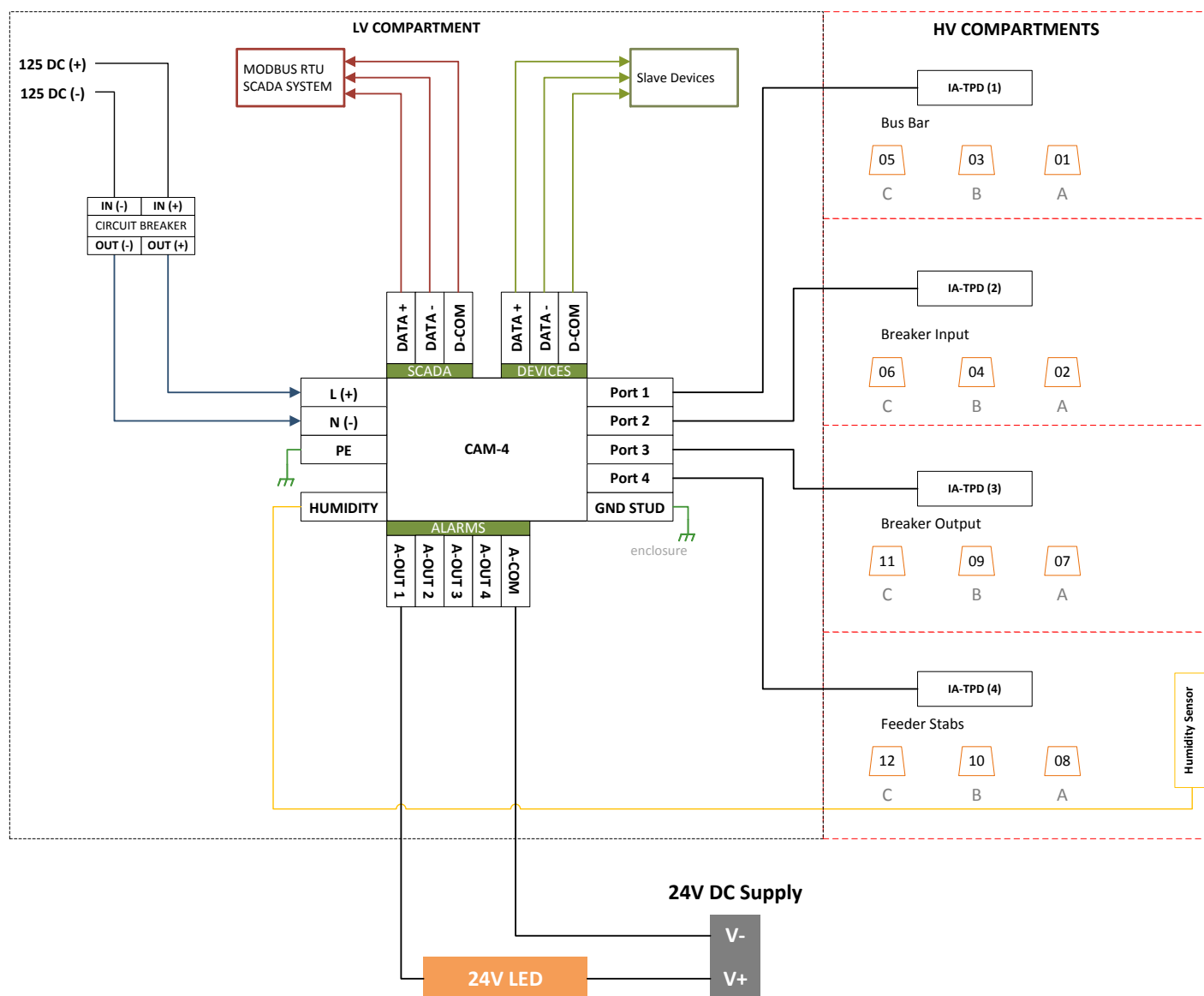
Figure 49: Example Wiring Diagram

8 SCADA SYSTEM INTEGRATION (MODBUS RTU OR TCP)

The CAM-4 connects multiple Readers through a master Modbus (RS485) connection. The SCADA system connects to a CAM-4 through Modbus RTU (RS485) or Modbus TCP (Ethernet connection). Either method will allow the SCADA system to query all connected Readers.

The following Modbus information is for CAM-4 Measurement Firmware rev.1123 or higher.

8.1 MODBUS COMMANDS

The CAM-4 treats holding and input registers identically; however, HOLDING registers are the preferred approach. Modbus-RTU payloads always begin with the address and a function code (FC). The CAM-4 supports the following Modbus function codes, as shown in the following table:

Command	FC	Description
	2	Function code required by CiTect
MBF_READHOLDING	3	Fetch up to 81 of 256 defined registers
MBF_READINPUT	4	Exactly duplicates the MBF_READHOLDING command with the same registers
MBF_PRESETSINGLE	6	Set a single register – do not use in reserved registers
MBF_DIAGNOSTICS	7	Sub-functions supported are 1, 4, 10-14
MBF_FETCH_CEC	11	Return 0x0000 if not busy, 0xFFFF if busy
MBF_PRESETMULTIPLE	16	Set up to registers
MBF_RESET_COMM	19	Reset CAM-4 HMI processor if successful.
MBF_RESET_COMM_ISR	7E	<address> <7E> <AA> <55> <crc1> <crc2> resets CAM-4 HMI
XMS_XMESSAGE_FC	7F	The remainder of the payload contains a native command.

Modbus-RTU payloads follow the MODICON standard except for special function codes, 7E and 7F. For the 0x7F function code, the payload begins with address and 0x7F followed by an IntelliSAW native protocol command payload.

The MBF_RESET_COMM_ISR command is a special sequence that reboots the processor from within the serial receive interrupt service routine, regardless of protocol, when it is detected from a serial line idle condition.

The MBF_RESET_COMM_ISR command must be properly formatted and successfully parsed. This special sequence offers a means of resetting a CAM-4 HMI that is otherwise externally unresponsive.

8.2 MODBUS REGISTERS

Note: table items highlighted in blue are not yet implemented.

REGISTER	DESCRIPTION	TYPE	MIN	MAX	SCALE	ERROR CODE
418[1]	temp 1	signed 16	-500	1675	0.1 C	0x8000
419	temp 2	signed 16	-500	1675	0.1 C	0x8000
420	temp 3	signed 16	-500	1675	0.1 C	0x8000
421	temp 4	signed 16	-500	1675	0.1 C	0x8000
422	temp 5	signed 16	-500	1675	0.1 C	0x8000
423	temp 6	signed 16	-500	1675	0.1 C	0x8000
424	temp 7	signed 16	-500	1675	0.1 C	0x8000
425	temp 8	signed 16	-500	1675	0.1 C	0x8000
426	temp 9	signed 16	-500	1675	0.1 C	0x8000
427	temp 10	signed 16	-500	1675	0.1 C	0x8000
428	temp 11	signed 16	-500	1675	0.1 C	0x8000
429	temp 12	signed 16	-500	1675	0.1 C	0x8000
430	ambient 1	signed 16	-400	1250	0.1 C	0x8000
431	RH 1	unsigned 16[2]	0	1000	0.1% RH	0xFFFF
432	ambient 2	signed 16	-400	1250	0.1 C	0x8000
433	RH 2	unsigned 16	0	1000	0.1% RH	0xFFFF
434	ambient 3	signed 16	-400	1250	0.1 C	0x8000
435	RH 3	unsigned 16	0	1000	0.1% RH	0xFFFF
436	ambient 4	signed 16	-400	1250	0.1 C	0x8000
437	RH 4	unsigned 16	0	1000	0.1% RH	0xFFFF
438	ambient 5	signed 16	-400	1250	0.1 C	0x8000
439	RH 5	unsigned 16	0	1000	0.1% RH	0xFFFF
440	ambient 6	signed 16	-400	1250	0.1 C	0x8000
441	RH 6	unsigned 16	0	1000	0.1% RH	0xFFFF
442	ambient 7	signed 16	-400	1250	0.1 C	0x8000
443	RH 7	unsigned 16	0	1000	0.1% RH	0xFFFF
444	ambient 8	signed 16	-400	1250	0.1 C	0x8000
445	RH 8	unsigned 16	0	1000	0.1% RH	0xFFFF
446	SD1 Total	unsigned 16	0	65534	10 "pC"[3]	0xFFFF
447	SD2 Total	unsigned 16	0	65534	10 "pC"	0xFFFF
448	SD3 Total	unsigned 16	0	65534	10 "pC"	0xFFFF
449	SD4 Total	unsigned 16	0	65534	10 "pC"	0xFFFF
450	PD1 Total	unsigned 16	0	65534	10 "pC"	0xFFFF
451	PD2 Total	unsigned 16	0	65534	10 "pC"	0xFFFF
452	PD3 Total	unsigned 16	0	65534	10 "pC"	0xFFFF
453	PD4 Total	unsigned 16	0	65534	10 "pC"	0xFFFF
454	Data version = 1	unsigned 16	0	65534	na	0xFFFF
455	noise 1	unsigned 16	0	65534	10 "pC"	0xFFFF

[1] **Registers start at 0. 418 is 400418 or 0x01A2 in the datagram.**
[2] RH may be treated as signed 16 making the error code translate to a small negative number.
[3] Partial discharge and surface discharge are nonlinear, and the scale is approximate.

456	surface 1	unsigned 16	0	65534	10 "pC"	0xFFFF
457	internal 1	unsigned 16	0	65534	10 "pC"	0xFFFF
458	noise 2	unsigned 16	0	65534	10 "pC"	0xFFFF
459	surface 2	unsigned 16	0	65534	10 "pC"	0xFFFF
460	internal 2	unsigned 16	0	65534	10 "pC"	0xFFFF
461	noise 3	unsigned 16	0	65534	10 "pC"	0xFFFF
462	surface 3	unsigned 16	0	65534	10 "pC"	0xFFFF
463	internal 3	unsigned 16	0	65534	10 "pC"	0xFFFF
464	noise 4	unsigned 16	0	65534	10 "pC"	0xFFFF
465	surface 4	unsigned 16	0	65534	10 "pC"	0xFFFF
466	internal 4	unsigned 16	0	65534	10 "pC"	0xFFFF
467	noise 5	unsigned 16	0	65534	10 "pC"	0xFFFF
468	surface 5	unsigned 16	0	65534	10 "pC"	0xFFFF
469	internal 5	unsigned 16	0	65534	10 "pC"	0xFFFF
470	noise 6	unsigned 16	0	65534	10 "pC"	0xFFFF
471	surface 6	unsigned 16	0	65534	10 "pC"	0xFFFF
472	internal 6	unsigned 16	0	65534	10 "pC"	0xFFFF
473	noise 7	unsigned 16	0	65534	10 "pC"	0xFFFF
474	surface 7	unsigned 16	0	65534	10 "pC"	0xFFFF
475	internal 7	unsigned 16	0	65534	10 "pC"	0xFFFF
476	noise 8	unsigned 16	0	65534	10 "pC"	0xFFFF
477	surface 8	unsigned 16	0	65534	10 "pC"	0xFFFF
478	internal 8	unsigned 16	0	65534	10 "pC"	0xFFFF
479	noise 9	unsigned 16	0	65534	10 "pC"	0xFFFF
480	surface 9	unsigned 16	0	65534	10 "pC"	0xFFFF
481	internal 9	unsigned 16	0	65534	10 "pC"	0xFFFF
482	noise 10	unsigned 16	0	65534	10 "pC"	0xFFFF
483	surface 10	unsigned 16	0	65534	10 "pC"	0xFFFF
484	internal 10	unsigned 16	0	65534	10 "pC"	0xFFFF
485	noise 11	unsigned 16	0	65534	10 "pC"	0xFFFF
486	surface 11	unsigned 16	0	65534	10 "pC"	0xFFFF
487	internal 11	unsigned 16	0	65534	10 "pC"	0xFFFF
488	noise 12	unsigned 16	0	65534	10 "pC"	0xFFFF
489	surface 12	unsigned 16	0	65534	10 "pC"	0xFFFF
490	internal 12	unsigned 16	0	65534	10 "pC"	0xFFFF
491	SD1 Num	unsigned 16	0	65534	counts	0xFFFF
492	SD2 Num	unsigned 16	0	65534	counts	0xFFFF
493	SD3 Num	unsigned 16	0	65534	counts	0xFFFF
494	SD4 Num	unsigned 16	0	65534	counts	0xFFFF
495	PD1 Num	unsigned 16	0	65534	counts	0xFFFF
496	PD2 Num	unsigned 16	0	65534	counts	0xFFFF
497	PD3 Num	unsigned 16	0	65534	counts	0xFFFF
498	PD4 Num	unsigned 16	0	65534	counts	0xFFFF

9 EXAMPLE SYSTEM CONFIGURATION

This section provides insight into a typical application, recommended IntelliSAW monitoring architecture, measurement locations (temp, PD, and humidity), and CAM-4 configuration.

9.1 TYPICAL INTELLISAW APPLICATION

A typical application would be a substation installation where a CAM-4 is installed in switchgear cabinet (taking advantage of the monitoring capabilities), connected to a SCADA system through Modbus TCP, and bussed to Readers monitoring sensors in other assets. The CAM-4 will also have local alarming.

The example application contains a step down transformer (36kV to 13.8kV), an enclosed bus duct, and a switchgear lineup with 4 vertical sections (Incomer, 2 Feeders, and a Bus Tie).
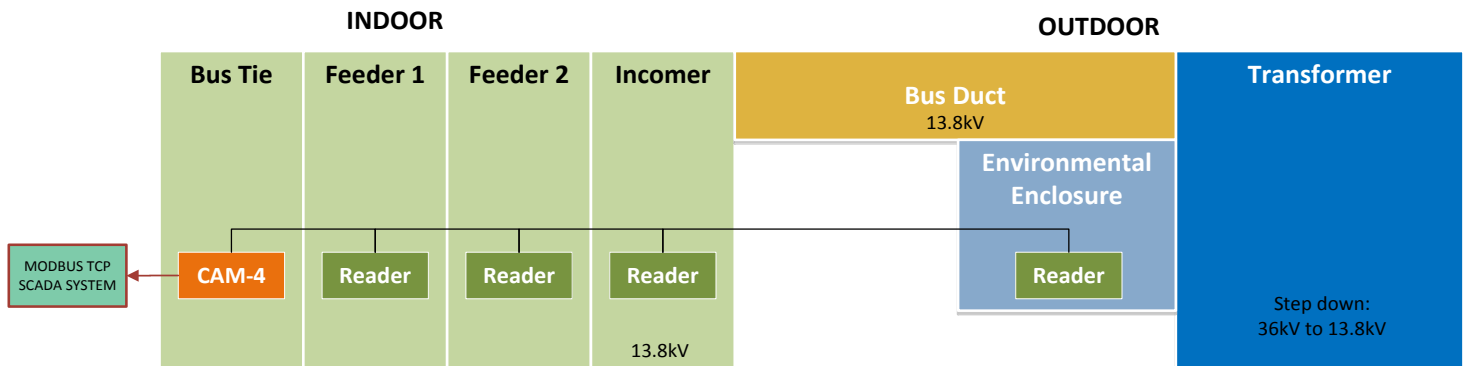
Figure 50: Typical IntelliSAW Application Block Diagram

9.2 MEASUREMENT LOCATIONS

The CAM-4 and Readers will all be configured to monitor the various asset's temperatures, partial discharge and humidity. The following details describe the IntelliSAW measurement locations per asset:

9.2.1 Transformer

- **Temperature:** 6 measurement locations
  - ○ (3) Incoming Connections
  - ○ (3) Outgoing Bus
- **Partial Discharge:** 2 measurement locations
  - ○ Incoming Cables
  - ○ Outgoing Bus
- **Humidity:** 1 measurement locations
  - ○ Incoming Connection box

9.2.2 Bus Duct

- **Humidity:** 2 measurement locations
  - Transformer Side (monitored by enclosure reader)
  - Incomer Switchgear Side (monitored by Incomer reader)

9.2.3 Incomer and Bus Tie Cabinets

- **Temperature:** 6 measurement location
  - (3) Incoming Bus
  - (3) Outgoing Bus
- **Partial Discharge**
  - Incoming Bus
  - Outgoing Bus
- **Humidity**
  - Outgoing Bus Compartment

9.2.4 Feeder Cabinets

- **Temperature:** 3 measurement location
  - (3) Outgoing Lines
- **Partial Discharge**
  - Outgoing Line
- **Humidity**
  - Outgoing Bus Compartment

9.3 BILL OF MATERIALS

The following BOM would be needed for this application. Note, it does not include power supplies, circuit breakers, cabling, environmental enclosures, or other standard hardware for installations.

Part Number	Description	Quantity
CAM4U-TPH-AMS0	Critical Asset Monitoring Unit, 4.3" HMI, Universal Input Power, Thermal, PD, and Humidity Monitoring, Alarm Outputs, Multi Unit (Modbus-RTU), Modbus RTU SCADA Interface, Modbus TPC Protocol	1
IRM-48-TPH	Remote Monitoring Unit, 48Vdc, Temperature, Partial Discharge, Humidity	4
IS01 to IS12	Temperature Sensors, Bands 01 thru 12	24
IA-MM-TPD-7	IntelliSAW CAM Air Interface (Temp & PD) , Magnetic Mount, with 7m cable	8
IH-PN-10-10	Humidity / Ambient Temp Sensor, Panel Mount, with 10m cable	7

9.4 MODBUS MAP & DEVICE IDENTIFICATION

Once the system hardware and locations have been determined, a Modbus map is required to identify all monitoring devices IP addresses, Modbus addresses, and types of measurements which will correlate to Modbus registers.

This is essential in creating the CAM-4 config.xml file and in integrating the IntelliSAW system into a SCADA system.
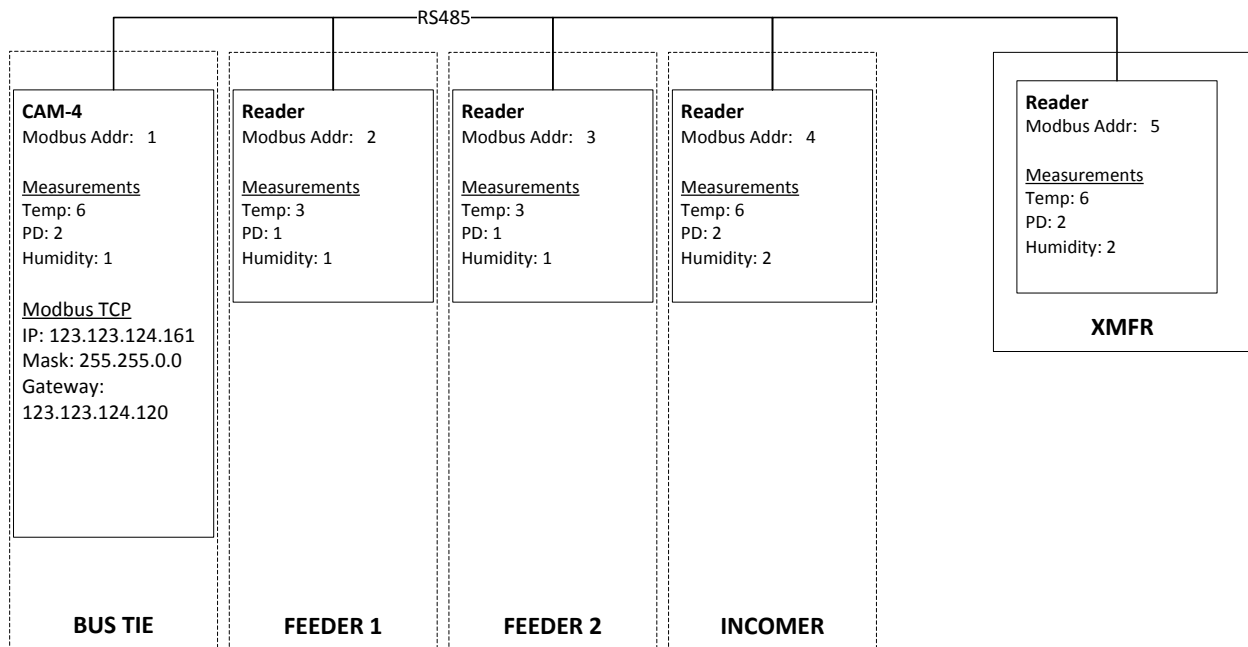

Figure 51: Example Modbus Map

9.5 MONITIROING UNIT MEASUREMENT CONFIGURATION

It is recommended to configure the CAM-4 and Readers measurement channels prior to creating the CAM-4 config.xml file. This manual assumes all units were configured for their specific measurements based on instructions outlined in *(910.00160.0001) IntelliSAW Configuration Tool User Manual*.

9.6   CONFIGURING THE CAM-4

9.6.1 Open CAM-4 Configuration Tool
- Launch the CAM-4 Configuration tool
- Select "Create New Config File"

9.6.2 Determine CAM-4 Features

Select the model (CAM4U-TPH-AMS0) from the list - all available features will be selected.

The CAM-4 will communicate to the SCADA through Modbus Server, therefore the SCADA Interface (RS485) can be de-selected. Once de-selected, continue to the next screen.
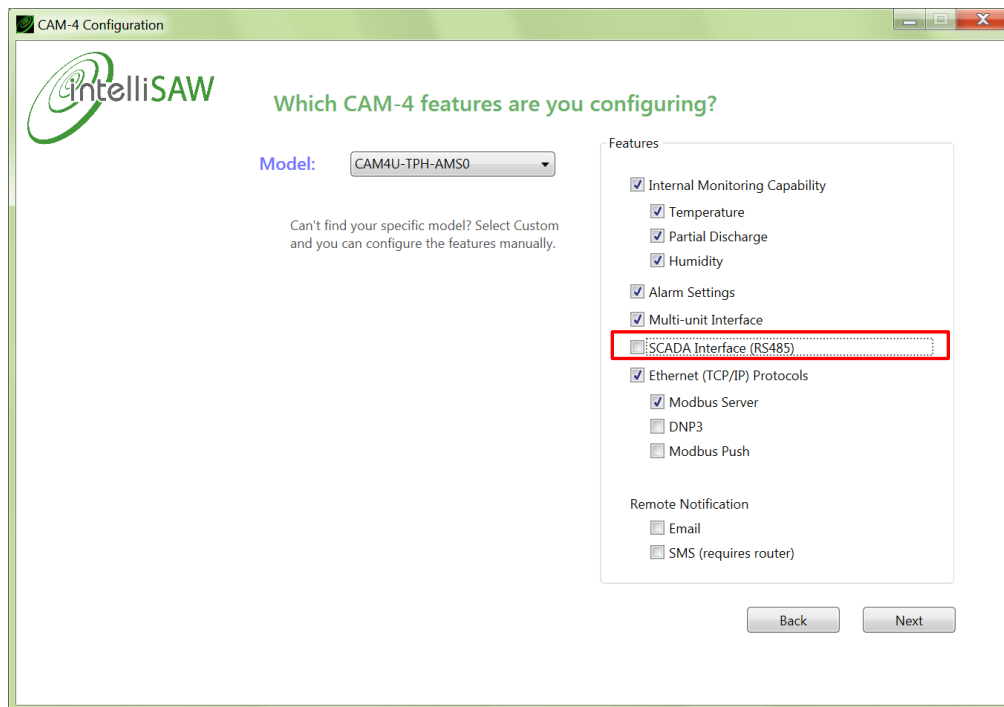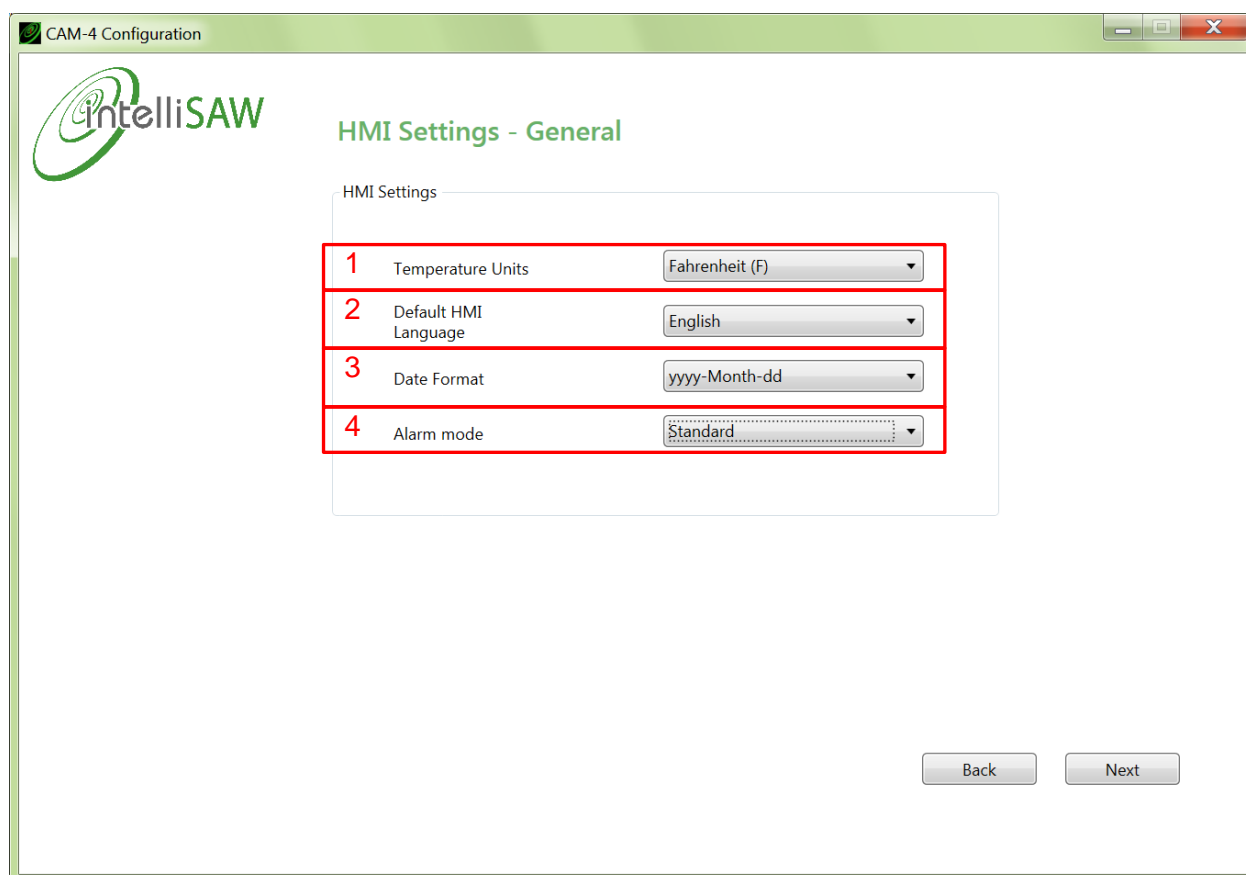

Figure 52: Select Model and Features

9.6.3 Selecting Temperature, Language and Date Formats

The following settings were made for this application:

- Temperature: Fahrenheit
- Default HMI Language: English
- Date / Time: yyyy-month-dd.
- Alarm mode: Standard

Figure 53: CAM-4 Temperature, Language and Date Formats

The fields will show on the HMI as follows:

Figure 54: HMI View

9.6.4 Determine Graphs and Triggers

The Graphs and Triggers for this installation will be modified to only display 6 hours of data on the graphs. The following settings should be made:

- Memory and Graphs > Stored Data: 6 hours
- Memory and Graphs > Graph Span: 6 hours
- Memory and Graphs > Expired Data: 1 minute

Triggers and Data Averaging have been left at default values.

Figure 55: Graphs and Triggers

9.6.5 Setting IP Address and Communication Protocols

9.6.5.1 Change CAM-4 IP Settings

In this installation we will assume a new IP address as described in Modbus & Device Map.

To change the IP address, de-select "Use existing CAM Settings" and type in the new IP address, Net Mask, Gateway and DNS.

Figure 56: Setting IP Address

9.6.5.2 Modbus TCP Protocols

The default Modbus TCP Protocol settings will be used.

9.6.6 Setup Multi-Unit for Communicating to Readers

The Multi-unit Setup Communication screen is used to configure the CAM-4 device RS485 port to communicate with the Readers. The default serial communication settings were used in this configuration.

NOTES:

- All Readers must have the same serial communication settings as the CAM-4
- Units shall have unique Modbus Device Number; follow the Modbus Map for assigning Modbus Device numbers.

9.6.7 Setup the HMI Details for Monitoring Devices

9.6.7.1 Select the Number of External Devices

The example application has 4 external readers. Select 4 from the drop down menu enabling the fields below for data entry.

9.6.7.2 Use Modbus Physical Address for Mapped Address

This is a new installation, and will not have any previous equipment installed. The Modbus Physical Address and Mapped address will be the same.

9.6.7.3 Set Device Name, Modbus Addresses, and Monitoring Capabilities

The following has been entered:

Name	Address	Temp	PD	Humidity
Bus Tie	1	X	X	X
Feeder 1	2	X	X	X
Feeder 2	3	X	X	X
Incomer	4	X	X	X
XFMR	5	x	X	X

Once configured, these names will show up on the device selection buttons, and they will also show on the individual device HMI pages.

Figure 57: Device Detail Setup

9.6.8 Configuring the Device Screens to Identify Sensor Locations

A Measurement Details page will be created for each device based on the application and location of sensors. The device name and Modbus address are shown at the top of the screen.

Naming conventions are based on the IntelliSAW standard identified in section 3.1.10 Measurement Details: Labels and Views

9.6.8.1 Bus Tie (Address 1)

Temperature: The Bus Tie has temperature sensors located at the Incoming and Outgoing bus. The HMI Views will be set to Data and Chart. The configuration screen would like as follows:

Figure 58: Bus Tie - Temperature View Settings

Partial Discharge: The Air Interfaces installed in each location (Incoming and Outgoing) are capable of monitoring PD. Data and Chart Views are enabled. The configuration screen would look as follows:

Figure 59: Bus Tie - PD Air Interface Settings

Humidity: One humidity sensor is installed in the High Voltage Compartment, it will be named HV. Data and Chart Views are enabled. The configuration screen would like as follows:

Figure 60: Bus Tie - Humidity Sensor Settings

9.6.8.2 Feeder 1 (Device 2)

Temperature: Only the Outgoing Line will be monitored in the Feeders. Data and Chart Views are enabled. The configuration screen would look as follows:

Figure 61: Feeder 1 - Temperature View Settings

Partial Discharge: Only the Outgoing Line is being monitored for PD. Data and Chart Views are enabled. The configuration screen would look as follows:

Figure 62: Feeder 1 - PD Data Settings

Humidity: Only the HV compartment is being monitored in the Switchgear. Data and Chart Views are enabled. The configuration screen would look as follows:

Figure 63: Feeder 1 - Humidity Settings

9.6.8.3 Feeder 2 (Device 3)

Feeder 2 configuration would be identical to Feeder 1 (Device 2) and is not shown.

9.6.8.4 Incomer (Device 4)

The Incomer settings are the same for all sections as the Bus Tie in all respects except for the humidity sensors. One humidity sensor will be in the incomer while another will be wired out to the bus duct. Data and Chart Views are enabled. The configuration screen would look as follows:

Figure 64: Incomer - Humidity Settings

9.6.8.5 Transformer (Device 5)

Temperature: The Transformer (XFMR) has temperature sensors located at the Incoming and Outgoing connections. The HMI Views will be set to Data and Chart. The configuration screen would look as follows:

Figure 65: XFMR Temperature Settings

Partial Discharge: The Air Interfaces installed in each location (Incoming and Outgoing) are capable of monitoring PD. Data and Chart Views are enabled. The configuration screen would look as follows:

Figure 66: PD View

Humidity: The Reader has two humidity sensors; one will be in the incomer while another will be wired out to the bus duct. Data and Chart Views are enabled. The configuration screen would look as follows:

Figure 67: XFMR - Humidity Settings

9.6.9 Warning and Alarm Configuration
Warnings and Alarms should be set based on Asset Manufacturer Specifications.

The warning and alarms for this example will be set as follows:

Name	Max Temp	Diff. Temp	% RH	Max PD	Max SD
	Warn / Alarm	Warn / Alarm	Warn / Alarm	Warn / Alarm	Warn / Alarm
Bus Tie	140˚F / 167˚F (60˚C / 75˚C)	27˚F / 36˚F (15˚C / 20˚C)	85% / 95%	5000 / 10000	5000 / 10000
Feeder 1	140˚F / 167˚F (60˚C / 75˚C)	27˚F / 36˚F (15˚C / 20˚C)	85% / 95%	5000 / 10000	5000 / 10000
Feeder 2	140˚F / 167˚F (60˚C / 75˚C)	27˚F / 36˚F (15˚C / 20˚C)	85% / 95%	5000 / 10000	5000 / 10000
Incomer	158˚F / 176˚F (70˚C / 80˚C)	27˚F / 36˚F (15˚C / 20˚C)	85% / 95%	5000 / 10000	5000 / 10000
Transformer	158˚F / 176˚F (70˚C / 80˚C)	27˚F / 36˚F (15˚C / 20˚C)	85% / 95%	5000 / 10000	5000 / 10000

PD and SD alarming: Establishing a baseline over 30 continuous days of running is recommended before setting alarm values. Analytics is not performed, alarming is currently on max values only.

Figure 68: Configuring Alarms

9.6.10 Configuration Completed / Load File

Once the configuration has been completed:

- Create the config.xml file
- Save and load it onto the CAM-4 (Section: 4 Loading a CAM-4 HMI Configuration File)
- Reboot the unit

9.7 SCADA INTEGRATION - EXAMPLE TAG LIST

The SCADA system connects to the CAM-4 Ethernet port for Modbus TCP communications and would poll each device / register. Below is the tag list for the example application.

Asset Name	Location	Source IP	Modbus Device	Modbus Registers	Source Format
Bus Tie	Incoming Phase A	123.123.124.161	1	419	signed 16 bit
	Incoming Phase B		1	420	signed 16 bit
	Incoming Phase C		1	421	signed 16 bit
	Outgoing Phase A		1	428	signed 16 bit
	Outgoing Phase B		1	429	signed 16 bit
	Outgoing Phase C		1	430	signed 16 bit
	Back Cable Ambient		1	431	signed 16 bit
	Back Cable RH%		1	432	signed 16 bit
	Incoming Bus _Surface Discharge		1	447	unsigned 16 bit
	Back Cable _Surface Discharge		1	450	unsigned 16 bit
	Incoming Bus _ Partial Discharge		1	451	unsigned 16 bit
	Back Cable _ Partial Discharge		1	454	unsigned 16 bit
Feeder 1	Incoming Phase A	123.123.124.161	2	419	signed 16 bit
	Incoming Phase B		2	420	signed 16 bit
	Incoming Phase C		2	421	signed 16 bit
	Back Cable Ambient		2	431	signed 16 bit
	Back Cable RH%		2	432	signed 16 bit
	Back Cable _Surface Discharge		2	447	unsigned 16 bit
	Back Cable _ Partial Discharge		2	451	unsigned 16 bit
Feeder 2	Incoming Phase A	123.123.124.161	3	419	signed 16 bit
	Incoming Phase B		3	420	signed 16 bit
	Incoming Phase C		3	421	signed 16 bit
	Back Cable Ambient		3	431	signed 16 bit
	Back Cable RH%		3	432	signed 16 bit
	Back Cable _Surface Discharge		3	447	unsigned 16 bit
	Back Cable _ Partial Discharge		3	451	unsigned 16 bit

Incomer	Incoming Phase A		4	419	signed 16 bit
	Incoming Phase B		4	420	signed 16 bit
	Incoming Phase C		4	421	signed 16 bit
	Outgoing Phase A		4	428	signed 16 bit
	Outgoing Phase B		4	429	signed 16 bit
	Outgoing Phase C		4	430	signed 16 bit
	Back Cable Ambient	123.123.124.161	4	431	signed 16 bit
	Back Cable RH%		4	432	signed 16 bit
	Bus Duct 1 Ambient		4	433	signed 16 bit
	Bus Duct 1 RH%		4	434	signed 16 bit
	Incoming Bus _Surface Discharge		4	447	unsigned 16 bit
	Back Cable _Surface Discharge		4	450	unsigned 16 bit
	Incoming Bus _ Partial Discharge		4	451	unsigned 16 bit
	Back Cable _ Partial Discharge		4	454	unsigned 16 bit
XFMR	Incoming Phase A		5	419	signed 16 bit
	Incoming Phase B		5	420	signed 16 bit
	Incoming Phase C		5	421	signed 16 bit
	Outgoing Phase A		5	428	signed 16 bit
	Outgoing Phase B		5	429	signed 16 bit
	Outgoing Phase C	123.123.124.161	5	430	signed 16 bit
	Back Cable Ambient		5	431	signed 16 bit
	Back Cable RH%		5	432	signed 16 bit
	Bus Duct 2 Ambient		5	433	signed 16 bit
	Bus Duct 2 RH%		5	434	signed 16 bit
	Back Cable _Surface Discharge		5	447	unsigned 16 bit
	Back Cable _ Partial Discharge		5	451	unsigned 16 bit

9.7.1 Register Details

The Table Below provides details for each register. The temperature values are always in °C therefore a scale and offset values would be used to convert between units.

Measurement	Registers	Error code (hex)	offset1	scale	offset2	Eng. units	Min Val	Max Val
SAW Temperatures	418 - 429	0x8000	0	0.18	32	°F	-58	302
Ambient Temp	430 – 445 even #s	0x8000	0	0.18	32	°F	-40	257
Relative Humidity	430 – 445 odd #s	0xFFFF	0	0.1	0	%RH	0	100
SD & PD	446 - 453	0xFFFF	0	10	0	n/a	0	655340

10 SPECIFICATIONS

TEMPERATURE

Operating Frequency	425 to 442 MHz
SAW Sensors	up to 12
Redundancy Model	Up to 4 air interfaces
RF Transmit Power	Pulsed, -6 to + 10 dBm [4]
RF Receive Sensitivity	-86 dBm
RF Receive Frequency Stability	± 700 Hz
RF Interrogation Distance	Up to 1.75 m (2.5 m with TPD air interface)
RF Interrogation Time	≤ 160 mSec

PARTIAL DISCHARGE

Number of Channels	Up to 4 IntelliSAW CAM Air Interfaces
Measurement Method	Ultra-High Frequency (UHF)
Selectable Bands (Center Frequency)	300MHz, 600MHz, or 1200MHz
Measurement Types	Noise Floor, Surface Discharge (Corona), Internal Discharge (PD)
Measurement Scale	nonlinear scale, capability to calibrate to reference source
Sensitivity	100pC Q_{pk} demonstrated in 24kV switchgear, installation dependent.
Response Time	100 mSec

HUMIDITY

Number of Channels	Up to 8 IntelliSAW IH-10 sensors (bussed)
Measurement Types	Relative Humidity, Ambient Temperature

ALARM OUTPUT CHANNELS

Contact Type	Dry Contact, Form A relays
Number of Channels	Up to 4 outputs (shared common)
Rated Voltage	250 V AC/DC
Continuous Withstand Capacity	10A
Make and Carry for 4s	15A
Breaking Capacity (AC)	2500VA
Breaking Capacity (DC)	24V, 5A / 125V, 0.45A DC
Contact Material	AgNi 90/10
Mechanical Operations (40°C)	
Full Load	30×10^3
No Load	$> 30 \times 10^6$
Open Contact Dielectric Strength	1000Vrms

---

[4] Using administrative settings, levels to -13.5dBm may be attained. FCC modes reduce the maximum power using these settings.

COMMUNICATION INTERFACES

RS485 Data Buses	2x RS485 (half duplex) (Master interface, Device Interface)
Data Bus Baud Rate	1200 to 38400 baud
Data Protocol	**SCADA**: Modbus-RTU device **Multi-unit**: Modbus-RTU master
Response Time	500 mS
LAN	1x 10/100 base-T RJ45 (1kV withstand)
Data Protocols	Modbus TCP, DNP3
USB	1x USB 2.0 mini – Configuration Only (IntelliSAW Native Protocol) 1x USB 1.1 type A host (extended Memory only)

PHYSICAL

HMI	Resistive Touch Panel (4.3" / 480 x 272 resolution)
Operating Power	100 to 250 V AC @ 50 / 60 Hz 120 to 250 V DC Power: 12W
Dimensions (body):	129.2 W x 132.6 L X 93.1 H
Weight	1.2 kg (2.6 lbs)
International Protection (IEC 60529)	Panel (IP 50), Body (IP 20)
Mounting Style	Panel Mount, Cutout: 130.5 W x 94.5 mm H
Operating Conditions	0°C to +50°C, 10 - 90% RH non-condensing

11 PRODUCT CERTIFICATIONS

11.1 COMPLIANCE

IEC61000-6-5	Level 4 substation EMC/EMI per IEC61000-4-x below
IEC 61000-4-2	ESD, ±8kV contact & ±15kV air discharge
IEC 61000-4-3	RFI, 10V/m
IEC 61000-4-4	EFT, ±4kV (power, humidity, and RS485)
IEC 61000-4-5	Surge, ±2kV line-line, ±4kV line-PE, Criteria B
IEC 61000-4-6	CRFI, 10Vrms (power, humidity, and RS485)
IEC 61000-4-8	Magnetic immunity, 100V/m, 50 & 60Hz, three axes
IEC 61000-4-9	Pulse magnetic field immunity test, 300A/m
IEC 61000-4-10	Damped oscillatory magnetic field immunity, 30A/m
IEC 61000-4-11	Voltage dips and interrupts, DC power
IEC 61000-4-12	Ring wave immunity
	5kV common mode, 1kV differential (power & signal)
IEC 61000-4-16	Conducted frequency immunity
	30V cont. and 300V/1s diff., common mode to earth (power)
	30V cont. and 300V/1s, common mode to earth (signal)
IEC 61000-4-17	Ripple on DC supply
IEC 60255-5	Dielectric strength, 500Vrms per IEC61010-1 for 24Vdc equipment
IEC 60255-5	Impulse voltage, 806V per IEC61010-1 for 24Vdc equipment
EN 300 220	Conducted spurious and EMI spurious
	(restricted frequency ranges)
EN 55011	Conducted Spurious, Class A

11.2 WIRELESS CERTIFICATIONS

11.2.1　Telecommunication Compliance

All wireless devices require certification to ensure that they adhere to regulations regarding the use of the RF spectrum. Nearly every country requires this type of product certification. IntelliSAW is working with governmental agencies around the world to supply fully compliant products and remove the risk of violating country directives or laws governing wireless device usage. However, certification is ultimately dependent on the class of asset into which the equipment is installed.

11.2.2　Approved Antennas

The CAM-4 RF module has been approved to operate with the Air Interface (antenna) types listed below with the maximum permissible gain indicated. Air Interface types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

IntelliSAW Part #	Type	Gain
IA-MM-5-y	Monopole (5 cm mast)	-1 dBi
IA-MM-9-y	Monopole (9 cm mast)	+1 dBi
IA-MM-17-y	Monopole (17 cm mast)	+3.2 dBi
IA-MM-TPD-y	Patch inverted F (PIFA)	+3.5 dBi
IA-MM-TMP-y	Patch inverted F (PIFA)	+3.5 dBi

Part Number ("y") indicates cable lengths

Note: Air Interface's highlighted in blue are discontinued for sale but are still supported.

11.2.3　Federal Communications Commission (FCC)

This product contains **FCCID: 2AEAE-ISAW-RF-H0215**

The design of the CAM-4 complies with U.S. Federal Communications Commission (FCC) guidelines respecting safety levels of radio frequency (RF) exposure for fixed location devices.

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules when the unit is professional installed in metal enclosures described in the IEEE standard C37.20. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

11.2.3.1   Installation Requirements

The IntelliSAW CAM-4 and approved Air Interfaces can be professionally installed in the following installation environments:

1. Metal enclosures described in the IEEE/ANSI Std C37.20, or UL and NEMA specifications derived from Std C37.20, as indicated in KDB 550099.
   a. The CAM-4 HMI is not required to be in such an enclosure since the Air Interface is wired away from the host.
   b. The CAM-4 HMI firmware shall be configured for ANSI
2. Open air operation
   a. The Air Interface and CAM-4 can operate outside of the metal enclosures when the CAM-4 firmware is configured for Open Air operation.

Changes or modification to the equipment not expressly approved by IntelliSAW could void the user's authority to operate the equipment.

11.2.4   Industry Canada (IC)

This product contains device certified under **IC: 11526A-ISAWRFH0215**

This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following conditions:

- This device may not cause harmful interference.
- This device must accept any interference received, including interference that may cause undesired operation.

Changes or modification to the equipment not expressly approved by IntelliSAW could void the user's authority to operate the equipment

Ce produit contient un appareil certifié en vertu IC: 11526A - ISAWRFH0215

Cet appareil se mets en conformité avec les normes CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux conditions suivantes:

- *L'appareil ne produit pas de brouillage malfaisant.*
- *L'appareil doit accepter tout brouillage radioélectrique reçu, y compris le brouillage qui pourrait provoquer le fonctionnement non désiré.*

Les changements ou les modifications apportés à l'équipement qui n'est pas expressément approuvé par IntelliSAW pourraient annuler l'autorité de l'utilisateur à utiliser cet équipement.

CONTACT

Head Office:

IntelliSAW
100 Burtt Rd.
Andover, MA 01810
contact@intellisaw.com
+1-978-409-1534
www.intellisaw.com

Regional Office:

IntelliSAW LATAM

IntelliSAW China

Regional Distributors:

Visit www.IntelliSAW.com for the latest distribution locations.